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ECONOMIC ANALYSIS OF SUPPLY AND DEMAND FOR FOOD UP TO 2030 – SPECIAL FOCUS ON FISH AND FISHERY PRODUCTS

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PREPARATION OF THIS DOCUMENT

This report contributes to FAO's ongoing activities and forecasts of food demand and supply. There is much concern about future food supply and demand on the basis of expected population growth as well as due to the large number of people still suffering from undernourishment. At the same time there are limits to the potential for expanded production from fisheries, aquaculture and agriculture. What is often overlooked in many studies is the economic impact of changes in supply and demand for example due to changes in food prices, household income and consumer preferences. This analysis takes an economic approach in analysing supply of and demand for food up to 2030, with a particular emphasis on fisheries and aquaculture.

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ABSTRACT

With the world's population expected to reach 8.2 billion people by 2030, and with 842 million people estimated as having been undernourished in the period 2011–13, food supply will present a growing challenge in the next two decades. With increases in income along with demographic changes related to family size, population ageing and urbanization, and consumer trends such as concerns for healthy eating and sustainable production, there will be great shifts in demand and major changes in the composition of demand. This will in turn have an impact on food supply, which will need to both increase and become more efficient if it is to grow within the constraints presented by the availability of natural resources and existing technology.

This publication presents projections of future food supply up to 2030, building on existing analyses but also providing more economic perspectives on the future evolution of food production. It thus looks at the main drivers of future demand and supply, with a particular focus on fisheries and aquaculture production. The analysis is supplemented with a number of new scenarios on fish production in the period until 2022.

CONTENTS

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ABBREVIATIONS AND ACRONYMS

CSR	corporate social responsibility
DHA	docosahexaenoic acid
EPA	eicosapentaenoic acid
GAEZ	Global Agro-Ecological Zones (methodology)
GDP	gross domestic product
HACCP	Hazard Analysis and Critical Control Point (system)
IMF	International Monetary Fund
IUU	illegal, unreported and unregulated (fishing)
MDG	Millennium Development Goal
MSC	Marine Stewardship Council
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
PDO	protected denomination of origin
TFP	total factor productivity
WFS	World Food Summit

EXECUTIVE SUMMARY

Global population growth is projected to slow by 2030. However, this will still result in an estimated 1.3 billion more people – a 19 percent increase. This will drive a significant increase in demand that will present a growing challenge for food supply in the next two decades. Population trends will not be uniform in all parts of the world but range from an increase of 50 percent for Africa to a minor decline in Europe. Different regions will also experience different demographic shifts, which, combined with population growth, will all have an impact on food demand. Population ageing around the world is likely to increase the demand for healthier products and reduce the consumption of starchy staple foods. There will probably be a higher demand for fish protein, while meat consumption is expected to level off. In theory, healthier eating habits will lengthen human life expectancy, which in turn will prolong the employment period. Along with this, the proportion of educated people is expected to rise; thus, work productivity and disposable income should also increase.

The income elasticity of demand for food varies greatly among countries. For low-income countries, increases in income will be accompanied by almost proportional increases in expenditure on food; whereas for high-income countries, elasticities are much lower. Thus, while per capita food consumption is reaching a plateau in more mature economies, the increase in disposable income in some emerging economies will result in an increase in food consumption, but also a composition change, with greater demand for important nutrients such as protein. Nonetheless, significant portions of the population in Africa and Asia will remain undernourished.

Consumer preferences for food products will probably continue to shift in the period until 2030. The main trends that will probably influence future food demand are food safety and health benefits, social concerns, production systems and innovations, sustainability and food origin. To contend with all these drivers of demand, fisheries, aquaculture and agriculture will need to intensify in sustainable and efficient ways.

World fish production has experienced tremendous growth, increasing from 20 million tonnes in 1950 to 156.2 million tonnes in 2012, of which 97 percent was used for direct human consumption. Per capita fish consumption increased from 9.9 kg in 1960 to 19.1 kg in 2012. The increase in production is mainly attributed to aquaculture, which has maintained high growth rates since the 1980s. By 2012, aquaculture production had increased to 66.5 million tonnes, or about 43 percent of total fish supply. Productivity growth and technological progress have been important factors underlying production growth in aquaculture. According to OECD–FAO (2013) projections, this trend is likely to continue, with world fish production reaching 181 million tonnes by 2022 – the main driver of this growth being growth in aquaculture production. Meanwhile, production in capture fisheries has levelled off since mid-1980s at about 85–95 million tonnes per annum, the main reason for this being the depletion of fishery resources.

The export value of fish has shown a tremendous increase in recent decades, reaching USD127 billion in 2011. High-value species are largely traded towards more prosperous markets while low-value species such as small pelagics are generally traded towards low-income markets. World agriculture has experienced fundamental changes in the past few decades. For example, production in developing countries has accelerated and there have been changes in the composition of production driven by consumer demands. However, looking to the future, OECD–FAO (2013) projections to 2022 show that growth in agricultural production is slowing owing to slower productivity and area expansion. Climate change is also expected to have a direct effect on the production of many food plants. In terms of productivity, whereas historically it was high-income economies that drove productivity increases, in the last decade the total factor productivity growth rate of developing countries overtook that of high-income countries.

Developing and emerging economies are likely to drive the growth of agricultural trade. By 2022, developing and emerging countries are likely to account for the majority of the exports of the main plant and animal foods. Many developing countries already register larger increases in export value than developed countries. Developing and emerging countries are also likely to account for a large part of the growth of imports of many foods such as cereals and meat, whereas developed economies will probably continue to be the major exporters of dairy products mainly towards developing countries.

Food supply chains are currently changing in many ways. Many are incorporating the value chain approach, whereby value is added or created along the value chain. Efficiency is also key, and can be improved through various means in order to reduce costs, enhance sustainability, food safety and nutrition, and increase the revenue of supply chain participants, including small producers.

The FAO Fish Model is used to make projections about future fish production up to 2022. Various scenarios for increased aquaculture production are analysed, from a production of 66 million tonnes in 2012 to 85–99 million tonnes in 2022. In the same period, capture production is expected to increase from 91 million to 95 million tonnes. Thus, world fish production is projected to increase from its 2012 level of 157 million tonnes to 181–194 million tonnes in 2022, depending on the assumptions.

According to the results, per capita fish consumption is expected to reach 20.7–22.4 kg in the different scenarios under consideration. In other words, per capita consumption is expected to keep increasing fairly substantially, owing to the continued expansion in aquaculture production, despite the expected increase in population.

The development in aquaculture prices very much depends on the expansion in aquaculture production. For some scenarios, prices are actually projected to decline over time.

The increase in capture fishery production is expected to be rather modest. Nevertheless, prices of capture fish will increase under all scenarios of aquaculture production. However, the larger is the increase in aquaculture production; the lower will be the increase in the price of capture fish. Therefore, in the future, aquaculture production will drive the prices of all fish products as capture is not expected to vary very much.

Production of fishmeal, which was about 6 million tonnes in 2012, is expected to reach 7–7.75 million tonnes in 2022. The use of by-products for fishmeal production will rise steadily from the starting point of 2.6 million tonnes in 2012 to reach 3.4–4 million tonnes in 2022. Aquaculture production will thus be able to expand quite considerably despite the rather modest increase in fishmeal production. This is due to improved efficiency in the use of fishmeal, substitution to other types of feed and expansion of farmed species that require no or little fishmeal as inputs.

1. INTRODUCTION

The purpose of this document is to analyse and project future supply and demand for food. Some analyses focus on the period up to 2030 while others cover up to 2022 only.

A number of studies analyse future food security. However, the subject is usually approached from a production and demographic perspective. This study builds on previous research and includes new scenarios looking at the future development of food production from more of an economic perspective. The FAO fish model is used to generate new scenarios for future fish production up to 2022.

The study can be viewed as consisting of two parts. The first part (demand) looks at the main drivers of future demand. In particular, Chapter 2, on population, examines demographic trends at the world and regional level up until 2030. It also considers various dimensions of population growth such as age, sex, level of education, urban and rural population and their impacts on the demand for food. Chapter 3, on gross domestic product (GDP), analyses future growth in GDP and GDP per capita. Chapter 4, on undernourishment, begins with a definition of the concept and then provides an overview of the current situation of undernourishment, its evolution over time, as well as the actions taken by governments and international organizations aiming at eradicating hunger. Chapter 5 investigates what information the food demand literature can provide about the relationship between changes in demand and changes in prices and income. Chapter 6, on consumer trends, identifies five such important trends and outlines what role governments, non-governmental organizations (NGOs) and the private sector have had in driving these. Chapter 7 summarizes all these changes, which will result in substantial shifts not only in demand but also in the composition of demand.

The second part analyses the main drivers of future supply. Chapter 8, on fisheries, describes the evolution of the fisheries sector over time and discusses the potential for increased production in fisheries and aquaculture in the future. Chapter 9 presents an outline of the development of agriculture in recent decades, together with a discussion of the constraints on further expansion of agricultural production and the potential for increased production in the future. Chapter 10, on supply chains, describes typical supply chains for agriculture, fisheries and aquaculture, both for domestic and international markets, discusses the value chain approach, relationships among agents along the supply and value chains, and analyses the scope for efficiency improvements. A summary of the supply side is presented in Chapter 11.

Finally, focusing on aquaculture, Chapter 12 presents various projections relating to future food supply for various scenarios. Moreover, the impact on fish prices is analysed.

All monetary values in the report are nominal and in United States dollars (USD) unless otherwise noted.

2. POPULATION

Population size is one of the main drivers for future food demand. This chapter examines the development in population until 2030, at the world level as well as at regional level. Moreover, it examines various dimensions of population growth such as urban and rural population, age, sex and level of education and their impacts on demand for food.

2.1 Future population growth

The total size of the world population will increase from 6.9 billion (2010) to 8.2 billion by 2030, and probably to more than 9 billion by 2050. (Table 1). These numbers clearly reflect the slowdown in population growth. According to the International Institute for Applied Systems Analysis (IIASA) projection (UN Scenario of the IIASA education projection), the increase in population in the decade from 2000–2010 was 761 million. It is projected to decline to 466 million for 2040–2050 (Table 1). In other words, world population may be levelling off.

Table 1. Projections of total population size for continents as well as selected countries and regions (millions)

Area	2000	2010	2020	2030	2040	2050
	(millions)					
World	6 124	6 885	7 617	8 233	8 699	9 021
Africa	821	1032	1271	1518	1765	1998
Asia	3 705	4 145	4 546	4 846	5 024	5 095
Europe	729	730	722	707	687	664
Latin America and Carribbean	523	594	660	713	750	769
North America	316	349	379	405	427	445
Oceania	31	35	39	43	46	49
Brazil	174	199	220	236	248	254
China	1 270	1330	1371	1374	1324	1238
India	1 046	1220	1379	1506	1597	1658
United Kingdom	59	62	64	66	68	69
European Union (Member Organization)	482	495	498	496	489	479
Former Soviet Union	289	284	279	271	261	249
NW Europe	246	253	258	262	262	261
Nile catchment	225	285	354	424	492	555
Sub-Saharan Africa	680	867	1081	1308	1540	1761

Source: UN Scenario of IIASA education projections as reported by Lutz and Samir (2010).

As Table 1 shows, there are important regional differences. It is particularly noteworthy that the population of Africa is estimated to increase from 1 032 million in 2010 to 1 518 million in 2030, i.e. almost a 50 percent increase, and roughly double by 2050. Sub-Saharan Africa, which not only represents the largest share of the population of the continent but is also the poorest area, will more than double in population by 2030 and more than triple by 2050. Thus, this area is the main driver of population growth in Africa.

In contrast, the population of Europe will experience a gradual decline. The rate of population growth in Asia will slow. Asia will increase its population by 17 percent in the period from 2010 to 2030 and by 5 percent from 2030 to 2050. The population of Latin America and the Caribbean will increase by 20 percent from 2010 to 2030. Subsequently, the growth will fall to 7 percent in the period from 2030 to 2050. The population of North America will follow a similar trend, growing by 16 percent in 2010–2030 and by 10 percent in 2030–2050.

China is currently the most populous country in the world with 1.33 billion inhabitants (2010). There will be a small increase up to 2030; subsequently it will start declining. The population of India is expected to increase from 1 22 billion in 2010 to 1 379 billion in 2030, at which time it will surpass that of China.

The population of the 48 least-developed countries – 34 of which are in Africa – is still the fastest-growing in the world, at 2.5 percent per year.

The above figures are taken from Lutz and Samir (2010). More recent population projections are available from the United Nations (2011), although they cannot be broken down in the same way as the figures presented in Table 1. Nevertheless, according to the United Nations (2011), the projected world population for 2050 is 9.3 billion, only slightly higher than the estimate in Table 1. In other words, the difference in projections is negligible.

The population increase very much depends on the fertility rate. The UN's medium variant projection sees fertility rate decline from 2.52 children per woman in 2005–2010 to 2.17 children per woman in 2045–2050. Despite the fact that the fertility rate in developed regions increased slightly to an estimated level of 1.66 children per woman in 2005–2010, all the major increases will happen in the developing world, in Africa and Western Asia in particular. According to Lutz and Samir (2010), the devastating AIDS pandemic in the worst-hit countries of Africa will shorten life expectancy and eventually slightly slow population growth. However, it will not have a significant impact on population over time.

Slow population growth brought about by reductions in fertility rate leads to population ageing. This refers to the process whereby the population's proportion of older persons increases while that of younger persons decreases. Currently, about 8 percent of the total world population is above the age of 65 years (Table 2).

According to the UN report *World Population Prospects. The 2010 Revision*, in the more developed regions,[1] 22 percent of the population is already aged 60 years or over, and this proportion is projected to reach 32 percent in 2050. In developed countries as a whole, the number of older persons has already surpassed the number of children (persons under 15 years), and by 2050 the number of older persons in developed countries will be nearly twice the number of children.

Lutz and Samir (2010) report that Asia is the most rapidly ageing continent, where the proportion of inhabitants above 65 will increase from the current 7 percent to 21 percent by 2050, that is, higher than current European level (16 percent). China's current proportion of people above 65 is only half of that of Europe. However, China's population is also experiencing a significant ageing trend and will rapidly be aligned with Europe, reaching 27 percent of people above 65 by the middle of this century.

Although the projected population growth varies from region to region, the projected increase in life expectancy together with declines in fertility rates will result in significant ageing of the population in all regions in the longer run. Even in Africa, where the population is still very young (only 3 percent of the population are above 65), the proportion of people aged 65 and older will reach 5 percent by 2030 and 7 percent by 2050 (Table 2).

[1] The more developed regions refer to Australia, New Zealand, Europe, Northern America and Japan.

Table 2**.** Projection of the proportion of the population aged 65 years **and over for continents as well as selected countries and regions**

Area	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
	(percentage)					
World	7	8	10	13	16	19
Africa	3	3	4	5	5	7
Asia	6	7	9	13	17	21
Europe	15	16	19	23	25	28
Latin America and Carribbean	6	7	9	12	15	19
North America	12	13	16	20	21	21
Oceania	10	11	14	16	18	19
Brazil	5	7	9	13	16	19
China	7	8	12	17	24	27
India	5	5	7	9	11	14
United Kingdom	16	17	19	22	24	24
European Union (Member Organization)	16	17	20	24	27	29
Former Soviet Union	11	11	13	16	18	21
NW Europe	16	18	21	24	26	26
Nile catchment	3	4	4	5	6	8
Sub-Saharan Africa	3	3	3	4	5	6

Source*:* UN Scenario of IIASA education projections as reported by Lutz and Samir (2010).

It is important to notice that, along with the increased average age of the world population, the average disability-free life expectancy is also increasing.

According to UN global predictions, life expectancy at birth is projected to rise from 68 years in 2005–2010 to 76 years in 2045-2050. The life expectancy increase is not uniform across different parts of the world. In the more developed regions, the projected increase is from 77 years in 2005–2010 to 83 years in 2045–2050, while in the less developed regions the expected increase is from 66 years currently to 74 years by mid-century. Life expectancy remains low in the least-developed countries and is projected to reach 69 years in 2045–2050, up from 57 years in 2005–2010.

The older persons of the future are expected to be in better health, and be better educated, than the ones of today and more likely to retire later in life. In case of the latter, a well-established employment incentive structure will be the main driver for developed and developing countries and the main challenge for the poorest countries where old age support does not exists outside one's own family.

Another challenge for the least-developed countries is to increase the overall level of education as there is a direct correlation between the level of education, better health conditions and higher productivity.

Recent studies have shown that there are some thresholds both with respect to health and to economic growth in the sense that universal primary education (one of the key Millennium Development Goals) is not sufficient but that it requires high proportions of the population with at least completed junior secondary education (to age 15) to help bring countries out of the vicious circle of poverty, high population growth and food insecurity (Lutz, Crespo Cuaresma and Sanderson, 2008).

Table 3 shows the proportion of the population with junior secondary or higher education. The projections are based on the Global Education Trend Scenario (KC *et al*., 2010) and assume that the countries later in the development process follow the trend of the more advanced countries in terms of the change of proportions in different educational attainment categories. As the values in Table 3 suggest, the level of education will increase almost universally and the proportion of men and women with at least secondary education in the society will be almost aligned by 2030. In some countries, the level of female school enrolment will surpass that of males.

The fact that the level of education is rising together with the population, provides a more optimistic projection for the future than a focus on population size alone. Even in Africa, more than 50 percent of boys and girls would have at least secondary education by 2030.

When analysing China and India, which are often mentioned as two great economic powers of the future, it is easy to notice that the human capital will be structurally different in the two countries. The difference is less noticeable when comparing the respective male populations: 87 percent of boys in China and 70 percent of boys in India will have at least secondary education by 2030. However, India will stay behind China with regard to the education of girls. By 2030, 42 percent of the total adult women population will remain uneducated, compared with only 18 percent for China.

Among other transformational changes are the changes in proportions of rural and urban population. According to the Foresight report (2011): “rising numbers of people [will] move from rural areas to cities and will need to be serviced with food, water and energy.” Half the world’s population now lives in urban environments, a figure projected to rise to 60 percent by 2030 (UNDP, 2007). It is estimated that there will be 26 cities with more than 10 million inhabitants in 2025, up from 19 today. Five of these new “megacities” will be in Asia (UN-HABITAT, 2008). According to the OECD–FAO (2011), urbanization will continue to reshape consumption patterns towards higher-value processed products and convenience foods

Due to urbanization, the cities will grow and some land that is used or can be used for agriculture will be lost. Taking into account that some of the land has already been lost to erosion, desertification, salinization and rising sea levels, urbanization will put more pressure on aquaculture and agriculture. In addition, growing urbanization lengthens the food supply chain and, in countries with poor infrastructure, may lead to an increase in the volume of food waste generated. The poorest countries, where infrastructure for storage and supply is often inadequate, will experience greater losses in post-harvest storage and the food supply chain. Urban people in low-income countries who cannot grow their own food or secure access to “wild food” will also suffer more from temporary spikes in food prices than their counterparts in richer countries

Table 3. Projections of the proportions of the population (above age 15) that have junior secondary or higher education for continents as well as selected countries and regions

Sex	Area	2000	2010	2020	2030	2040	2050
		(percentage)					
Female	World	*53*	*59*	*65*	*71*	*77*	*82*
	Africa	26	35	43	52	60	67
	Asia	45	54	62	69	76	82
	Europe	85	89	92	94	95	96
	Latin America and Carribbean	53	62	70	78	84	89
	North America	95	94	94	94	94	95
	Oceania	96	99	100	100	100	100
	Brazil	52	62	71	80	86	91
	China	56	66	75	82	89	93
	India	28	38	48	58	67	75
	United Kingdom	73	81	87	90	92	94
	European Union (Member Organization)	80	85	90	93	94	95
	Former Soviet Union	96	98	99	99	99	99
	NW Europe	83	87	91	93	94	95
	Nile catchment	25	34	42	52	60	67
	Sub-Saharan Africa	21	29	38	47	55	63
Male	World	*62*	*67*	*72*	*76*	*79*	*83*
	Africa	38	45	52	58	63	68
	Asia	59	66	72	76	81	84
	Europe	86	89	92	93	94	96
	Latin America and Carribbean	52	60	67	73	79	83
	North America	94	94	94	94	95	95
	Oceania	96	98	100	100	100	100
	Brazil	48	56	64	72	78	83
	China	71	78	84	87	91	94
	India	47	55	63	70	75	80
	United Kingdom	73	81	86	89	91	92
	European Union (Member Organization)	82	86	89	92	93	94
	Former Soviet Union	96	98	98	99	99	99
	NW Europe	84	87	90	93	94	95
	Nile catchment	37	43	50	56	61	66
	Sub-Saharan Africa	33	39	47	54	59	65

Source: UN Scenario of IIASA education projections as reported by Lutz and Samir (2010).

2.2 Summary and discussion

Based on the analysis above, Table 4 summarizes the main changes that are projected to take place in population growth and composition over time. Although population growth will slow, compared with 2010 there will be 1.3 billion more people by 2030 – a 19 percent increase.

Table 4. Projected population changes 2010–2030

Area	Population change 2010-2030
World	Population growth, although slowing, 19.6 percent increase to 2030 to 8.2 billion
Africa	Almost 50 percent increase in population The largest increase in sub-Saharan Africa – 92 percent Highest population growth rate of any region
Europe	Minor decline in population Ageing population
Asia	Almost 17 percent increase to 2030
Latin America and the Caribbean	Almost 20 percent increase to 2030
North America	Almost 16 percent increase to 2030
China	Slight increase to 2030
India	India will surpass China in terms of population by 2030 44 percent increase

Population growth will not be uniform in all parts of the world (section 2.1 and Table 1). The population also will experience demographical shifts that combined with its growth will affect food demand and put pressure on global food supply (Table 5).

Table 5. Demographic changes and impact on food demand

Demographic change	Impact on food demand
Ageing population	• Shift in food consumption towards healthier products by the population over 65 • Stable demand for meat protein in developed countries. Increased demand in some developing countries • Overall increased demand for fish protein • Decreased consumption of starch-based staple foods
Increased life expectancy	• Increased average employment period of the population will affect GDP and ability to purchase food
Improved level of education	• Improved productivity in all sectors of the economy including the food industry • More conscious choice of food consumed (healthy trend) • Possible reduction in number of children per household in developing countries
Increased urbanization	• In 2030, 60 percent of the world's population will live in urban areas • Loss of land for agriculture • Lengthened food supply chain • Increased food waste generation in the countries with poor supply chain infrastructure • Shift in consumption towards processed and ready-made foods. • Increased consumption of foods high in fats and sugar due to advertising..

In terms of the average age of the population, the African continent has the youngest population structure due to high fertility rate. The number of older persons will reach 5 percent of the total population by 2030, a relatively small proportion when compared with other regions. Reduced fertility rates in Europe will eventually result in significant ageing of the population, as in most countries of the developed world (8 percent of the total world population are above the age of 65 already). Currently, 22 percent of the European population are older than 60, and the proportion is projected to reach 32 percent in 2050. Asia is the continent with most rapidly ageing population and the percentage of older persons will reach the current European level by 2050.

The ageing of the population in the world, especially in developed countries, will increase the demand for healthier products and reduce the consumption of starch staple foods. There will be a higher demand for fish protein while meat consumption will level off.

As a consequence of population ageing and a healthier diet, human life expectancy is projected to be higher. This will result in a longer employment period. The increased disposable income will affect the demand for food.

The proportion of educated people will rise worldwide and will affect demand in different ways. First, improved productivity through improved use of resources will influence disposable income. Second, it will have an impact in developing countries over time by increasing the population's awareness of the value, and meaning, of healthy eating – this is already a clearly apparent trend in developed countries. Finally, education will result in fewer children per family in some countries, thereby negatively affecting household demand for food and reducing overall demand.

The increased size of the urban population will have an impact on the demand for food (section 2.1). Urbanization will also influence the diet of the city inhabitants who are shifting their preferences towards more processed and ready-made food. Owing to economies of scale, even relatively poor people in cities will be able to buy processed foods, while the adoption of urban lifestyles and exposure to advertising can lead to increased consumption of foods high in fats and sugars.

3. DEVELOPMENT IN GROSS DOMESTIC PRODUCT

Income is one of the most important determinants of food demand. This chapter analyses future growth in GDP as this variable is considered a good measurement of income. It also looks at population growth (Chapter 2), which combined with the analysis of GDP growth, allows something to be said about the development in GDP per capita and its implications for future food demand. As before, the focus is on the period up to 2030.

3.1 Future GDP growth

Projections of future GDP growth are available from two sources: the Conference Board,[2] and the International Monetary Fund (IMF). This study looks at both. While the Conference Board gives projections up to 2025, the IMF presents forecasts only until 2018. All growth rates presented are annual unless otherwise specified.

According to the IMF, average yearly GDP growth in the world in 2013–18 will be 4.2 percent (Table 2.1), although it will slow during this period. The decrease is expected to be driven largely by structural transformations in the emerging economies. This is because China, India, Brazil and other emerging economies are maturing from a rapid, investment-intensive growth stage to a more balanced model of growth. The current growth speed will probably reach its structural limits, bringing down global growth despite the recovery from global economic crises expected in advanced economies after 2013.

Major advanced economies (the G7) are expected to grow at an average annual rate of 2.2 percent in this period, with expected growth rates of 3.1 percent and 1.3 percent for the United States of America and Japan, respectively. Major advanced economies excluding the G7 are predicted to grow at 3.3 percent.

Europe is predicted to grow at 1.45 percent per year on average in 2013–18 with growth in the Eurozone being slightly lower (1.17 percent) and growth in Eastern and Central Europe slightly higher (3.23 percent).

In emerging markets and developing economies, GDP growth is forecast to average 5.9 percent, which is high compared with developed countries. The GDP growth rate in developing Asia is projected to be even higher, at an average of 7.54 percent. China's GDP will grow at an average annual rate of 8.38 percent and India's at 6.55 percent.

Average yearly GDP growth in Latin America and the Caribbean is projected to be 3.79 percent, and the Near East and North Africa averaging 4.2 percent.

According to projections, African regions will grow at different rates. The economy of sub-Saharan Africa is expected to experience average annual growth of 5.69 percent, Central Africa 5.47 percent and South Africa 3.19 percent in 2013–18.

[2] The Conference Board is a global, independent business membership and research association working in the public interest. Founded in 1916, the Conference Board works within and across four main subject areas: corporate leadership; economies, markets and value creation; high-performing organizations; and human capital. The International Monetary Fund is an organization of 188 countries, working to foster global monetary cooperation, secure financial stability and facilitate economic growth.

Table 6. GDP growth projection, 2013–2018

Countries and Country groups	2013	2014	2015	2016	2017	2018	Avg. yearly growth rate
	(percentage)						
Advanced economies	1.23	2.25	2.58	2.61	2.60	2.45	2.29
United States of America	1.85	2.95	3.56	3.44	3.34	2.92	3.01
Japan	1.58	1.41	1.05	1.22	1.19	1.13	1.26
Euro area	-0.34	1.07	1.45	1.60	1.62	1.61	1.17
Major advanced economies (G7)	1.26	2.16	2.53	2.53	2.49	2.28	2.21
Other advanced economies (advanced economies excluding G7 and euro area)	2.46	3.37	3.44	3.46	3.55	3.59	3.31
European Union (Member Organization)	0.00	1.28	1.67	1.84	1.91	1.97	1.45
Emerging market and developing economies	5.31	5.72	5.98	6.08	6.12	6.15	5.89
China	8.04	8.24	8.51	8.53	8.50	8.46	8.38
India	5.68	6.23	6.63	6.86	6.92	6.97	6.55
Central and Eastern Europe	2.15	2.78	3.31	3.59	3.75	3.82	3.23
Commonwealth of Independent States	3.41	4.02	4.03	3.94	3.94	3.96	3.88
Developing Asia	7.13	7.35	7.62	7.71	7.72	7.72	7.54
ASEAN-5	5.88	5.51	5.48	5.63	5.70	5.70	5.65
Latin America and the Caribbean	3.38	3.88	3.86	3.87	3.88	3.89	3.79
Near East, North Africa, Afghanistan, and Pakistan	3.14	3.66	4.33	4.47	4.51	4.46	4.09
Near East and North Africa	3.10	3.69	4.46	4.63	4.67	4.63	4.20
South Africa	2.84	3.35	3.43	3.30	3.11	3.08	3.19
Central Africa	4.33	6.00	5.30	5.70	5.70	5.80	5.47
Sub-Saharan Africa	5.57	6.10	5.86	5.67	5.48	5.45	5.69
World	3.31	4.04	4.37	4.46	4.51	4.49	4.20

Note: Gross domestic product, constant prices, percentage change.
Source: International Monetary Fund, World Economic Outlook Database.

The Conference Board Global Economic Outlook 2013 projects GDP growth in different regions according to three scenarios: optimistic, base and pessimistic. The projections are for the periods 2013–18 and 2019–2025 (Table 7).

The world GDP growth in base scenario is forecast to decrease from 3.1 percent in 2013–18 to 2.6 percent in 2019–2025, a decrease of 0.5 of a percentage point. The slowdown in average GDP growth of advanced economies will see an average annual rate of 1.8 percent in 2013–18 fall to 1.6 percent in 2019–2025, according to projections. The United States economy is expected to grow at 2 percent in 2019–2025 in contrast to 2.3 percent in 2013–18. The GDP growth in other advanced economies[3] is expected to fall by 0.8 of a percentage point in 2019–2025 from 2.6 percent in 2013–18. The economy of Japan will probably continue on a stable growth trajectory of 0.9 percent in 2013–2025, according to the base scenario.

In Europe,[4] GDP growth is projected to increase by 0.1 of a percentage point in 2019–2025 from its current level of 1.2 percent. The growth rate in the Eurozone is estimated to be aligned with Europe as a whole by 2019–2025, reaching 1.3 percent in this period, an increase of 0.2 of a percentage point from 2013–2018. That suggests that European economy will have recovered from global economic crises by this time.

[3] The category other advanced economies includes Australia, Canada, China, Hong Kong SAR, Israel, New Zealand, Republic of Korea, Singapore and Taiwan Province of China.
[4] Here, the term Europe includes 27 members of the European Union (Member Organization) (not Croatia), as well as Iceland, Norway and Switzerland.

The emerging and developing economies are estimated to grow at an average rate of 3.3 percent for 2019–2025, a decrease of 1.1 percentage points from the 2013–18 level, according to the Conference Board base scenario.

Table 7. Comparison of base, optimistic and pessimistic scenarios, 2013–2025 (January 2013)

GDP growth in differend scenarios	2013–2018			2019–2025			Distribution of world output 2025
	Optimistic	Baseline	Pessimistic	Optimistic	Baseline	Pessimistic	
United States of America	2.5	2.3	2.1	2.4	2.0	1.6	18.30%
Europe*	1.5	1.2	0.8	1.6	1.3	0.9	17.40%
of which: Euro Area	*1.4*	*1.1*	*0.8*	*1.6*	*1.3*	*1.0*	12.00%
Japan	1.3	0.9	0.5	1.2	0.9	0.7	4.80%
Other advanced**	3.5	2.6	1.7	2.5	1.8	1.2	7.30%
Advanced economies	2.1	1.8	1.4	2.0	1.6	1.2	47.80%
China	8.0	5.8	3.7	4.9	3.7	2.5	22.70%
India	5.7	4.7	3.6	4.5	3.8	3.2	8.20%
Other developing Asia	6.4	5.0	3.6	5.5	4.4	3.2	4.90%
Latin America	3.9	3.2	2.5	3.4	2.8	2.2	7.10%
Near East	2.7	2.5	2.3	2.5	2.3	2.0	2.50%
Africa	5.1	4.1	3.2	5.0	4.1	3.2	2.60%
Russian Federation, Central Asia and Southeast Europe	3.1	2.1	1.2	2.1	1.5	1.0	4.10%
Emerging and developing economies	5.7	4.4	3.0	4.2	3.3	2.5	52.20%
World total	**4.0**	**3.1**	**2.2**	**3.3**	**2.6**	**1.9**	**100%**

Source: www.conference-board.org/data/globaloutlook.cfm

Note: * Europe includes 27 members of the European Union (Member Organization) (excluding Croatia) as well as Switzerland and Norway.

** Other advanced economies include Australia, Canada, China, Hong Kong SAR, Cyprus, New Zealand, Norway, Iceland, Israel, Republic of Korea, Singapore, Switzerland, and Taiwan Province of China.

Of the other regions and countries, the lower growth rate in China is the most noticeable. It is projected to lose 2.1 percent in GDP growth by 2019–2025 from the 2013–18 level of 5.8 percent. India is also expected to experience a decrease in GDP growth from 4.7 percent to 3.8 percent per year.

The growth rates are estimated to decrease by 0.6 of a percentage point in the Russian Federation, Central Asia and Southeast Europe[5] and other developing Asia from their current 2.1 percent and 5 percent, respectively.

Growth in Latin America and the Near East is projected to slow by 0.4 percent and 0.5 percent of a percentage point, respectively, over the 2019–2025 period.

The African economy is expected to continue to grow steadily at 4.1 percent in 2013–18. Despite its stable GDP growth, Africa will contribute only 2.6 percent to the total world output.

It is difficult to make direct comparisons between the two sets of GDP projections in some cases owing to differing geographical definitions of world regions. However, both the IMF and the Conference Board predict a slowdown in world GDP growth. The IMF projects positive GDP growth in the majority of regions and countries, although growth is expected to level off or even decline for several countries in 2017–18. The figure for average GDP in the base scenario of the Conference Board in 2013–18 is lower than that in 2019–2025 for all regions.

[5] The percentage contributions to global growth are computed as log differences and therefore do not exactly add up to the percentage growth rate for the world economy.

The projected figures by IMF are slightly higher than those in the base scenario of the Conference Board and more aligned with its optimistic scenario. However, the numbers vary in some countries. According to the IMF, the average yearly growth in the United States of America is estimated to be 3 percent in 2013–18 while the Conference Board projects 2.3 percent in its base scenario and 2.5 percent in the optimistic scenario. The IMF projections for average yearly GDP growth in India are also higher than those of the Conference Board in both scenarios, 6.55 percent versus 4.7 percent and 5.7 percent in the pessimistic and optimistic scenarios, respectively. The IMF is also more optimistic about GDP growth in developing Asia in this period, projecting 7.54 percent yearly, while the Conference Board suggests 6.4 percent in its optimistic scenario.

3.2 GDP per capita

This section examines IMF projections for GDP per capita up to 2018.

The Conference Board does not provide per capita projections. Their projections are examined in combination with population growth, which enables growth in GDP per capita to be determined, which can then be compared with the IMF forecasts.

Contemporaneously with the decrease in GDP growth rate, world population growth is also slowing. As outlined in Chapter 2, the world's population is predicted to reach a plateau and possibly decline in the second half of the century although the total size of the world population is projected to increase from 6.9 billion in 2010 to 8.2 billion 2030, and probably to more than 9 billion to 2050.

Similarly to GDP growth, population growth varies considerably among regions (see Chapter 2).

Table 8 provides projections of GDP per capita change in selected countries of major regions in 2013–18. The predictions for 2019–2030 are not available for further comparison.

The sample of selected countries in Europe suggests that all countries will experience GDP per capita growth in 2013–18. The GDP per capita growth rate will be stable at 3.6 percent in Germany while in other countries the growth rate will increase in most years. The predicted yearly change in GDP growth rates is especially noticeable in Greece, increasing from 2.8 percent in 2014 to 5.4 percent in 2018. This fact suggests the country is expected to recover from consequences of the global economic crisis.

Among advanced economies, GDP per capita growth in the Republic of Korea is projected to increase from 5.5 percent in 2014 to 5.7 percent in 2018, that is, faster than in the other countries presented. By 2018, the Republic of Korea is estimated to add 32 percent to its GDP per capita compared with 2013. In the United States of America, GDP per capita will probably grow at 4.5 percent annually. China and India are projected to continue on their rapid growth paths in the 2013–18 period with average GDP per capita growth per year of 10 percent and 7.5 percent, respectively. China is expected to have increased its GDP per capita by 62 percent and India by 44 percent in 2018 compared with 2013.

In Latin America, GDP per capita is predicted to grow at different rates in different countries. Brazil and Chile will growth at 5.5 percent and 5.9 percent, respectively, and will increase their GDP per capita by 31 percent and 33 percent, respectively. Argentina's GDP per capita growth rate will probably decrease from 4.3 percent in 2014 to 3.9 percent in 2015, but will later stabilize at 4 percent in 2016–18.

Table 8. Per capita GDP growth rates for selected countries, 2013–2018

Selected regions	Yearly increase (%)					2013–2018 increase (%)
	2014	2015	2016	2017	2018	
European Union (Member Organization)						
Germany	3.7	3.6	3.6	3.7	3.6	19
United Kingdom	2.7	3.1	3.3	3.5	3.9	18
France	2.4	3.0	3.4	3.6	3.6	17
Italy	2.2	3.0	3.3	3.4	3.2	16
Spain	3.0	3.6	3.8	3.9	4.0	20
Greece	2.8	5.1	6.0	5.8	5.6	28
Portugal	2.5	3.5	3.9	4.0	4.0	19
Advanced economies						
Canada	3.5	3.6	3.6	3.6	3.4	19
Japan	3.7	3.4	3.6	3.7	3.7	19
United States of America	4.1	4.7	4.7	4.6	4.2	24
Republic of Korea	5.5	5.6	5.7	5.7	5.7	32
New Zealand	3.1	3.0	3.1	3.2	3.1	16
Sweden	3.6	3.7	3.9	4.0	3.9	21
Switzerland	3.2	3.3	3.4	3.5	3.5	18
Developing Asia						
China	9.8	10.1	10.2	10.3	10.2	62
India	6.9	7.4	7.7	7.8	7.8	44
Latin America						
Argentina	4.3	3.9	4.0	4.0	4.0	22
Brazil	5.3	5.4	5.7	5.7	5.7	31
Chile	5.8	5.8	6.0	6.0	6.0	33
Venezuela (Bolivarian Republic of)	2.7	2.7	3.0	3.1	3.1	15
Near East						
Egypt	3.2	5.5	6.6	6.7	6.1	31
Saudi Arabia	4.1	4.5	4.5	4.5	4.4	24
Africa						
Algeria	3.9	4.1	4.3	4.5	4.5	23
Angola	7.0	6.9	7.0	7.1	6.5	40
Botswana	5.0	5.2	5.3	5.7	5.1	29
South Africa	4.2	4.3	4.2	4.1	4.0	23
Ethiopia	6.0	6.3	6.4	6.4	6.6	36
Nigeria	6.2	6.3	6.3	6.4	6.1	36
Mozambique	8.0	8.0	7.9	7.9	7.9	47
Russian Federation and Eastern Europe						
Russian Federation	6.2	6.2	6.2	6.2	6.2	35
Ukraine	5.4	6.1	6.2	6.3	6.2	34
Romania	4.2	4.6	5.2	5.7	5.9	28

Note: Gross domestic product based on purchasing power parity (PPP) per capita GDP in USD.
Source: International Monetary Fund, World Economic Outlook Database.

In the Near East, GDP per capita is estimated to grow by from 3.2 percent in 2014 to 6.1 percent in 2018 in Egypt and at a more stable rate in Saudi Arabia (4.4 percent on average).

Per capita GDP in Africa is projected to grow at different rates. Some countries such as Angola, Ethiopia, Mozambique and Nigeria will probably increase their per capita GDP by more than 6 percent annually in 2013–18 and will probably add 40, 36, 47 and 36 percent, respectively, to their

GDP per capita by 2018 compared with 2013. However, growth in GDP per capita in Algeria and South Africa is expected to be more modest – an increase of 23 percent in 2018 compared with the current level (2013).

Among Eastern European countries, the Russian Federation is projected to increase its per capita GDP by 6.2 percent annually in 2013–18, adding 35 percent to the current GDP per capita level by 2018. Similarly to the Russian Federation, per capita GDP in Ukraine will increase on average by 6 percent annually in the same period, increasing by 34 percent by 2018 compared with 2013. Romania is predicted to experience consistent but more modest growth in GDP per capita, ranging from 4.2 percent in 2013 to 5.9 percent in 2018.

Owing to population ageing and increased life expectancy, spending on public pensions is likely to increase significantly. According to "The Challenge of Public Pension Reform in Advanced and Emerging Economies" (an IMF working paper): "over the next 20 years, the average present discounted value (PDV) of pension spending increases is 9 percent of 2010 GDP in the advanced economies and 7 percent in the emerging. The cumulative PDV of increases in pension spending over 2010–2050 is 36 percent of 2010 GDP in advanced and 48 percent for emerging economies." Thus, despite the expected widespread increases in GDP per capita, corresponding increases in the personal wealth of individuals are uncertain.

3.3 Impact on food demand

According to the Foresight report (2011), the extent to which increased GDP is correlated with reduced population growth and increased per capita food demand, and the precise nature of how these different trade-offs develop, will have a major effect on gross food demand.

Table 9 summarizes the main changes in food demand that are expected to occur in different regions and selected countries up to 2025.

The change in per capita food consumption driven by the change in income is difficult to estimate. The Foresight report (2011) suggests that the relationship between income and demand is non-linear. According to Engel's law, with a given set of tastes and preferences, as income rises, consumers increase their expenditures on food products (in percentage terms) less than their increases in income.

Table 9 indicates that demand in richer and more mature economies is not expected to increase significantly. According to the OECD–FAO Agricultural Outlook (2012), in higher-income countries where food expenditure represents a small share of income (10–15 percent), per capita food consumption is reaching a plateau. Thus, increased GDP per capita in advanced economies, Europe and richer regions of the Near East and Eastern Europe will affect the composition of consumption rather than cause an overall increase in food consumption. The GDP per capita increase in some emerging economies (developing Asia, Latin America, developing regions of the Near East and Eastern Europe) will result in both food consumption increase and composition change.

It is difficult to predict the exact magnitude of the expected consumption increase in developing regions owing to the differing rates of economic growth seen throughout these regions. An increase in consumption of some particular products will depend not only on income but on the cultural and religious traditions of a particular country – these add a degree of uncertainty to a prediction based purely on income gain.

While the IMF projections go up to 2018 and those of the Conference Board to 2025, the focus of this analysis is the situation up to 2030. It is inherently difficult to make good predictions for such a long period. However, it is fair to assume that, barring unforeseen circumstances, the qualitative nature of the predictions up to 2025 are likely to continue until the end of that decade.

Table 9. Projected impact of GDP per capita on food consumption in regions and selected countries, 2013–2025

Region	GDP and GDP per capita change	Impact on food demand
Europe and European Union (Member Organization)	• Europe will contribute 17.4 percent to world GDP by 2025. • On average, selected countries will add 19 percent to their GDP per capita by 2019. • Greece and Spain will have higher yearly change in GDP per capita growth rates than others and will add 28 percent and 20 percent, respectively, to their GDP by 2019.	• Increase in disposable income will not have significant impact on food composition in majority of countries as current income levels already sufficient to meet dietary needs. In countries such as Greece and Spain, increased per capita GDP will bring the consumption of luxury foods up to the average European level. • Trends such as ageing of population and health consciousness will probably shift diet composition towards more healthy foods.
Advanced economies	• Advanced economies will contribute 47.8 percent to world output by 2025. • The increase in GDP per capita by 2019 of selected countries will vary from 16 percent in New Zealand to 32 percent in the Republic of Korea. • GDP per capita growth rate is highest in the Republic of Korea, although it will stabilize in 2016–18 at 5.7 percent annually.	• Similarly to Europe, the increase in disposable income will not be accompanied by a significant increase in food consumption. • There will probably be a shift in diet composition owing to the healthy eating trend, more conscious food choices of consumers and higher consumption of luxury foods.
Developing Asia	• China's economy will continue to grow from 2013 to 2025 although at decreased pace. China will contribute 22.7 percent to world GDP by 2025. • China's GDP per capita increase will continue to be high at about 10 percent on a yearly basis in 2014–18 and will add 62 percent to its GDP per capita by 2018. • India will contribute 8.2 percent to world GDP by 2025. • GDP per capita growth in India will rise steadily from 6.9 percent in 2014 to 7.8 percent in 2018, and GDP per capita will have increased by 44 percent by 2018.	• High income growth will lead to food consumption increase in developing Asia in general and China and India in particular in all product categories. • Luxury food products will become an increasingly important component of food expenditure for upper-middle-class families.
Latin America	• The countries will grow at different speeds and contribute around 7.1 percent to world GDP by 2025. • Brazil and Chile will continue to develop with high growth rates and add 31 percent and 33 percent, respectively, to their GDP per capita by 2013–18.	• Similarly to developing Asia, there will be a demand increase in all product categories in Latin America. • Demand for luxury food products will be important especially in Brazil and Chile owing to significant increase in GDP per capita.

Region	GDP and GDP per capita change	Impact on food demand
Near East	• The Near East will contribute 2.5 percent to world GDP output by 2015. • GDP per capita growth rate will vary from country to country. • Upward trend in GDP per capita growth in Egypt will add 31 percent to its GDP per capita by 2018.	• Rich Near East countries such as Saudi Arabia will not experience much increase in food consumption although there will probably be shifts in diet composition. Developing countries such as Egypt will experience a food consumption increase in the majority of categories owing to higher income.
Africa	• Despite high GDP growth in certain regions, Africa will contribute only 2.6 percent to the World GDP output by 2025. • Countries grow at very different rates. • GDP per capita in Angola, Ethiopia, Mozambique and Nigeria will increase by more than 6 percent annually in 2013–2018 and will add 40, 36, 47 and 36 percent, respectively, to their GDP per capita by 2018.	• Increased disposable income in Africa will cause an increase in consumption. • The increase will be especially noticeable in consumption of important nutrients such as proteins. • The magnitude of this increase is unclear owing to the differing rates of economic development within the continent.
Russian Federation and Eastern Europe	• The region will continue its GDP growth at 2.1 percent on average in 2014–18 and 1.5 percent in 2019–2025 and will contribute 4.1 percent to world GDP by 2025. • GDP per capita growth in the Russian Federation will stabilize at 6.2 percent in 2014–18. GDP per capita will have increased by 35 percent by 2018. • The GDP per capita growth rate in Ukraine and Romania will rise steadily and reach about 6.2 percent and 5.9 percent by 2018, adding 34 percent and 28 percent to their GDP, respectively, by the same year.	• As in Europe, the increase in disposable income will not translate into a significant increase in food consumption in the majority of countries. • A shift in consumption towards healthier and more expensive food products is predicted owing to increases in income and the influence of the healthy eating trend from developed countries.

4. UNDERNOURISHMENT AND HUNGER

Chapter 6 highlights the fact that in some developed countries obesity and increased risks of broad fatal and non-fatal diseases are important problems while at the same time some developing countries suffer from undernourishment and its consequences. It is important to understand how the needs of people who are undernourished and hungry will be met by 2030. This represents a major challenge to society.

This chapter defines what undernourishment is and provides an overview of the current situation in relation to undernourishment, its development over time and actions aimed at eradicating hunger by governments and international organizations.

4.1 Hunger

This section, including the quotes, is based on the FAO Hunger Portal unless otherwise noted.[6]

FAO defines food insecurity as "a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life."[7] At the same time, "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life"[8].

On average, a person needs about 1 800 kcal per day as a minimum energy intake. Millions of people in the world suffer from undernutrition, undernourishment or chronic hunger. Undernutrition generally applies to energy, protein and sometimes to vitamins and mineral deficiencies in a one's diet. Undernourishment or hunger is a condition when a person's daily food consumption is less than his/her minimum energy needs. Undernourishment makes it difficult to perform physical activities such as study and work. It is particularly harmful for women and children. Hungry mothers often give birth to underweight and sick babies. Undernourishment in children prevents them from ever reaching their full physical and cognitive potential, costing lives, livelihoods and economic growth. Constantly hungry mothers and children are vulnerable to diseases and infections due to weakened immune system. Hunger "leads to distress behaviour that undermines development, including the sale of assets, the withdrawal of children from school (particularly girls) and into the labour force, the prompting of outmigration and, at worst, permanent destitution, prostitution and child trafficking. It also contributes to the onset of armed conflict" (Foresight, 2011, p. 24).

Three categories of people are mainly at risk of hunger: the rural poor, the urban poor and victims of catastrophes. The rural poor mostly live in the poor rural areas of developing countries. Many of them do not have sufficient access to electricity and safe drinking-water. "Public health, education and sanitation services are often of low quality. The world's most food-insecure and hungry people are often directly involved in producing food. They cultivate crops on small plots of land. They raise animals. They catch fish. They do what they can to provide food for their families or earn money at the local produce market. Many have no land of their own and work as hired hands to earn enough money to get by. Often the work is seasonal, and the family must move or split up to earn a living. It is hard work and it is difficult to set anything aside in case of an emergency. Even when there is enough food, the threat of hunger is always present."

The urban poor normally do not produce food and lack the means to buy it. More than half the world's population now live in urban environments, a figure projected to rise to 60 percent by 2030 (Chapter 2). With the increased urban population, the percentage of urban poor will also increase. They will need to be provided with food and water. Victims of catastrophes are people affected by

[6] FAO. 2013. Hunger Portal. In: *FAO* [online]. Rome. [Cited 16 June 2013]. www.fao.org/hunger/en/
[7] FAO. 2013. Glossary. In: *FAO* [online]. Rome. [Cited 16 June 2013]. www.fao.org/economic/esa/seed2d/glossary/en/
[8] FAO. 2013. Food security statistics. In: *FAO* [online]. Rome. [Cited 16 June 2013]. www.fao.org/economic/ess/ess-fs/it/

natural disasters or armed conflicts. Very often, they are forced to abandon their homes and possessions in dangerous areas. These unfortunate circumstances put them at risk of starvation.

4.2 Geography of hunger and its development over time

The assessment of the number of undernourished or chronically hungry people in the world varies. The Foresight report (2011, p. 24) states that "there are an estimated 925 million people who suffer from hunger and perhaps an additional billion who, while having access to sufficient macronutrients, suffer from the 'hidden hunger' of not having enough vitamins and minerals". FAO presents slightly different statistics. According to the FAO, WFP and IFAD (2013), about 842 million people are estimated to have been undernourished (in terms of energy supply) in the period 2011–13. This represents 12.5 percent of the global population, or one in eight people. The discrepancy in the estimates might be due to different methodologies applied, availability of data analysed and assumptions used to assess the effect of the 2007–08 spike in food prices in developing countries. There is a serious shortfall in the evidence and data available to assess undernourishment. The Foresight report (2011, p. 24) states: "household surveys have demonstrated that, in some countries, FAO data may underestimate the number of people suffering from hunger by as much as a factor of three".

According to the FAO Hunger Portal, the proportion of hungry in the world is decreasing over time. There were one billion undernourished people in the world in 1990–92, 919 million in 1991–2001, 898 million in 2004–06, 867 million in 2007–09 and 868 million in 2010–12 (Table 10). The prevalence of undernourishment, defined as probability that an individual randomly selected from a population is found to be undernourished, in the world is also gradually declining, down from 18.6 percent in 1990–92 to 12.5 percent in 2010–12. However, the period 2007–2010 was characterized by a general and significant slowdown in progress towards lower hunger rates. This was due to the price increases for food in this period.

Table 10 shows the development of undernourishment and its prevalence by region over time. The vast majority of undernourished people live in developing regions (more than 98 percent in 2010–12). The largest number of undernourished people in 2010–2012 was in Asia (563 million) followed by Africa (239 million). However, relatively speaking Africa, and in particular sub-Saharan Africa, is the most affected.

Southern Asia and Eastern Asia are the most stricken areas of Asia, with counts of 304 million and 167 million people, respectively. The prevalence of undernourishment, although still high in these regions (17.6 percent and 11.5 percent, respectively), is declining. In South-Eastern Asia, hunger reduction accelerated from 3.1 percent per year before 2007 to 4.6 percent thereafter, while the pace in Eastern Asia improved from 0.1 percent to more than 4 percent (FAO, WFP and IFAD, 2013). A smaller number of undernourished people lived in Western Asia (21 million) in 2010–12. However, in contrast to Southern and Eastern Asia, hunger and its prevalence have been progressing in these areas over time. The number of hungry people has almost tripled and the prevalence increased by 3.5 percent since 1990.

Table 10. Undernourishment in developing regions, 1990–92 to 2010–12, number (millions) and prevalence (percentage) of undernourishment

	1990-92	1999–2001	2004–06	2007–09	2010–12*
WORLD	**1 000**	**919**	**898**	**867**	**868**
	18.6%	15.0%	13.8%	12.9%	12.5%
DEVELOPED REGIONS	**20**	**18**	**13**	**15**	**16**
	1.9%	1.6%	1.2%	1.3%	1.4%
DEVELOPING REGIONS	**980**	**901**	**885**	**852**	**852**
	23.2%	18.3%	16.8%	15.5%	14.9%
Africa	**175**	**205**	**210**	**220**	**239**
	27.3%	25.3%	23.1%	22.6%	22.9%
Northern Africa	5	5	5	4	4
	3.8%	3.3%	3.1%	2.7%	2.7%
Sub-Saharan Africa	170	200	205	216	234
	38.2%	30.0%	27.2%	26.5%	26.8%
Asia	**739**	**643**	**620**	**581**	**563**
	23.7%	17.7%	16.3%	14.8%	19.9%
Western Asia	8	13	16	18	21
	6.6%	8.0%	8.8%	9.4%	10.1%
Southern Asia	327	309	323	311	304
	26.8%	21.2%	20.4%	18.8%	17.6%
Caucasus and Central Asia	9	11	7	7	6
	12.8%	15.8%	9.9%	9.2%	7.4%
Eastern Asia	261	197	186	169	167
	20.8%	14.4%	13.2%	11.8%	11.5%
South-Eastern Asia	134	104	88	76	65
	29.6%	20.0%	15.8%	13.2%	10.9%
Latin America and the Caribbean	**65**	**60**	**54**	**50**	**49**
	14.6%	11.6%	9.7%	8.7%	8.3%
Latin America	57	53	46	43	42
	13.6%	11.0%	9.0%	8.1%	7.7%
Caribbean	9	7	7	7	7
	28.5%	21.4%	20.9%	18.6%	17.8%
Oceania	**1**	**1**	**1**	**1**	**1**
	13.6%	15.5%	13.7%	11.9%	12.1%

* Projections.
Source: FAO, WFP and IFAD (2013).

The prevalence of undernourishment in Southern Asia and Eastern Asia varies slightly from country to country (Table 11).

Table 11. Undernourishment in selected countries of Southern Asia and Eastern Asia

Country	Total population (million)	Number of undernourished (million)	Prevalence (percentage)
Cambodia	14.3	2	17
Philippines	94.9	16	17
India	1 241.5	217	18
China	1 378.4	158	12

Source*:* FAO Hunger Portal: www.fao.org/hunger/en/

As noted, relatively speaking, Africa is the continent with most undernourished people – 13.9 percent of the population is undernourished in Asia and 22.9 percent in Africa (FAO, WFP and IFAD, 2013). Sub-Saharan Africa is the region with the highest proportion of undernourished people. In terms of absolute numbers, undernourishment has been constantly increasing in this region, up from 170 million in 1990–92 to 234 million in 2010–12. The high fertility rate and consequent population increase are among the factors that have contributed to this increase (Chapter 2).

However, progress has been made in the reduction of undernourishment. The prevalence of undernourishment has been gradually slowing, down from 38.2 percent in 1990–92 to 26.5 percent in 2007–09 (with an exception in 2010–12, when it increased to 26.8 percent). However, there are significant variations in prevalence within the countries of the region (Table 3.3).

Table 12. Undernourishment in selected countries of sub-Saharan Africa

Country	Total population (million)	Number of undernourished(million)	Prevalence (percentage)
Botswana	2	1	28
Burundi	8.6	6	73
Congo	4.1	2	37
Sierra Leone	6	2	29
Ghana	25	1	< 5
South Africa	50.4	NS million	5
Nigeria	162.5	14	9

***Source**:* FAO Hunger Portal: www.fao.org/hunger/en/

In Burundi, Botswana and Congo, the percentage of undernourished population is 70 percent, 50 percent and 49 percent while the prevalence is 73 percent, 28 percent and 37 percent, respectively. In Ghana, only 0.04 percent of the population is hungry and the prevalence of undernourishment is less than 5 percent. In South Africa, the prevalence of undernourishment is also only 5 percent (Table 12).

4.3 The fight against hunger

The United Nations has set two major hunger targets: the World Food Summit (WFS) target and Goal 1 of the Millennium Development Goals (MDGs).[9]

At the 1996 WFS in Rome, world leaders committed to cut hunger in the world by half by not later than 2015. Thus, the target is to reduce the number of hungry people to about 425 million from the current 850 million people by 2015.

The MDGs were set during the 2000 Millennium Summit held at UN headquarters in New York. The MDG 1, eradicate extreme poverty and hunger, is linked to the population and its growth rather than to a particular number. It aims to halve the proportion of the total population being hungry between 1990 and 2015.

Eradicating hunger and food insecurity is challenging. Thus, a broad range of issues and causes of hunger are taken into account in developing the strategy on how to reach these goals. Among them are: economic and agricultural growth; provision of the public goods and services to developing countries access to necessary resources such as water and sanitation; empowerment of girls and women; equal access to education; creation of decent employment; and provision of long-term

[9] This section is based on information stated in FAO Hunger Portal unless indicated differently.

finance that includes the creation of a fair and development-friendly trading system and reforms to ensure stability of the global financial system.

There are 130 million fewer hungry people in the world now than 20 years ago and the MDG 1 hunger target is still within reach. The progress that has been made to date was announced by FAO in Rome on 12 June 2013.[10]

Twenty countries satisfied MDG 1 alone: Algeria, Angola, Bangladesh, Benin, Brazil, Cambodia, Cameroon, Chile, Dominican Republic, Fiji, Honduras, Indonesia, Jordan, Malawi, Maldives, Niger, Nigeria, Panama, Togo and Uruguay. The 18 countries achieving both MDG 1 and the more rigid WFS goal are: Armenia, Azerbaijan, Cuba, Djibouti, Georgia, Ghana, Guyana, Kuwait, Kyrgyzstan, Nicaragua, Peru, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Thailand, Turkmenistan, Venezuela (Bolivarian Republic of) and Viet Nam.

As a follow-up on the progress and targets of MDGs 2015, world leaders agreed during the United Nations Conference on Sustainable Development in Rio in 2012 that new goals and targets need to be grounded in respect for universal human rights. Central to this is eradicating extreme poverty from the face of the earth by 2030 (United Nations, 2013).

4.4 Role of agricultural growth in reduction of hunger and malnutrition

This section is mainly based on FAO, WFP and IFAD (2012) unless other references are indicated.

The role of agricultural growth is particularly effective in the reduction of hunger and malnutrition.[11]

Most of the poor and most nutritionally vulnerable depend in large part upon agriculture for their livelihoods. The majority of them are smallholder farmers. Together with their families, they represent two billion people, or one-third of the world's population (FAO, 2009a). In Africa, 85 percent of farms are less than two hectares.

The importance of agriculture in national economics varies significantly between countries and over time. As a general rule, the importance of agriculture declines as GDP per capita increases and the country undergoes a structural transformation. "For the least-developed countries, the share of the total economically active population in agriculture was 66 percent in 2009, more than double the share of agriculture in GDP" (FAO, WFP and IFAD, 2012, p.28). That is why agricultural growth is important for poor countries. Growth in agriculture contributes less to long-term economic growth than the development of other sectors, but it affects a large proportion of the population and helps to eradicate poverty and hunger.

The findings of a recent analysis of cross-country growth experience have shown that growth in agriculture reduces poverty among the poorest of the poor if the income gap is not significant. In low-income countries (excluding sub-Saharan Africa), the increase in GDP due to agricultural growth reduces poverty five times more than does an identical increase in non-agricultural growth. In sub-Saharan Africa, its impact on the reduction of poverty is 11 times greater than that of non-agricultural growth.

The production and productivity of fisheries and aquaculture in developing and poor countries also play an important role. First, a large fraction of poor people are employed in the sector, especially women who are traditionally involved in processing activities. The income from fisheries contributes significantly to improved nutrition.

[10] FAO. 2013. 38 countries meet anti-hunger targets for 2015. In: FAO [online[. Rome. [Cited 30 December 2013]. www.fao.org/news/story/en/item/177728/icode/?utm_source=intranet&utm_medium=intranet-dyk&utm_campaign=dyk

[11] Agriculture includes all food-producing sectors, such as crop production, livestock, aquaculture, fisheries and forestry.

Second, fishery resources are an important source of both macronutrients and micronutrients for humans. Although globally fish accounts for about 17 percent of animal protein intake, there is a significant difference in consumption between countries – low-income food-deficient developing countries consume on overage 10.1 kg per capita while industrialized countries consume 28.7 kg per capita.

However, in some poor countries, fish contributes more than 50 percent of animal protein intake. In West African coastal countries, the proportion of dietary protein that comes from fish is very high: 63 percent in Sierra Leone and Ghana, 62 percent in the Gambia and 47 percent in Senegal. Also in Asia and some small island States the contribution is high: 71 percent in Maldives, 59 percent in Cambodia, 57 percent in Bangladesh, 54 percent in Indonesia and 53 percent in Sri Lanka (FAO, 2012).

Foods from the aquatic environment are a unique source of the essential long-chain omega-3 fatty acids, which are important for optimal brain and neurodevelopment in children (docosahexaenoic acid [DHA]) and vascular health (eicosapentaenoic acid [EPA]). Sufficient intake of omega-3 fatty acids is particularly important during pregnancy and the first two years of life. Fish consumption among adults lowers the risk of coronary heart disease mortality by up to 36 percent owing to a combination of the effects of EPA and DHA.

As mentioned above, labour force participation rates are usually highest in the poorest countries. In sub-Saharan Africa, more than 60 percent of the entire workforce are involved in agriculture.[12] More people are employed out of necessity rather than by choice, as only a fraction of the working-age population can afford not to work. In these countries, low unemployment figures in conjunction with high labour participation rates result in the situation where the majority are engaged in vulnerable employment and many work in poverty. Therefore, generation of decent employment is essential in order to achieve agricultural growth and food security.

The International Labour Organization defines decent work as that which "involves opportunities for work that is productive and 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, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men" (FAO, WFP and IFAD, 2012, p. 29).

Despite the importance of agriculture in eradicating poverty and hunger, farmers continue to face many complex challenges such as lack of rural infrastructure and education, access to credit, lack of enabling legal and policy frameworks for agricultural development and a gender gap. "Rural labour markets are highly informal, with a prevalence of casual work arrangements and information asymmetries, as well as gender and age-based inequalities. Rural working conditions are often poor, access to social protection is limited, and labour legislation is often not enforced; rural workers are the least organized and least protected by legislative frameworks" (FAO, WFP and IFAD, 2012, p. 29).

Thus, support of government and policy-makers is crucial for growth of the agriculture sector and its productivity. The policies should be directed not only at increasing agricultural production but also at better employment.

4.5 Summary and discussions

Chronic hunger weakens people's immune systems, makes them vulnerable to disease and infections, and prevents them from engaging in normal physical activity such as study and work. It is particularly harmful for mothers and babies, increasing the mortality of both.

[12] *Source:* KILM (ILO) Metalink: P1.RES.WBK.WDI.LAB.EATx, p. 78.

The categories of people who suffer from hunger the most are the rural poor, the urban poor and victims of catastrophes.

There are different estimates of the number of undernourished in the world (section 4.2). According to the most recent estimates of FAO, the fraction of hungry people in the world as well as hunger prevalence is declining over time. However, progress towards hunger reduction has slowed since 2007.

The vast majority of undernourished people live in developing regions (section 4.2 and Table 10).

The prevalence of undernourishment in Asia and Africa is declining. However, the number of undernourished has continued to grow in the last two decades due to increasing population, especially in sub-Saharan Africa (section 4.2).

The United Nations has repeatedly expressed its desire to eradicate hunger, and committed to halving the number of hungry at the WFS in 1996 and through MDG 1 (section 4.3). There are also strong indications that in a Post-2015 Development Agenda, Members will commit to eradicating hunger. According to UN statistics, progress has been achieved in many countries and the MDG1 and WFS target are still within reach by 2015.

Increased productivity and better employment in agriculture are essential in eradicating hunger. This is because most of the poor in developing countries are employed in the agriculture sector and directly involved in food production.

5. IMPACT OF CHANGES IN PRICE AND INCOME ON FOOD DEMAND

The previous chapters analysed shifts in demand up to 2030 caused by population growth, increases in income and in an undernourishment perspective; the next chapter considers the impact of changes in consumer trends and preferences. Changes in demand as well as shifts in supply will affect the prices of food products. An understanding of food demand and the ability to predict potential shifts in demand for food products is essential in an analysis of future food markets. The purpose of this chapter is to investigate what information the food demand literature can provide in this respect, in particular what can be expected in terms of changes in demand caused by changes in prices and income.

According to the OECD–FAO: "On the demand side, growing populations and the rising incomes in the larger emerging economies such as China and India will sustain strong demand for commodities. Rising income will also drive a shift in diets from staple foods to more value-added and higher protein products, especially for consumers in the emerging economies who will increasingly demand meat and dairy products in their consumption choices" (OECD–FAO, 2011, p. 24).

The most common approach in this literature is demand analysis, where demand equations are estimated either individually or in a system of equations. These studies of the demand structure focus on the price sensitivity of demand, on the degree of substitution between potentially competing products and on income/expenditure effects.

This chapter reviews some demand studies with respect to food products, focusing on how this information can be used to predict changes in future demand. To present results from many different studies creates a number of problems that one should be aware of when comparing the results. In addition to the different markets and products studied, a number of different methods have also been used. As the methods used affect the interpretation of the results, it is also important to be aware of the potential differences. Moreover, measuring data at different market levels, e.g. import or retail, has important implications for the interpretation of the results. These issues are not covered in this chapter, but the interested reader is referred to Asche, Bjørndal and Gordon (2005, 2007), who also provide a good overview over relevant methodologies.

Some implications of economic theory for the magnitudes of the elasticities are worth noting. If the price elasticity of demand is between zero and –1, demand is considered inelastic as a price change has little impact on quantity demanded. If, on the other hand, the price elasticity of demand is less than –1 (greater than 1, in absolute value), demand is said to be elastic.

A price elasticity of demand of –1 is a focal point. A good with constant budget share and no substitutes will have a price elasticity of demand of –1, so that a 1 percent increase in the price will lead to a 1 percent reduction in the quantity demanded and vice versa. The value of a market in terms of total revenue is at its highest when the price elasticity is –1. If the supplied quantity increases above the level that gives a price elasticity of demand of –1, the value of the market will fall. Finally, the more elastic the demand for the good, the greater substitution possibilities there will be and therefore the keener the competition.

According to what is called Timmer's proposition (Timmer, 1989), own-price elasticities of demand are larger in absolute value for low-income countries than for high-income countries. As this study includes many different countries, it will be interesting to investigate this property.

In general, it is expected that households differing in their characteristics (such as size, age composition, educational and income levels) will also have a different expenditure pattern (Deaton and Meullbauer, 1980). In this sense, Engel (1821–1896) empirically studied the relation between expenditure and income, resulting in what has become known as Engel's law. Engel's law implies that the proportion of food expenditures by a household decreases as the income level increases. This means that the poorer the household, the higher the share of total expenditure spent on food (Deaton

and Muellbauer, 1980). Studies such as Huothakker (1957) and Khoja and Pirzada (2009), empirically comparing food consumption by income level for many countries, have corroborated Engel's law. These insights and results are particularly relevant for this study, which encompasses different countries with very different income levels.

When it comes to income elasticities, a good with a value between zero and one is often referred to as a "normal" good, while a good with an elasticity greater than one is called a "luxury" good.

5.1 Empirical demand studies for food products

A comprehensive review of demand studies for food conducted by Andreyeva, Lond and Brownell (2010) demonstrates how price changes affect demand for various types of food. In total, 160 United States studies on the price elasticity of demand for 13 food and beverage categories were reviewed in order to determine mean price elasticities by food category and assess variations in estimates by study design. This included 51 studies for beef and 49 studies for pork while the number of studies for other categories varied between 13 and 26 (Table 13). The studies in question were published between 1938 and 2007; however, only 38 studies were published before 1970.

Table 13 presents mean price elasticity estimates for the 13 food and beverage groups considered, along with their 95 percent confidence intervals and range of observed elasticities. Absolute values of the elasticity are reported. The table also specifies the number of estimates for each category.

Table 13. United States price elasticity estimates, by food and beverage category, from 1938–2007

Food and beverage category	Absolute value of mean price elasticity estimates (95% CI)	Range	No. of estimates
Food away from home	0.81 (0.56, 1.07)	0.23–1.76	13
Soft drinks	0.79 (0.33, 1.24)	0.13–3.18	14
Juice	0.76 (0.55, 0.98)	0.33–1.77	14
Beef	0.75 (0.67, 0.83)	0.29–1.42	51
Pork	0.72 (0.66, 0.78)	0.17–1.23	49
Fruit	0.70 (0.41, 0.98)	0.16–3.02	20
Poultry	0.68 (0.44, 0.92)	0.16–2.72	23
Dairy	0.65 (0.46, 0.84)	0.19–1.16	13
Cereals	0.60 (0.43, 0.77)	0.07–1.67	24
Milk	0.59 (0.40, 0.79)	0.02–1.68	26
Vegetables	0.58 (0.44, 0.71)	0.21–1.11	20
Fish	0.50 (0.30, 0.69)	0.05–1.41	18
Fats/oils	0.48 (0.29, 0.66)	0.14–1.00	13
Cheese	0.44 (0.25, 0.63)	0.01–1.95	20
Sweets/sugars	0.34 (0.14, 0.53)	0.05–1.00	13
Eggs	0.27 (0.08, 0.45)	0.06–1.28	14

***Source**:* Andreyeva, Lond and Brownell (2010).

The study supports the notion that demand response to food prices is inelastic. All mean price elasticities for the 13 food categories presented are less than 1.0 and range from 0.27 to 0.76. Moreover, the upper limit of the 95 percent confidence limit is in all cases less than one. The estimates are most inelastic for categories such as eggs, cheese, fats and oils, and fish. The most elastic categories are fruit, pork, beef and juice, with vegetables, milk, cereals, dairy and poultry in between. Food away from home, essentially restaurant meals, has the highest own-price elasticity.

Nevertheless, there are point estimates indicating elastic demand for all food categories. There can be many reasons for this. Food categories are broad and are likely to include some products that may

be fairly elastic. Also, as pointed out, the studies cover a period going back to 1938, and elasticities are likely to change over the lifecycle of products. Muhammad *et al.* (2013) present results from a two-stage demand system using 2005 International Comparison Programme[13] data. In the study, demand is analysed for 144 countries. The study provides own-price and income elasticities for 9 broad consumption categories and 8 food subcategories.

The 144 countries covered are divided into low-, middle- and high-income countries. Low-income countries represent those with real per capita incomes less than 15 percent of the United States level, middle-income those with incomes of between 15 and 45 percent of the United States level, while high-income countries have incomes equal to or greater than 45 percent of the Unites States level.

The average budget shares for the aggregate consumption categories and each of the three country groups are presented in Table 14, along with the conditional budget shares for eight food subcategories.[14]

In terms of the broad aggregates, food, beverages and tobacco has a budget share of 0.485 in low-income countries but only 0.204 in high-income countries.

As for the conditional budget shares, it is noticeable that for high-income countries, they are very low for cereals, meats, fish, dairy, oils and fats, and fruits and vegetables; these budget shares are higher for low-income countries, in some cases considerably higher, relatively speaking. For food others, i.e. meals away from home, and beverages and tobacco, high-income countries have the highest shares.

Table 14. Budget shares for broad aggregates and conditional budget shares for food categories

Country group	Food, beverages & tobacco	Clothing & footwear	Housing	Housing furnishing	Medical & health	Transport & communication	Recreation	Education	Other
Low income	0.485	0.061	0.135	0.052	0.045	0.102	0.031	0.034	0.054
Middle income	0.311	0.055	0.183	0.056	0.059	0.155	0.061	0.033	0.087
High income	0.204	0.051	0.187	0.060	0.089	0.149	0.095	0.031	0.134
	Cereals	**Meats**	**Fish**	**Dairy**	**Oils & fats**	**Fruits & vegetables**	**Food others**	**Beverages & tobacco**	
Low income	0.233	0.134	0.063	0.078	0.049	0.181	0.146	0.116	
Middle income	0.124	0.172	0.035	0.099	0.030	0.145	0.208	0.187	
High income	0.086	0.118	0.041	0.066	0.014	0.098	0.369	0.208	

Source: Muhammad *et al.* (2013).

Stepwise demand analysis assumes that consumers spend their income in stages. The first stage (step) involves estimating aggregate demand across nine broad consumption categories: food, clothing, housing, house furnishings, medical care, transportation, recreation and other. Then, in the second stage, a demand system is estimated across eight food subcategories: cereals, meats, fish, dairy products, oils and fats, fruits and vegetables, beverages and tobacco, and other food products

Average income elasticities[15] for aggregate consumption categories for low-, middle- and high-income countries are presented in Table 15. The elasticities conform to Engel's law for all

[13] Expenditure and price data were obtained from the International Comparison Project (ICP), which is maintained by the ICP Development Data Group of the World Bank.
[14] Conditional budget shares for the eight food categories mean they are conditional on the budget for food, beverages and tobacco.
[15] Technically, these are expenditure elasticities.

consumption categories, i.e. income elasticity is lower for high-income countries than middle-income countries, which in turn is lower than for low-income countries.

Table 15. Income elasticities for aggregate consumption categories: averages for low, middle and high-income countries, 2005

Country group	Food, beverages & tobacco	Clothing & footwear	Housing	House furnishing	Medical & health	Transport & communication	Recrecreation	Education	Other
Low income	0.778	0.967	1.074	1.054	1.851	1.211	2.901	0.93	1.795
Middle income	0.655	0.965	1.066	1.05	1.306	1.153	1.401	0.92	1.309
High income	0.495	0.964	1.062	1.047	1.236	1.133	1.288	0.914	1.238

***Source**:* Muhammad *et al.* (2013).

The income elasticity of demand for food, beverages and tobacco varies greatly among countries and is highest among low-income countries. Indeed, the elasticity is 57 percent higher for low-income countries than for high-income countries.

The unconditional expenditure elasticity measures the percentage change in demand from a percentage change in overall income (or total spending). Table 16 gives the values for the different food subcategories as averages for the three groups of countries.

Table 16. Unconditional expenditure elasticities of demand for food subcategories: averages for low-, middle- and high-income countries

Country group	Per capita food	Cereals	Meats	Fish	Dairy	Oils & fats	Fruits & vegetables	Food other	Beverages & tobacco
Low income	0.13	0.514	0.771	0.65	0.798	0.531	0.615	1.42	1.325
Middle income	0.439	0.253	0.649	0.52	0.671	0.297	0.462	0.882	0.839
High income	0.781	0.019	0.49	0.38	0.506	0.097	0.319	0.636	0.613

Note: Per capita food is an index of total food spending per person (normalized to United States food expenditures per person).
***Source**:* Muhammad *et al.* (2013, Appendix Table 5).

When comparing elasticities across country groups, they conform to Engel's law. For high-income countries, the demand for cereals and oils and fats is virtually unaffected by changes in price. The other elasticities vary between 0.379 and 0.636. The two highest are for beverages and tobacco (0.613) and food other (0.636), which includes meals away from home. As such, the results make intuitive sense.

Low-income countries show much larger elasticities, varying between 0.514 and 1.42. An increase in income will lead to fairly substantial increases in demand for all food categories under consideration. Food other and beverages and tobacco are "luxury" products.

Elasticities for middle-income countries are between those for low- and high-income countries. The same pattern can be observed in terms of which elasticities are low and high. Unconditional own-price elasticities[16] for the different food categories are presented in Table 4.5.

The unconditional own-price elasticities for the food subcategories in question vary with affluence: consumers in low-income countries are more responsive to price changes than consumers in high-

[16] Technically, these are Frisch own-price elasticities. The unconditional own-price elasticities represent elasticities estimated at a point when the marginal utility of income is held constant. See Muhammad *et al.* (2013) for further details as well as estimates of alternative elasticities.

income countries. Thus, they conform to Timmer's proposition: own-price elasticities of demand are larger in absolute value for low-income countries than for high-income countries.

Table 17. Unconditional own-price elasticities of demand for food subcategories: averages for low-, middle- and high-income countries

Country group	Per capita food	Cereals	Meats	Fish	Dairy	Oils & fats	Fruits & vegetables	Food other	Beverages & tobacco
Low income	0.13	-0.377	-0.566	-0.48	-0.585	-0.39	-0.451	-1.042	-0.972
Middle income	0.439	-0.186	-0.476	-0.382	-0.492	-0.218	-0.339	-0.647	-0.615
High income	0.781	-0.036	-0.359	-0.278	-0.371	-0.076	-0.234	-0.467	-0.45

Note: Per capita food is an index of total food spending per person (normalized to United States food expenditures per person).
Source*:* Muhammad *et al.* (2013, appendix Table 6).

For high-income countries, the demand for cereals and oils and fats is particularly inelastic: changes in price will have virtually no impact on demand, so that quantity consumed is more or less constant. Demand for other food categories is also inelastic, with the absolute value of the elasticity varying between 0.234 and 0.467.

For low-income countries, the results are very different. Food other and beverages and tobacco have elasticities close to –1, so that quantity demanded varies more or less proportionately with price. Demand for other food subcategories is inelastic, particularly so for cereals and oils and fats, with elasticities of –0.377 and –0.390, respectively.

Information is also available for many countries. Results for selected countries are given in Table 18. Essentially, these figures reinforce what is presented above.

In Muhammad *et al.* (2013), various food aggregates including fish are essentially considered homogenous products. Andreyeva, Lond and Brownell (2010) review also disaggregated studies, and Asche, Bjørndal and Gordon (2005, 2007) review demand for different types of fish products. Dey *et al.* (2008) investigate demand for various types of fish by households with varying incomes in nine different Asian countries. Own-price elasticities are found to vary substantially for different fish types, demonstrating the heterogeneity of fish demand in the region. Moreover, the own-price elasticity of demand was observed to be lower among households with higher incomes. All country income elasticities, on average, were found to be elastic, which implies that Asian consumers generally consider fish a luxury good. As for income, in general, high-income groups exhibited lower income elasticities than low-income households.

Singh, Dey and Surathal (2012) found similar results in the United States of America. Own-price, cross-price and expenditure (income) elasticities were found to vary considerably across species, which indicates the importance of studying consumer demand at the disaggregate level.

In a study of fish demand in inland areas of Bangladesh, Dey, Alam and Paraguas (2011) find that almost all estimated fish type and income class specific income elasticities of demand are positive. Thus, fish demand will increase with population growth and increases in per capita incomes. Moreover, income elasticities tend to be higher among poorer households than among more affluent consumers. Thus, a major share of shifts in the demand for fish is expected to come from poorer households with increasing income. The authors also find that, while demand for low-valued fish is inelastic, demand for high-valued products is elastic. This indicates that there will be shifts in the composition of demand over time.

Table 18. Own-price and expenditure elasticity for fish, selected countries

Country	Own-price elasticity for fish	Expenditure elasticity for fish
European Union (Member Organization)		
United Kingdom	-0.258	0.351
France	-0.273	0.372
Spain	-0.281	0.384
Portugal	-0.316	0.431
Hungary	-0.352	0.480
Advanced economies		
Canada	-0.271	0.369
Japan	-0.279	0.380
United States of America	-0.191	0.260
Republic of Korea	-0.351	0.479
New Zealand	0.299	0.407
Developing Asia		
China	-0.480	0.654
India	-0.484	0.660
Bangladesh	-0.490	0.667
Latin America		
Brazil	-0.419	0.571
Chile	-0.402	0.548
Near East		
Egypt	-0.434	0.592
Saudi Arabia	-0.401	0.546
Africa		
Angola	-0.512	0.698
South Africa	-0.415	0.566
Ethiopia	-0.523	0.713
Nigeria	-0.489	0.667
Mozambique	-0.516	0.703
Russian Federation and Eastern Europe		
Russian Federation	-0.390	0.532
Ukraine	-0.418	0.570
Kazakhstan	-0.403	0.550

Source: Muhammad *et al.* (2013, appendix Table 6 for own-price elasticities, Table 5 for expenditure elasticities).

5.2 Summary and discussion

According to Muhammad *et al.* (2013), the income elasticity of demand for food, beverages and tobacco varies greatly among countries (Table 15), ranging between 0.778 as an average for low-income countries to 0.495 as is the average for high-income countries. These results imply that for low-income countries increases in income will be accompanied by almost proportional increases in expenditure on food. This is confirmed when looking at food subcategories, with elasticities ranging from 0.514 to 1.42. For high-income countries, elasticities are much lower, and for food groups such as cereals and oils and fats increases in income will have virtually no impact on demand.

Developing and emerging economics are expected to show substantial economic growth over the coming decades (Chapter 3). This means that food demand in these countries will increase substantially.

However, food prices are expected to increase. As food demand in low-income countries is more elastic than in high-income countries, this means that there will be a decline in demand owing to the price effect, and most so in low-income countries. This will to some degree counteract the income effect.

Income distribution is another important variable. Countries such as India and China have substantial middle classes as well as large numbers of very affluent consumers, but at the same time the proportion of low-income earners is large. Thus, even inside developing and emerging economies, the patterns in terms of increased food consumption will be very different.

6. CONSUMER TRENDS AND PREFERENCES IN THE DEMAND FOR FOOD

6.1 Background

This chapter analyses the major tastes and preferences of consumers in food consumption, as well as expected changes in these over time, and the impact that consumers have in establishing these trends. It identifies five important consumer trends and purchase drivers: food safety and health benefits; corporate social responsibility; production systems and innovations; sustainability; and food origin. For each of these trends, it then considers the actions that are consequently being implemented by governments, NGOs and the private sector. The final section of this chapter summarizes the findings and discusses their implications for future food demand.

Consumers play a powerful role in how retailers and companies market their products and interact with one another. It is evident that consumers generally care about what they eat, how their food is produced and the impact that food production and consumption have on the environment and society. Consumers' concerns about the methods of food production and the conditions under which foods are grown have increased in the developed world in the last two decades. This increase in concerns was primarily motivated by the "mad cow" disease crisis in Europe (Hoffman, 2000; Loureiro and McCluskey, 2000; Davidson, Schröeder and Bower, 2003). The result has been an increased demand for information about the origin of food and harvest methods used in food production. Some segments of concerned consumers are using this kind of information as an indicator of product attributes such as technical quality, food safety, environmental and social sustainability.

The way retailers react to these demands for information by consumers will vary significantly across cultures, countries, chains and products. Different factors affect the consumer's decisions to act responsibly (Nayga, 1999; Thogersen, 2000), including the role of social agents, governmental or not, in consumers' information and education (Roheim, 2008), as well as certain conditions and capabilities in both media and consumers (Sapp, 2003).

According to the Foresight report (2011), the change in values and ethical stances of consumers will have a major influence on consumption. As a result, food security and food system governance will be affected. "Examples include issues of national interest and food sovereignty, the acceptability of modern technology (for example genetic modification, nanotechnology, cloning of livestock, synthetic biology), the importance accorded to particular regulated and highly specified production methods such as organic and related management systems, the value placed on animal welfare, the relative importance of environmental sustainability and biodiversity protection, and issues of equity and fair trade" (Foresight, 2011, p. 16).

Retailers may accept and adopt new trends in food consumption if they perceive them as a way to improve sales and customer satisfaction. However, consumers and retailers differ in the way they select and process information and make decisions about product attributes because they have different attitudes, different buying policies and different goals.

The perception of value depends on the degree to which customers believe that the product will contribute to fulfilling their goals. Creating value for consumers is a very important source of competitive advantage for a retailer. However, retailers have strong beliefs about those aspects of their business demonstrated by past experience as being important for obtaining the goals and profits they are looking for (Skytte and Bove, 2004). From a retailer's point of view, most food products are substitutes to one another in attracting consumers. Undifferentiated generic foods can be easily replaced by a multiplicity of providers. Among a group of substitute goods, the more popular products are those with the higher probability to be put on sale and promoted by retailers (Hosken and Reiffen, 2004).

The economic criterion of maximizing profits will prevail in retailers' decision-making. This can be a barrier for developing the market for new food products demanded by consumers that may not

offer retailers the margins require. However, at the same time that the agrifood system becomes globalized and the retail chains increase their market power, the responsibility for securing food safety and quality standards has been moving from public to private institutions. The rise in private retailer standards and labelling (Codron, Giraud-Héraud and Soler, 2005) has precipitated the rise of third-party certifiers. This trend reflects the growing power of supermarkets in their aim to regulate the global agrifood system, but at the same time the trend in private retailer standards offers opportunities to create and promote responsible practices across producers and consumers (Hatanaka, Bain and Busch, 2005).

6.2 Safety and health benefits

Deloitte (2012) suggests that healthy eating is a critically important consumer driver, a trend that will have considerable influence over company strategies in coming years. Population increases and ageing as well as rising GDP (as discussed in Chapters 2 and 3) support the assumption that this trend will continue to gain importance until 2030. The trend is reinforced by the fact that the consumer of the future will have a better level of education worldwide (Chapter 2) and better knowledge about health and healthy eating.

The benefits derived from a healthy diet include enhanced health. It can therefore be expected that information on potential health benefits increases the demand for a specific food and consumers' willingness to pay (Marette, Roosen and Blanchemanche, 2008). However, the effects on buying behaviour from expected health benefits are not uniform across individuals. Consumers' ability to process information and understand health benefits will affect the adoption and consumption of these healthy foods. Consumers' perceptions about food risks and benefits arise from social interaction, and are strongly dependent upon the trust in the public and private institutions involved (Sapp, 2003). Individuals have different levels of qualifications, cognitive skills to process information, and personal experiences with the product, which may affect the perception of potential risks or health benefits. Some attributes such as taste may dominate the decision to consume a product, but aspects such as cost or safety may be more important in deciding how much to consume (Lin and Milon, 1993). Similarly, the effect on buying behaviour may be affected by the level of consumers' involvement in personal health care, and related to other habits. Consumers that are concerned with nutrition and health are more likely to use nutritional labels than those less concerned (Nayga, 1999, 2000). On the other hand, consumers find it difficult to respect dietary guidelines. They may be receptive and able to process the information related to a healthy diet, but many of them will be unable or unwilling to comply with the diet (Hamilton *et al*., 2000; Leipämaa-Leskinen, 2007).

Consumer buying behaviour guided by food health benefits is not uniform across countries and individuals. Euromonitor International (2012) finds that respondents globally rank good health as the most important determinant of happiness and that consumers both in emerging and developed markets show interest in dieting. The results of the Euromonitor global youth survey suggest that in the 15 leading youth markets[17] one-third of 16–24-year-olds claim to be trying to lose weight, and healthy food was found to be popular worldwide, with 56 percent of global youth buying healthy products. Although the survey result might reflect only intention toward healthy eating on some occasions, it proves that many consumers recognize its importance.

The main driver of this trend is the concern about global rises in proportions of overweight and obese consumers. Obesity increases the broad range of elevated risks of fatal and non-fatal diseases in developed countries, and there is a concern that a similar trend will be seen in developing countries if food consumption increases as a result of anticipated improvements in GDP (Chapter 3). According to the World Health Organization, in 2008, more than 1.4 billion adults (aged 20 years and older) were overweight.[18] Greece, the United States of America, Italy, Mexico, New Zealand, Chile and the

[17] Leading youth markets feature China, India, Indonesia, Malaysia, the Philippines, the Russian Federation, South Africa, Turkey, Brazil, Colombia, Mexico, Germany, Japan, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

[18] The information is taken from:www.who.int/mediacentre/factsheets/fs311/en/Downloaded on 27 May 2013.

United Kingdom of Great Britain and Northern Ireland have the highest rates of obese children aged 5–17 years where the percentage of obese boys and girls is more than 25 percent of the whole population. Countries with the highest obesity rates among adults are the Unites States of America, Mexico, New Zealand, Chile and Australia where 33.8, 30, 26.5, 25.1 and 24.6 percent, respectively, are obese (OECD, 2012). In most of these countries, meat consumption is high. Even countries such as China and India that were not concerned by obesity in the past are now battling epidemics of diabetes and obesity.

Along with improvements in GDP per capita, urbanization contributes to increased concerns about obesity. Changing work habits of urban people demand convenience in food consumption. According to Deloitte (2012), consumers today demand convenience and are willing to pay more for it as they would rather buy time than prepare food. Thus, the amount of processed foods in consumption increases. However, according to de Morais and de Almeida (2010), processed, functional and convenience foods are still less familiar to older persons in Europe. This is supported by their survey conducted among a group of older persons in Portugal, which states: "for the Portuguese elderly, good taste was strictly related to the fresh and unprepared products, which is in fact the opposite of the convenience food concept". However, adoption of urban lifestyles provides more exposure to advertising (Chapter 2), which increases awareness about both the benefits and disadvantages of convenience food to both young and older consumers.

As a response to the global problems of people being overweight or obese, many policy-makers, health professionals and health bodies advocate greater state intervention in the habits and lifestyles of citizens. Foresight (2011) suggests that "campaigns to change individual behaviour involving public education, advertising, targeted programmes in schools and workplaces, and the provision of better labelling enable the public to make more informed decisions".

Among the countries that have taken such measures are Hungary, Brazil, India and the United States of America. Andreyeva, Lond and Brownell (2010) state that one way to address the issue of obesity is to change the relative prices of selected foods through carefully designed tax or subsidy policies. According to Euromonitor International (2011), Hungary has imposed higher taxes on products rich in salt, sugar and carbohydrates, and in Bangalore (India) authorities are discouraging parents from giving processed foods to their children. Brazil's public health authorities "are arguing for aggressive official measures, ranging from healthier school meals and the aggressive promotion of breast-feeding to taxes and tougher warnings on unhealthy food products" (Euromonitor International, 2011). The authorities in the United States of America try to reduce fast-food consumption through zoning, counter-advertising, taxing unhealthy food, calorie labelling, warning labels and other nutritional information. Corporate Accountability International has published a report (Gagnon, Freudenberg and Corporate Accountability International, 2012) encouraging United States citizens to take an active part in reducing the number of fast-food restaurants in their community and suggesting a number of policies that might help to do so, depending on the situation and the demands of the specific zone.

Closely related to health concerns are food safety concerns. Epidemic crises such as "mad cow" disease have triggered greater calls for increased transparency, meaning the ability to trace the food bought by consumes. Transparency represents an important aspect of quality and safety assurance by allowing the tracing of products, ingredients, suppliers, retailers, processing operations or storage procedures throughout the food production chain. This is especially relevant when failures occur. As the food chain has lengthened from local production, processing and consumption to more global commercial opportunities, the need to transfer information related to production and public health and the complexity of these transfer vehicles has expanded (McKean, 2001). With the increase in complexity, consumers want to know the origin (species, place, condition of rearing or catch), the transformations and the distribution of their food products (Pascal and Mahé, 2001). Thus, the Hazard Analysis and Critical Control Points **(**HACCP) standards have been applied to international trade as a response to consumer demand.

HACCP International is a food science organization specializing in the HACCP food safety methodology and its application within the food and related non-food industries. It develops standards for preserving the basic environmental conditions of food: cleaning and disinfection, maintenance, personnel hygiene and training, pest control, plant and equipment, premises and structure, services (compressed air, ice, steam, ventilation, water, etc.), storage, distribution and transport, waste management, and zoning (physical separation of activities to prevent potential food contamination).[19]

The HACCP standards are an example of legislation supporting safety of production and trade as developed countries have made them a prerequisite for exports and imports. Initially introduced as a voluntary requirement, HACCP systems are becoming mandatory for all imported food or for certain food sectors in many countries today.

Many food processing companies already have effective internal traceability systems as part of their HACCP-based quality assurance systems (Frederiksen and Gram, 2003). However, in many cases, traceability is lost before and after the company deals with the raw materials and the final products. Consequently, several e-business companies produce software allowing the integration of financial and production data in one programme package, and most of these have traceability capability components implemented (e.g. i2 Technologies Inc., Dallas, the United States of America; SAP AG, Walldorf, Germany). The UN/EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport) standard is currently the most widely used standard for transferring data between steps in the chain.

A good example[20] of food digital tracking is the Chinese organic farm Yi Mu Tian. Mindful of Chinese consumers' concerns over food safety, the high-tech farm, which uses computers for temperature regulation, lighting and watering, operates a traceability code system that allows consumers to track any food item back to the field in which it was grown. Customers can also track the growth of vegetables by camera. As of October 2012, the farm had fulfilled home delivery orders to more than 60 000 families in Shanghai.

Another example of food traceability is the Japanese restaurant Kimitachi that opened a franchise in Curitiba, Brazil, in September 2012 after a successful pilot in Florianópolis. Customers ordering takeout can follow their food preparation via a video system installed in the restaurant's kitchen. Kimitachi created the system to "humanize sushi delivery" and give consumers more transparency with regard to dish preparation.

In addition to HACCP quality assurance standards, legislation and standards have been issued in order to control sanitary standards of food. Established by FAO and the World Health Organization in 1963, the Codex Alimentarius Commission develops harmonized international food standards, guidelines and codes of practice to protect the health of consumers and to ensure fair practices in the food trade.

6.3 Corporate social responsibility

Another trend that is gaining importance globally is corporate social responsibility (CSR). According to Deloitte (2012), CSR is increasingly important for consumers as they consider sustainability, ethical sourcing, and food miles, among other factors. Consumers may support companies that provide "socially responsible" products and be willing to pay more.

[19] This information was taken from the website of HACCP International (http://haccp-international.com/). [Cited 5 June 2013].

[20] This and the following example are taken from trendwatching.com (www.trendwatching.com/trends/10trends2013/?fullfrontal). [Cited 5 June 2013].

Increasing concerns about healthy eating and social responsibility have been manifested in another trend – transparency. Despite the development of efficient traceability systems all over the world, it is still difficult for interested consumers to find adequate and reliable information regarding where food is grown and its impact on the planet. However, according to Hoffman (2012): "never before has it been easier to find data and information about food. It is now possible to locate your closest farmer's market, to learn about the sustainability of your favourite brand, and to uncover the environmental and social score of products compared with similar items. You can subscribe to countless food publications, blogs and recipe sites." Consumers are learning about food more and more via the World Wide Web and share the information with one another. Transparency helps consumers make better decisions regarding their food consumption. According to Lippincott Mercer (2006): "consumer brands have critical roles to play as educators, leaders, facilitators, contributors and marketers. Individual consumers may have different sustainability agendas from the companies that serve them.

A new partnership is needed between corporate social responsibility and marketing communities to reconcile a company's own responsibility initiatives with its consumers' aspirations" for a sustainable supply chain. "The informed consumer can effect change in the food system by choosing to purchase items that promote sustainability, equitability or other desirable goals. Clear labelling and information is essential for this to happen" (Foresight, 2011, p. 36). As a result, transparency is no longer a consumer-driven trend, but a retailer's CSR policy.

Consciousness of CSR is often driven by the media, NGOs and shareholders. The transparency that today's better informed consumers demand goes beyond the values stated in a company's code of ethics. Consumers are interested not only in what the company has planned to achieve in the direction of social responsibility, but also what has not been achieved in reality.

According to Edelman (2012), the percentage of global consumers who trust businesses to do what is right fell from 56 percent in 2011 to 53 percent in 2012. Cone Communications (2012) states that 69 percent of United States consumers said they are more likely to buy from a brand that talks publicly about its CSR results, versus the 31 percent who would purchase from a brand that talks about its CSR mission and purpose. As a response to the trend, many companies are motivated to actively communicate to the consumer that they carry out their business responsibly, providing full information about the product and its movement through the value chain. As an example, in September 2012, McDonald's began publishing calorie information on all its restaurant menus and drive-through windows in the United States of America, while the company also started promoting its "Favourites Under 400 Calories" menu, which includes lighter dishes.[21]

6.4 Production systems and innovation

Traditional procedures of food production and processing, sometimes related to local cultures, are linked with positive associations in the assessments made by consumers about the expected quality of food products. This idea is sometimes included in the "designation of origin" schemes in the countries of the European Union (Member Organization) (Bertozzi, 1995; Fotopoulos and Krystallis, 2003). It has been demonstrated that a traditional appearance of food can be identified by consumers as a sign of superior quality in contrast to standardized commercial foods (Kupiec and Revell, 2001). In a similar way, some consumers tend to distrust innovation and the use of new technologies in food production (Yeung and Morris, 2006; Yeung and Yee, 2003), considering their outcomes as less authentic, of lower quality, and even hazardous (Sapp, 2003). When making food choice decisions, technology appears to be a potential source of risk for concerned consumers. Uncertainty about the possible consequences derived from consuming foods having used innovative food harvest methods can adversely affect consumers' willingness to purchase (Loureiro and Hine, 2004). Unfavourable beliefs and attitudes towards these new foods may impede adoption and diffusion, negatively

[21] This, and the following two examples, are taken from trendwatching.com (www.trendwatching.com/trends/flawsome/ and www.trendwatching.com/trends/10trends2013/). [Cited 28 May 2013].

affecting product perceptions and appraisal. Mistrust of innovation may also prevent the adoption of convenience foods in the most traditional societies (Choo, Chung and Pysarchik, 2004).

This is the case of aquaculture and other new developments in food production, including genetically modified organisms. In some countries with significant rates of seafood consumption, farmed species are also suffering from low consumer appraisal and a low expected quality. Aquaculture is a relatively new source of food supply that is not as appreciated as traditional wild fisheries in high-seafood-consumption communities (EG DG MARE, 2008; Fernandez-Polanco *et al*., 2013). This is the case in southern European countries, where seafood is culturally related to the traditional diet. As a result of this preference for wild species, farmed products result in negative perceptions and a less competitive position in terms of preferences and prices.

Conversely, organic food has been made very popular by trends in healthy eating. Organic food certification is a reflection of consumers' concerns about both health and the environment. The term "organic" refers to the way agricultural products are grown and processed. Specific requirements must be met and maintained in order for products to be labelled as "organic" (Council Regulation [EC] No. 834/2007). Organic crops must be grown in safe soil, have no modifications, and must remain separate from conventional products. Farmers are not allowed to use synthetic pesticides, bioengineered genes (genetically modified organisms), petroleum-based fertilizers, or sewage sludge-based fertilizers. Organically raised animals are not given antibiotics, growth hormones, or fed animal by-products. In addition, the animals are given more space to move around and access to the outdoors, both of which help to keep them healthy. The more crowded the living environment is, the more likely the animal is to fall sick. In order to raise animals organically, clear communication with farmers is important. Germany and the European Commission work together in the direction of animal welfare. They have identified the principles of welfare quality, which are good housing, good feeding, good health and especially appropriate behaviour.

On its Organic Agriculture web page, FAO states: "An organic label indicates that a product has been certified against specific organic standards. The label carries the name of the certification body and the standards with which it complies (e.g. EU 2092/91)."[22] The label of a given certification body informs the consumer about the type of standards complied with during production and processing as well as on the type of recognition granted to the certification body. The same FAO web page states: "Many certification bodies operate worldwide, most of which are private and originate in developed countries. ..To the informed consumer, this label can function as a guide."[23]

In July 2010, the European Union (Member Organization) introduced a mandatory logo for organic food to strengthen the organic sector by making the identification of organic products easier for consumers. The European Commission (2013) states: "The placement of the EU logo is mandatory from 1 July 2010 for pre-packaged food. It remains voluntary for imported products after this date. From 1 July 2010, where the Community logo is used, an indication of the place where the agricultural raw materials were farmed should accompany it. It should be indicated that the raw materials originate from 'EU Agriculture', 'non-EU Agriculture' or 'EU/non-EU Agriculture'. If all raw materials have been farmed in only one country, the name of this specific country, in or outside the EU, can be indicated instead. If operators wish to sell their products in another EU Member State than their own, they may place an additional national or private logo that will be recognised by the consumers of this particular country."

However, according to Deloitte (2012), while consumers want healthy food: "they often don't know what healthy means and are easily confused. For example, organic means "not enhanced," while functional foods usually signify "enhanced"."

[22] [Cited 6 June 2013]. www.fao.org/organicag/oa-faq/oa-faq3/en/
[23] Ibid.

The global organic food market grew by 9.8 percent in 2011 to reach a value of USD67.2 billion. North America and South America account for 50.3 percent of the global organic food market by value with large amounts of output in South America exported to North America. In 2016, the global organic food market is forecast to have a value of USD102.5 billion, an increase of 52.6 percent with respect to 2011 (MarketLine, 2012). Taking into account the above, the standardization of labelling and increased consumer awareness about it are very relevant. Janssen and Hamm (2012), in analysing the consumer perception of the mandatory logo for organic food in the European Union (Member Organization), found that while the introduction of the logo was generally welcomed in all countries, consumers were concerned about the trustworthiness of the inspection system. It is suggested that communication campaigns informing consumers about what the new logo stands for and how the inspection is done should be conducted to address these concerns. This could involve topical publications and activities arranged by different social groups.

The development of the organic market also has its own brakes. Despite its growing popularity, premium prices are still a problem for increasing demand in developed countries (Magnuson *et al*., 2001), and limit the potentiality of markets in less-developed countries, which become suppliers of organic food for foreign richer market. Spain is, within the European Union (Member Organization), a good example of this gap between producer countries and destination markets. Spanish organic agriculture may benefit from enlarging the local market. However, despite increasing concerns about health and environment across the population, consumers' and retailers' attitudes towards organic food do not favour demand expansion. Although small segments are willing to accept premium prices for the expected benefits of an organic diet, these premiums are not large enough to compensate the cost differential between organic and conventional agriculture (Sanjuan, 2003).

While the organic food concept and labelling met with ready approval from consumers, acceptance of genetically modified crops and nanotechnology is low. Genetic engineering is a science that involves deliberate modification and transformation of certain genetic materials of plants or animals to create new variations of products. Genetically modified foods first appeared on food markets in the 1960s.

As suggested in Chen's (2008) research about consumer attitudes and purchase intentions towards genetically modified foods, many foods consumed today are either genetically modified whole foods or foods containing ingredients brought about by gene modification technology. Nanotechnology is a technology dealing with nanoparticles and allowing materials to achieve new qualities in this dimension. Although this technology enables interesting innovations in the food domain such as by adding additional benefits (e.g. better solubility of vitamins, longer shelf-life, cancer prophylaxis), the possible negative consequences of this technology for humans and the environment are unknown.

Despite the perceived benefits of these technologies, consumers are rather sceptical when they see "genetically modified" in the labels. As reported in many studies and publications (e.g. Bredahl, 2001; Grunert *et al*., 2001; , consumer attitudes in Europe towards genetically modified foods appear to be strongly negative. United States consumers historically remained neutral toward genetically modified foods until recently when research studies suggest their slight disapproval of such foods (Gaskell *et al*., 1999, pp. 384–387). Batrinou, Spiliotis and Sakellaris (2008) demonstrated in an emphatic way a degree of phobia concerning genetically modified food and the importance of carefully worded labelling among younger consumers. Siegrist, Stampfli and Kastenholz (2009, p. 660) summarize the results of a survey detailing consumers' decision-making process with regard to nanotechnology products in this way: "Results suggest that consumers attribute a negative utility to nanotechnology foods, even though the products had a clear benefit for the consumers. Results suggest that consumers are interested in products with additional health effects only when the effect is due to natural additives".

6.5 Sustainability

Sustainable consumption and production in food and agriculture is another consumer-driven trend. The availability of natural capital such as fish stocks and land is limited by nature. Thus, the informed consumer cares about integrated implementation of sustainable patterns of food consumption and production, respecting the carrying capacities of natural ecosystems. Consumer choice plays a leading role in orienting production, as consumers select certain types of products according to place of origin, production processes, or producer.

Kurien (2005, p. 58) provides an example of how consumers can influence sustainable production in the fishing industry: "Fish-exporting developing nations need to reassert their commitment to immediate resource rejuvenation and long-term conservation and management. Consumers in developed countries play an important role in this context. It is they, finally, who will decide the contours of luxury consumption. Harvesting of small Nile Perch in Kenya is based on the export demand for fillets obtained from immature fish with a body weight below one kilogram. There is a vibrant, illegal market in the United States for immature lobsters from Brazil. As long as such demands persist, it actually pays developing country fishers to fish unsustainably."

FAO (2012) reveals the latest statistics about fish stock depletion: almost 30 percent of fish stocks are overexploited – a slight decrease from the previous two years – and about 57 percent are fully exploited (i.e. at or very close to their maximum sustainable production (Chapter 8). Overexploitation not only causes negative ecological consequences, it also reduces fish production, which leads to negative social and economic consequences.

Poor natural resource use in aquaculture influences fish stock depletion and threatens biodiversity. According to FAO (2007), mangroves, which are commonly found along sheltered coastlines in the tropics and subtropics, declined from 18.8 million ha in 1980 to 15.2 million ha in 2005. FAO (2007, p. ix) asserts: "Human pressure on coastal ecosystems and the competition for land for aquaculture, agriculture, infrastructure and tourism are often high and are major causes of the decrease in [mangrove] area reported."

The sustainability of fisheries, assured to consumers through ecolabels, reflects the seafood sector's increasing willingness to be environmentally friendly. From a retailer's point of view, ecolabelled products increase transparency in aspects going beyond food safety and quality standards. The goal of ecolabels is to create market incentives for the implementation of sustainable processes in the food industry. Research has provided evidence pointing to a positive effect from the use of ecolabels on seafood demand and consumers' willingness to pay. Within the same species, certified fish may be preferred to non-certified, provided the premiums do not exceed a limit of tolerance (Wessells, Johnston and Donath, 1999). Environmental labels are more useful than quality claims in obtaining premium prices for seafood products and for particular species (Jaffry *et al*., 2004). However, it has been found that consumers are not willing to shift from their preferred species to other lower priced ones because of the presence of environmental labels (Johnston and Roheim, 2006). The effects of ecolabels differ among species and certifying agencies (Wessells, Johnston and Donath, 1999; Jaffry *et al*., 2004), and across countries (Johnston *et al*., 2001). The former is related to the intensity of public concerns, governmental and non-governmental actions and presence in media dealing with environmental issues (Roheim, 2008).

The number of consumers persuaded to purchase these environmentally labelled products, and their willingness to pay a premium for them, become key factors in the success of these kinds of strategies (Roheim, 2008). One cannot expect consumers to be attracted by the presence of ecolabels alone in a set of buying options; they need to be convinced to act environmentally friendly. As with healthy behaviour, it is a process that begins with consumers' concerns, which do not necessarily result in a willingness to behave sustainably without the concurrency of other psychological factors (Abdul-Muhmin, 2007). Consumers will not pay attention to ecolabels unless they are environmentally concerned and convinced to act for environmental protection through their buying

decisions. Consumers have to perceive that buying those products is an effective means to achieve this goal, and they need to recognize that the information in the label is useful for this purpose (Thogersen, 2000). Confusion on the meaning of the term sustainability and on the wide number of different options is one factor that may affect the conclusion of the process. In addition, the availability of these labels in stores is the main requirement for the success of ecolabelled products, and this decision lies in retailers' hands.

The proliferation of ecolabels in fish consumption in the last decade or so has led to calls for some international guidance in the area. As a response, FAO (2009b) published *Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries*. The guidelines set out principles, minimum requirements and procedural aspects that any ecolabelling scheme should encompass, and they provide a benchmark against which various schemes can be compared. Washington (2008, p. 2) states that "by purchasing fish and seafood products certified to a respected ecolabelling scheme [consumers] can reassure themselves that their consumption is not having an adverse effect on fish stocks or the marine environment, and assuming no price premium, they can 'do the right thing' at no additional cost." At the same time, information on potential health benefits was shown to increase demand for specific seafood species and consumers' willingness to pay (Marette, Roosen and Blanchemanche, 2008).

The world's leading certification programme for wild capture fisheries is the Marine Stewardship Council (MSC). The organization has developed standards for sustainable fishing and seafood traceability and follows certifications set out by FAO and the ISEAL Alliance (the global membership association for sustainability standards). The MSC programme is not mandatory, but certain retail chains in countries such as Germany and the United Kingdom of Great Britain and Northern Ireland have a preference for MSC-certified sea products. In other countries, it is voluntary and any fishery can try to become certified if it passes the rigid standards of the MSC. However, MSC certification is expensive, which puts small-scale fisheries at a disadvantage. In addition, the preference for MSC in some countries of the European Union (Member Organization) creates market access problems for developing countries. In 2013, 188 fisheries were certified to the MSC standard, while another 106 were in the formal process of being assessed but were not yet certified. The total landings of MSC-certified fish are 6.5 million tonnes, amounting to 7 percent of the global seafood supply (O. Oloruntuyi, Marine Stewardship Council, private communication). Regression results of hedonic analysis of MSC-certified frozen processed Alaska pollock products in the London metropolitan area using scanner data show a statistically significant price premium of 14.2 percent (Roheim, Asche and Santos, 2011).

The benefits of carrying the MSC logo have recently been brought into question by certain producers and governmental institutions, Alaskan salmon processors being the best-known case. A group of salmon processors from Alaska withdrew from the MSC in 2011 and kept selling their products under the coverage of the local and governmental certification programme alone (Alaska Sea Food Marketing Institute). This withdrawal appears to have had no significant consequences on their sales, even in markets with a strong presence of MSC-certified products such as Germany. Among other well-known government certification programmes are Krav (Sweden), Iceland Responsible Fisheries and Ø-mark (Denmark).

Consumers also have concerns about how food production affects climate change. Lippincott Mercer (2006) states that "28 percent of consumers in the UK, and 19 percent in the U.S., are 'strongly concerned' about climate change. This group shows a latent demand for products, services and brands that would allow people to reflect their climate-change concern in their spending". "Global climate change has been largely driven by the activities of the industrialised countries. Yet its most severe consequences will be and, indeed, are already being felt by the developing countries. Moreover, it is the poor of those countries who, in part because of the poverty, are most vulnerable. If left unchecked, climate change will increase hunger and cause further deterioration of the environmental resources on which sustainable agriculture depends." (Conway, 2012, p. 286).

In Europe, the concept of buying local products is heavily promoted. The food miles concept originated in the United Kingdom of Great Britain and Northern Ireland in the early 1990s and has been supported by a range of environmental, community and farmer groups. It has become very popular among consumers and stakeholders in assessing the sustainability of production and the impact on climate change. Food miles represent the distance that food travels from its production until it reaches the consumer. Long-haul trucking and flying require large amounts of fossil fuel, the combustion of which releases carbon dioxide and other pollutants into the atmosphere. Extended supply chains due to big flows of imported products have significantly increased the distance in recent decades. According to the Worldwatch Institute (2013): "in the United States, food now travels between 1 500 and 2 500 miles from farm to table, as much as 25 percent farther than two decades ago." In the same vein, reflecting "the consumer's" concern about the carbon intensity of transportation, two major retailers (Tesco, and Marks and Spencer) in the United Kingdom of Great Britain and Northern Ireland now place plane stickers on fresh produce that has been air freighted from abroad (Hogan and Thorpe, 2009).

Forestry sustainability is another environmental concern among consumers. Forests are the lung of the planet. They absorb and recycle carbon dioxide, helping to reduce global greenhouse gas emissions and stabilize the climate. The loss of forests has major climate, biodiversity and socio-economic impacts. Deforestation accounts for an estimated 10 percent of global greenhouse gas emissions and 60 percent of Brazil's emissions, its largest source (Mata no Peito, 2013). In addition, the Amazon is the most biodiversity-rich rainforest in the world and is home to one in ten known plant and animal species. According to the BBC (2011): "last December, a government report said deforestation in the Brazilian Amazon had fallen to its lowest rate for 22 years. However, the latest data shows a 27 percent jump in deforestation from August 2010 to April 2011."

As Brazil is the largest importer of soybeans in the world, some environmentalists argue that rising demand from both developed and developing countries motivates farmers to clear more and more of their rainforest land.

Many aspects of sustainable production rely on government and policy makers. Therefore, the onus of a major transformation of the market to ensure sustainable production and consumption rests in the hands of different agents. Consumers, especially those in wealthy developed countries, can influence production conditions. However, the ability to effectively affect or influence the way food is produced, especially in developing countries, will be limited by the size of the segments, their purchasing power, and their dependence on imports for supplying these concerned and involved consumers. Actions focused on consumer education may be effective, but this is a complex process. The role of relevant government agencies, certifiers and NGOs in this process consists in providing information, clarifying concepts and options and promoting environmentally responsible behaviour among consumers, which may support the producers' increasing costs of becoming sustainable by increasing market returns (Roheim, 2008).

6.6 Country and region of origin

As mentioned above, a country or region of origin is an important determinant of consumers' food preferences. Some regions have special environmental conditions or processing traditions that make their products especially appreciated and celebrated in national and overseas markets. The protection of geographical indications was extended to foodstuffs and other agricultural products in 1992 (European Council, 1992). One example of this differentiated strategy is the programme of protected denomination of origin (PDO) of the European Union (Member Organization), which is currently governed by Council Regulation (EC) No 510/2006 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs (European Council, 2006). According to the programme, products from certain geographical areas are identified with a collective brand related to certain land, climate or process advantages particular to that region. Feta cheese has been a protected designation of origin product in the European Union (Member Organization) since 2002. According to the PDO, only those cheeses produced in a traditional way in some areas of Greece,

and made from sheep's milk, or from a mixture of sheep and goat's milk (up to 30 percent) of the same area, may bear the name "feta". Among more recent PDO protected products is Aceite de Navarra, an olive oil registered by Spain in September 2009. Despite the globalization of some ethnic or regional cuisines, there are some foods and preparation methods that tend to be associated with certain geographic areas. Other important variables that may affect consumers' preferences, such as attitudes and traditions, may be related to geography (Larson, 1998). Country or region of origin is used by consumers as an external clue in making quality assessments of food products (Hoffman, 2000; Scarpa, Philippidis and Spalatro, 2005; Kim, 2008).

A second aspect of origin is reflected in consumers' predisposition to prefer local or domestic food over food imported from other regions or countries. This consumer attitude, also called "ethnocentrism" (Shimp and Sharma, 1987; Sharma, Shimp and Shin, 1995), represents the consumer's beliefs about the appropriateness of purchasing products made in foreign countries. Highly ethnocentric consumers may be systematically refusing to purchase imported products. Consumer ethnocentrism may be a significant predictor of consumers' assessments of domestically made foods, and its effects seem to be stronger in food choices than those of demographic variables (Orth and Firbasová, 2003) or even health and sustainability claims (Fernandez Polanco *et al*., 2013).

The effects of claims based on the region or country of origin may vary across products and regions (Scarpa, Philippidis and Spalatro, 2005). When testing the interest in local farm-raised species, familiarity with aquaculture and frequent seafood consumption were found to be determinant factors of preferences and the willingness to pay (Quagraine, Hart and Brown, 2008). Experience with the product, both on the side of consumption and production, may be affecting the strength of the influence of country or region of origin claims.

6.7 Summary and discussions

Following the analysis above, Table 19 summarizes some of the main trends that will influence food demand through to 2030.

Table 19. Consumer trends up to 2030

Trends	Actions	Impact on food demand
Food safety and health benefits	• State intervention in the diets and lifestyles of citizens in order to control obesity. • Campaigns to change individual behaviour involving public education, advertising, targeted programmes in school and workplaces. • Established systems for food traceability.	• Increased demand for food that is ecolabelled and certified by the authorized body. • Increasing popularity of organic food. • Decreased consumption of fast food.
Product systems and innovations	• Change of food production processes. • Revert towards traditional production processes in cases such as organic foods. • Application of genetic modification and nanotechnology to production of new foods.	• Further adaptation to new foods, although slow in cases where genetic modification, nanotechnology, aquaculture and convenience apply. • Growth in relevant certification and ecolabelling.
Corporate social responsibility	• Increased awareness about social issues in food production by media, NGOs, consumer brands and other stakeholders. • Full information about the product and its movement through the value chain provided by producers. • Increased availability of information about product flaws, production mistakes, failures and unreached social responsibility goals provided by producers. • A tendency to shift business practices toward social responsibility by producers and other stakeholders involved.	• Increased preference of consumers to buy "socially responsible" products • More informed consumer choice about food products. • Increased demand for products from reliable brands/producers. • Affinity with "honest" brands/producers.
Sustainability	• Established legislation towards sustainable and safe food production. • Ecolabels.	• Increase production and demand for products that are produced sustainably and certified.
Country and region of origin	• Promotional actions towards local food by social agents (governments and NGOs).	• Choice of local foods over exported by consumers if products prices are competitive.

Food safety and health benefits

Healthy eating will be a dominant trend in food consumption in the coming decades. Driven by concerns about a global rise in the proportion of overweight and obese consumers and obesity-related diseases, governments will play an important role in promoting healthy eating habits to the public through campaigns, advertisements, targeted programmes in schools and workplaces. As a consequence, demand for food that is certified by an authorized body, labelled with safety assurances, whether public or private, or organic labelled, will increase, and the consumption of fast and fatty food will decline. The adoption and consumption of healthy foods will not be universal among countries and individuals owing to differing abilities to process information and understand health benefits and consumer involvement in personal health care.

Consumers' concerns about health are closely related to food safety concerns. Consumers will demand more information about food products and the possibility to trace their movements through the value chain.

Corporate social responsibility

Corporate social responsibility is a rising trend among consumers and retailers. Consumers will demand more transparency from producers about food products, and will pay more attention to production sustainability, food ethical sourcing, and food miles, among other factors. An abundance of publicly available information related to the food industry, product flaws, production mistakes, failures and unreached social responsibility goals will motivate producers to fully disclose information about their products. The reliability and honesty of the producer will increasingly influence consumers' choice towards food. Corporations will progressively change their practices by making them more socially responsible as a response to media, NGOs and consumer demands.

Production systems and innovations

Food production and processing procedures will be affected by consumers. In some cases, such as the cultivation of organic foods, production systems will revert towards more traditional ones. In other cases, developments in nanotechnology and genetic modification will stimulate the production of new foods. The acceptance of genetically modified products and nanotechnology will continue to be low owing to the negative perception by consumers about modified foods. These developments in the food industry will further facilitate the growth in relevant ecolabelling and certification schemes among producers.

Sustainability

Consumers' interest in the sustainable production of foods will continue to be an increasing trend, especially in wealthy developed countries. Fish stock and forest depletion as well as the effect of production on climate are among some areas of consumers' concerns to be mentioned. Legislation will reinforce the trend towards sustainable production. The popularity of sustainable and "socially responsible" products will increase as a result.

Country and region of origin

The concept of buying local products is heavily promoted among consumers, in Europe in particular. Attitudes, traditions, and special production methods distinguishing the food in national and international markets are the elements that will influence the choice for local foods over imported products among consumers.

Discussion

The extent to which these new trends will in fact affect food demand in the future is conditioned by the level of involvement in promotion of retailers as well as the size and the economic value of the segments of concerned consumers. Unless the segments of those concerned consumers reach a minimum profitable size for producers and retailers, the main drivers in global food consumption will remain price, health and safety and technical quality. Given that the majority of the issues mainly concern consumers in developed countries, expected future changes in international food flows will have some influence in this respect. An interesting question is whether all these consumers' concerns that seem to have some impact in the demand for food in South–North trade will have any impact in South–South flows and the production of food to address local demand.

The rise in consumer concerns strongly depends on the promotional efforts undertaken by stakeholders, mainly governments and NGOs, but also media, groups of influence and others. These stakeholders do not always act in the same way, or share the same interests and goals, often resulting in increased confusion rather than increased concerns. Price sensitivity is a major constraint in the market development of these food trends. Even concerned consumers are limited in their budget when they make food choices and this will affect the acceptability of premium prices. The fall in households' purchasing power in many Western countries owing to the policies adopted to overcome the financial crisis will also have an impact on the demand for premium foods and may become an

obstacle for market development. Finally, even in countries with similar levels of income, cultural issues may result in differences in terms of concerns and consumption.

7. SUMMARY – DEMAND SIDE

This chapter summarizes the main findings from the different aspects of the demand side analysis as presented in Chapters 2–6. The future demand for food is considered through factors such as population growth, demographic trends, income growth and shifting consumer preferences and how food will be produced. The future prevalence of undernourishment is also discussed. As this presentation is based on previous chapters, the reader is referred to these chapters for more detailed discussion and references.

Population growth is projected to slow by 2030. Nonetheless, in 2030 there will be 1.3 billion more people on Earth compared with 2010 – a 19 percent increase. However, population growth will not be uniform in all parts of the world. Africa will experience a 50 percent increase between 2010 and 2030, with most of this in sub-Saharan Africa, owing to the high fertility rate. The population of Europe will show a minor decline. Asia, on the other hand, will add 17 percent to its current level and will comprise 60 percent of the world population in 2030. China will experience only a slight increase of less than 2 percent by 2030 to 1.374 billion inhabitants and will be overtaken by India, which will expand by 44 percent to 1.379 billion inhabitants by 2030. Growth rates in the Americas will be less than in recent years, yet the population of North America will still grow by 16 percent and that of Latin America and the Caribbean by 20 percent.

Different regions will also experience demographic shifts, which combined with population growth, will have an impact on food demand. In terms of the average age of the population, Africa has the youngest population structure owing to a high fertility rate and lower life expectancy. The number of older persons, defined as people 65 years and above, will reach only 5 percent of the total population by 2030. Reduced fertility in Europe and Asia will continue to cause significant ageing of the population – the proportion of older persons in the total population in 2030 is estimated at 23 percent in Europe and 13 percent in Asia – and a similar trend will be observed in most countries of the developed world.

Population ageing around the world, and especially in developed countries, is likely to increase the demand for healthier products and reduce the consumption of starchy staple foods. This will mean a higher demand for fish protein, while meat consumption will level off. Healthier eating habits will probably cause human life expectancy to be higher, which in turn will prolong the employment period. The proportion of educated people will rise over time, thus work productivity and disposable income will increase. At the same time, the expansion of urban land will result in a loss of land for agriculture and aquaculture.

The extent to which increased GDP is correlated with reduced population growth and increased per capita demand will have a major effect on gross demand for food. The predicted demand in richer and more mature economies will not be significantly higher. Especially in higher income countries where food expenditure represents a small share of income (10–15 percent), per capita food consumption is reaching a plateau. Instead, increased GDP per capita in these advanced economies, such as in Europe and richer regions of the Near East and Eastern Europe, will affect the composition of consumption, that is, what people are actually eating, rather than cause an overall increase in food consumption. With more disposable income, people can choose to be more particular about what they eat and choose healthier protein sources, such as fish.

The GDP per capita increase in some emerging economies (such as developing countries in Asia, Latin America, as well as developing regions in the Near East and Eastern Europe) will result in both an increase in food consumption and a composition change. However, it is difficult to predict by how much consumption will increase in developing regions owing to the diverse speeds of their economic growth. In addition, the increase in consumption of some products will also depend on cultural and religious traditions of particular countries. Africa is expected to experience an increase in consumption that will be especially noticeable with respect to more important nutrients such as proteins. However, the increase in income and consumption in some Asian and African countries

will continue to prove insufficient for food security and nutrition, and large portions of the population are expected to remain malnourished and food insecure. It will therefore prove an important challenge for the United Nations and its Members to commit to eradicating hunger by 2030 in the context of a Post-2015 Development Agenda.

According to Engel's law, the proportion of food expenditures by a household decreases as the income level increases. However, this income elasticity of demand for food varies greatly among countries. For low-income countries, increases in income will be accompanied by almost proportional increases in expenditure on food, whereas for high-income countries, where elasticities are much lower, and for food groups such as cereals and oils and fats, increases in income will have virtually no impact on demand.

However, it is vital to note that food prices are expected to increase. As food demand in low-income countries is more elastic than in high-income countries, this means that there will be a decline in demand, especially in developing countries, owing to the price effect. This will to some degree counteract the income effect. It is also important to keep in mind that income distribution is an important variable. Countries such as India and China have a substantial middle class as well as large numbers of very affluent consumers. At the same time, their proportion of low-income households remains significant. Thus, even inside developing and emerging economies, the patterns in terms of increased food consumption will be very different.

There are different estimates of the number of undernourished in the world today – varying from 842 million people to 925 million people. According to FAO's latest statistics, 842 million people are undernourished (12 percent of the world population). Most undernourished people live in developing regions, especially in Asia and Africa, where 13.9 percent and 22.9 percent of the total population, respectively, are undernourished. Among Asian regions, Southern Asia and Eastern Asia are the most affected areas. Sub-Saharan Africa is the most afflicted region of Africa. The prevalence of undernourishment is declining over time in both regions. However, in Africa, especially in its sub-Saharan part, the number of undernourished has continued to grow in the last two decades owing to increasing population.

Consumers' preferences for food products will continue to change. The main trends that will influence future food demand are: food safety and health benefits, social concerns, production systems and innovations, sustainability and food origin.

In addition to the increasing health consciousness of many consumers, the trend in healthy eating is often driven by government and societal concerns about the global rise in the proportion of overweight and obese people as well as the increase in obesity-related diseases. Governments can play an important role in promoting healthy eating habits to the public through campaigns, advertisements and targeted programmes in schools and workplaces as well as through preventive health care and making healthy food accessible and affordable, especially for low-income populations. As a consequence, demand for food that is certified by an authorized body or is ecolabelled or organic is expected to increase, while the consumption of fast food may decline in the Western world. If consumers become more health conscious themselves, they will demand more information about the products they consume and will want to be able to trace their movements through the value chain.

Demands for greater CSR and sustainable practices are a growing trend among consumers. Consumers will demand more transparency from producers and retailers about food products, in terms of their origin as well as their farming/fishing practices. Consumers will pay more attention to resource sustainability, seeking out products farmed or caught in a way that has lower impacts on the environment. They will be more concerned about ethical issues, such as fair wages and livelihood practices, and food miles, among other factors. The reliability and reputation of the producer, brand, ecolabel or ecoguide will increasingly influence consumers' choices of food. In response to these

consumer demands as well as to “name and shame” practices in the media and NGO sector, corporations may progressively change their practices to make them more socially responsible.

Consumers’ interest in the sustainable production of foods will continue to be an increasing trend, especially in wealthy developed countries. Multiple legislations related to sustainable production and food safety will reinforce the trend. The popularity of sustainable and “socially responsible” products will increase as a result.

Attitudes, traditions and special production methods distinguishing foods in national and international markets are elements that will influence the choice for local foods over imported products among consumers on occasions when product prices are competitive.

With consumers’ buying practices shifting, this will in turn influence how food is produced and processed. In some instances, such as the cultivation of organic foods, production systems will revert towards using less synthetic inputs (e.g. reduced use of pesticides). As organic foods become big business, organic methods will continue to expand beyond their traditional, small-scale ambit. The definition of organic will remain driven by government standards for certification, with some countries having more stringent standards than others. In other cases, developments in nanotechnology and genetic modification will stimulate the production of new foods and growing methods. These developments in the food industry will further facilitate the growth in relevant ecolabelling and certification schemes among producers.

8. FISHERIES AND AQUACULTURE PRODUCTION

As highlighted in Chapter 4, fisheries and aquaculture production and productivity have an important role to play in meeting the demand for food in the world and reducing hunger and poverty in the poorest regions. This chapter describes the evolution of the sector over time and discusses the potential for increased production in fisheries and aquaculture in the future.

8.1 World production of fish from 1950 to the present

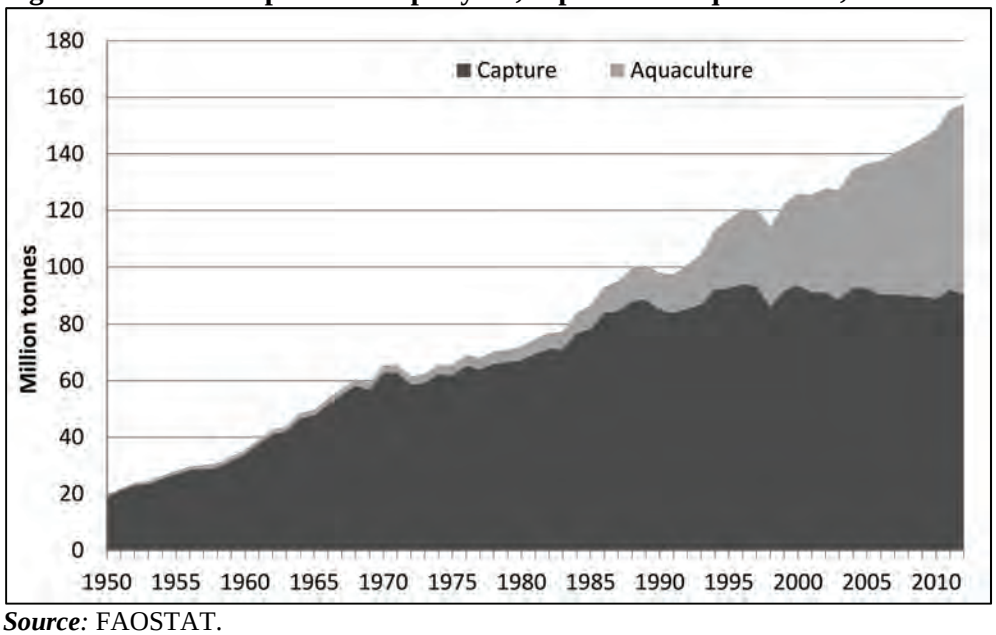
Figure 1 shows world fish production of aquaculture and capture fisheries from 1950 to 2012. World fish production has grown dramatically since 1950. Total catches (capture fisheries and aquaculture) were only 20 million tonnes in 1950. In 2010, capture fisheries and aquaculture produced 148 million tonnes of fish valued at USD217.5 billion. Production increased to 156.2 million tonnes in 2011 and 156.7 million tonnes in 2012 (preliminary figures), of which 131 million and 134.6 million tonnes were used for direct human consumption.

Catches from capture fisheries were 18.7 million tonnes in 1950. There were significant increases on a yearly basis over the following decades until the mid-1980s when the catches levelled off at about 85–95 million tonnes per annum. In 2012, capture fisheries accounted for 90.2 million tonnes or 58 percent of the total world fish production.

The contribution of aquaculture or fish farming to total production was negligible in 1950. Even in 1970, aquaculture production (excluding aquatic plants) was only about 2.5 million tonnes, or about 4 percent of total seafood production. Production took off in the 1980s, when aquaculture achieved the high growth rates that the sector continues to sustain today. By 2012, aquaculture production had increased to 66.5 million tonnes, or about 43 percent of total seafood supply.

Thus, even with stable landings of wild fish, the supply of seafood has been steadily increasing. Moreover, the supply of seafood has been growing not only in absolute quantity, but also more rapidly than the global population. Per capita fish consumption increased from 9.9 kg (live weight equivalent) in 1960 to 18.6 kg in 2010, 18.8 kg in 2011 and 19.1 kg in 2012. Taking into account the population growth over this period (Chapter 2), this increase is remarkable. The importance of aquaculture, not only as a source for seafood but also for food in general, is also set to continue to increase (Smith *et al.* 2010).

Figure 1. World fish production per year, capture and aquaculture, 1950–2012



Source: FAOSTAT.

Per capita consumption in developing regions and low-income countries is still lower than in developed countries. Of the 126 million tonnes available for human consumption in 2009, only 7 percent was consumed in Africa, representing 9.1 kg per capita. However, the gap in consumption is slowly narrowing (FAO, 2012).

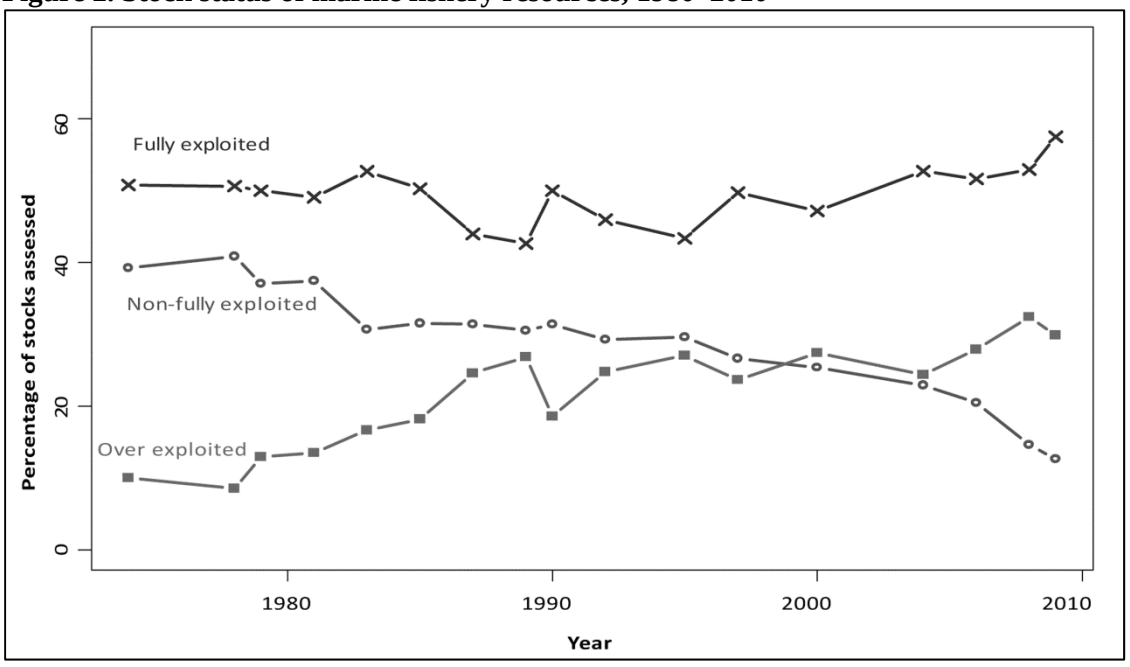
As for employment in the sector, in 2012, small-scale fisheries employed 90 percent of the 54.8 million people involved in fisheries globally (capture fisheries and aquaculture) and accounted for half of world fish production (FAO, 2012).

8.2 Capture fisheries

As marine capture fisheries account for almost 90 percent of world capture fisheries production, with the remainder coming from inland waters, this section concentrates on marine capture fisheries.

As mentioned above, production from capture fisheries reached a plateau in the mid-1980s. This is simply because many fishery resources have been depleted. FAO statistics show that in the first half of the 1950s, no more that 5 percent of the world marine capture fishery resources were overexploited or overfished. By the mid-1970s, this number had already risen to 10 percent. The latest FAO statistics suggest that 30 percent of the world capture fishery resources are overexploited and 57 percent are fully exploited (Figure 2). In other words, almost 90 percent of fishery resources are either overexploited or fully exploited (FAO, 2012). Moreover, there is a concern that fully exploited resources may become overexploited in the near future.

Figure 2. Stock status of marine fishery resources, 1980–2010



***Source**:* FAO Statistics and Information Branch.

Table 20 presents capture production for the top ten species groups. Most of the stocks in these groups, which account for 30 percent of world marine capture fisheries production, are fully exploited and do not have the potential to increase production, or are overexploited. In the case of the former, increases in production may be possible if fisheries managers develop effective rebuilding plans.

Table 20. Top ten capture species by groups (tonnes)

Species	2005	2006	2007	2008	2009	2010
Herrings, sardines, anchovies	22 219557	19 077167	19 933146	20 256090	19 938507	17 096817
Carps, barbels and other cyprinids	775 147	756 657	811 025	902 889	911 130	7 426 888
Cods, hakes, haddocks	8 971 420	8 986 730	8 352 379	7 689 964	6 949 409	6 620 373
Tunas, bonitos, billfishes	6 426 898	6 472 101	6 618 929	6 544 594	6 634 797	3 129 250
Shrimps, prawns	3 205 737	3 269 605	3 262 436	3 132 546	3 166 970	1 424 867
Crab, sea-spiders	1 235 077	1 304 357	1 306 841	1 330 522	1 341 696	1 371 685
Salmons, trouts, smelts	1 032 505	930 818	1 101 158	828 210	1 207 562	979 590
Flounders, halibuts, soles	900 497	875 355	916 106	945 937	924 564	955 350
Tilapias and other cichlids	738 894	717 837	743 351	764 765	764 593	801 542
Sharks, rays, chimaeras	738 894	717 837	743 351	764 765	764 593	738 924

Source: FAO Statistics and Information Branch.

Although the production of global capture fisheries remains stable (about 90 million tonnes), there have been changes in catches by region, country, fishing areas and species. According to FAO (2012), from 2004 to 2010, the landings of marine species excluding anchoveta ranged from 72.1 million to 73.3 million tonnes. This indicates stability in terms of aggregate catches.

Anchoveta is the most harvested species in the world but with significant variations over time – from 10.7 million tonnes in 2004 to 4.2 million tonnes in 2010.

Chilean jack mackerel catches have declined in the national exclusive economic zones and on the high seas. Catches have been declining gradually since they peaked at 5 million tonnes in the 1990s and steeply since 2000 when they fell to 2 million tonnes. For this species, 2010 saw the lowest level of catches since 1976 (0.7 million tonnes). As a consequence, Chilean jack mackerel disappeared from the list of the top ten caught species worldwide.

The whole group of gadiform species (cods, hakes, haddocks) has followed a downward trend, from 8.9 million tonnes caught in 2005 to 6.6 million tonnes in 2010. Capture production of tuna and shrimps experienced a substantial drop in 2010.

The top 12 fish producers are listed in Table 21. In 2011, China still ranked as the largest producer with 15.8 million tonnes. Peru, where total catches vary considerably over time owing to variability in the anchoveta stock, follows China in most years. Peru was surpassed by Indonesia and the United States in 2010 owing to reduced anchoveta catches, but it regained second place in 2011 with a catch of more than 8.2 million tonnes. Major Asian fishing countries (China, Indonesia, Viet Nam and Myanmar) recorded significant increases in catches. Norway and some other countries also saw growth in catches after a small decrease in previous years. The increase in catches in the Russian Federation of one million tonnes from 2006 to 2011 is particularly remarkable. The increase is partially due to the government's decision to remove excessive formalities for the documentation of landing operations. Catch projections by the Russian Federation suggest a further 40 percent increase to 6 million tonnes by 2020.

Table 21. Top 12 producers (capture only) of fish and fishery products 2002–2011 (tonnes)

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
China	14 173 776	14 347 274	14 464 803	14 588 940	14 631 018	14 659 036	14 791 163	14 919 596	15 417 011	15 772 054
Peru	8 765 189	6 086 058	9 604 527	9 388 488	7 017 502	7 210 545	7 392 096	6 914 452	4 621 091	8 248 482
Indonesia	4 322 764	4 627 149	4 643 893	4 695 977	4 800 621	5 050 340	5 002 333	5 099 355	5 380 196	5 707 684
United States of America	4 937 305	4 938 956	4 959 826	4 892 967	4 852 284	4 767 596	4 349 853	4 222 052	4 425 961	5 153 452
India	3 736 603	3 712 149	3 391 009	3 691 362	3 844 837	3 859 293	4 099 227	4 053 241	4 689 316	4 301 534
Russian Federation	3 232 351	3 281 510	2 941 595	3 197 686	3 284 306	3 454 218	3 383 724	3 826 129	4 069 624	4 254 864
Japan	4 373 840	4 680 360	4 330 029	4 312 113	4 318 136	4 277 682	4 323 590	3 847 017	4 069 135	3 761 176
Myanmar	1 284 340	1 343 860	1 586 600	1 732 250	2 006 790	2 235 580	2 493 750	2 766 940	3 063 210	3 332 979
Chile	4 271 417	3 612 075	4 926 810	4 328 316	4 160 741	3 819 303	3 554 808	3 453 786	2 679 742	3 063 449
Viet Nam	1 802 598	1 856 105	1 879 488	1 929 900	1 970 600	2 020 400	2 087 500	2 243 100	2 414 400	2 502 500
Philippines	2 029 914	2 165 876	2 211 301	2 269 721	2 319 031	2 499 680	2 561 237	2 602 454	2 611 762	2 363 221
Norway	2 740 475	2 548 803	2 524 377	2 392 594	2 256 405	2 380 425	2 431 371	2 524 437	2 680 187	2 281 429
Total	**91 044 355**	**88 284 269**	**92 739 644**	**92 478 416**	**90 216 440**	**90 744 781**	**90 073 491**	**90 018 660**	**88 970 124**	**93 494 340**

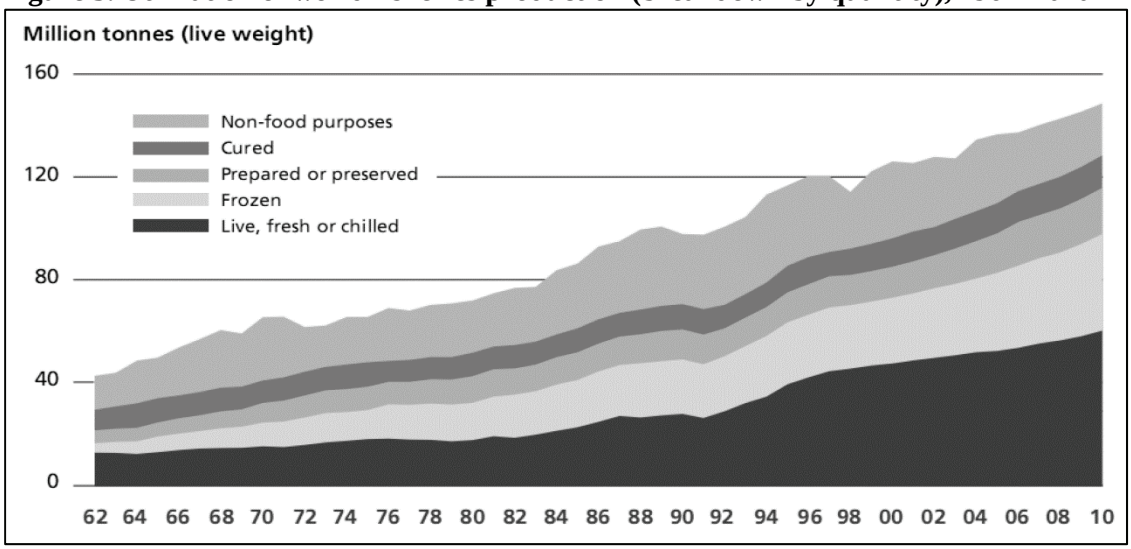
Source: FAO Statistics and Information Branch.

Chile and Japan registered decreased catches in 2009–2011. Outside of the list of top 12 producers, other countries such as the Republic of Korea and Thailand in Asia, Argentina, Canada and Mexico in the Americas, Iceland in Europe and New Zealand in Oceania also decreased their catches in 2011. The major marine producers in Africa (Morocco, South Africa and Senegal) maintained their position.

8.3 Usage[24]

In 2010, 40.5 percent (60.2 million tonnes) of world fish production was marketed in live, fresh or chilled forms; 45.9 percent (68.1 million tonnes) was processed in frozen, cured or otherwise prepared forms for direct human consumption; and 13.6 percent was destined to non-food uses (Figure 3).

Figure 3. Utilization of world fisheries production (breakdown by quantity), 1962–2010



Source: FAO (2012).

The proportion of fish directly used for human consumption has been steadily increasing, up from about 68 percent in the 1980s to 73 percent in the 1990s and to more than 86 percent (128.3 million tonnes) in 2010.

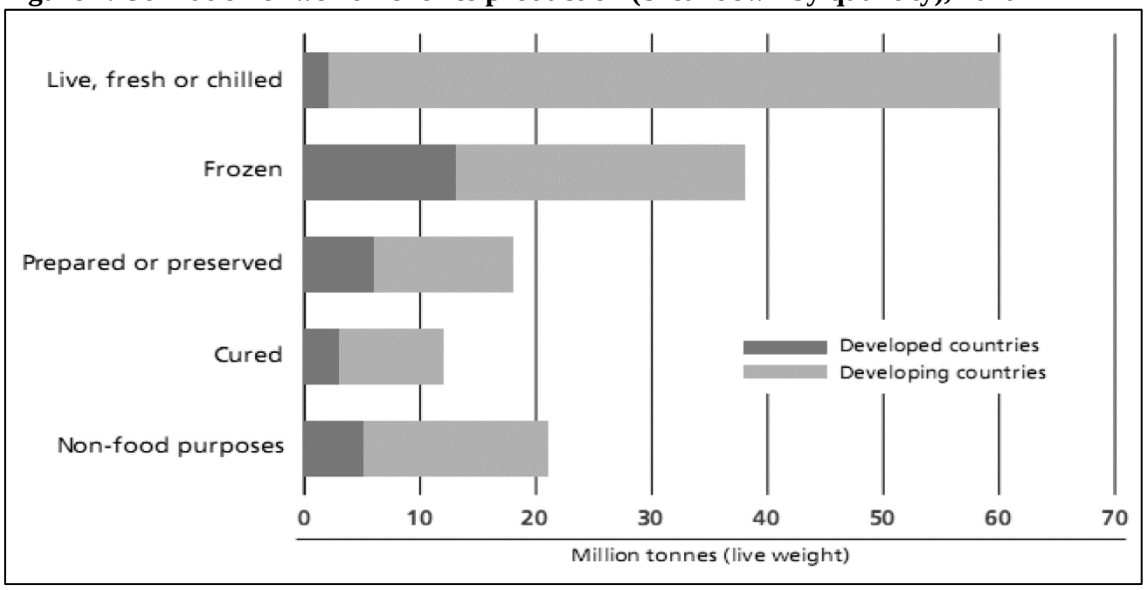
[24] This part is based on FAO (2012) unless otherwise indicated.

In 2010, of the fish used for direct human consumption, the most important product forms were live, fresh or chilled fish (46.9 percent). Frozen fish represented 29.3 percent and prepared or preserved fish 14 percent. The most popular method of processing is freezing, which accounts for 55.2 percent of total processed fish for human consumption.

In 2010, 20.2 million tonnes were processed for non-food purposes. Of this total, 15 million tonnes (75 percent) were utilized for fishmeal and fish oil, 5.1 million tonnes as fish for ornamental purposes, for culture (fingerlings, fry, etc.), for bait, for pharmaceutical uses and for direct feeding in aquaculture, livestock and for fur animals.

Utilization varies widely among regions and countries. As Figure 4 suggests, the main utilization type in developed countries in 2010 was frozen fish, while developing countries mainly utilized live, fresh or chilled fish. In Africa, but also significantly in Asia (especially China), a large amount of production is commercialized in live or fresh forms. The increased consumption of live, fresh and chilled food is mainly due to improved technologies to preserve and transport fish (designed or modified tanks and containers, trucks and other transportation vehicles equipped with aeration or oxygenation facilities). These technologies allow fish to be kept alive during transportation, holding and display. The lower commercialization of live, fresh and chilled fish in markets such as the European Union (Member Organization) is explained by strict regulations, *inter alia*, concerning animal welfare during transportation. In many developing countries, fish commercialization is based on tradition rather than formally regulated.

Figure 4. Utilization of world fisheries production (breakdown by quantity), 2010



Source: FAO (2012).

Table 22 describes the production of fishmeal and fish oil in the period from 1980 to 2022. Fishmeal production increased from 4.77 million tonnes in 1980 to a peak of 7.48 million tonnes in 1994. It then decreased steadily to about 6 million tonnes in 2012. Likewise, global fish-oil production rose gradually from 1.22 million tonnes in 1980 to 1.50 million tonnes in 1994, and thereafter steadily decreased to 1.01 million tonnes in 2012.

Table 22. Fishmeal and fish oil production in product weight (million tonnes), 1980–2012

Production	1980	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012
Fishmeal	4.77	6.36	6.25	7.48	6.94	5.39	6.97	6.24	6.55	5.47	6.25	5.55	5.99
Fish oil	1.22	1.41	1.07	1.5	1.38	0.86	1.33	0.86	1.07	0.97	1.11	0.89	1.01

Source: FAO statistics.

According to a historical overview of fishmeal and fish oil production from 1964 to 2010 provided by the International Fishmeal and Fish Oil Organisation and cited in Shepherd and Jackson (2013), production peaked in 1995 and then followed a downward trend with fluctuations thereafter. The occurrence of El Niño events contributed to a reduction in volumes especially in 1973, 1998, 2003 and 2010.

Several factors have contributed to the decline in fishmeal production. Fishmeal and fish oil are produced from many different species. However, small pelagic species, anchoveta in particular, are the main raw material for production. As noted above, in 2010 the El Niño phenomenon caused a significant drop in the catches of anchoveta, which in turn reduced the production of fishmeal and fish oil. Many countries, including all the major producing countries, applied stricter control measures of wild fishery resources (Mittaine, 2012). In particular, management control measures for the anchoveta fishery in Peru and a reduction in fleet capacity caused by the introduction of individual vessel quota systems contributed to the production decline (Aranda, 2009). Increased processing for direct human consumption of fish formerly used for fishmeal was an additional factor behind the downward trend in production.

Another source of raw material for the production of fishmeal is the processed waste from fish species used for human consumption. According to recent estimates, about 36 percent of world fishmeal production was obtained from offal in 2010. The more efficient utilization of fish by-products including waste was made possible by improved processing technologies and a focus on safe and hygienic methods of processing in many countries.

The increase in global aquaculture production has led to a concern that increased demand for feed from a growing aquaculture sector will increase fishing pressure on wild stocks and consequently threaten the sustainability of the associated capture fisheries. This is also known as the “fishmeal trap”.

Increased aquaculture production has the potential to influence wild fish stocks via increased demand for feed. This generally happens when the management system for the species in question is weak. Fishmeal has been a part of the much larger protein meal market, and, in particular, fishmeal is a close substitute for soybean meal. With this market structure, it is the total supply of and demand for protein meals, of which fishmeal makes up only a small part, that determines prices for fishmeal. Moreover, the growth in aquaculture production has not been influenced much by fishmeal prices, and one seems to be able to (at least partly) substitute away from fishmeal as a feed ingredient when prices are high. One is then led to the conclusion that increased demand for fishmeal from aquaculture cannot have any significant impact on fishmeal prices in the long run, and accordingly does not lead to increased fishing pressure.

It is a fact that demand for fishmeal by the aquaculture sector has grown from virtually nothing to more than half of total production in only 20 years. If this demand for fishmeal continues to grow, it is possible that this structure may change. However, this does not have to be the case. Moreover, productivity growth leading to lower production costs has been a major factor in the growth of aquaculture production for many species. If the market structure changes so that fishmeal is demanded because of its unique characteristics, production costs will also increase and, therefore, limit the demand for feed from aquaculture. Hence, even with a structural change in the fishmeal market, the increase in demand from aquaculture and feed prices is likely to be limited. However, this change in production costs may well influence which species are to be large-volume species in aquaculture.

As per Tacon and Metian (2008), fishmeal is not an essential feed for aquaculture, but it provides the most complete feed in a convenient, cost-effective product form. Fishmeal as a global commodity shows fluctuations in price reflecting changes in supply and demand, especially supply effects due to El Niño events. This is why cheaper alternatives to fishmeal, mostly using vegetable protein and animal by-products, have been developed where technically and economically feasible. As soybean

is the most common vegetable protein for fishmeal production, the fishmeal to soybean meal price ratio is very often used to determine the price trend of these interrelated commodities. Despite the effect of El Niño events, there was an upward trend in the relative value of fishmeal in the period from 1993 to 2012 owing to a diminishing supply of marine feed ingredients and the increasing market price of wild fishery inputs (Shepherd and Jackson, 2013, p. 17).

The use of marine ingredients for aquaculture feed is criticized by some commentators who claim that increased aquaculture production is based on the depletion of capture fishery resources. Although there is no agreement among specialists on this issue, the areas of potential concern are recognized. "It is concluded that future growth of fed aquaculture will be associated with proportionately greater use of land animal and plant proteins, oils and carbohydrates sources, and with a continuing decline in dependence on marine ingredients" (Shepherd, 2013).

8.4 Aquaculture

Aquaculture can be defined as the human cultivation of organisms in water (Asche and Bjørndal, 2011). The production process in aquaculture is determined by biological, technological, economic and environmental factors. The production process can be closed in the sense that it does not depend on wild stocks to provide fingerlings or fry.

A number of criteria can be used to classify an aquaculture system. From an economic point of view, the most significant criterion is intensity. The most interesting feature in this regard is the degree of control over the production process.

In intensive aquaculture, the production system is closed. Fish are reared in confined areas and the farmer controls production factors such as farm size, stocking and feeding of fish. Traditional aquaculture varies between semi-intensive and extensive. The small ponds used in Chinese aquaculture were traditionally operated on an extensive basis, as the farmer did little to control growth and biomass. While this system is still common, many farms have become semi-intensive as farmers actively feed their fish to enhance production and undertake other productivity enhancing measures such as maintaining higher densities.

Table 23 describes world aquaculture production by main group of species in the period from 1970 to 2011. Finfish is the largest group of species in terms of production, followed by that of molluscs, whose production increased from 1970 to 2011 (with the exception of the period from 2000 to 2005, when production remained flat at 9.8 million tonnes). The production of crustaceans started growing in 1995. The contribution of other species to aquaculture production has been less important and stood at less than 1 million tonnes in 1970–2011.

Table 23. World aquaculture production of food fish by main groups of species (million tonnes), 1970–2011

Groups of species	1970	1975	1980	1985	1990	1995	2000	2005	2010	2011
Fin fish	1.5	2.1	2.8	5.2	8.7	15.0	20.8	28.0	38.3	41.6
Molluscs	1.1	1.5	1.8	2.5	3.6	8.2	9.8	9.8	14.2	14.4
Crustaceans	0.0	0.0	0.1	0.3	0.8	1.1	1.1	1.7	5.7	5.9
Others	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.8	0.8
Total	**2.6**	**3.6**	**4.7**	**8**	**13.1**	**24.4**	**32.4**	**44.3**	**59**	**62.7**

***Source**:* www.fao.org/fishery/aquaculture/en

Table 24 shows the ten main species in world aquaculture production in the period 2002–2010. In 2010, grass carp and silver carp were at the top of the list. Production of silver carp had been the highest in the world until 2007, when it was overtaken by grass carp. Production of catla grew substantially throughout the period (almost a sixfold increase), which moved catla fish from fifth position in the list in 2002 to third in 2010. Similarly, white leg shrimp recorded almost a fivefold

increase in production in the period to up tenth to sixth. Other important species are Japanese carpet shell, common carp, bighead carp, Nile tilapia, crucian carp and Atlantic salmon.

Table 24. Ten main species in world aquaculture production (tonnes), 2002–2010

Species	2002	2003	2004	2005	2006	2007	2008	2009	2010
Grass carp	3 136 669	3 273 999	3 249 099	3 396 586	3 494 918	3 640 609	3 797 768	4 184 257	4 337 114
Silver carp	3 392 263	3 387 183	3 559 336	3 689 434	3 850 877	3 609 399	3 793 125	4 101 588	4 116 835
Catla	564 891	585 087	1 187 139	1 317 472	1 394 507	2 133 929	2 375 231	2 439 521	3 869 984
Japanese carpet shell	2 074 651	2 287 787	2 511 186	2 590 759	2 719 941	3 045 708	3 110 037	3 249 213	3 604 247
Common carp	2 813 632	2 956 211	2 559 681	2 666 116	2 795 681	2 817 194	3 043 289	3 228 169	3 444 203
Whiteleg shrimp	475 363	988 392	1 313 745	1 667 973	2 121 142	2 348 549	2 314 460	2 429 126	2 720 929
Bighead carp	1 494 721	1 671 091	1 821 534	1 912 188	2 073 473	2 165 341	2 320 528	2 466 930	2 585 962
Nile tilapia	1 115 584	1 271 877	1 458 260	1 659 055	1 890 696	1 862 878	2 061 816	2 240 589	2 538 052
Crucian carp	1 472 258	1 550 200	1 683 858	1 800 708	1 809 470	1 938 938	1 957 033	2 056 849	2 217 799
Atlantic salmon	1 086 134	1 147 682	1 261 926	1 267 297	1 318 720	1 378 874	1 451 262	1 440 085	1 425 968
Roho labeo	668 987	796 645	1 382 118	1 435 861	1 635 873	1 007 175	1 191 075	1 262 312	1 167 315
Milkfish	527 977	552 043	573 735	594 787	585 383	667 515	676 236	717 734	808 559
World total	**36 785 687**	**38 915 093**	**41 907 649**	**44 295 996**	**47 290 220**	**49 937 426**	**52 946 447**	**55 714 357**	**59 872 600**

Source: FAO Statistics and Information Branch**.**

As far as modern industrialized aquaculture is concerned, salmon and shrimp are the leading species. These are also high-value species, so that the value share is considerably higher than the quantity share. Farmed salmon and shrimp are now sold all over the world.

Table 25 lists the top 20 aquaculture producers in 2010 and 2011. China is by far the biggest aquaculture producer with a production of 38.6 million tonnes in 2011, 65 percent of the world output. China is followed by India, Viet Nam, Indonesia, Bangladesh, Norway and Thailand. Other important producers are Egypt, Chile, Myanmar, the Philippines, Brazil, Japan, the Republic of Korea, the United States of America, Taiwan Province of China, Ecuador, Malaysia, Spain and Iran (Islamic Republic of). When looking at production growth in 2010–2011, all the main produces registered an increase except the United States of America, Taiwan Province of China, Norway and Brazil, whose production decreased by 20, 19, 13 and 11 percent, respectively. However, these facts say little about future production as short-run variability may not be a good indicator of long-term trends.

Productivity growth and technological progress have been important factors underlying production growth in aquaculture. The prices of many farmed products have declined over time. Thus, for production to be profitable, production costs have had to be substantially reduced. The main factor in reducing production costs has been productivity growth through improved technologies and better production practices.

Reduced production costs are primarily due to two factors. First, fish farmers have become more efficient, as they produce a larger quantity with the same amount of inputs. This is normally referred to as productivity growth. Second, improved input factors make the production process less costly. This is evident from the lower quantities of inputs used per unit of output and the lower prices for inputs. Changes in the quality of inputs or their prices can also change the mix of input factors.

Feed is the most vital input factor in the production process, and improvement in feed quality is one of the most important reasons for productivity growth.

Table 25. Top 20 aquaculture producers (tonnes), 2010 and 2011

	Country	2010	2011
1	China	36 734 215	38 621 269
2	India	3 785 779	4 573 465
3	Viet Nam	2 671 800	2 845 600
4	Indonesia	2 304 828	2 718 421
5	Bangladesh	1 308 515	1 523 759
6	Norway	1 286 122	1 138 797
7	Thailand	1 008 010	1 008 049
8	Egypt	919 585	986 820
9	Chile	850 697	954 845
10	Myanmar	744 695	816 820
11	Philippines	718 284	767 287
12	Brazil	701 062	629 309
13	Japan	496 699	556 761
14	Republic of Korea	479 399	507 052
15	United States of America	475 561	396 841
16	Taiwan, Province of China	373 151	314 363
17	Ecuador	310 338	308 900
18	Malaysia	271 919	287 076
19	Spain	252 351	271 961
20	Iran (Islamic Republic of)	224 400	247 262
Total of top 20 producers		**55 917 410**	**59 474 657**
Others		3 104 775	3 225 644
World total		**59 022 185**	**62 700 300**

Source: www.fao.org/fishery/aquaculture/en

In nature, fish are affected by disease, and they are likewise affected in captivity. Moreover, the high densities of fish in captivity substantially increase the risk of diseases spreading. To facilitate industrial production, it must be possible to control diseases.

Systematic breeding, simply described, is choosing the best parents to produce offspring with the most desirable traits. The aim of systematic breeding is to use breeding animals with the best genes as parents of the next generation and at the same time to avoid inbreeding.

Commonly, technological progress can be divided into two parts, depending on how advanced the producers in question are. State-of-the-art producers will exploit the best technology, and can only improve productivity if technology itself improves. However, at any point in time, there will be a number of firms that do not employ state-of-the-art technology. These producers can improve productivity, even if technology is not improving, by catching up with best practices.

Any production process that interacts with the natural environment has the potential to damage the environment around the production site. The environmental issues that arose in intensive salmon and shrimp farming in the 1980s and 1990s must be considered in relation to the introduction of a new technology that uses the environment as an input. The larger is the production at any site and the more intensive is the process, the larger is the potential for environmental damage. However, having a greater degree of control over the production process in intensive aquaculture also makes it easier to address these issues.

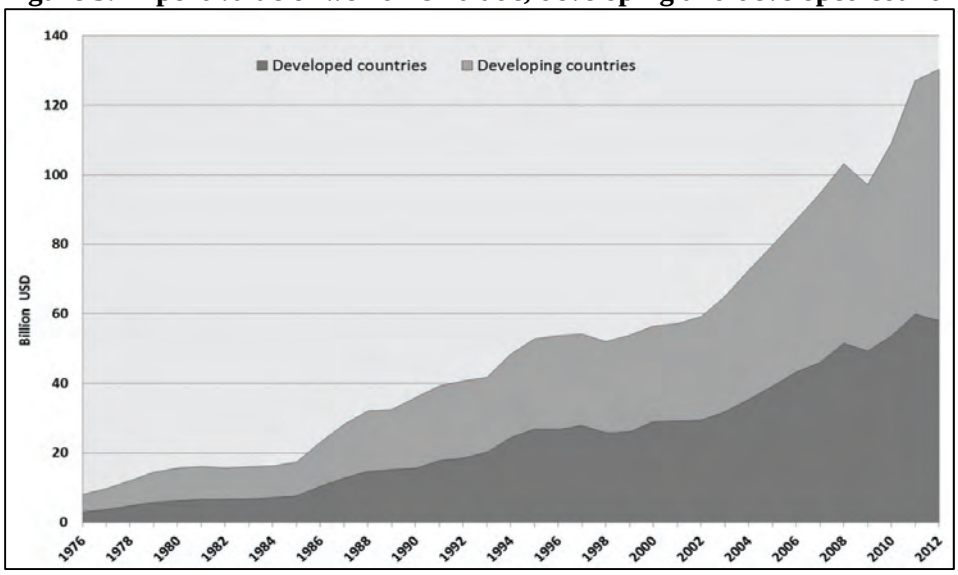
There are two main motivations for the industry to address environmental effects: (i) the effects reduce productivity and therefore profits; and/or (ii) government regulations force the industry to do so. There is some form of environmental regulation in virtually all countries where aquaculture has some prominence, limiting what the industry can and cannot do.

8.5 Global fish exports and imports

The export value of fish – capture and farmed – has increased rapidly in recent decades, up from almost USD8 billion in 1976 to USD98 billion in 2009 (nominal values, Figure 5). The figure reached USD109 billion in 2010 and, according to FAO preliminary estimates, in 2011, trade volumes and values reached the highest level ever reported at USD127 billion, an increase of 28 percent compared with 2009, despite the turbulent economic situation and currency fluctuations.

The increase in fishery trade was motivated by strong demand from developed countries. It is important to note that developing countries represent more than 50 percent of fish exports.

Figure 5. Export value of world fish trade, developing and developed countries, 1976–2012



Source: FAO statistics (2011).

The fisheries and aquaculture sector has demonstrated openness to integration in international trade in the last three decades. Sustained demand, trade liberalization policies, the globalization of food systems and technological advancements in the food value chain have resulted in an increased proportion of production being exported (up from 25 percent in 1976 to 38 percent in 2010, which corresponds to 57 million tonnes).

Fish trade involves a wide range of products and participants. Among the most highly traded fish commodities are shrimps, salmon, tuna and groundfish. High-value species are largely directed towards more prosperous markets while low-value species such as small pelagics are generally exported to low-income markets.

Table 26 shows the top ten exporters and importers of fishery products in 2000 and 2010 as well as annual percentage growth rates for each country. In 2010, total fish exports amounted to USD108.6 billion.

As mentioned above, developing countries play an important role in world fish food exports. China, Thailand and Viet Nam are the leading exporters of fish products among developing countries. China's exports have expanded considerably since the 1990s, and represented 12 percent of total world fish exports in 2010, with a value of USD13.3 billion. The projected share of China in world fish trade in 2011 is USD17.7 billion – a 33 percent increase compared with 2010. Developing countries are the main exporters of non-food fish products (74 percent in 2011).

Among developed countries, Norway, the United States of America, Denmark, Canada, the Netherlands and Spain are the leading fish exporters.

Table 26. Average percentage growth rates for top ten exporters and importers of fishery products in 2000 and 2010

	2000	2010	APR
	(USD millions)		(Percentage)
Exporters			
China	3 603	13 268	14
Norway	3 533	8 817	10
Thailand	4 367	7 128	5
Viet Nam	1 481	5 109	13
United States of America	3 055	4 661	4
Denmark	2 756	4 147	4
Canada	2 818	3 843	3
Netherlands	1 344	3 558	10
Spain	1 597	3 396	8
Chile	1 794	3 394	7
Top ten subtotal	*26 349*	*57 321*	*8*
Rest of the world total	*29 401*	*51 242*	*6*
World Total	**55 750**	**108 562**	**7**
Importers			
United States of America	10 451	15 496	4
Japan	15 513	14 973	
Spain	3 352	6 637	7
China	1 796	6 162	13
France	2 984	5 983	7
Italy	2 535	5 449	8
Germany	2 262	5 037	8
United Kingdom	2 184	3 702	5
Sweden	709	3 316	17
Republic of Korea	1 385	3 193	9
Top ten subtotal	*26 349*	*69 949*	*10*
Rest of the world total	*33 740*	*41 837*	*2*
World Total	**60 089**	**111 786**	**6**

Note: APR refers to the average annual percentage growth rate for 2000–2010.

Seafood imports also reached a record high in 2011 at USD127.6 billion. Preliminary estimations for 2012 point to a further increase in trade value to USD128.2 billion.

The increasing trend in seafood consumption, as well as a growing population, lifted United States imports to USD15.5 billion in 2010 and a further 13 percent higher to an estimated USD17.5 billion in 2011. In 2010, China was the fourth-largest importer in the world with one of the largest increases in the period under consideration. China increased its fish food and fish products imports mostly by outsourcing. China imports raw materials from major regions for further processing and export.

Japan's imports of fish and fish products grew by 13 percent in 2010 and 16 percent in 2011 according to preliminary estimations, reaching USD17.4 billion. The European Union (Member Organization) is by far the largest single market for imported fish and fishery products. Among individual countries, Spain, France, Italy, Germany and the United Kingdom of Great Britain and Northern Ireland are large importers.

8.6 The potential for increased production

According to OECD–FAO (2013), world fisheries and aquaculture production is expected to reach 181 million tonnes by 2022, which is 18 percent higher than the average level for 2010–12 (see also Chapter 12). The main driver of this growth will be aquaculture production. Climate change has the potential to influence both capture fisheries and aquaculture.

Climate change

Global climate change policy has been mostly driven by the activities of the industrialized countries, but the most severe consequences are being felt by developing countries as most of them are located in regions already subject to climate extremes (Conway, 2012, p. 286)

Predicting the long-term consequences of climate change is difficult. Cheung *et al.* (2009) concluded that climate change might lead to a large-scale redistribution of global catch potential, with an average increase of 30–70 percent in high-latitude regions and a drop of up to 40 percent in the tropics. In addition, in the last few years the maximum catch potential has been declining considerably in the southward margins of semi-enclosed seas (a gulf, basin or sea surrounded by two or more coastal States) while increasing in the poleward tips of continental shelf margins.

Climate change and climate variability impact have already increased uncertainty in the supply of fish from capture fisheries and aquaculture. The priorities and focus of countries with respect to mitigating climate effects, as well as increasing their resilience to these effects, vary according to the number of issues that might affect them. An assessment of risks faced by, and the vulnerability of, an individual region's fisheries and aquaculture resources is necessary in order to establish proper management techniques. Local programmes for climate change adaptation need to be fully integrated within the United Nations Framework Convention on Climate Change.

Capture fisheries

In the same OECD–FAO report, capture fisheries production is forecast to grow by 5 percent, from about 91 million tonnes to about 95 million tonnes by 2022. The increase is attributed to stock recovery resulting from improved resource management. Among other factors contributing to growth are more efficient uses of fishery production through reduced discards, waste and losses, increased production in countries still not subject to production quotas, increased efficiency of small-scale fisheries, improved fishing technologies, and decreases in illegal, unreported and unregulated (IUU) fishing.

A key element of sustainable production is waste minimization, taking into account the mandatory landing and usage of bycatch. As reported by Kelleher (2005, p. 6), in the 1992–2001 period, the yearly average discards are estimated to be 7.3 million tonnes, which is lower than previous estimates of 27 million and 20 million tonnes. Bycatch reduction is largely a result of the use of more-selective fishing gear, the introduction of bycatch and discard regulations, improved enforcement of regulatory measures, increased retention of bycatch for human or animal food results from better processing technologies and expanding market opportunities for lower-value catch.

Increased efficiency of the value chain in small-scale fisheries will lead to higher production volumes in the future. With the globalization of the fisheries sector, the ability to adhere to market access requirements becomes a crucial task. Small-scale producers, especially in countries with low domestic consumption rates, need to focus on markets and marketing. This will not only benefit producers and production, but it could also help the country achieve improved food security and nutrition. More information about value chains of small-scale fisheries is given in Chapter 10.

Fishing technologies have an impact on fish production and fishing sustainability (FAO, 2012). Most fishing gear in use today, especially in developing countries, was developed when fisheries resources

were abundant, energy costs were much lower and less attention was paid to the negative impact of fishing on the ecosystem. Taking into account the scarcity of resources today, low-impact fuel-efficient fishing is highly relevant for production. The impact of fishing gear on the ecosystem largely depends on physical characteristics, the mechanics of its operation, where, when and how the gear is used and the extent of its use. The undeniable fact is that when gear is poorly selected it leads to an incidental catch of fish and juveniles and the accidental mortality of non-target species and seabirds.

Addressing fisheries overcapacity and IUU fishing through more effective governance is also important for a growth in production. While it is difficult to estimate precisely the total IUU catch, IUU fishing accounts for the major proportion of catches for some species.

Aquaculture

Products from aquaculture will account for a growing share of international trade while continuing to play a key role in food security, with significant production also destined for domestic consumption. Aquaculture is expected to expand in all continents in terms of new areas and species, as well as through the intensification of production and diversification of the product range to better meet consumer needs. The global distribution of aquaculture production is likely to continue to remain imbalanced, with China dominating world production (see Chapter 12).

In aquaculture in particular, the degree to which technological advances and better management practices directed towards sustainable production are incorporated into business practices will determine future growth. Taking into account the projected increases in fishmeal and fish oil prices, improvements in feed efficiency and greater use of substitutes are essential.

As noted above, according to OECD-FAO (2013), world aquaculture production is expected to increase by 35 percent to 85 million tonnes by 2022. This corresponds to an average annual growth rate of 2.54 percent, which is considerably less than the 5.9 percent achieved in the decade up to 2012. According to the report, the lower growth rate will mainly be caused by water scarcity, less optimal production location availability and high input costs (fishmeal, fish oil and other feeds). Despite the slower growth rate, aquaculture will remain one of the fastest-growing food producing sectors.

This assumption is somewhat pessimistic. Although the annual growth rate is likely to be reduced, a reduction of more than a half in the next decade does not appear to be very realistic. First, although there may be less optimal production location availability, there is scope for increased production at existing locations and some scope for production in new locations. Second, as for fishmeal, history shows there is great scope for productivity improvements in the use of fish feed as well as substitution of other types of meal. The research currently being undertaken in this area will allow for continued expansion. In addition, numerous farmed species are herbivorous and thus not affected by developments in the market for fishmeal. Third, and importantly, when it comes to technology, there is enormous scope for catching up. This is particularly true for developing countries, which represent the bulk of aquaculture production.

For all these reasons, it may be expected that aquaculture production will continue to grow at a fairly rapid rate also in the coming decades. Chapter 12 analyses various scenarios to this effect.

9. AGRICULTURE

There is evidence that agricultural growth has a high poverty reduction pay-off (Chapter 4). Agricultural growth has an especially important role to play in reducing and preventing undernourishment through a number of channels. Its impact extends from increased household ability to purchase and produce more nutritious food to economy-wide effects, such as lowering food prices and increasing government revenues to fund health, infrastructure, and nutrition intervention programmes (Fan, S. & Brzeska, J. 2012).

Although the global population growth rate is projected to decline to just over 1 percent per annum in the next decade (Chapter 2), population growth will still place additional demands on the global food system. Additional production will also be necessary to provide feedstocks for expanding biofuel production, which has become an important source of additional demand. The global scope for production area expansion is limited and geographically concentrated in a few regions. In these circumstances, most of the additional agricultural production will need to come from increased productivity, as has been the case in the past.

At the same time, there is a growing need to improve the sustainable use of available land, water, marine ecosystems, forests and biodiversity. It is estimated that some 24 percent of all agricultural land is highly degraded, with growing water scarcity a fact for many countries (OECD–FAO, 2013, p. 43).

This chapter illustrates the development of agriculture in recent decades and then analyses the potential for increased production from agriculture in the future.

9.1 Historical production

Average world yield growth for crops and especially for cereals has been slowing for at least the past two decades, in part due to reduced investment in crop research and development and dissemination of improved varieties.

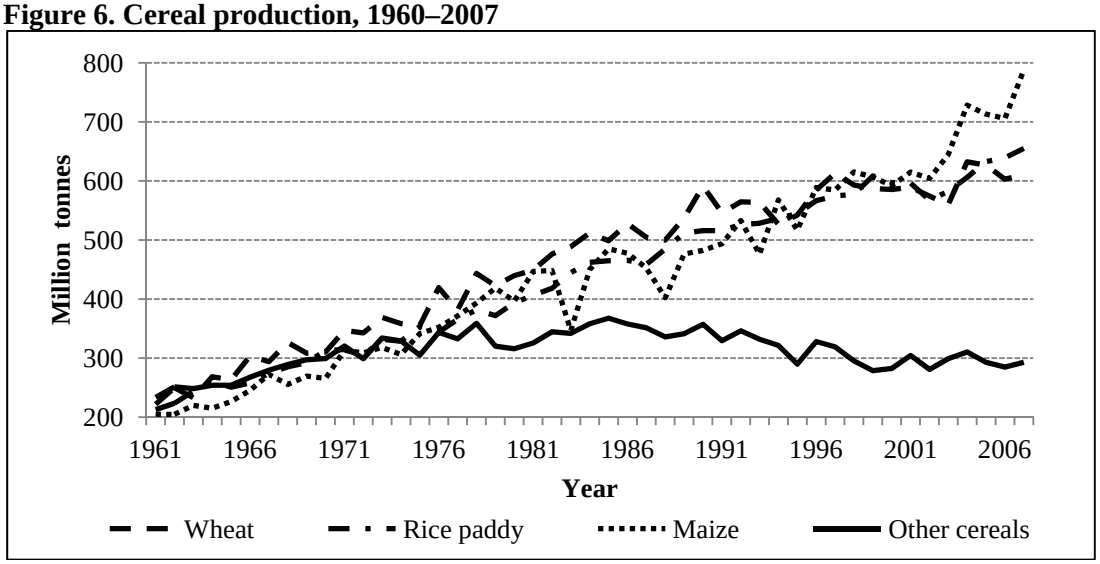
Figure 6 shows annual production of wheat, rice, maize and other cereals from 1961 to 2007, where “other cereals” include barley, millet, sorghum and others.

The production of wheat experienced an upward trend, increasing almost threefold from 222 million tonnes in 1961 to a peak of 613 million tonnes in 1997. It subsequently levelled off with an annual production of about 600 million tonnes, although it fluctuated significantly from year to year.

The production of maize increased from 205 million tonnes in 1961 to 655 million tonnes in 2007. The production of rice increased from 212 million tonnes to 787 million tonnes in the same period. Similarly to wheat, there were been significant fluctuations from year to year.

“Other cereals” production increased from 234 million tonnes in 1961 up to 1979, when it peaked at 359 million tonnes and levelled off up to 1991. Subsequently, the trend was negative, with 293 million tonnes recorded in 2007.

Figure 6. Cereal production, 1960–2007



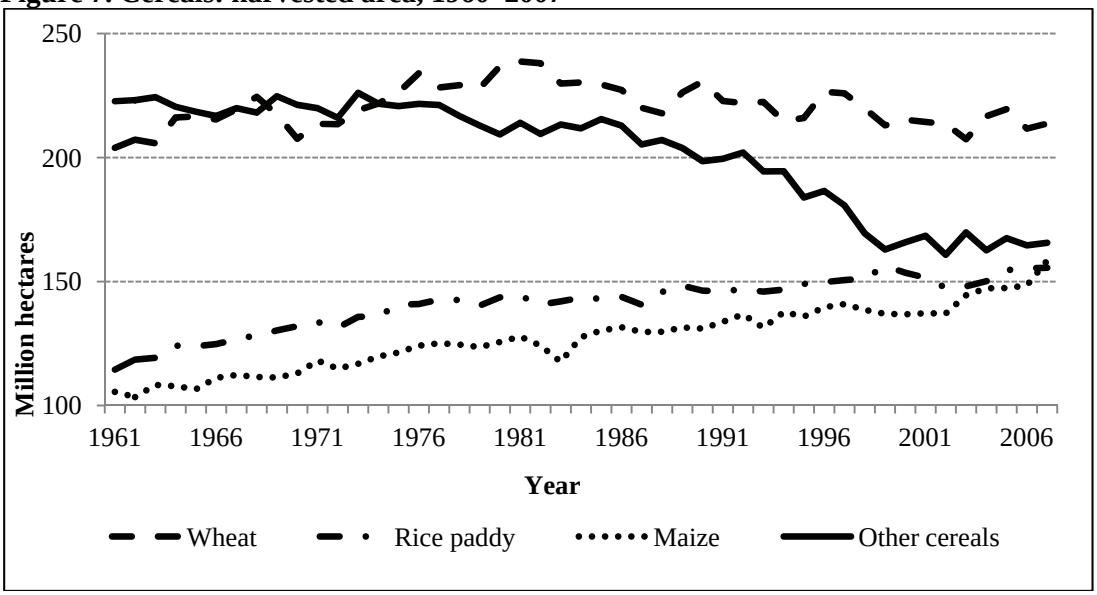
Source: FAOSTAT for wheat, rice paddy and maize. "Other cereals" compiled by the authors from FAOSTAT.

Some of the developments described above can be explained by the expansion of harvest areas over time. Figure 7 describes harvested areas for wheat, maize, rice paddy and other cereals from 1961 to 2007.

The harvested area of rice paddy expanded from 114.4 million hectares in 1961 to 155.5 million hectares in 2007. Similarly, the harvest area of maize increased from 105.5 million hectares to 158.5 million hectares in the period. The harvest area dedicated to wheat rose from 204 million hectares in 1961 up to 1982, when it reached a peak of 238 million hectares before declining gradually to 214 million hectares by 2007. The harvest area of "other cereals" declined from 223 million hectares in 1961 to 166 million hectares in 2007, a 26 percent drop.

When comparing these statistics with production figures in Figure 6, it is obvious that production per hectare has increased for all varieties. In other words, there have been productivity improvements.

Figure 7. Cereals: harvested area, 1960–2007

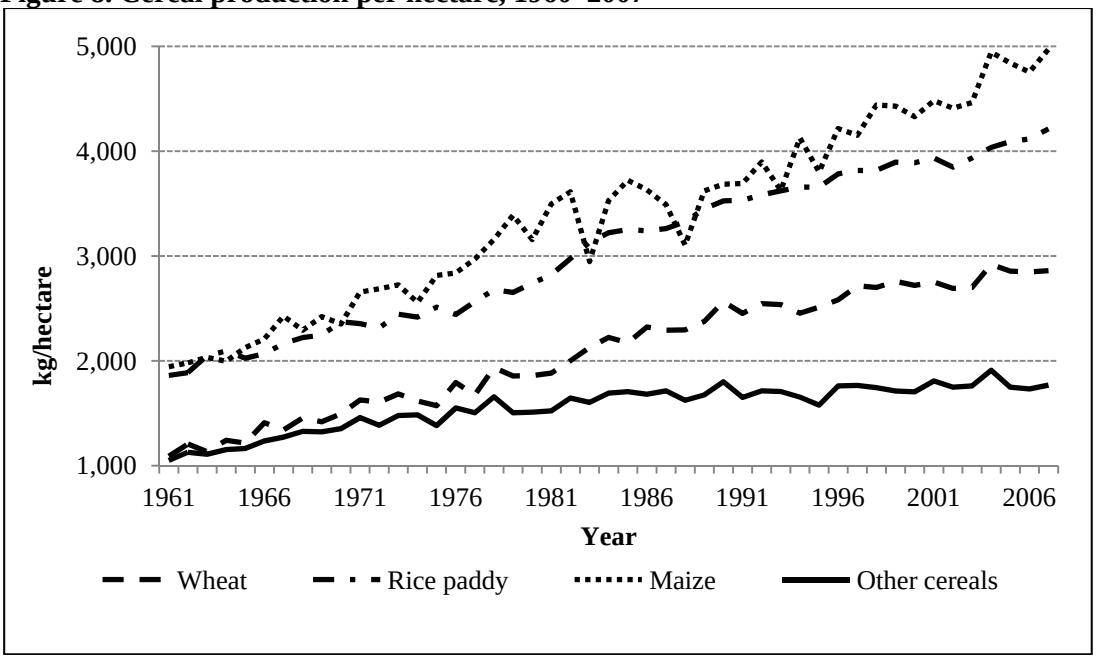


Source: FAOSTAT for wheat, rice paddy and maize. "Other cereals" compiled by the authors from FAOSTAT.

Figure 8 shows cereal production per hectare of wheat, rice paddy, maize and "other cereals" for the period 1961–2007.

Per hectare maize production increased by 156 percent from 1 943 kg/ha in 1961 to 4 972 kg/ha in 2007. Similarly, per hectare wheat production increased by 160 percent from 1 090 kg/ha in 1961 to 2 859 kg/ha in 2007. Per hectare rice production grew by 126 percent from 1 860 kg/ha to 4 213 kg/ha in the period. The increase was relatively less for "other cereals", but it still grew by 68 percent from 1 050 kg/ha in 1961 to 1 768 kg/ha in 2007.

Figure 8. Cereal production per hectare, 1960–2007



Source: FAOSTAT for wheat, rice paddy and maize. "Other" cereals compiled by the authors from FAOSTAT.

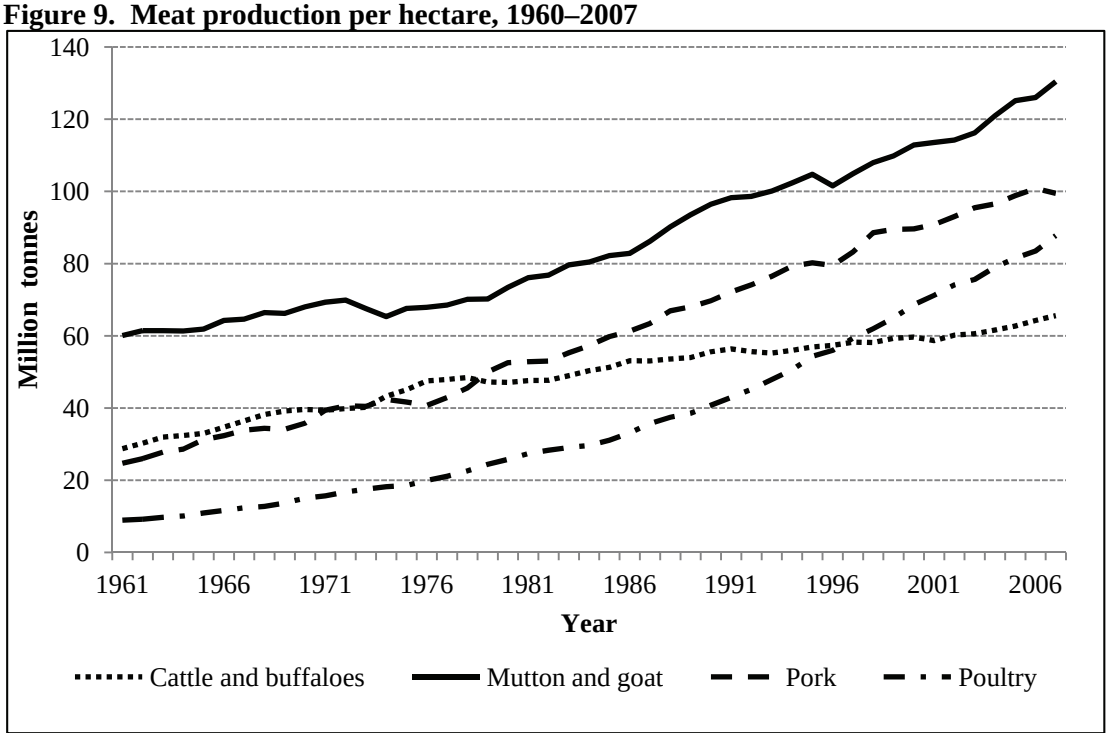
Figure 9 describes the production of meat (beef, mutton, pork and poultry) from 1961 to 2007. The total world production of meat increased greatly in this period, among other things in response to a general increase in the world population and income growth.

The rate of growth for the different commodities varied notably throughout the period. Before 1979, growth rates for cattle and buffalo meat were aligned with that of pork. However, starting from 1979, the growth rate slowed, so that by 2007 production was 130 percent greater than in 1961, when it stood at 28.7 million tonnes. The production of pork continued its rapid growth after 1979 and increased fourfold from 24.7 million tonnes in 1961 to 99.5 million tonnes in 2007.

Poultry production increased almost tenfold from 8.9 million to 87.8 million tonnes in 2007, and after 1997 it overtook cattle and buffaloes in terms of production.

The production of mutton and goat meat increased by 117 percent from 60 million tonnes in 1961 to 130 million tonnes in 2007.

Figure 9. Meat production per hectare, 1960–2007



Source: FAOSTAT.

9.2 Production projections

The latest FAO statistics put the value of world agricultural production of food crops in 2011 at USD2 318 billion. According to OECD–FAO (2013) projections up until 2022, the growth in agricultural production is expected to slow owing to slower productivity and area growth, at least in the medium term.

Owing to resource constraints, both developed countries and large emerging economies are projected to see lower yield and production growth for most crops in the coming decade.

In order to encourage production, many developing countries and emerging economies try to increase the area of land allocated to agriculture and improve productivity by using advanced farming practices aligned with those of advanced economies.

Wheat and coarse grains yields are estimated to increase by about 12 percent on average between the base period 2010–12 and 2022. In terms of area expansion, coarse grains are projected to exhibit faster growth than wheat or rice as a result of increased demand. The increase will be driven mainly by rising demand for feed and especially for industrial use, biofuels in particular, while direct use for human consumption will be stable at 68 percent of the total. Cereal harvests are also expected to be higher, but the stock-to-use ratio will remain below historical averages over the baseline period, with rice being an exception. This projection highlights the vulnerability of the cereal market to external shocks such as droughts.

As projected, production in the meat and dairy sectors will also follow a downward trend in production, although it will be less notable than that for some crops.

Meat production is projected to increase, although at a slower pace. The predicted growth rate is 1.6 percent per annum, which is 0.7 percent per annum lower than in the previous decade. The lower supply growth is the result of a combination of factors that are expected to push production costs higher: increased energy and feed costs, increasing pressure from competing land uses (pasture vs

crops) and growing water constraints. Developing countries are projected to account for 80 percent of the additional output by the end of the period.

Compared with the past decade, the average annual growth rate of global production for dairy products up to 2022 is estimated to decrease from 1.8 percent to 1.3 percent. The slowdown in growth reflects increasing shortages of water and suitable land in developing countries.

Experts predict that the production of palm oil will rise, reaching 34 percent of the total vegetable oil production. Similarly to the production of meat, output expansion will slow in comparison with the previous decade owing to decreasing land supply in Malaysia and Indonesia – major producing countries.

The production of oilseeds, by-products of protein meals and vegetable oils is expected to expand by 26 percent by 2022, continuing to utilize land at the expense of other crops. The growth in vegetable oil production for direct human consumption is projected to be driven by demand from developing countries. However, the direct human consumption of vegetable oil in developing countries is predicted to still not have reached that of developed countries by 2022. As mentioned above, increased demand for vegetable oils in developed countries will be due to increased use of vegetable oils for biodiesel as a result of the Renewable Energy Directive.

The supply and use of ethanol will increase significantly, especially in the United States of America and the European Union (Member Organization). Driven by related regulations (Renewable Fuel Standard 2 and the Renewable Energy Directive), ethanol production is projected to increase by 70 percent by 2022 compared with 2010–-12, reaching a growth rate of 4 percent per annum and production of 168 billion litres. Biodiesel production is projected to grow at 4.5 percent per annum, slightly lower than in the previous decade, reaching 41 billion litres in 2022. By that time, biofuel production will potentially consume 28 percent of total world production of sugar cane, 15 percent of vegetable oils and 12 percent of coarse grains (OECD–FAO, 2013, p. 21).

Sugar yields in the period 2012–2022 are expected to be lower than in the previous decade. Most of the production (88 percent) is predicted to come from sugar cane with little contribution from sugar beets that will mainly come from projected production increases in the European Union (Member Organization) and the Russian Federation. Brazil, the European Union (Member Organization), the United States of America, Australia, Thailand and China will remain the main sugar-cane producers in 2012–2022.

The world production and consumption of cotton is expected to grow but at slightly below its long-term average rate. Increased demand by India’s textile industry will account for about 70 percent of the expected increase in consumption from the base period. The growth rate slowdown is the result of increased competition from artificial fibres. Higher yields of cotton are expected in sub-Saharan Africa, mainly owing to investment in new advanced technologies.

9.3 Trade

Analysts expect that emerging economies and developing countries will drive the growth in agricultural trade.

Table 27 lists the world’s top 12 exporters of agricultural commodities. Developed country exporters such as the European Union (Member Organization), the United States of America, Canada, Australia and New Zealand still play an important role in world exports. The European Union (Member Organization) and the United States of America continue to be the leading exporters in terms of value, with export values in 2010 of USD197.2 billion and USD71.6 billion respectively.

Table 27. Top 12 exporters of agricultural products, USD billions

Exporters	2009	2010	Main products
European Union (Member Organization)	198.1	197.2	Wine, cheese, alcoholic and non-alcoholic beverages, chocolate and other foods containing cocoa, pastry, wheat, cigarettes and pork
United States of America	67.8	71.6	Soybeans, maize, wheat, cotton, pork, beef, veal and chicken meat
Brazil	29.2	32.7	Soybeans, sugar, green coffee beans, meat, chicken, beef, veal, tobacco and maize
China (excluding China, Hong Kong SAR & China, Macao SAR)	20.2	25.3	Garlic, preserved, dehydrated and frozen vegetables and fruits, tea and tomato paste
Canada	20.2	21.8	Wheat, rapeseed and rapeseed oil, pork and soybeans
Australia	17.1	19.5	Wheat, meat, beef, veal, mutton, cotton, wool, wine and barley
Argentina	20.6	18.5	Soybeans and soybean oil, maize, wheat, sunflower oil, beef, veal and wine
Malaysia	12.4	15.9	Palm oil, fatty acids, cocoa powder and green coffee beans
Indonesia	9.8	13.3	Palm oil, natural rubber, fatty acids, coconut oil, cocoa beans, green coffee beans and cigarettes
Thailand	11.0	12.8	Natural rubber, sugar and pet food
New Zealand	9.2	11.2	Milk products, mutton, beef and veal meat, kiwi fruit and wine
India	8.8	9.7	Cotton, soybeans, maize, tea, oil of castor beans and green coffee beans

Source: FAOSTAT.

However, the export growth rates of many developing countries are higher than those of developed countries. Brazil and China grew by 11.9 percent and 25 percent, respectively, in 2010 while the United States of America grew by 5.6 percent and the European Union (Member Organization) experienced a slight decline.

On the import side, developed countries and regions such as the European Union (Member Organization), the United States of America and Japan are the most important with total import values of agricultural products standing at USD213.5 billion, USD42.7 billion and USD36.2 billion, respectively, in 2010 (Table 28). Other important developed country importers are Canada and the Republic of Korea, which imported agricultural products valued at USD14.8 billion and USD10.2 billion, respectively, in 2010.

Despite the relatively greater individual importance of these developed States, most importers on the list are developing and emerging countries. China and the Russian Federation follow the European Union (Member Organization), the United States of America in the list of top world importers of agricultural commodities with import values of USD32.5 billion and USD21 billion, respectively, in 2010. Among other developing and emerging country importers are Mexico, Malaysia and India.

Table 28. Top 12 importers of agricultural products, USD billions

Importers	2009	2010	Main products
European Union (Member Organization)	210.2	213.5	Cheese, wine, green coffee beans, soybeans, cocoa powder and other foods containing cocoa, wheat, cigarettes, beef, veal and palm oil
United States of America	39.5	42.7	Green coffee beans, wine, alcoholic beverages, beer of barley, beef, veal, fruit and nuts in different forms (frozen, prepared, dried, paste and jams), tomatoes, sugar and cocoa beans
Japan	33.5	36.2	Cigarettes, maize, meat (pork, beef, veal and chicken), wheat and green coffee beans
China (excluding China, Hong Kong SAR & China, Macao SAR)	29.2	32.5	Soybeans, cotton, palm oil, wool, sugar and wine
Russian Federation	20.3	21.0	Sugar, meat (beef, pork and veal), cheese, tobacco and wine
Canada	15.6	17.4	Wine, pastry, beef, veal, green coffee beans, roasted coffee, alcoholic and non-alcoholic beverages and sugar
Mexico	14.3	14.8	Maize, soybeans, wheat, rapeseed, beef, veal, chicken, pork and cotton
Republic of Korea	9.5	10.2	Maize, wheat, pork, beef, veal, sugar, soybeans, cotton and green coffee beans
Malaysia	7.6	9.0	Palm oil, cocoa beans, sugar, maize, soybeans and wheat
Saudi Arabia	7.7	8.8	Barley, chicken meat, maize, cigarettes, wheat, sugar, palm oil and dried milk
India	6.7	8.2	Palm oil, soybean oil, cashew nuts, sunflower oil, fatty acids, wool and raw silk
China, Hong Kong SAR	7.1	7.7	Chicken meat, wine, offals of pigs and cattle, pork, and dried milk

Source: FAOSTAT.

Table 29 shows the share of countries of the Organisation for Economic Co-operation and Development (OECD) in global exports and imports of agricultural commodities. It is evident that, by 2022, developing countries will potentially account for the majority of exports of coarse grains, rice, oilseeds, vegetable oils, protein meals, sugar, beef, poultry and meat (OECD–FAO, 2013, p. 50). The share of agricultural commodities traded by developed countries has shrunk over time owing to the expansion of trade and production by developing countries.

The main traditional exporters (advanced economies such as the European Union [Member Organization], the United States of America, Australia and Canada) will still play an important role in world trade during the period. Compared with developing countries, they have a competitive advantage in the fast-growing trade of value-added processed agricultural products.

Table 29. The percentage share of OECD countries in world imports and exports of agricultural products, 2003–2012 and 2013–2022

Commodity	Export		Import	
	Average 2003–2012	Average 2013–2022	Average 2003–2012	Average 2013–2022
Wheat	66.07	58.59	23.61	21.73
Rice	12.98	10.33	14.46	13.82
Coarse grains	62.01	48.78	47.79	38.15
Oilseeds	50.30	46.27	38.79	26.75
Protein meals	16.54	16.99	62.84	53.19
Beef	49.75	47.44	53.21	46.81
Pork meat	78.65	83.89	55.88	45.32
Poultry meat	9.86	6.92	24.35	19.59
Mutton meat	77.49	80.58	41.71	32.92
Butter	83.35	81.00	19.20	15.15
Cheese	69.60	64.15	41.51	31.51
Skimmed milk powder	82.03	89.32	20.20	17.37
Whole milk powder	69.91	74.56	5.59	2.41
Vegetable oils	7.74	8.08	29.10	25.26
Sugar	18.72	12.84	26.10	22.29
Cotton	48.63	50.23	23.91	23.23

Sources: OECD–FAO Secretariats. StatLink http://dx.doi.org/10.1787/888932860636

As stated by Alexandratos and Bruinsma (2012), in recent years India and China – the traditional exporters of rice – have become net exporters of other cereals as well. China's net exports of coarse grains have been growing since the 1980s, while India has been an occasional net exporter of wheat in the last decade.

Traditional South American and Eastern European net exporters are projected to be accelerators of agricultural growth. Brazil is expected to increase its exports up to 2022 and potentially will thereafter become a net exporter. New entrants, such as the Russian Federation, Ukraine and Kazakhstan are projected to become the principal suppliers of coarse grains and wheat. According to OECD–FAO projections, these countries will account for 51 percent of cereal exports by 2022.

Some areas traditionally registering a food deficit in the Near East, North Africa, Southeast Asia and China are projected to increase their agricultural imports, with an increasing population and growing per capita income driving this trend. Thus, cereals imports will also be dominated by developing countries where rising demand for food and feed for livestock expansion is projected to rise.

The global trade of rice is expected to grow by 8 percent of global rice consumption by 2022 and to be driven primarily by higher imports from African countries where the local climate and infrastructure are less suitable for rice cultivation.

World trade of meat has been characterized by an increased import share for Japan, the Russian Federation and various developing countries. Since the mid-1970s, developing countries as a whole have become growing net importers of meat, although in recent years the expansion of exports from Brazil has significantly reversed this trend. Alexandratos and Bruinsma (2012) expect that higher imports by developing countries will be counterbalanced by exports from the same country group by 2050. The demand for meat in major developed importing countries is likely to decline owing to an ageing population and changing diets (Chapters 4 and 6).

The United States of America, the European Union(Member Organization), New Zealand, Australia and Argentina will continue to be the major exporters of dairy products directed mainly to developing countries, whose consumption will rise faster than production.

The next decade is expected to be characterized by the dominant role of China in Asian and global agriculture, with the country being much focused on its strategic goal to reach food security and self-sufficiency in rice and wheat. Agricultural output grew almost fivefold between 1978 and 2011 (OECD–FAO, 2013, p. 20). In recent years, the growth in output has slowed owing to rising food prices and labour constraints.

Oilseed imports are projected to rise by 40 percent to almost 83 million tonnes in 2022. China is projected to maintain its dominant role in the import of this commodity (OECD–FAO, 2013, p. 53). Indonesia and Malaysia are expected to continue to be the main exporters of vegetable oil, two-thirds of which is palm oil. The European Union (Member Organization), India and China are projected to remain the major importers of more diversified vegetable oils. Many developing countries will probably continue to import vegetable oils for food consumption while developed regions are expected to import vegetable oils for non-food uses, especially biodiesel production.

The rising price of crude oil together with the implementation of biofuel policies by governments around the world will increase demand for biofuels. As projected, global ethanol trade will expand substantially, while growth in biodiesel trade will be more moderate. Most of the increase in ethanol trade is expected to take place between Brazil and the United States of America up until 2022. In the case of biodiesel trade, Argentina and Indonesia will remain among the major exporters, while the European Union (Member Organization) will remain the major importer.

9.4 Constraints

A number of factors are expected to cause agricultural production to grow less rapidly than in the past. There are fears that ensuring food security for the growing population will become increasingly difficult because there are currently fewer unused land and water resources and more limited yield growth potential compared with the past.

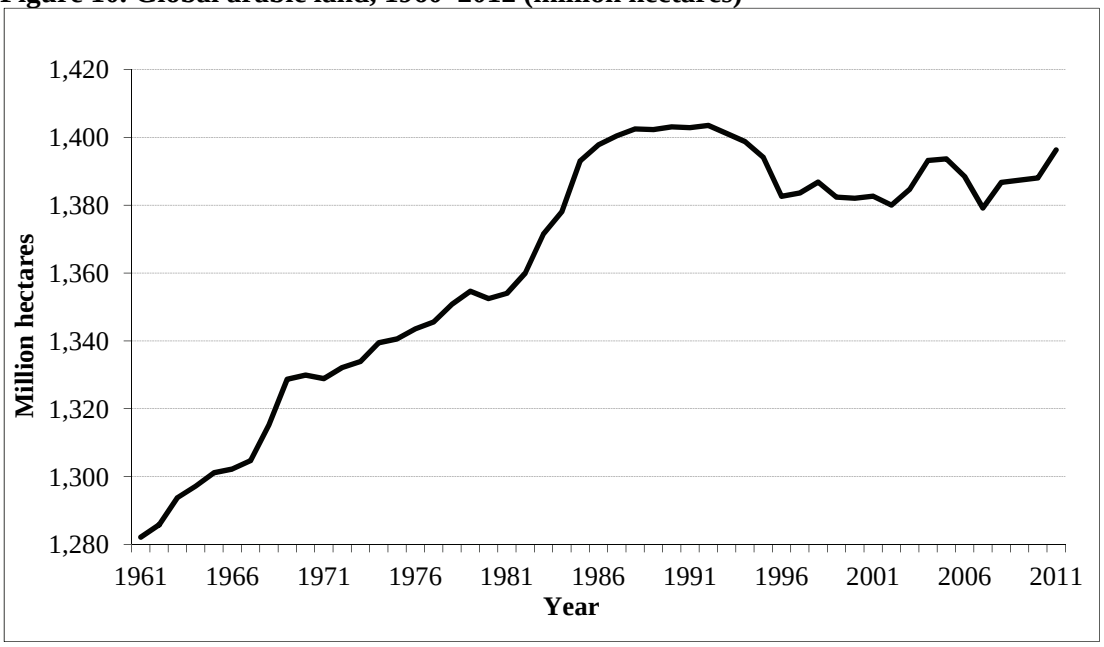
Figure 10 shows the development of the global arable land area from 1960 to 2011. The area of global arable land expanded from 1 280 million hectares in 1960 to 1 400 million hectares in 1986, and then remained almost constant until 1995. Subsequently, the growth trend was negative, although with some fluctuation from year to year, so that in 2011 the area of total arable land levelled off at about 1 395 million hectares, slightly below its 1986 level. Climate change, urbanization and soil degradation affected the expansion of arable land after 1995.

FAO and the IIASA have developed the Global Agro-Ecological Zones (GAEZ) methodology over the past 30 years for assessing agricultural resources and potential. In their assessment of the sustainability of land for crop production based on the GAEZ methodology, Alexandratos and Bruinsma (2012) state that there are 7.2 billion hectares of land with rainfed production potential, of which 1.6 billion hectares are currently used for production. However, the land has different degrees of suitability. Nearly 75 million hectares are classified as non-suitable for crop production because they are in irrigated desert areas. Out of the 5.7 billion hectares that make up the remainder, 2.8 billion hectares are used for other non-agricultural purposes that will further expand in the future or forested and 1.5 billion hectares are marginally, or very marginally, suitable owing to poor land quality for rainfed crops. “About 24 percent of global land area has been affected by land degradation. This area is equivalent to the annual loss of about 1 percent of global land area, which could produce 20 million tonnes of grain each year, or 1 percent of global annual grain production. Globally, 1.5 billion people and 42 percent of the very poor live on degraded lands” (IFPRI, 2012, p. 63). According to the GAEZ classification[25], only 1.4 billion hectares of very suitable (prime

[25] The GAEZ classification is available at: www.fao.org/nr/gaez/en/

land), suitable and moderately suitable (good land) could potentially be used for cultivation. This is of course true assuming that this land is not appropriated for other purposes such as pasture and that it does not require considerable investment in infrastructure and market development, and in land disease and degradation prevention.

Figure 10. Global arable land, 1960–2012 (million hectares)



Source: FAOSTAT.

As estimated by Alexandratos and Bruinsma (2012), the net land available for crops may potentially have increased by 70 million hectares by 2050 in countries that are projected to expand crop land area (most of them in sub-Saharan Africa and Latin America, in particular in Brazil). According to OECD–FAO (2013), the Russian Federation is also among the countries with spare land suitable for agricultural production. The harvest area could almost double owing to multiple cropping if it can be assumed that rising cropping intensities would not cause significant further land degradation as many experts believe. Rising cropping intensities could be one of the factors responsible for increasing the risk of land degradation and thereby threatening sustainability, in particular where not accompanied by land conservation measures such as adequate and balanced use of fertilizers to compensate for the removal of soil nutrient by crops.

A 63 million hectare decline in use of the land available for crops is expected in the developed countries and some developing countries.

In theory, the end result is that more than 1.3 billion hectares of prime and good land will remain available for production expansion. However, this is not strictly accurate. The cost of development of necessary infrastructure very often makes the use of this land economically unjustifiable. In addition, the distribution of spare land might be very unequal among the countries, a factor that can cause problems on a regional level.

Water is another critical and scarce resource. It is difficult to overstate the importance of irrigation in agriculture. Yields of irrigated crops are well above those that are rainfed and much of the production increase in the recent years has been due to more widespread irrigation usage.

The world's irrigation area is estimated to be 300 million hectares, and 80–90 percent of it is in use (Alexandratos and Bruinsma, 2012). However, the possibility of further expanding the irrigation system is limited.

The major issue is that majority of renewable water resources are scarce in regions such as North Africa and northern China where land expansion is expected and where they are mostly needed. In addition, some of the renewable water resources suitable for irrigation might be utilized for other non-irrigational purposes. It is also necessary to keep in mind the impact of climate change on water resources that will possibly affect precipitation and evapotranspiration patterns – the transportation of water from the earth to the atmosphere by evaporation of water and transpiration from plants. Finally, existing irrigation systems may be depleted and beyond repair. In this case, additional investments would be necessary to modernize obsolete irrigation systems.

9.5 Productivity

Productivity, or the ability to obtain more output from productive resources, will play a pivotal role in future food security for agriculture as well as for aquaculture (Chapter 8). As highlighted above, greater productivity in developing country agriculture has the potential to raise average global productivity, which would be important for future food security.

Productivity growth in agriculture in the past few decades has largely been driven by growth in labour productivity; and labour productivity in agriculture has on average been growing faster than labour productivity outside agriculture since the 1960s. In addition, annual growth of total factor productivity (TFP) in agriculture has been up to 1.5 percent higher than in non-agriculture, countering the notion of agriculture as a backward sector where investments and policies are automatically less effective in generating growth than other sectors (FAO, WFP and IFAD, 2012, p. 28).

Table 30 provides estimates of annual growth rates for land, labour and TFP – the ratio of commodity output to total inputs used in production – in different regions for the periods 1971–2009 and 2001–09. Although the trends in growth are not homogeneous, it is possible to highlight some general trends.

In high-income countries, the overall amount of resources (labour, land and TFP) has been falling since 1980. However, TFP has remained high in most countries, thus rebalancing the decline in resources. Over time, the agricultural labour force in these countries has declined and average farm size increased, meaning that labour productivity has risen much faster than land productivity.

It is noticeable that TFP in developing regions in 2001–09 rose substantially compared with 1971–2009. China and Brazil maintained high TFP growth rates in the period while Southeast Asia, West Asia, North America, and Latin America and the Caribbean also saw accelerated growth in the 2000s. The major exception is sub-Saharan Africa where TFP remained below 1 percent per year.

Table 30. Percentage annual growth rates for land, labour and total factor productivity (TFP), by region

Region	2001–2009			1971–2009		
	Land	Labour	TFP	Land	Labour	TFP
World	2.37	1.94	1.22	2.06	1.26	0.65
High income	0.97	3.93	1.44	1.44	4.25	1.36
Transition	2.41	4.58	1.15	0.14	1.15	-0.13
Developing	0.82	0.36	1.29	1.11	0.24	0.28
Latin America and the Caribbean	3.38	4.12	1.30	2.62	2.79	0.53
West Asia and North Africa	2.52	2.08	1.33	2.38	2.44	0.42
China and Northeast Asia	3.71	5.26	1.34	3.80	4.05	0.69
South Asia	2.69	1.34	0.85	2.82	1.34	0.20
Southeast Asia	3.76	4.00	1.43	2.74	2.24	0.45
Sub-Saharan Africa	2.34	0.77	0.85	2.27	0.62	0.50

Source: IFPRI (2013, Table 2).

In the transition countries, the collapse of the Soviet Union caused a major shock to agricultural productivity. During the transition from centrally planned to market-oriented economies, agricultural output fell sharply. Their output has begun to recover and has led to an improvement in TFP, which has increased rapidly since 2001.

Research by Nin-Pratt measured agricultural TFP growth not only for most countries, but also for various states and provinces within large countries. The research found TFP growth in Australia, Brazil, China, Indonesia and the United States of America to be highly uneven not only across countries, but also across different parts (states or regions) of the countries in question. For example, TFP growth in China and Brazil has been very strong in coastal areas but less so in the interior. In Indonesia, TFP growth was positive in Sumatra and Kalimantan, the western and northern regions of the country, but was stagnant in Java and the eastern provinces. In the United States of America, TFP growth was fairly strong in areas such as the Corn Belt and the Great Lakes but low in the Great Plains, Appalachia, California and Florida. In eastern and southern areas of Australia, TFP was affected by the stagnation of broadacre – land suitable for farms practising large-scale crop operations.

9.6 Summary

Agricultural growth plays a vital role in reducing poverty and ensuring future food security. Although the population growth rate is projected to decline in the future, increased population will still place additional demands on the global food system (Chapter 2). As the global scope for area expansion is limited and geographically concentrated in a few regions, additional agricultural production will need to come mainly from increased productivity.

According to OECD–FAO (2013) projections up to 2022, growth in agricultural production will slow in the mid-term owing to lower productivity and reduction in the rate of expansion. Owing to resource constraints, both developing countries and developed economies are projected to have lower yields and production growth for most crops. In order to encourage production and increase productivity, many emerging and developing countries aim to expand agricultural land and use more-advanced farming practices.

Developed economies such as the European Union (Member Organization) and the United States of America are by far the largest agricultural exporters in the world. However, 7 out of the 12 top exporters are emerging and developing countries, and many developing countries are registering larger increases in export value than developed countries. On the import side, developed economies such as the European Union (Member Organization), the United States of America and Japan top the list, but again most the major importers are developing and emerging countries. It is these countries that will drive the growth in agricultural trade. By 2022, developing and emerging countries are expected to account for the majority of exports of coarse grains, rice, oilseeds, vegetable oils, protein meals, sugar, beef, poultry and meat. Developing and emerging countries will also account for a large proportion of the growth in imports of many foods such as cereals and meat, whereas advanced economies will continue to be the major exporters of dairy products imported mainly by developing countries. Moreover, the rising price of crude oil and the different biofuel policies around the world will lead to an increasing demand for biofuels.

A number of factors are expected to cause agricultural production to grow less rapidly than in the past. Some of the most important of these are less unused land and water resources and more limited yield growth potential, compared with the past. Any further expansion of the world’s irrigation area is also difficult, owing to scarce and diminishing water resources, exacerbated by climate change.

Productivity plays a pivotal role in future food security. However, the challenge here, besides climate change, will also reside in the uneven access to natural and technological resources. In high-income countries, the overall amount of resources has been falling since 1980, but this has been largely

offset by strong TFP. In developing regions, TFP has been rising more slowly, except in the last decade, when their TFP growth rate has overtaken that of high-income countries.

An important tool that provides a multitude of ways to increase productivity is a supply chain. The supply chain takes on importance in terms of the efficiency with which distribution brings products from the producer to the consumer. The next chapter discusses supply and value chains in detail.

10. SUPPLY CHAINS

Products from fisheries, aquaculture and agriculture are consumed in local, regional and international markets. The global export value of fish and fish products has increased dramatically in recent decades, up from USD15 billion in 1980 to USD127 billion in 2011 (Chapter 8). About 50 percent of this comes from developing countries, where the net export revenue that countries receive from fish trade is larger than their exports of tea, rice, cocoa and coffee combined.

As far as agricultural exports are concerned, the increase in value in recent decades is similarly significant, rising from USD233 billion in 1980 to more than USD1.3 trillion in 2011 (FAOSTAT). Thus, magnitudes are considerably higher than for fisheries. This overall rise has been accompanied by a marked shift in the relative export growth patterns of developed versus developing countries. In 2010, 7 out of the top 12 exporters of agricultural products were developing and emerging countries and their share in the total value of the top 12 exporters increased from 27 percent (USD112 billion) in 2009 to 29 percent (USD128 billion) in 2010 (Chapter 9). Moreover, OECD–FAO estimates project that this rebound will continue to 2022, with emerging economies and developing countries driving growth in agricultural trade in the coming years (Chapter 9).

This growth in trade has been coupled with dramatic changes in the supply chains and with improvement in logistics, distribution and packaging. This has happened in a context of markets becoming ever more globalized. At the same time, there have been growing concerns over food safety standards, food waste, environmental issues and sustainability (FAO, 2013a).

This chapter outlines typical supply chains for agriculture, fisheries and aquaculture, both for domestic and international markets, discusses the value chain approach, examines relationships among agents along supply and value chains, and analyses the scope for efficiency improvements.

10.1 Typical supply chains for domestic and international markets

A supply chain is a network of product-related business enterprises through which products move from the point of production to consumption, including pre-production and post-consumption activities. Each link in a food supply chain affects the availability, affordability, diversity and nutritional quality of foods. Moreover, as discussed in Chapter 6, the handling of food throughout a chain has an impact on nutrition, price and accessibility, which in turn affects consumer choices, dietary patterns and nutritional outcomes (FAO, 2013b).

In supply chains, production is focused on efficient logistics using upstream and downstream businesses aimed mostly at pushing products to market. Supply chains are concerned with costs and how long it takes to present the product for sale, with the main objective of chain management being to maximize profits by reducing the number of links in the chain and improving efficiency. Supply chains work to keep to a minimum issues such as bottlenecks in supply, costs incurred, and time to market. Food supply chains are currently changing in many ways, driven by economic development, rapid urbanization and facilitated in some cases by policy reforms that are resulting in consumers receiving food in many diverse ways (FAO, 2013b).

With globalization and the liberalization of markets as well as the rise of the middle class in developing countries, fish trade has liberalized, with supply chains lengthening. Traditionally, developing countries mostly exported to major developed country markets, whereas today some developing countries are likely to export within their own regions to meet growing demand for food, especially in the growing economies of Latin America, Africa and Asia (FAO, 2013a).

International supply chains are diverse and complex, but are typically led by vertically integrated companies, including large processors, distributors and retailers. These companies coordinate activities to set themselves apart from the competition (FAO, 2013b; De Silva, 2011). A typical international supply chain consists of three key parts: supplying raw materials to manufacturing

units; manufacturing raw materials into semi-finished or finished products; and distribution to ensure products reach consumers (De Silva, 2011). These types of vertically integrated supply chains are expanding rapidly in many developing countries, where they may complement rather than replace traditional supply chains. These modern chains can exist alongside and intersect to some degree with traditional supply chains such as traders, direct markets, small independent stores and street vendors (FAO, 2013b; Gómez and Ricketts, 2012).

Generally, international supply chains of economically important species for trade, such as tuna, salmon, skipjack, shrimp and tilapia, are composed of several nodes with products passing through longer chains to reach the consumer. In the salmon industry in Canada, for example, salmon goes from the fishers to wholesalers, to processors to exporters and then, in the importing country, it will pass through one or more nodes before it typically ends up in a supermarket (FAO, 2014). International supply chains are highly market oriented compared with domestic supply chains, with market orientation being a key to access, function and remain in the international market. However, technical barriers to trade including duties, taxes, tariffs, certification and other standards, can act as barriers to market access. Technical barriers to trade are particularly significant to international value chains originating in developing countries compared with those initiated in developed countries (De Silva, 2013).

In contrast, domestic supply chains usually involve buying and selling with small, independent retailers on a much smaller scale, owing to lack of storage, distribution and processing infrastructure. Domestic supply chains have typically high market access but may be weak in market orientation (De Silva, 2013). Species in domestic supply chains that are not economically significant (relevant to other species) but are vital to local food security are part of a shorter supply chain. For example, a fish called hilsa in Bangladesh goes only from the fisher to the wholesaler, who also often acts as retailer (De Silva, 2011; FAO, 2014). Another example of a domestic supply chain can be seen in Liberia, where fishers sell their catch to fish traders (known as mammies). The fish mammies then sell as much fresh fish as they can to individuals (including restaurant buyers and household buyers) on the beach itself or sometimes at outdoor markets for the public. They will then sell any leftover fish for a lower price to small-scale processors, who smoke the fish for future sale to individuals, usually at outdoor markets.

With supermarket chains being introduced and growing in developing countries, these traditional trends in supply chains are shifting. Supermarket chains bring with them new technologies, more integrated supply chains and, frequently, stronger links to their own suppliers outside the country, all of which can cause major changes to the supply chain (FAO, 2013b; Reardon and Timmer, 2012). Despite this, research has shown that for animal sourced foods that are more perishable, such as fish and agricultural products, consumers in developing countries are most likely to still access them through traditional retail outlets (Jabbar, Baker and Fadiga, 2010). Research has demonstrated that these traditional retail outlets seem to have the following advantages: ability to offer products at low prices; considerable flexibility in product standards; and convenience for consumers owing to flexible market locations (Schipmann and Qaim, 2010; Wanyoike *et al*., 2010; Jabbar and Admassu, 2010; Minten, 2008).

10.2 The value chain approach

The term supply chain is often used interchangeably with the term value chain. Although there is no single standardized definition for either term, general characteristics and definitions have been applied to both supply and value chains that can be discussed here. Note that the terms here are used as one and the same, as many supply chains are now taking a value chain approach.

Like supply chains, value chains have the main objective to maximize net revenue. However, the method in which value chains seek to maximize net revenue is inherently different. As the name suggests, value chains add incremental value to the product in the different nodes of a chain either by value addition or value creation. This value is then realized from higher prices and/or the

development of new, niche or expanded markets. For example, within fisheries and aquaculture, the term value addition is used to characterize adding value in products through some type of processing methods; essentially converting raw fish to a resulting finished or semi-finished product that has more value in the market place. Value creation, on the other hand, is used to characterize primary products that have incremental value in the marketplace by differentiating them from similar products based on product attributes such as: geographical location (Mediterranean olive oil, Norwegian salmon, Thailand black tiger shrimp, etc.); environmental stewardship (Marine Stewardship Council label, ecolabelling, fair trade), organic products, and food safety (HACCP, free from antibiotics and heavy metals, etc.) (De Silva, 2011). The final value added or value created product can be a new product in the marketplace that has a competitive advantage over generic products as it fits a specific consumer demand and attracts a higher price.

As international trade in different food products has grown, a number of supply chains have begun taking a value chain approach in order to add value to the end product. This can be viewed as a result of seafood consumption rising and taste preferences towards different foods shifting (Chapter 6), with new markets for value-added food products emerging.

A particular challenge to the value chain approach is to scale the initiative, both in terms of developing the integrated chain itself to produce higher-value-added goods and to increase the amount of goods produced, processed and sold. Moreover, it has been difficult to ensure that the scaled-up initiatives benefit the poor, as they typically favour better-off farmers/fishers, processors and traders, while poorer agents in the chain, especially smallholders, can be squeezed out (Hartmann, 2012).

In a policy brief on scaling up value chains for pro-poor development, Hartmann, 2012 outlines common impediments to scaling up initiatives, including lack of infrastructure, access to financing, access to markets, knowledge of appropriate technology, and the inability to delivery products at sufficient quantity and quality. In addition, it is important to remember that in scaling up, “more” is not necessarily better, as most value chains operate in restricted local markets, where strong supply responses lead to declines in prices (Hartmann, 2012).

10.3 Relationships among agents along supply/value chains

A recent FAO project on value chains in 14 countries, including both developed and developing countries, found reoccurring themes identifying the relationships among agents. In general, many fish suppliers in developing countries act as raw material suppliers to developed countries, demonstrating they earn limited profits from their valuable natural resources. Processors and retail markets were found to be receiving more of the distributional benefits of the value chain owing to their more concentrated structure and stronger bargaining power as compared with the primary producers (FAO, 2014).

One of the most interesting project findings about relationships among agents in value chains concerned gender. Men and women undertake different and changing roles in these value chains, with the roles depending on a wide range of factors, including culture, values, attitudes and norms concerning access to resources and control over them, social mobility, type of technology utilized, the extent of commercialization, and the product involved. Female roles in fisheries are principally designed in terms of ethnicity, religion and socio-economic status.

In general, the majority of women take part in the processing and marketing nodes of the fishery value chain owing largely to social and cultural norms, which have generally reduced women’s access to resources and their decision-making power. Processing is done either at the small-scale level using traditional techniques (usually only in developing countries) or at the industrial level as factory workers (common in both developing and developed countries). Financial returns for processing activities are often low and no profit-sharing arrangements such as Fair Trade have been employed. Decision-making in the male-dominated management levels does not allow room for a

gender perspective and, thus, female participation rates in trade union activities are low (FAO, 2014).

Women who are more highly educated or have better access to resources can be involved in the higher levels of the fishery value chains, meaning that they can manage and operate fishing enterprises. Although this is not the norm, women can enjoy increased financial benefits and access to resources at this higher level. Generally, men are involved more in the production (upstream) activities and invest in fishing vessels, nets, other fishing gear and pond construction. Women generally invest more in processing equipment and are responsible for fish purchasing, processing and retailing, although it is important to note that this differs in every fishing area and country.

10.4 Scope for efficiency improvements in supply chains

Potential methods to improve efficiency in supply chains are numerous. They include growth in production, more efficient processing and distribution, transparent market information, proper market orientation, a reduction in food loss, a stronger focus on nutrition and, for the long-term, improved resource management. Raising the efficiency of supply chains can help meet the simultaneous challenge of reducing the costs of food to consumers and increasing the revenue of supply chain participants. Both lower prices for consumers and increased incomes for producers support the possibility of improving nutrition through a more adequate and varied diet (FAO, 2013b).

In terms of production, the importance of expanded production in aquaculture and agriculture has been previously discussed in Chapters 8 and 9. However, as Asche and Bjørndal (2011) point out, productivity growth in the distribution chain to retailers is equally important. This is because consumers are primarily interested in the final price for a product of any given quality, and from their perspective, whether a price reduction is due to a lower cost of production or better logistics is of little importance.

Productivity growth is most easily observed in the production process and significant input factors, but another important source is improved distribution and processing logistics in the supply chain (Asche and Bjørndal, 2011). When considering industry growth, it is important to keep in mind that improved logistics account for a substantial part of productivity growth. Economies of scale, as well as new and improved transportation methods such as airfreight for fresh fish and agricultural products, have reduced the cost of bringing the product to the consumer. Distribution and logistics in the supply chain have also been improved in many places through vertical coordination of primary producers, input suppliers and processors. In an integrated system, consumer demand and production information flow upstream from retailers to suppliers, who make contractual arrangements with producers (Reardon and Barrett, 2000). These contracts may include provision of inputs, credit and technical and marketing assistance, which can enable producers to increase their productivity and profits. At the same time, integrated supply chains can improve the nutrient content of food and nutritional outcomes for consumers.

Public and/or private sector investment to support the development of transport, communication and service infrastructure could help integrate smallholders into supply chains and help to improve value chain performance (FAO, 2013b). Modernizing and consolidated processing units can also play a significant role in helping supply chains to become more efficient. A recent study of transformational changes in rice supply chains in China and Bangladesh found that processing units (rice mills) that were consolidating and modernizing their technology were making the chain more efficient. In addition, rice mills were found to be changing their procedures in order to buy directly from farmers, brand and package the rice themselves and sell directly to agents in wholesale markets. Not only does this help improve supply chain efficiency, but these changes were also seen to aid in quality differentiation and traceability (Reardon *et al.*, 2012).

Improving the efficiency of supply chains requires not only factors of production and technology but also efficient market information systems and management. As fisheries and agriculture increasingly rely on regional and international trade for their sales, it has become vital for agents involved to have consistent, independent and trustworthy information. Many of the case studies as part of the FAO value chain project discussed above identified the need for transparent marketing pricing to fishers (FAO, 2013a).

Creating a successful and efficient supply chain has numerous challenges and must begin with strong market orientation, that is, an understanding of a specific consumer demand at the right time and place. As De Silva (2011) notes, a wide range of factors drives consumer demand for food products and should be taken into consideration when bringing a product to market. These factors include: price, consumer demographics, convenience, nutritional content, safety, substitutes, tastes, fashion, advertising and consumer expectations. Once a specific demand is identified, stakeholders must then work to create relationships between production, processing, distribution and marketing stakeholders that can be trusted and in which information is shared freely. If taking a value chain approach, it is also important to distinguish between value addition and value creation; recognizing that value addition may require more cost inputs in terms of processing infrastructure but that value creation will take time and funding as well.

A significant approach for improving efficiencies of supply chains that has recently been gaining increasing international attention is reduction in food waste. Global estimates of food waste have demonstrated that as much as 30 percent of all food grown worldwide may be lost or wasted before and after it reaches the consumer, some estimates have placed it as high as 50 percent (Foresight, 2011). A recent FAO study on food loss (FAO, 2011) suggests that roughly one-third of food production for human consumption is lost or wasted globally, which amounts to about 1.3 billion tonnes per year. The study found that food is lost or wasted throughout the supply chain, from initial agricultural production to final household consumption.

In medium- and high-income countries, food is most significantly wasted at the consumption stage, meaning that it is discarded even though it is still suitable for eating. This is in contrast to low-income countries, where food loss mostly takes place during the beginning and intermediary stages of the supply chain. Low-income-country food waste was found to be a result of the financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packing and marketing systems. For all developed country regions that the study examined, the study found losses in primary fish and seafood production significant owing to discard rates of 9–15 percent of marine catches. The study also found that a large proportion of purchased fish and seafood is wasted by households. In developing countries, losses in primary production were found to mostly depend on discard rates of between 6–8 percent of marine catches. High losses at the distribution level can be explained by high levels of deterioration occurring during fresh fish and seafood distribution (FAO, 2011).

The study recommended that supply chains in developing countries be strengthened by “encouraging small farmers to organize and to diversify and upscale their production and marketing. Investments in infrastructure, transportation, food industries and packing industries are also required” with both the public and private sector to play a role. In developed countries, the study recommended that food waste be reduced by “raising awareness among food industries, retailers and consumers” and the need to “find good and beneficial use for safe food that is presently being thrown away” (FAO, 2011).

Another significant issue in supply chains that must be addressed is food safety. In developing countries, consumption of unsafe food and water is a major cause of preventable illness and death (Trench *et al.*, 2012). Trench *et al.* (2012) outline three factors that drive increasing health risks in food and along the supply chain that are especially pertinent to fisheries and aquaculture: (i) shifts in consumption patterns, often linked to increasing income, towards highly perishable products that are very susceptible to food-safety risks; (ii) higher demand for cheap foods to address food insecurity

for a growing global population, which leads to health risks related to intensification of production methods (such as in aquaculture); and (iii) increasing urbanization, which leads to greater anonymity along the supply chain and therefore fewer incentives for individuals and institutions to invest in food safety.

It is vital to remember that efficiency improvements in supply chains are not always about numbers related to production, distribution, food waste, etc. One important approach that thus far has not been widely used as an objective for food growth lies in nutrition. Food and nutrition often fall under several government entities; with the result that nutrition is a political and institutional orphan. Fan and Brzeska (2012) stress that growth strategies must be designed with a nutritional lens and take into account what types of sectoral and subsectoral practices and policies can enhance nutrition.

Finally, improved policy and management is crucial to improving the efficiency of capture fishery supply chains from an economic perspective. *The Sunken Billions* report (FAO and World Bank, 2009) found that global marine capture fisheries are an underperforming global asset. The study recommended that improved governance could recapture a substantial proportion of the annual economic loss. In addition, with effective economic incentives sustainable fisheries could create an economic surplus and be a driver of economic growth as well as a basis for livelihood opportunities (FAO and The World Bank, 2009).

10.5 Summary

Using fisheries and aquaculture as examples, this chapter has outlined typical international and domestic supply chains for food products, discussed the value chain approach and the relationships among agents in these chains, as well as discussed the scope for efficiency improvements. A supply chain is a network of product-related business enterprises through which products move from the point of production to consumption, each link in the chain affecting the availability, affordability, diversity and nutritional quality of foods.

Food supply chains are currently changing in many ways, driven by economic development, rapid urbanization and various policy reforms as well as in response to changing consumer preferences. For example, the liberalization of the fish trade has lengthened supply chains and resulted in developing countries exporting not only to developed countries but also to emerging or other developing countries. International supply chains led by vertically integrated companies are expanding in many developing countries, despite certain persisting technical barriers to trade. Nonetheless, domestic supply chains continue to be vital to local food security and thus have typically high market access but weaker market orientation. In addition, although supermarket chains are also growing in developing countries, traditional retail outlets still maintain certain advantages such as low prices, flexibility and convenience.

Like supply chains, value chains seek to maximize revenue, either by adding value (mainly though processing) or by creating value (mainly through product differentiation). As food consumption increases around the world, some supply chains have begun adopting this approach, although there are a number of challenges to be addressed, principally in terms of scaling up initiatives and ensuring that poor, small producers benefit equally. Moreover, gender roles, although slowly evolving, are still differentiated within value chains, often to the detriment of women’s empowerment.

Efficiency in supply chains can be improved through various means, including growth in production, more efficient processing and distribution, transparent market information, proper market orientation, a reduction in food loss, a stronger focus on nutrition and, for the long term, improved policy and resource management. Raising the efficiency of supply chains can help meet the simultaneous challenge of reducing the costs of food to consumers, enhancing sustainability, food safety and nutrition, and increasing the revenue of supply chain participants, including smallholders.

11. SUMMARY – SUPPLY SIDE

This chapter summarizes the main findings from the different aspects of supply-side analysis as presented in Chapters 8–10. Discussion on world fish production, broken down by captures fisheries and aquaculture, is presented, highlighting major world producers, utilization, technological progress, exports and imports, and projections for fish production in the future. This chapter also outlines agriculture production as well as trends in exports and imports, future challenges and discusses the evolving supply and value chains. For references and more details, the reader is referred to earlier chapters.

World fish production has experienced considerable growth since 1950. The supply of seafood has been steadily increasing from 20 million tonnes in 1950 to 156.7 million tonnes in 2012 (preliminary estimate), of which 86 percent was used for direct human consumption. Per capita fish consumption increased from 9.9 kg in 1960 to 19.1 kg in 2012. However, per capita consumption in developing regions and low-income countries is on average still lower than in developed countries.

Production in capture fisheries increased from 1950 to mid-1980s when catches levelled off at about 85–95 million tonnes per annum. According to the latest FAO statistics, almost 90 percent of world fishery resources are ether overexploited or fully exploited.

In terms of the top producers of marine capture fisheries, China, Peru, Indonesia and the United States of America accounted for most of the world's fish production in 2011. Besides China, the most significant fishing countries are Viet Nam and Myanmar, which are among the top 12 marine fishing countries. In the period from 2006 to 2011, the Russian Federation increased its catches by 1 million tonnes. However, Chile and Japan experienced a decline in catches between 2009 and 2011.

The proportion of fish directly used for direct human consumption has been steadily increasing. In 2010, 40.5 percent (60.2 million tonnes) of world fish production was marketed in live, fresh or chilled forms, 45.9 percent (68.1 million tonnes) was processed in frozen, cured or otherwise prepared forms for direct human consumption, and 13.6 percent was destined for non-food uses. In developed countries, fish is mostly utilized in frozen form, while in developing countries, most of the fish is consumed live, fresh or chilled.

Of the 13.6 percent destined for non-food uses, 75 percent of that was processed to be utilized for fishmeal and fish oil. The production of fishmeal and fish oil has experienced a decline since its peak in 1995, and the use of fishmeal in aquafeeds has gradually fallen since 2006. This is because of: decreased supplies of industrially caught fish as a result of tighter quotas; reduced catches of small pelagic species, in particular anchoveta; additional controls on unregulated fishing; and increased use of more cost-effective dietary fishmeal replacers. In 2010, about 43 percent of fishmeal was produced from raw materials other than fish. Cheaper alternatives to fishmeal, mostly using vegetable protein and animal by-products, have been developed, but a continued emphasis on alternative sources for fishmeal will be key to the sustainability of the aquaculture sector. In the near future, the amount of captured fish destined for non-food uses is likely to decrease further.

The importance of aquaculture as a source of food has been increasing since 1950. Production rose rapidly in the 1980s, with aquaculture expanding by almost 12 times in the last three decades to attain an all-time high in 2010 of 60 million tonnes (excluding aquatic plants and non-food products). Global aquaculture production has continued to grow in the new millennium, albeit more slowly than in the 1980s and 1990s. In 2012, aquaculture production reached an estimated production volume of about 66.5 million tonnes, or about 43 percent of total seafood supply.

China is by far the largest aquaculture producer. Its production was 38.6 million tonnes in 2011, accounting for roughly 65 percent of the world's production. In 2011, among the leading producers, China was followed by India, Viet Nam, Indonesia, Bangladesh, Thailand and Norway. Smaller

producers, but nonetheless important, include Egypt, Myanmar, the Philippines, Japan, Chile, the United States of America, Brazil, the Republic of Korea, Ecuador, Spain, Taiwan Province of China and Malaysia.

Technological progress and selective breeding have been important factors underlying production growth in aquaculture. Through improved technologies, better production practices and genetic improvements, production costs have been substantially reduced, leading to declining prices for many farmed products over time and increased profitability in fish farming. Reduced production costs are primarily due to two factors. First, fish farmers have become more efficient, as they produce larger volumes with improved inputs. This productivity growth is enabled by the improved inputs, such as state-of-the-art technology, as well as the application of best practices, which have been honed over time. Second, these improved input factors, such as improved feeding technology and more efficient feed, make the production process less costly. Feed is the most vital input factor in the production process, and improvement in feed quality is one of the most important reasons for productivity growth.

The export value of fish – capture and farmed – has shown a tremendous increase in recent decades. According to FAO preliminary estimates, in 2011, trade export value reached the highest level ever reported (USD127 billion). Among the most highly traded fish commodities are shrimps, salmon, tuna and groundfish. High-value species are largely traded towards higher-value markets while low-value species such as small pelagics are generally sold in low-income markets. Developing countries play an important role in world fish food exports, with China, Thailand and Viet Nam acting as the largest exporters of fish products among developing countries. China's exports have expanded considerably since the 1990s. The projected share of China in world fish trade in 2011 is USD17.7 billion, which is a 33 percent increase compared with 2010. Among developed countries, Norway, the United States of America, Denmark, Canada, the Netherlands and Spain are the leading fish exporters.

In terms of imports, 2011 was a record year for fish imports, reaching USD127.6 billion, and preliminary estimations for 2012 suggest further increase in trade volume to USD128.2 billion. In 2011, China was the fourth-largest importer in the world and, after the European Union (Member Organization), the United States of America and Japan, demonstrated the largest import increases over the period under consideration. Traditional importers such the European Union (Member Organization) and Japan increased their share of imports.

According to joint FAO and OECD projections, world fisheries and aquaculture production is expected to reach 181 million tonnes by 2022, which is 18 percent higher than the average level for 2010–12 (OECD–FAO, 2013). The main driver of this growth will be aquaculture production, projected to grow at an annual rate of 2.4 percent, which is considerably less than the 5.9 percent achieved in the decade up to 2012. The lower growth rate is mainly attributed to constraints such as water scarcity, less optimal production location availability and high input costs. The degree of improvements in technologies and management practices will determine future growth. For capture fisheries, production growth is predicted at only 5 percent through to 2022 to a level of 95 million tonnes. This increase is mostly attributed to stock recovery due to improved resource management.

Climate change and climate variability will continue to increase uncertainty in the supply of fish from fisheries and aquaculture.

In agriculture, world production has experienced fundamental changes in the past few decades. Most significantly, there has been a geographic shift in where agricultural production takes place globally. Production in high-income and transition economies of the former Soviet Union has been declining since 1990, whereas production in developing countries has accelerated due to expanded capacities in agricultural research, advanced technologies and practices and policy reforms. In addition to agricultural production, there have been changes in the composition of production driven by

consumer demand. While the production of cereals has decreased, that of fruits and vegetables has accelerated. The share of livestock products in agricultural production has remained stable.

According to FAO statistics, the value of world agricultural production of food in 2011 was USD2 318 billion. OECD–FAO (2013) projections through to 2022 suggest that growth in agricultural production is slowing in the medium-term owing to slower productivity growth and area expansion. Owing to resource constraints, both developing countries and large economies are projected to have lower production growth for most crops. In order to encourage production and increase productivity, many emerging and developing countries aim to expand agricultural land and use more-advanced farming practices.

Agriculture production projections include the following:

- World production of wheat and coarse grains will continue to increase through to 2022, but with a slower annual growth rate than that in 2010–2012. In terms of area expansion, coarse grains are projected to experience a faster growth than wheat or rice.
- Meat and dairy products will also decline in production, although less so than for some crops. Demand from developing countries will drive the expansion of the meat and dairy sector through to 2022.
- The production of oilseeds, by-products of protein meals and vegetable oils will expand by 26 percent by 2022, continuing to attract land from other crops. In developing countries, demand will be driven by an increase in use of vegetable oils for human consumption, while in developed countries the rise will occur due to increased usage of vegetable oils for biodiesel production.
- The supply and use of ethanol will increase significantly, especially in the United States of America, owing to related environmental regulations. Biodiesel production will continue to grow, although at a slower rate than in 2010–2012.
- The yields of sugar, whose production will come mostly from sugar cane rather than from sugar beets, are expected to be lower than in the previous decade.
- The world production and consumption of cotton is expected to grow, but slightly below its long-term average rates. However, higher yields of cotton though are expected in sub-Saharan Africa, which is investing in new advanced technologies.

Although the European Union (Member Organization) and the United States of America are by far the largest agricultural exporters in the world, the role of developing and emerging economies will drive the growth of agricultural trade. Currently, 7 of the top 12 exporters are emerging and developing countries, and, many developing countries register larger increases in export value than developed countries. By 2022, developing and emerging countries will account for the majority of the exports of coarse grains, rice, oilseeds, vegetable oils, protein meals, sugar, beef, poultry and meat. On the import side, developed economies such as the European Union (Member Organization), the United States of America and Japan will account for the largest imports, but once again most of the top 12 importers will be developing and emerging countries. In this group, China and the Russian Federation are the largest importers with import values of USD32.5 billion and USD21 billion, respectively, in 2010. Among other developing and emerging country importers are Mexico, Malaysia and India. Developing and emerging countries will also account for a large part of the growth of imports of many foods such as cereals and meat, whereas developed economies will continue to be the major exporters of dairy products, mainly to developing countries. A number of factors are expected to cause agricultural production to grow less rapidly than in the past, but mainly this is due to limited natural resources, particularly less unused land and water resources. In addition, there is limited yield growth potential, compared with the past.

Climate change also has a direct effect on agriculture. Whereas a rise in global temperatures may benefit agricultural production in some regions, for others it may be catastrophic, destroying large volumes of temperature-sensitive crops. The change in temperature and rainfall may also alter the crop growing season, which may threaten the viability of cultivating second crops and even a single

crop in some areas. The debate on best methods for future agriculture production continues, with some experts pointing to the need for use of genetically modified crops that could be heat/drought tolerant, while others highlight the need to foster small-scale polyculture practices.

Productivity plays a pivotal role in future food security. Besides climate change, a main challenge will also reside in the uneven access to natural and technological resources. In high-income countries, the overall amount of resources has been falling since 1980, but this has been largely counterbalanced by strong TFP. In developing regions, TFP has been rising more slowly, except in the last decade, when their TFP growth rate overtook that of high-income countries.

Products from fisheries, aquaculture and agriculture are consumed in local, regional and international markets. Food supply chains are currently changing in many ways, driven by economic development, rapid urbanization and various policy reforms as well as in response to changing consumer preferences. For example, the liberalization of the fish trade has lengthened supply chains and resulted in developing countries exporting not only to developed countries but also to emerging or other developing countries.

Like supply chains, value chains seek to maximize revenue, either by adding value (mainly though processing) or by creating value (mainly through product differentiation). As food consumption increases around the world, a number of supply chains have begun adopting this approach, although there are a number of challenges to be addressed, principally in terms of scaling up initiatives and ensuring that poor, small producers benefit equally.

Efficiency in supply chains can be improved through various means, including growth in production, more efficient processing and distribution, transparent market information, proper market orientation, a reduction in food loss, a stronger focus on nutrition and, for the long term, improved policy and resource management.

Raising the efficiency of supply chains can help meet the simultaneous challenge of reducing the costs of food to consumers, enhancing sustainability, food safety and nutrition, and increasing the revenue of supply chain participants, including smallholders.

12. FUTURE MARKETS

OECD–FAO (2013) presents production forecasts and market analyses for food up to 2022. As argued in Chapter 8, it is believed that the assumptions underlying future growth in aquaculture are somewhat pessimistic. For this reason, additional scenarios have been prepared for future fish production.

This chapter looks at the following five scenarios:

1. The base case, as per OECD–FAO (2013).This involves an increase in aquaculture production from 66.2 million tonnes in 2012 to 85 million tonnes in 2022, or a total increase of 28.5 percent over the period. This gives an average annual growth rate of 2.54 percent.
2. An "intermediate" scenario, which predicts an increase in aquaculture production from 66.2 million tonnes in 2012 to 92 million tonnes in 2022, or a total growth of 39.6 percent over the period. This gives an average annual growth rate of 3.39 percent.
3. An "optimistic" scenario, which involves an increase in aquaculture production from 66.2 million tonnes in 2012 to 99 million tonnes in 2022, or a total growth of 50 percent over the period. This gives an average annual growth rate of 4.14 percent.
4. A "mixed" scenario where total aquaculture production will reach 99 million tonnes in 2022, as in scenario 3; however, most of the growth will take place in Asia: annual growth outside of Asia will be as in the base case (scenario 1), while growth in Asia will be such that a total production of 99.3 million tonnes will be reached in 2022. This gives an average annual growth rate of 4.14 percent.
5. This scenario, called "revised demand elasticities", introduces a new set of demand elasticities (see Appendix). In terms of production, it is identical to the "mixed" scenario. This gives an average annual growth rate of 4.14 percent.

All the scenarios have been analysed by the FAO fish model.

As pointed out in OECD–FAO (2013), average annual growth rate in aquaculture production in the last decade has been 5.9 percent, and for the coming decade this is expected to be reduced to 2.54 percent per year – which here represents the base case (scenario 1). It is felt that this assumption is somewhat pessimistic. Although growth in any expanding industry is likely to be reduced over time, more than halving of the growth rate in the coming decade is not very likely. For this reason, alternative scenarios are presented: an intermediate scenario with an annual growth rate of 3.39 percent, and a more optimistic growth rate of 4.14 percent per year.

The potential for increased aquaculture production varies from country to country. It is believed that the potential for "catching up", in terms of technology, is particularly large in Asia. This is taken into account in scenario 4 – while total growth is the same as in the optimistic scenario, regions outside of Asia grow according to the base case with growth in Asia at a higher rate so that the overall annual expansion of 4.14 percent per year is achieved.

Chapter 5 reviewed demand studies for food in general and fish in particular, with an emphasis on own price and income elasticities. The results presented are the most comprehensive and up-to-date estimates available, and for this reason in scenario 5 an alternative set of demand elasticities have been used. Both sets of elasticities are presented in the Appendix. The revised set of elasticities in general implies lower absolute values for own price elasticities, i.e. more inelastic demand. In addition, income elasticities are lower. As for production growth, this is the same as for the mixed scenario.

For capture fisheries, based on OECD–FAO (2013), production in 2012 is 91 million tonnes with a projection of 95 million tonnes for 2022. These assumptions are the same in all the scenarios under consideration. As the increase in capture production is limited, most of the increase in total production comes from aquaculture.

In the following, results from the five scenarios are presented, with an emphasis on production, prices and developments in the fishmeal and fish oil market.

12.1 Production

Annual aquaculture production for the five scenarios is illustrated in Figure 11. As can be seen, scenarios 3–5 are identical in terms of annual production.

Figure 11. World aquaculture production, 2012–2022

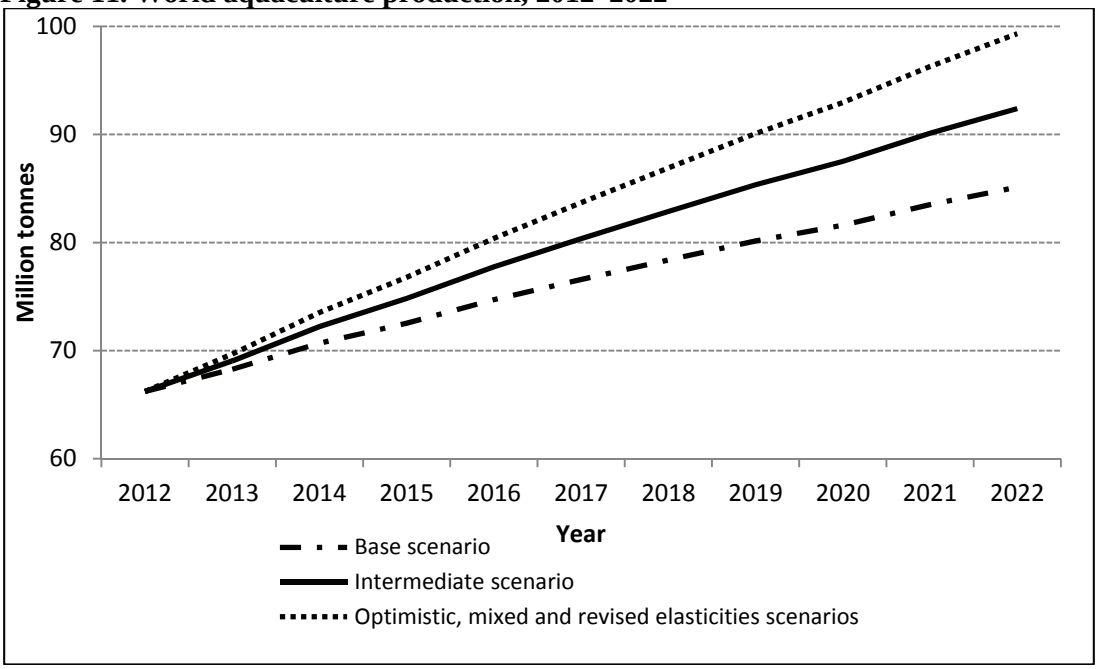


Table 31 presents production per region and for the world in 2012 and 2022. The increase in world production is as illustrated in Figure 11. The relative increase in Africa and Australia is higher than the world average, while it is lower for America and Europe. Asia, on the other hand, increases at roughly the same rate as the world. This indicates that, in relative terms, the potential for increased production is largest in Asia, Africa and Australia. However, compared with Asia, production in Africa is small, while that of Australia is negligible.

Scenario 4 is different. The total increase in production is the same as for the optimistic scenario, i.e. 50 percent. Growth in Africa, America, Asia, Australia and Europe is the same as in the base case, while the increase in Asia is 54 percent.

In terms of absolute quantities, Table 31 underlines the importance of Asia in world aquaculture production. In 2012, Asia produced 86 percent of the total production of 66.22 million tonnes. In 2022, according to the optimistic scenario, aquaculture production in Asia will have increased to 88.635 million tonnes, or 89 percent of the total. Again, in terms of this scenario, America will rank second in 2022 with 4,593 million tonnes (4.63 percent of the total). Then comes Europe with 3,435 million tonnes (3.5 percent of the total), Africa with 2,373 million tonnes (2.4) and Australia with 0.117 million tonnes (0.1 percent). The overall growth in Africa of 63 percent by 2022 according to the optimistic scenario is noteworthy.

Table 31. Aquaculture production, by region and for the world in 2012 and 2022 for different scenario

Continent	Scenario	2012	2022	Percentage increase
	(million tonnes)			
Africa	Base	1.46	2.03	40%
	Intermediate	1.46	2.21	52%
	Optimistic	1.46	2.37	63%
	Mixed/revised elasticities	1.46	2.03	40%
America	Base	3.22	3.94	22%
	Intermediate	3.22	4.27	33%
	Optimistic	3.22	4.59	43%
	Mixed/revised elasticities	3.22	3.94	22%
Asia	Base	58.68	75.96	29%
	Intermediate	58.68	82.45	41%
	Optimistic	58.68	88.64	51%
	Mixed/revised elasticities	58.68	90.17	54%
Australia	Base	0.07	0.1	39%
	Intermediate	0.07	0.1	51%
	Optimistic	0.07	0.1	63%
	Mixed/revised elasticities	0.07	0.1	39%
Europe	Base	2.68	2.94	10%
	Intermediate	2.68	3.20	19%
	Optimistic	2.68	3.44	28%
	Mixed/revised elasticities	2.68	2.94	10%
World	Base	66.22	85.124	29%
	Intermediate	66.22	92.402	40%
	Optimistic	66.22	99.33	50%

Figure 12 describes the total production of the fish globally from capture fisheries and aquaculture. As noted above, capture production is expected to increase from 91 million to 95 million tonnes over the period. There is a small dip in production in of about 1.6 million tonnes in 2015 and 2020. This is due to an El Niño effect (c.f. Chapter 8) that has been built into the model. The world fish production will increase in all four scenarios from its 2012 level of 157 million tonnes. The baseline scenario predicts a steady increase to 181 million tonnes by 2022, the intermediate to 188 million tonnes, while scenarios 3–5 project an increase to 194 million tonnes. The average growth rates predicted in the first two scenarios are 1.45 percent and 1.83 percent, respectively, while the estimated rate for scenarios 3–5 is 2.19 percent.

Figure 12. Annual world fish production, 2012–2022

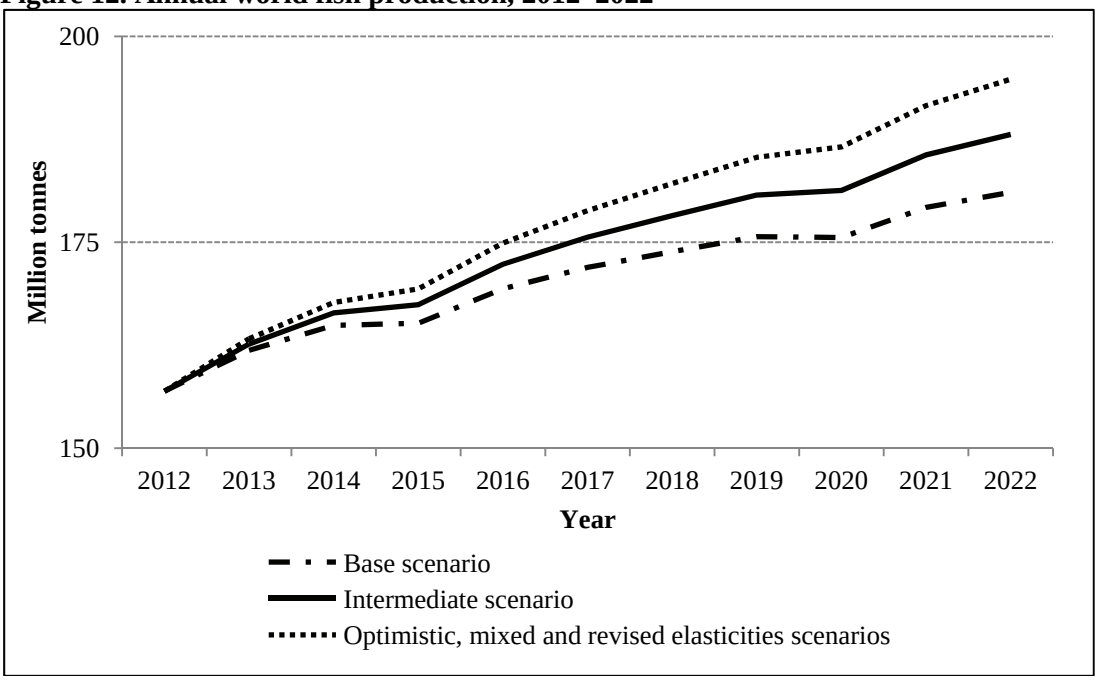


Table 32 gives total fish production for the different scenarios in 2012 and 2022. When capture fisheries are included, the growth is less than when aquaculture only is considered. Although Asia is still the dominant producer, this is less prominent than when aquaculture only is considered, as other regions also have important capture fisheries. The production of fish in Asia accounted for 69 percent (108.5 million tonnes) of the total production in 2012. In 2022, according to the optimistic scenario, it will rise to 141 million tonnes or 72 percent of the total. Again, in this scenario, America follows Asia in 2022 with 24.42 million tonnes (12.5 percent of the total). Europe is third with 17.164 million tonnes (8.8 percent of the total), Africa is fourth with 10.634 million tonnes (5.5 percent) and Australia is fifth with 278 000 tonnes (0.1 percent). Nevertheless, it is noteworthy that, for all scenarios, only Asia grows at a higher rate than the world total.

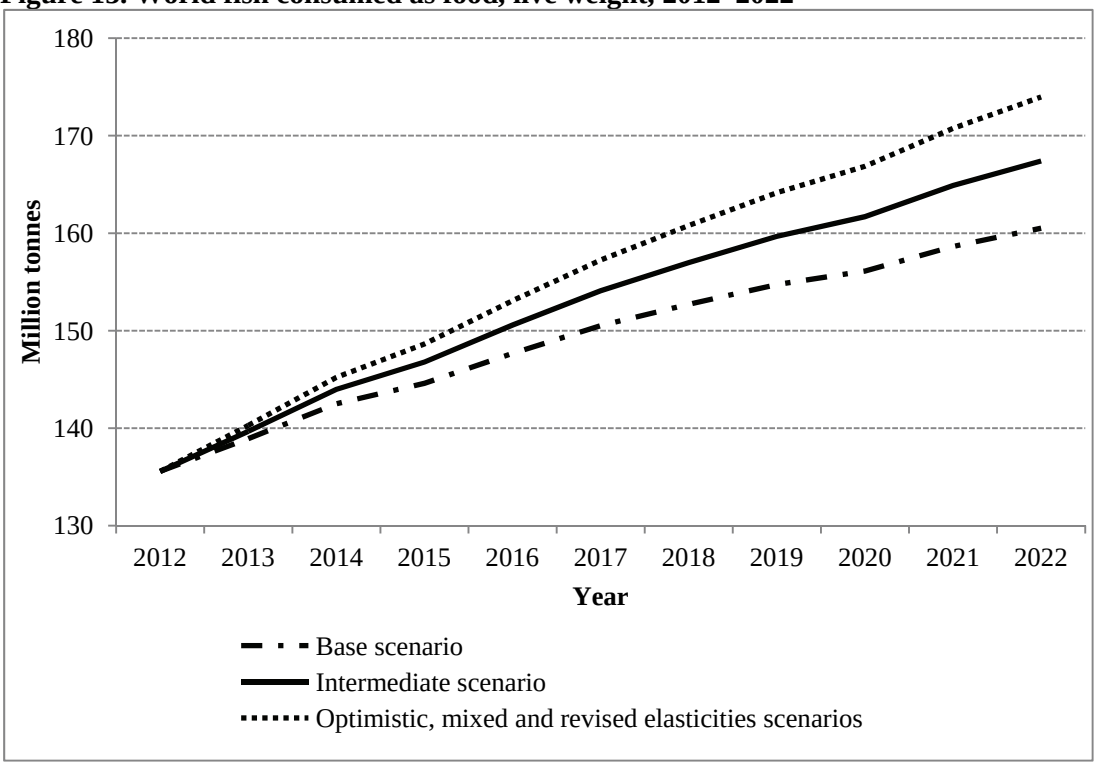
Table 32. Total fish production, by region and for the world in 2012 and 2022 for different scenarios (thousand tonnes)

Continent	Scenario	2012	2022	% increase
Africa	Base	9 157	10 427	13.9
	Intermediate	9 157	10 528	15.0
	Optimistic	9 157	10 634	16.1
	Mixed/revised elasticities	9 157	10 296	12.4
America	Base	21 707	23 795	9.6
	Intermediate	21 707	24 120	11.1
	Optimistic	21 707	24 428	12.5
	Mixed	21 707	23 781	9.6
	Mixed/revised elasticities	21 707	23 770	9.5
Asia	Base	108 520	128 506	18.4
	Intermediate	108 520	134 833	24.2
	Optimistic	108 520	140 868	29.8
	Mixed	108 520	142 378	31.2
	Mixed/revised elasticities	108 520	142 279	31.1
Australia	Base	237	270	13.9
	Intermediate	237	279	17.6
	Optimistic	237	287	21.1
	Mixed	237	270	13.9
	Mixed/revised elasticities	237	270	13.9
Europe	Base	15 861	16 677	5.1
	Intermediate	15 861	16 926	6.7
	Optimistic	15 861	17 164	8.2
	Mixed	15 861	16 672	5.1
	Mixed/revised elasticities	15 861	16 669	5.1
World	Base	156 910	181 070	15.4
	Intermediate	156 910	188 093	19.9
	Optimistic	156 910	194 800	24.1
	Mixed	156 910	194 792	24.1
	Mixed/revised elasticities	156 910	194 617	24.0

Figure 13 describes the development in world production of fish destined for food consumption in 2012–2022.

The contribution of fish to global diets has been increasing substantially in recent decades (Chapter 8). According to estimates in Figure 13, fish consumption for food purposes will continue to increase steadily up to 2022 from a starting point of 135.6 million tonnes in 2012 in all five scenarios. In 2022, consumption will reach 160.5 million tonnes in the baseline scenario and 167.4 million tonnes in the intermediate scenario, increases of 18 percent and 23 percent, respectively, compared with 2012. The optimistic, mixed and revised elasticities scenarios all show an increase in consumption to 174 million tonnes in 2022, a 28 percent gain from the 2012 level.

Figure 13. World fish consumed as food, live weight, 2012–2022



The share of aquaculture in total fish production will increase from 41 percent in 2012 to 47 percent in 2022 in the base scenario, 49 percent in the intermediate scenario and 51 percent in the optimistic scenario, the mixed scenario and the scenario with revised elasticities. As farmed fish is used almost exclusively for direct human consumption, the share of aquaculture in fish for direct food consumption will be higher.

Per capita fish consumption was 18.6 kg in 2010, 18.8 kg in 2011 and 19.1 kg in 2012 (Chapter 8). According to the results presented here, per capita fish consumption will reach 20.7 kg in the base scenario, 21.6 kg in the intermediate scenario and 22.4 kg in the optimistic, mixed and revised elasticities scenarios, increases of 8, 13 and 17 percent, respectively. In other words, per capita consumption will continue increasing. As in recent decades, this will primarily be due to the continued expansion in aquaculture production.

The quantity of fish destined for non-food use will decrease from 21.3 million tonnes in 2012 to 20.6 million tonnes in 2022 in the base scenario, 20.7 million tonnes in the intermediate scenario and 20.8 million tonnes in the optimistic, mixed and revised elasticities scenarios. This represents a decrease of 3–4 percent over the period. In 2012, 75 percent of fish destined for non-food use was reduced to fishmeal and fish oil and 25 percent was utilized as fish for ornamental purposes, for culture (fingerlings, fry, etc.), for bait, for pharmaceutical uses as well as for direct feeding in aquaculture, for livestock and for fur animals (Chapter 8). Assuming that a similar trend will continue up to 2012, this implies less fish will be available for fishmeal production in the future.

12.2 Prices

Figure 14 shows the development in the product prices of world aquaculture in 2012–2022 according to the five scenarios described above. The starting point is a 2012 price of USD2 127 per tonne.

Slow growth in aquaculture production in the baseline scenario (2.54 percent per annum) will result in a significant increase in prices over time. Prices will increase gradually to USD2 225 per tonne in

2015 where they will level off until 2017 and then soar to USD2 700 per tonne in 2022. This represents an increase of 27 percent over the period.

In the intermediate scenario, prices will initially decline from USD2 127 per tonne in 2012 to USD2 017 per tonne in 2017, and then they will start to rise and reach USD2 262 per tonne in 2022, a 6 percent increase above the 2012 price level.

The optimistic scenario shows a gradual decline in prices for aquaculture products through the period from USD2 127 per tonne in 2012 to USD1 827 per tonne in 2018. They will then increase to about USD1 900 per tonne in 2019 and will level off at about USD1 930 per tonnes in 2020–2022. The development in price in the mixed scenario is very similar to that of the optimistic scenario.

In the scenario with revised elasticities, prices will decline substantially from the initial USD2 127 per tonne in 2012 to USD1 723 per tonne in 2022, a decrease of 23 percent

It is clear that the development in prices depends very much on the expansion in aquaculture production. For the optimistic and mixed scenarios, prices will actually decline. They will decline even more in the scenario with revised elasticities, where demand is more inelastic and where income elasticities are lower than in the other scenarios.

Figure 14. World aquaculture product prices, 2012–2022

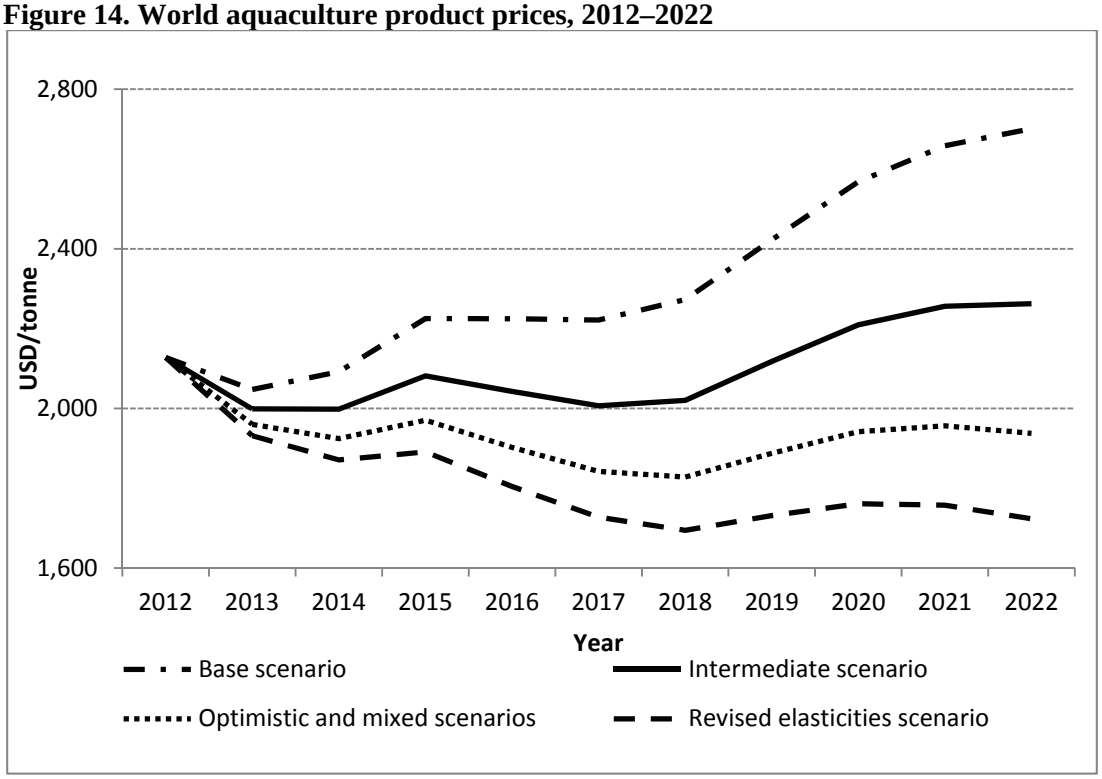
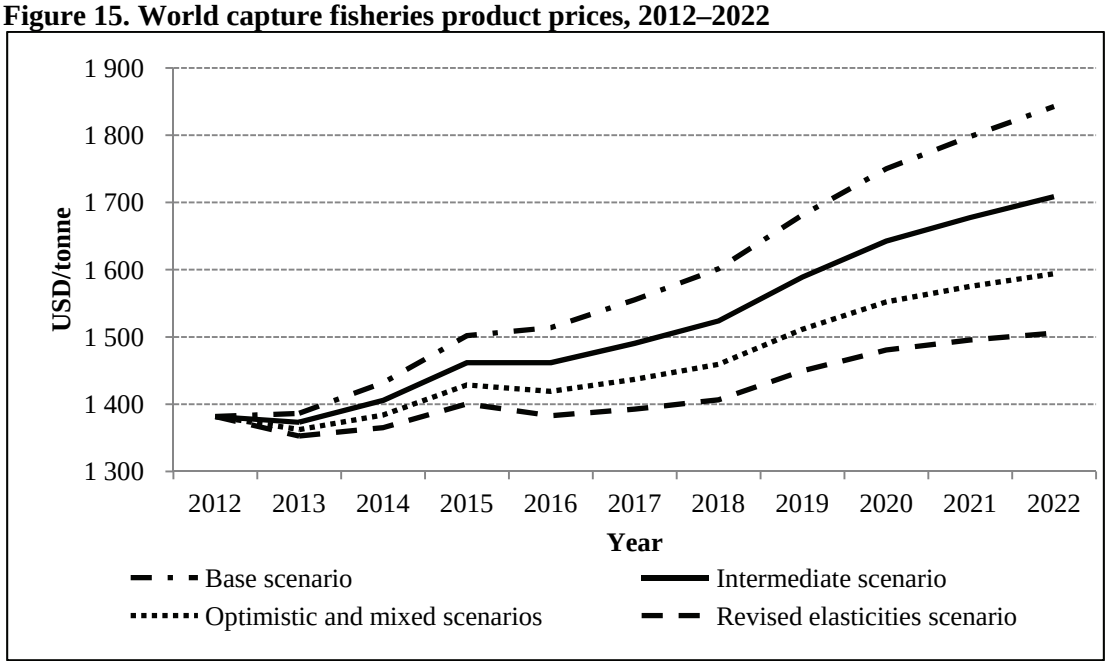


Figure 15 describes the development in product prices for capture fish in 2012–2022. Prices will gradually increase in all scenarios from a starting point of USD1 381 per tonne in 2012. In the base and the intermediate scenarios prices will reach USD1 843 and USD1 709 per tonne by 2022, which represent increases of 33 and 24 percent, respectively. In the optimistic scenario, prices will initially increase before levelling off at about USD1 400 per tonne in 2013–15 and then increase again to USD1 594 per tonne in 2022, 15 percent higher than in 2012. Predicted prices in the mixed scenario are very similar to those of the optimistic scenario. In the scenario with revised elasticities, prices will remain more or less unchanged until 2018, then increase to USD1 506 per tonne by 2022, an increase of 14.2 percent compared with 2012.

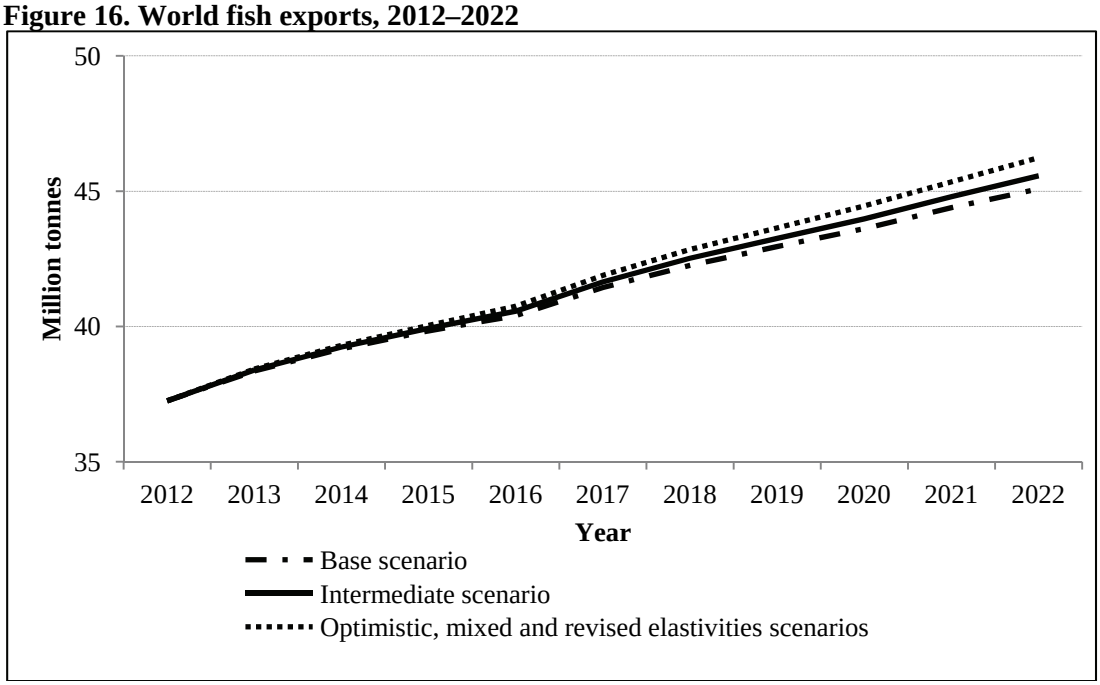
As noted above, capture fishery production is expected to increase from 91 million tonnes in 2012 to 95 million tonnes in 2022, an increase of 4.4 percent. Prices will increase in all scenarios. However, it is also important to note that the larger the increase in aquaculture production, the lower the increase in the price of capture fish. This is due to the substitutability of the products and illustrates the importance of aquaculture for the fish market as a whole.

Figure 15. World capture fisheries product prices, 2012–2022



Fish is very much an internationally traded commodity, and exports represent a substantial part of total production (Chapter 8). Figure 16 shows the development in world exports of fish in 2012–2022. In this model, fish exports are identical to fish imports over the outlook period.

Figure 16. World fish exports, 2012–2022



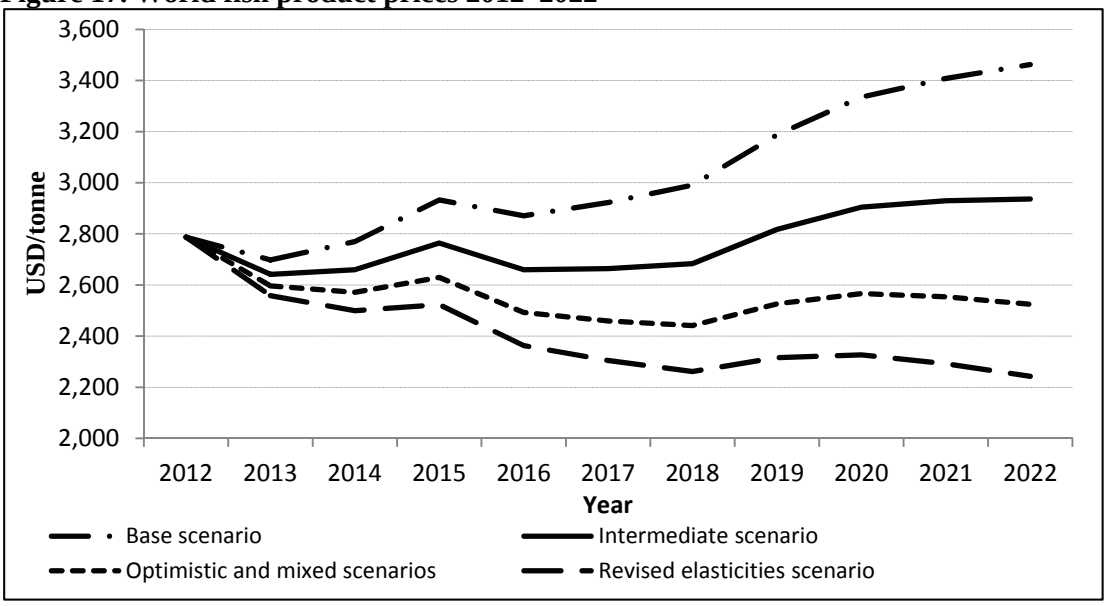
The export volume and value of fish have shown considerable growth in recent decades (Chapter 8). According to Figure 16, the export volume will continue to grow steadily to 2022 from its 2012 level of 37.2 million tonnes. It will reach 45 million tonnes in the base scenario, 45.6 million tonnes in the intermediate scenario and about 46.5 million tonnes in the optimistic, mixed and revised elasticities scenarios, representing increases of 20, 22.5 and 25 percent, respectively.

In terms of export quantity as a share of world production, 24 percent of output was exported in 2012, meaning that 76 percent was consumed in the region in which it was produced. The share of exports in world production will not change much by 2022 – 25 percent of output in the base scenario and 24 percent of output in the intermediate, optimistic, mixed and revised elasticities scenarios. For China, which exported 14.2 percent of production in 2012 and is the largest producer of fish, the difference between scenarios in 2022 is more noticeable. By 2022, it will reach 14.5 percent in the base scenario, 15.7 percent in the intermediate scenario, 16.8 percent in the optimistic scenario and 16.5 percent in the scenario with revised elasticities.

Figure 17 presents the development in the product prices for world fish in 2012–2022. The prices of all traded fish will increase in the baseline scenario from an initial USD2 787 per tonne in 2012 to USD3 462 per tonne in 2022, a price increase of 24 percent.

In the intermediate scenario, prices will initially decline until 2018 when they reach USD2 683 per tonne and then climb to USD2 936 per tonne in 2022, an increase of 5.3 percent. In the optimistic scenario, prices will decline with some fluctuations during the period to USD2 524 per tonne in 2022, a price decline of 10.4 percent. The development in prices in the mixed scenario closely follows the patterns of the optimistic scenario, with prices throughout the period being just less than 1 percent lower than those of the optimistic scenario. In the scenario with revised elasticities, prices will have declined by 2022 from an initial USD2 787 per tonne in 2012 to USD2 243 per tonne, a total decline of 24.2 percent.

Figure 17. World fish product prices 2012–2022



12.3 Fishmeal and fish oil

Fishmeal

Fishmeal is one of the main ingredients in aquaculture feed for many species and one of the main components of the cost of production, although for some species fishmeal is not used. Concerns have

been raised as to whether the availability of fishmeal might limit future expansion of aquaculture (Chapter 8).

Figure 18 describes the development in total fishmeal production for 2012–2022, i.e. fishmeal from whole fish and from by-products. Production of fishmeal in 2012 is about 6 million tonnes (Chapter 8). Production in 2022 will reach 7 million tonnes in the base scenario, 7.3 million tonnes in the intermediate scenario, 7.7 million tonnes in the optimistic scenario and 7.75 million tonnes in the mixed scenario and the scenario with revised elasticities.

However, there are some fluctuations throughout the period. Production will drop by about 300 000 tonnes in 2015 and by about 200 000 tonnes in 2020 in all five scenarios. This is due to the El Niño effect referred to above.

Figure 18. World fishmeal production, 2012–2022

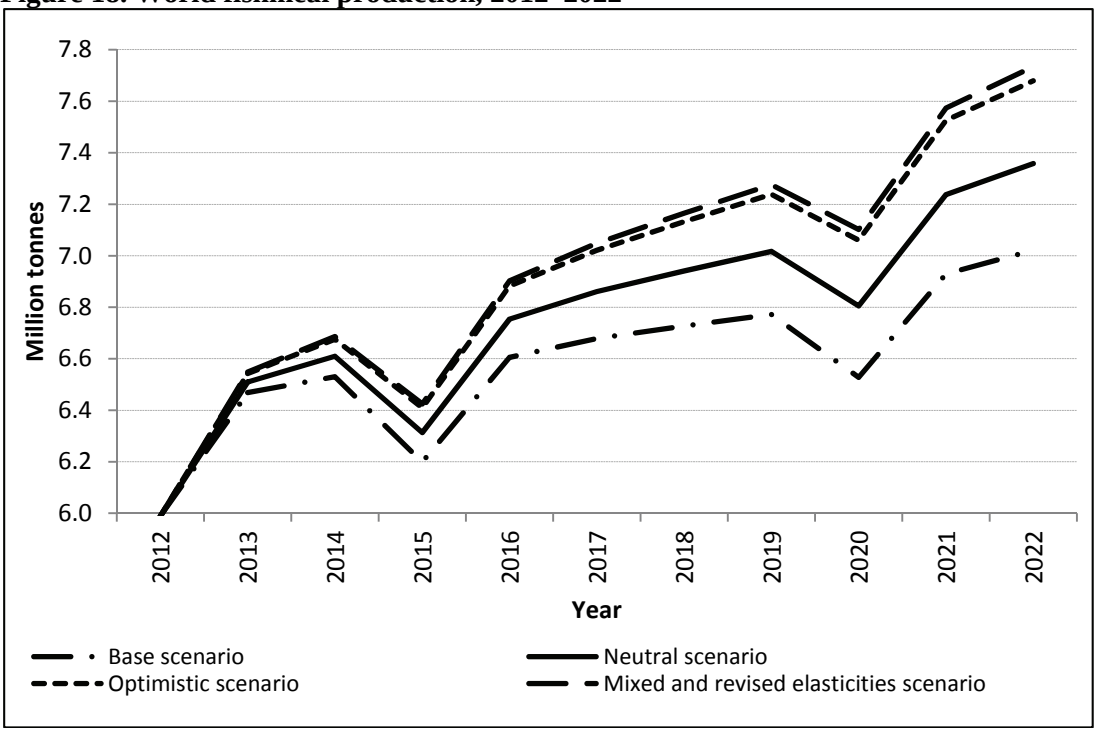
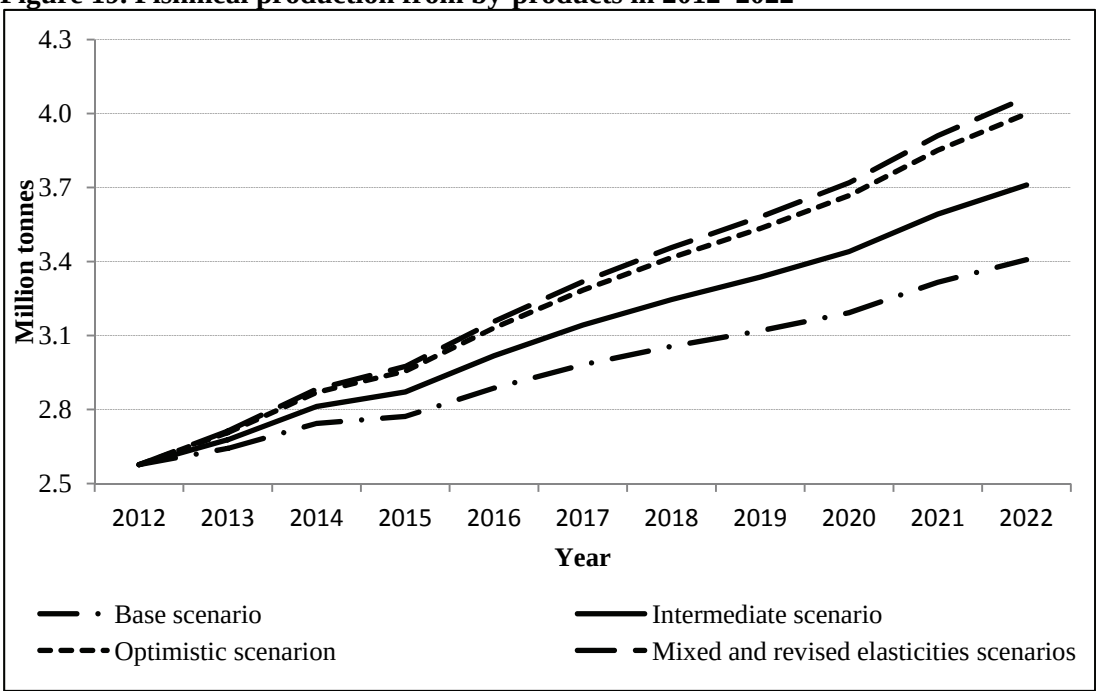


Figure 19 shows production of fishmeal from by-products. In 2012, the production of fishmeal from by-products was 2.6 million tonnes, or 43 percent of total production. Production in 2022 will reach 3.4 million tonnes in the base scenario, 3.7 million tonnes in the intermediate scenario and 4 million tonnes in the optimistic scenario, increases of 30, 42 and 53 percent, respectively. The figures in the mixed scenario and the scenario with revised elasticities are very similar to that of the optimistic scenario.

By 2022, the proportion of fishmeal from by-products in total fishmeal production will reach 49 percent in the base scenario, 51 percent in the intermediate scenario, and 52 percent in the optimistic, mixed and revised elasticities scenarios. Thus, the increase in fishmeal production will mostly come from by-product production. As noted above, the quantity of fish destined for non-food use is expected to decrease over time.

Figure 19. Fishmeal production from by-products in 2012–2022



The increased usage of by-products for fishmeal production might affect the composition and nutrients of fishmeal that will contain more minerals and less protein.

Figure 20 shows the amount of cereals (or cereal substitutes) that will be consumed as feed in aquaculture production in 2012–2022.

The use of cereals as feed will increase from 38.7 million tonnes in 2012 to 52.4 million tonnes in the base scenario, 56.9 million tonnes in the intermediate scenario and 61.1 million tonnes in the optimistic scenario, increases of 35, 47 and 57 percent, respectively. The figures in the mixed and revised elasticities scenarios with are very similar to that of the optimistic scenario.

Figure 20. Cereals consumed as feed in aquaculture, 2012–2022

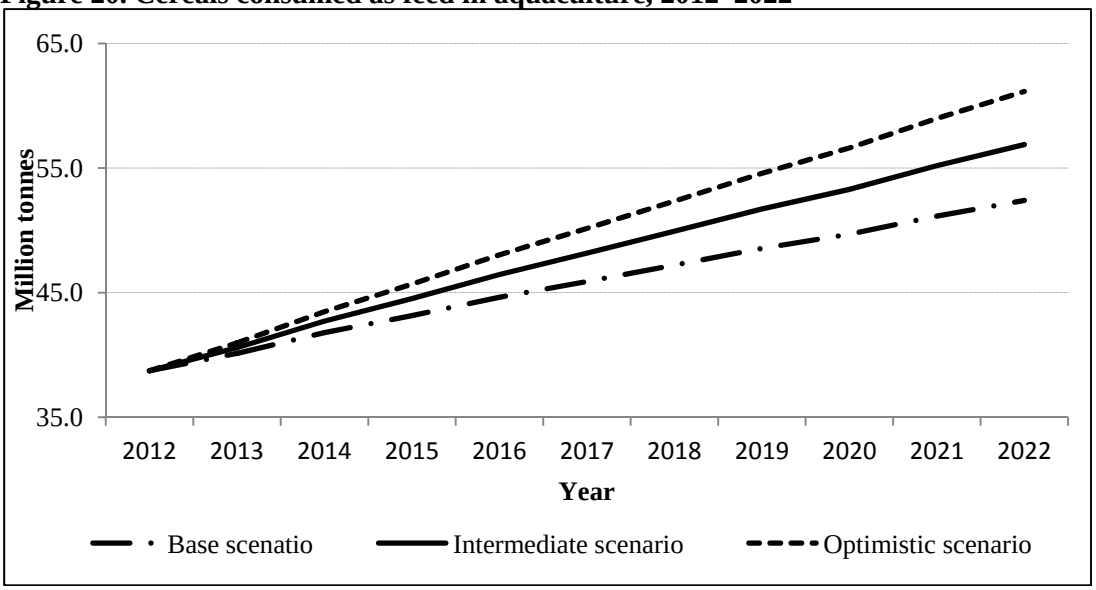


Figure 21 shows the relationship between fish produced by aquaculture and the fishmeal required in the process, for the period 2012–2022. Aquaculture production per input of one tonne of fishmeal will rise from 10 tonnes in 2012 to 12 tonnes in the base scenario, 12.5 tonnes in the intermediate scenario, 12.7 tonnes in the mixed scenario, 12.9 tonnes in the optimistic scenario and 12.8 tonnes in the revised elasticities scenario in 2022. The reason for this is that productivity is increasing owing to improved management and waste minimization. Moreover, there will be much greater use of cereals as feed in aquaculture.

Figure 21. Aquaculture production per tonne of fishmeal consumed, 2012–2022

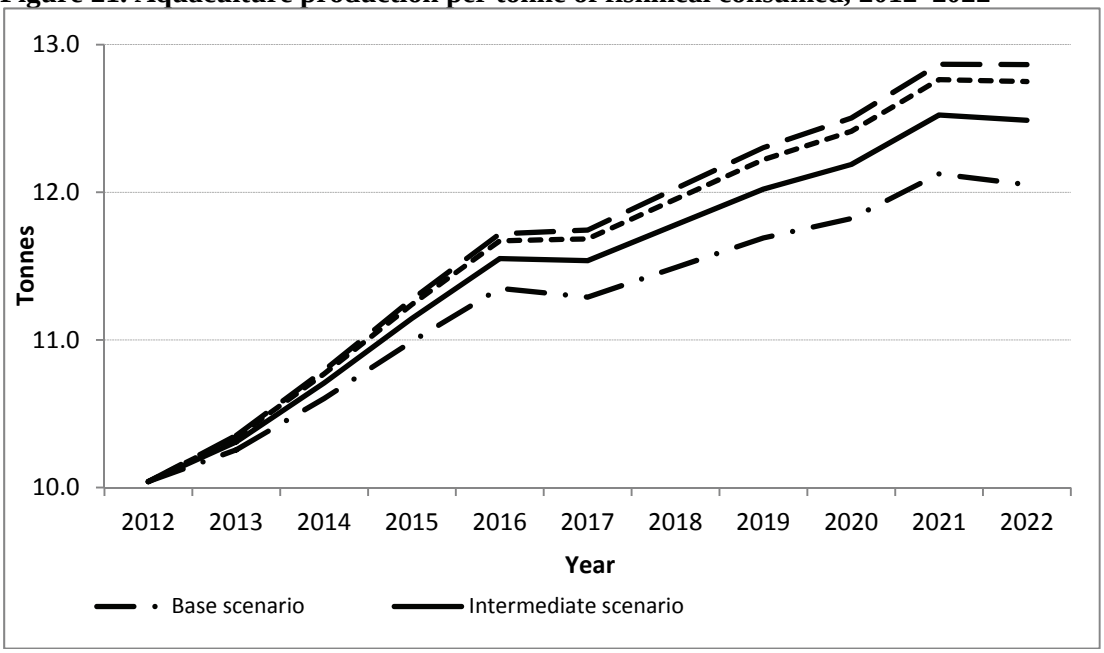
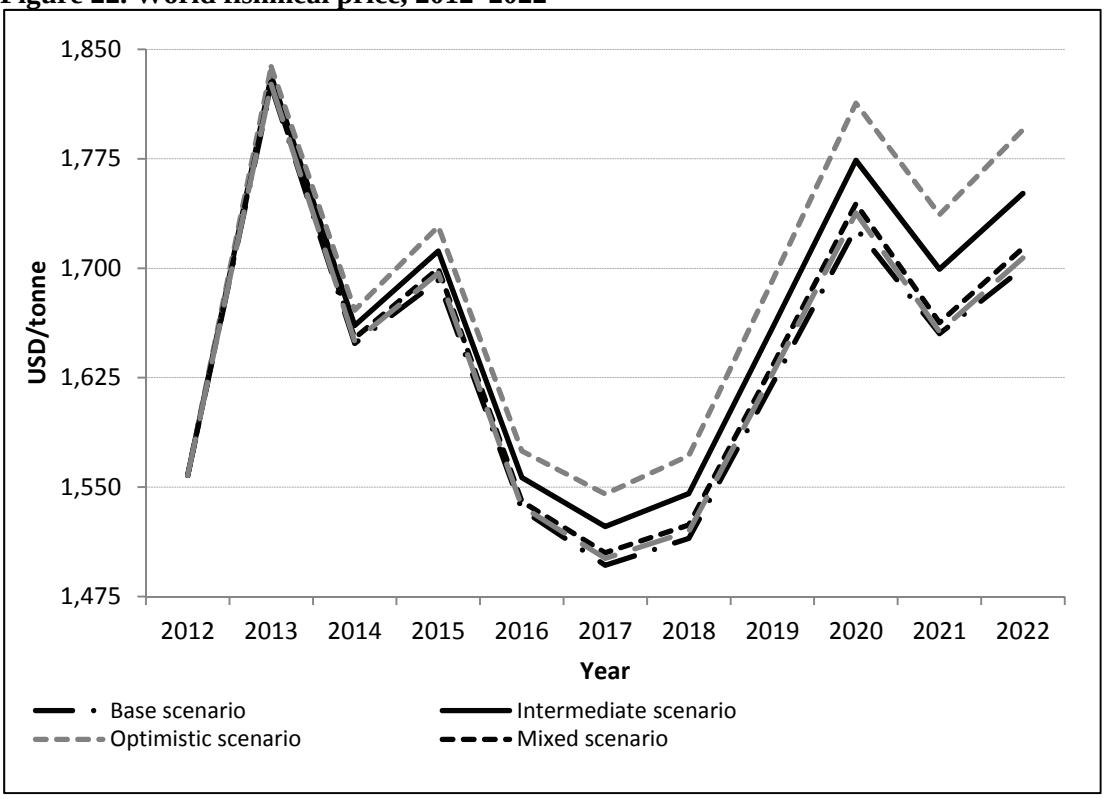


Figure 22 shows the product prices of fishmeal in 2012–2022. Qualitatively, the prices show the same patterns in all scenarios. This includes price spikes in 2013 (partly due to the general increase in feed prices resulting from the severe drought in the United States of America in the crop year 2012–13), 2015 and 2020, the latter two associated with reduced production due to the El Niño effect. The price in 2012 is USD1 557 per tonne. After the first two spikes, there will be a price decline bottoming out in 2017 at USD1 496 per tonne in the base scenario, USD1 522 per tonne in the intermediate scenario and USD1 545 tonne in the optimistic, mixed and revised elasticities scenarios. The prices will then recover and increase steeply, reaching USD1 700 per tonne in the base scenario, USD1 751 per tonne in the intermediate scenario and USD1 795 per tonne in the optimistic scenario. It is interesting to consider the development in the mixed scenario that assumes a higher growth rate of aquaculture in Asia in 2012–2022. In that case, the prices are very similar to those of the base scenario and not the optimistic scenario, as with other variables under consideration. This is consistent with the fact that species raised in Asia use much less fishmeal per unit of output than in Europe and the Americas.

Figure 22. World fishmeal price, 2012–2022



Fish oil

The use of fish oil in aquafeeds is more prevalent for higher-trophic-level finfishes and crustaceans (FAO, 2012, p. 176). Fish oil supplements rich in omega-3 fatty acids are also used in human consumption for a balanced diet. According to the International Fishmeal and Fish Oil Organisation, omega-3 fatty acids are especially important for pregnant women.

Figure 23 describes world fish oil production in 2012–2022. Production of fish oil is projected to average about 1.06 million tonnes throughout the period in all five scenarios, changing by 0.1 million from year to year. Reduced production in 2015 and 2020 is due to the El Niño phenomenon referred to above.

Figure 23. World fish oil production, 2012–2022

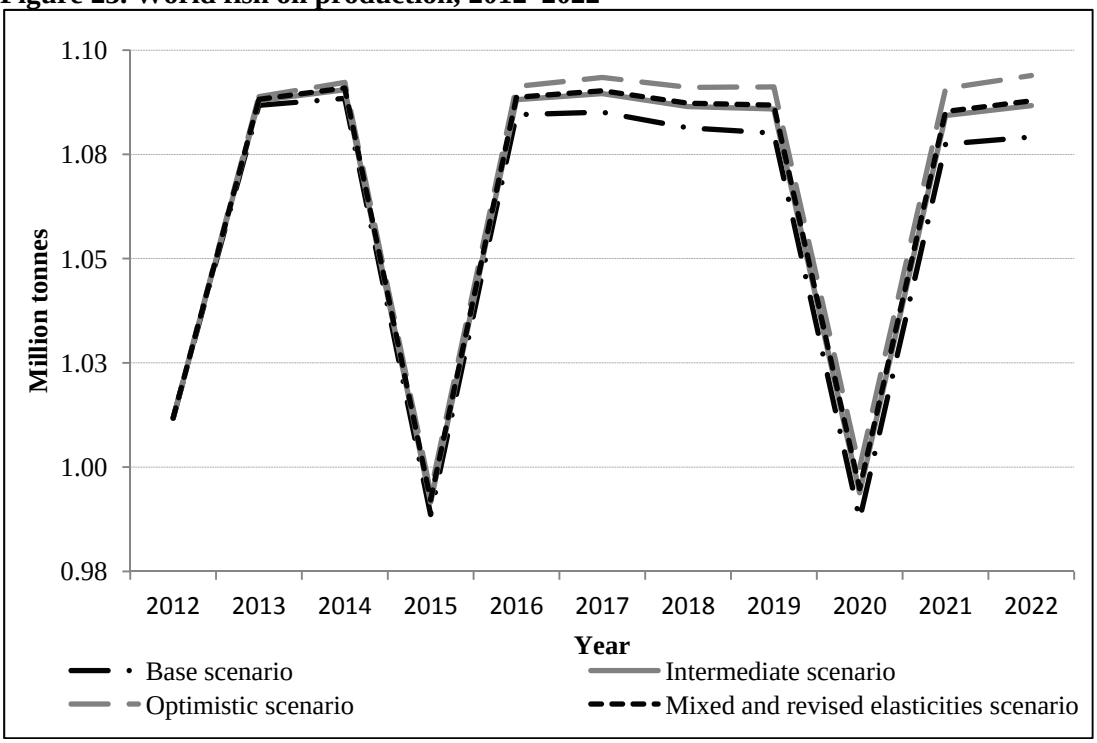


Figure 24 shows projected development in the production of fish oil from by-products in 2012–2022. The fish oil produced from by-products will increase throughout the period from 332 000 tonnes in 2012 to 377 000 tonnes in the base scenario, 379 000 tonnes in the intermediate scenario and 380 000 tonnes in the optimistic scenario. The figures in the mixed scenario and the scenario with revised elasticities are very similar to that of the base scenario.

Figure 24. World fish oil production from by-products, 2012–2022

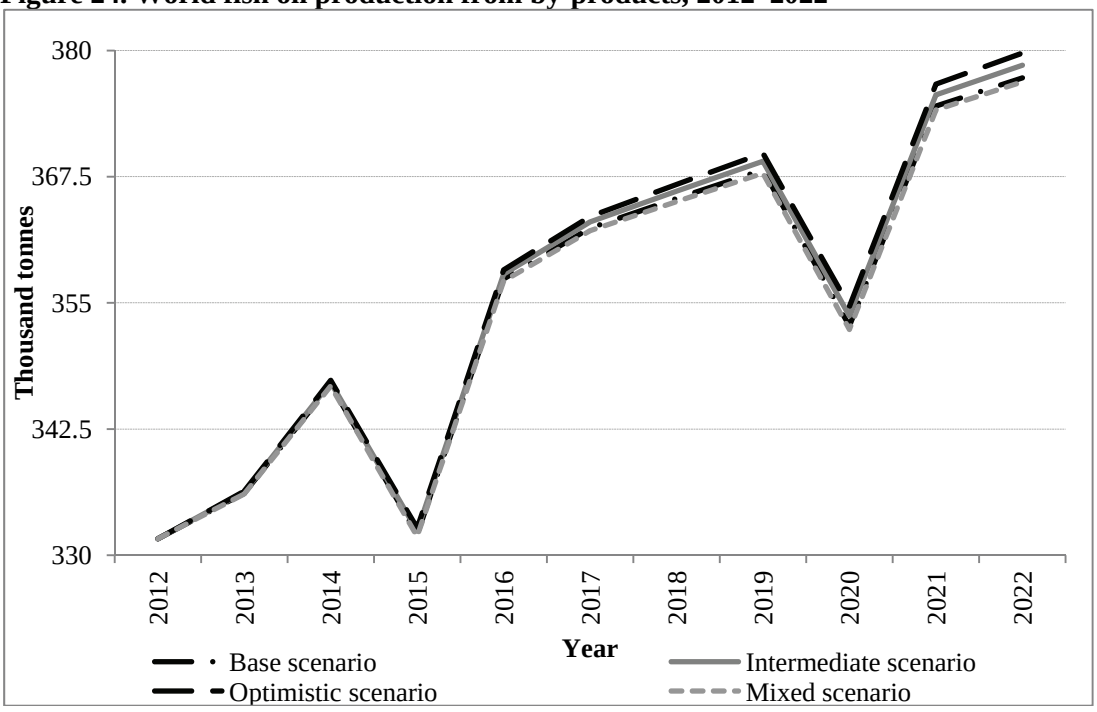
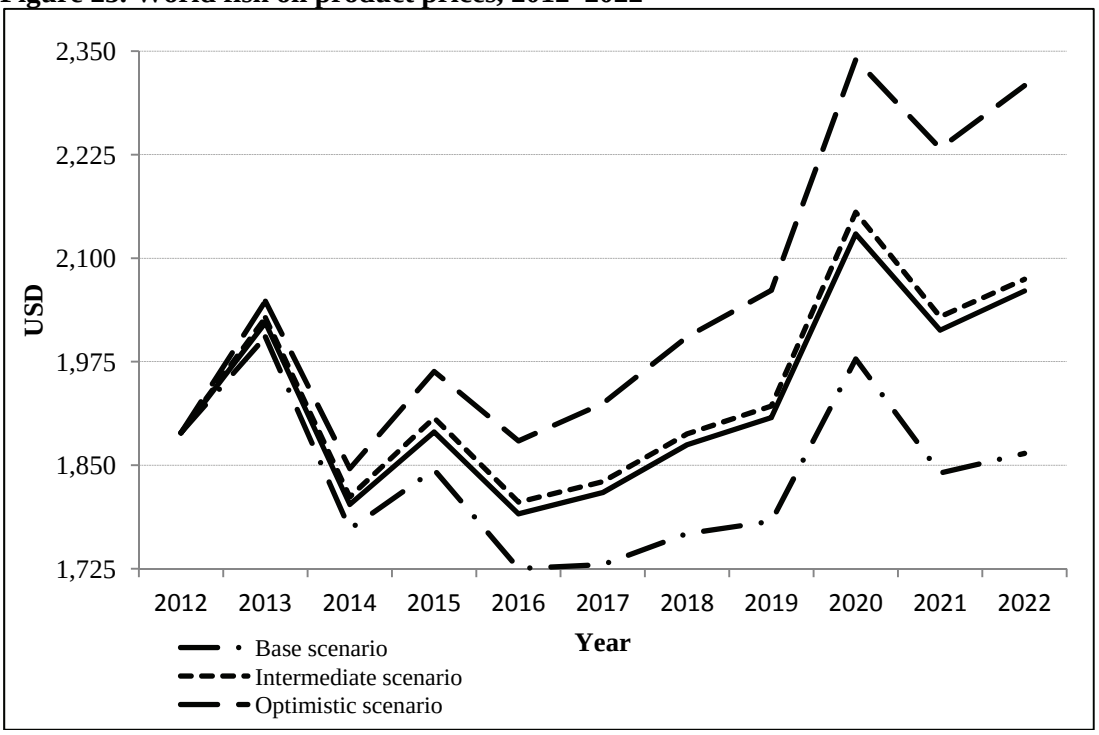


Figure 25 presents the development in fish oil prices from 2012 to 2022. The starting point here is USD1 889 per tonne in 2012. For all scenarios, there are price spikes in 2015 and 2020 in response to reduced production due to the El Niño effect. In the base scenario, prices will decrease until 2016 when they reach USD1 725 per tonne and then they will recover gradually to USD1 864 per tonne in 2022, a decrease of 1 percent from the 2012 level. In the intermediate, mixed and revised elasticities scenarios, prices will decline up to 2016 when they will stay at about USD1 800 per tonne and then rise to USD2 067 per tonne in 2022, a 9 percent increase compared with the 2012 level. In the optimistic scenario, prices will decrease in 2014 to USD1 846 per tonne and then rise to USD2 308 per tonne in 2022, an increase of 22 percent from the 2012 level.

Figure 25. World fish oil product prices, 2012–2022



Analysis

This chapter analyses various scenarios for increased aquaculture production – from a production of 66 million tonnes in 2012 to 85–99 million tonnes in 2022. In the same period, capture production is expected to increase from 91 million to 95 million tonnes. Thus, world fish production will increase from its 2012 level of 157 million tonnes to 181–194 million tonnes in 2022 depending on the assumptions. This implies that the share of aquaculture in total fish production will increase.

Per capita fish consumption was estimated at 19.1 kg in 2012. According to the results presented here, it will reach 20.7–22.4 kg in the different scenarios under consideration. In other words, per capita consumption will continue increasing fairly substantially, owing to the continued expansion in aquaculture production, despite the expected increase in population.

It is clear that the development in aquaculture prices very much depends on the expansion in aquaculture production. For the optimistic and mixed scenarios, prices will actually decline. They will decline even more in the scenario with revised elasticities, where demand is more inelastic and where income elasticities are lower than in the other scenarios.

As noted above, capture fisheries production is expected to grow from 91 million tonnes in 2012 to 95 million tonnes in 2022, an increase of 4.4 percent. Prices will increase under all scenarios.

However, it is also important to note that the larger is the increase in aquaculture production, the lower is the increase in the price of capture fish. This is due to the substitutability of the products and illustrates the importance of aquaculture for the fish market as a whole.

The analysis clearly shows that in the future, aquaculture production will drive the prices of all fish products as capture fisheries production is not expected to vary significantly.

Production of fishmeal in 2012 was about 6 million tonnes. In the base scenario, production will reach 7–7.75 million tonnes in 2022. The use of by-products for fishmeal production will rise steadily from 2.6 million tonnes in 2012 to 3.4–4 million tonnes in 2022. It is interesting to note that aquaculture production will be able to expand quite considerably despite the rather modest increase in fishmeal production. This is due to improved efficiency in the use of fishmeal, substitution to other types of feed and expansion of farmed species that require no or little fishmeal as inputs. In other words, there is no reason to believe that limited availability of fishmeal will hinder future aquaculture expansion at the world level and for all species taken together.

13. REFERENCES

Abdul-Muhmin, A.G. 2007. Explaining consumers' willingness to be environmentally friendly. *International Journal of Consumer Studies*, 31: 237–247.

Alexandratos, N. & Bruinsma, J. 2012. *World agriculture towards 2030/2050: the 2012 revision.* ESA Working Paper No. 12-03. Rome, FAO.

Andreyeva, T., Lond, M.W. & Brownell, K.D. 2010. The impact of food prices on consumption: a systematic review on research on the price elasticity of demand for food. *American Journal of Public Health*, 100: 216–222.

Aranda, M. 2009. Developments on fisheries management in Peru: the new individual quota system for the anchoveta fishery. *Fisheries Research*, 96: 308–312.

Asche, F. & Bjørndal, T. 2011. *The economics of salmon aquaculture.* Oxford, UK, Blackwell-Wiley.

Asche, F., Bjørndal, T. & Gordon, D.V. 2005. *Demand structure for fish*. SNF Working Paper No. 37/05.

Asche, F., Bjørndal, T. & Gordon, D.V. 2007. *Studies in the demand structure for fish and seafood products*. Handbook of operations research in natural resources.**Batrinou, A., Spiliotis, V. & Sakellaris, G.** 2008. Acceptability of genetically modified maize by young people. *British Food Journal*, 110(3): 250–259.

BBC. 2011. *Brazil: Amazon rainforest deforestation rises sharply* [online]. [Cited 31 December 2013]. www.bbc.co.uk/news/world-latin-america-13449792

Bertozzi, L. 1995. Designation of origin: quality and specification. *Food Quality and Preference*, 6: 143–147.

Chen, M.-F. 2008. An integrated research framework to understand consumer attitudes and purchase intentions toward genetically modified foods. British Food Journal, 110(6): 559–579.

Bredahl, L. 2001. Determinants of consumer attitudes and purchase intentions with regard to genetically modified foods: results of a cross national survey. *Journal of Consumer Policy*, 24, 23–61.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R., Zeller, D. & Pauly, D. 2009. Large-scale redistribution of the maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology*, doi: 10.1111/j.1365-2486.2009.01995.x.

Choo, H., Chung, J.-E. & Pysarchik, D.T. 2004. Antecedents to new food product purchasing behaviour among innovator groups in India. *European Journal of Marketing*, 38(5/6): 608–625.

Codron, J.M., Giraud-Héraud, E. & Soler, L.G. 2005. Minimum quality standards, premium private labels, and European meat and fresh produce retailing. *Food Policy*, 30: 270–283.

Cone Communications. 2012. *Cone Communications corporate social return trend tracker. Research & insights*. (also available at www.conecomm.com/new-csr-approach).

Conway, G. 2012. *One billion hungry; can we feed the world?* Cornell University Press.

Davidson, A., Schröeder, M.J.A. & Bower, J.A. 2003. The importance of origin as a quality attribute for beef: results from a Scottish consumer survey. *International Journal of Consumer Studies*, 27(2): 91–98.

Deloitte. 2012. *Food and beverage 2012: a taste of things to come* [online]. [Cited 30 December 2013]. www.deloitte.com/assets/Dcom-Russia/Local%20Assets/Documents/Foodandbeverage202012_web.pdf

Deaton, A. & J. Muellbauer. 1980. Economics and Consumer Behaviour, Cambridge. University Press. 450 pp.

Dey, M.M., Garcia, Y.T., Praduman, K., Piumsombun, S., Sirajul, H., Li, L., Radamn, A., Senaratne, A., Khiem, N.T. & Koeshendrajana, S. 2008. Demand for fish in Asia: a cross-country analysis. *The Australian Journal of Agricultural and Resource Economics*, 52: 321–338.

De Morais, C., Afonso, C. & De Almeida, M.D.V. 2010. Ageing and food consumption in Portugal: new or old paradigms? *British Food Journal*, 112(5): 511–521.

De Silva, D. 2011. *Value chain of fish and fishery products: origin, functions and application in developed and developing country markets.* FAO Value chain project reports. Rome, FAO. 63 pp. (also available at www.fao.org/valuechaininsmallscalefisheries/projectreports/en/).

De Silva, D.A.M. 2013. *Agricultural value chains: developing country perspective.* (mimeo).

Deaton, A. & Meullbauer, J. 1993. *Economics and consumer behaviour*. Cambridge, UK, Cambridge University Press.

Dey, M.M., Alam, M.F. & Paraguas, F.J. 2011. A multistage budgeting approach to the analysis of demand for fish: an application to inland areas of Bangladesh. *Marine Resource Economics*, 26: 35–58.

Edelman. 2012. *Edelman trust barometer 2012. Annual global study*. (also available at http://trust.edelman.com/).

Euromonitor International. 2012. *Top 10 consumer trends for 2012: weight as a hot topic* [online]. [Cited 30 December 2013]. http://blog.euromonitor.com/2012/05/top-10-consumer-trends-for-2012-weight-as-a-hot-topic.html

European Commission DG MARE. 2008. Image survey on the perception of fishery and aquaculture products, Available at:http://ec.europa.eu/fisheries/publications/studies_reports_en.htm

European Commission. 2013. Logo and labelling. In: *European Commission* [online]. [Cited 31 December 2013]. http://ec.europa.eu/agriculture/organic/consumer-confidence/logo-labelling_en

European Council. 1992. Council Regulation (EEC) No 2081/92 of 14 July 1992 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. In: *EUR-Lex* [online]. [Cited 31 December 2013]. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:
31992R2081:EN:HTML

European Council. 2006. Council Regulation (EC) No 510/2006 of 20 March 2006 on the protection of geographical indications and designations of origin for agricultural products and foodstuffs. In: *Europa* [online]. [Cited 31 December 2013]. http://europa.eu/legislation_summaries/internal_market/businesses/intellectual_property/l66044_en.htm

Fan, S. & Brzeska, J. 2012. The nexus between agriculture and nutrition: do growth patterns and conditional factors matter? *In* S. Fan & R. Pandya-Lorch, eds. *Reshaping agriculture for nutrition and health*, pp. 31–38. Washington, DC, International Food Policy Research Institute.

FAO. 2007. *The world's mangroves 1980–2005*. A thematic study prepared in the framework of Global Forest Resources Assessment. Rome (also available at ftp://ftp.fao.org/docrep/fao/010/a1427e/a1427e00.pdf).

FAO. 2009a. *Pathways to success: success stories in agriculture production and food security*. Rome. 34 pp. (also available at www.fao.org/fileadmin/user_upload/newsroom/docs/pathways.pdf).

FAO. 2009b. *Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries. Revision 1. Directives pour l'étiquetage écologique du poisson et des produits des pêches de capture marines. Révision 1. Directrices para el ecoetiquetado de pescado y productos pesqueros de la pesca de captura marina. Revisión 1.* Rome/Roma. 97 pp. (also available at www.fao.org/docrep/012/i1119t/i1119t.pdf).

FAO. 2011. *Global food losses and food waste*. Rome. 29 pp. (also available at www.fao.org/docrep/014/mb060e/mb060e00.pdf).

FAO. 2012. *The State of World Fisheries and Aquaculture*. Rome. 209 pp. (also available at www.fao.org/docrep/016/i2727e/i2727e00.htm).

FAO. 2013a. *Establishing and linking global fish-trade information networks.* Rome. 2 pp. (also available at www.fao.org/docrep/018/i2940e/i2940e04.pdf).

FAO. 2013b. *The State of Food and Agriculture 2013.* Rome. 100 pp. (also available at www.fao.org/fishery/sofia/en).

FAO. 2014. *Value chain dynamics and the small-scale sector. Policy recommendations for small-scale fisheries and aquaculture trade.* Rome. 112 pp. (also available at www.fao.org/docrep/019/i3630e/i3630e.pdf).

FAO, WFP & IFAD. 2012. *The State of Food Insecurity in the World 2012. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition.* Rome, FAO. 61 pp. (also available at www.fao.org/docrep/016/i3027e/i3027e.pdf).

FAO, WFP & IFAD .2013. *The State of Food Insecurity in the World 2013. The multiple dimension of food security.* Rome, FAO. 52 pp. (also available at www.fao.org/docrep/018/i3434e/i3434e.pdf).

FAO and World Bank. 2009. *The sunken billions. The economic justification for fisheries reform*. Agriculture and rural development. Sustainable Development Network. 100 pp. (also available at http://siteresources.worldbank.org/EXTARD/Resources/336681-1224775570533/SunkenBillions Final.pdf)

Fernández Polanco, J., Mueller, S. & Luna, L. 2013. Are Retailers' Preferences for Seafood Attributes Predictive for Consumer Wants? Results from a Discrete Choice Experiment for Seabream (*Sparus aurata*). *Aquaculture Economics and Management*. 17, 2, 1–20.

Fotopoulos, C. & Krystallis, A. 2003. Quality labels as a marketing advantage. The case of 'PDO Zagora' apples in the Greek market. *European Journal of Marketing*, 37(10): 1350–1374.

Foresight. 2011. *The future of food and farming. 2011. Final project report*. London, The Government Office for Science. (also available at www.bis.gov.uk/assets/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf).

Frederiksen, M. & Gram, L. 2003. Traceability. *In* H.H. Huss, L. Ababouch & L. Gram. *Assessment and management of seafood safety and quality*, pp. 210–215. FAO Fisheries Technical Paper No. 444. Rome, FAO. 230 pp. (also available at www.fao.org/docrep/006/y4743e/y4743e0p.htm).

Gagnon, M, Freudenberg, N. & Corporate Accountability International. 2012. *Slowing down fast food: a policy guide for healthier kids and families.* Boston, USA, Corporate Accountability International. (also available at www.StopCorporateAbuse.org).

Gaskell, G., Brauer, M., Durant, J. & Allum, N. 1999. Worlds apart? The reception of genetically modified foods in Europe and the US. *Science*, 295(5426): 384–387.

Gómez, M.I. & Ricketts, K. 2012. Food value chains and policies influencing nutritional outcomes.

Grunert, K.G., Lahteenmaki, L., Nielsen, N.A., Poulsen, J.B., Ueland, O., & Astrom, A. 2001. Consumer perceptions of food products involving genetic modification: results from a qualitative study in four Nordic countries. *Food Quality and Preference*, 12, 527-542.Background paper for The State of Food and Agriculture 2013: Food systems for better nutrition. Rome, FAO.

Hamilton, J., Knox, B., Hill, D. & Parr, H. 2000. Reduced fat products – consumer perceptions and preferences. *British Food Journal*, 102(7): 494.

Hatanaka, M., Bain, C. & Busch, L. 2005. Third-party certification in the global agrifood system. *Food Policy*, 30(3): 354–369.

Hartmann, A. 2012. Scaling up Value Chains for Pro-Poor Development. Washington D.C., International Food Policy Research Institute.

Hoffman, B. 2012. *Three consumer trends will change what we eat* [online]. [Cited 30 December 2013]. www.forbes.com/sites/bethhoffman/2012/11/29/three-consumer-trends-will-change-what-we-eat/

Hoffman, R. 2000. Country of origin – a consumer perception perspective of fresh meat. *British Food Journal*, 102: 211–229.

Hogan, L. & Thorpe, S. 2009. *Issues on food miles and labeling*. ABARE research report 09.18. Canberra.

Hosken, D & D. Reiffen. 2004. How Retailers Determine Which Products Should Go on Sale: Evidence from Store-Level Data. Journal of Consumer Policy, 27, 2, 141–177.

Houthakker, H.S. 1957. An international comparison of household expenditure patterns, commemorating the centenary of Engel's law. *Econometrica*, 25: 532–551.

International Food Plicy Report Institute (IFPRI). 2012. *2011 Global Food Policy Report*". International Food Policy Research Institute, Washington, DC http://www.ifpri.org/gfpr/2011

International Food Policy Research Institute (IFPRI). 2013. *2012 Global Food Policy Report*. Washington, DC. 130 pp.

Jabbar, M.A. & Admassu, S.A. 2010. Assessing consumer preferences for quality and safety attributes of food in the absence of official standards: the case of beef, raw milk and local butter in Ethiopia. *In* M.A. Jabbar, D. Baker & M.L. Fadiga, eds. *Demand for livestock products in developing countries with a focus on quality and safety attributes: evidence from Asia and Africa*, pp. 38–58. ILRI Research Report 24. Nairobi, International Livestock Research Institute.

Jabbar, M.A., Baker, D. & Fadiga, M.L., eds. 2010. *Demand for livestock products in developing countries with a focus on quality and safety attributes: evidence from Asia and Africa*. ILRI Research Report 24. Nairobi, International Livestock Research Institute.

Jaffry, S., Pickering, H., Ghulam, Y., Whitmarsh, D. & Wattage, P. 2004. Consumer choices for quality and sustainability labeled seafood products in the UK. *Food Policy*, 29: 215–228.

Janssen, M., Hamm, Ulrich. 2012. The mandatory EU logo for organic food: consumer perceptions (2012). *British Food Journal* 114.3: 335–352.

Johnston, R.J. & Roheim, C.R. 2006. A battle of taste and environmental convictions for ecolabeled seafood: a contingent ranking experiment. *Journal of Agricultural and Resource Economics*, 31: 283–300.

Johnston, R.J., Wessells, C.R., Donath, H. & Asche, F. 2001 Measuring consumer preferences for ecolabeled seafood: an international comparison. *Journal of Agricultural and Resource Economics*, 26: 20–39.

KC, S. 2010. Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. 2010. Research Article. *Demographic Research* - a free, expedited, online journal (also available at http://www.demographic-research.org/Volumes/Vol22/15).

Kelleher, K. 2005**.** *Discards in the world's marine fisheries. An update*. FAO Fisheries Technical Paper No. 470. Rome, FAO. 131 pp.

Khoja, S. & Pirzada, I.A. 2009. An analysis of Engel's Law: comparative countries study. *Proc. 5th International Statistical Conference*, 17: 147–152.

Kim, R. 2008. Japanese consumer's use of extrinsic and intrinsic cues to mitigate risky food choices. *International Journal of Consumer Studies*, 32: 49–58.

Kupiec, B. & Revell, **B.** 2001. Measuring consumer quality judgements. *British Food Journal*, 103(1): 7.

Kurien, J. 2005. *Responsible fish trade and food security*. FAO Fisheries Technical Paper No. 456. Rome, FAO. 102 pp.

Larson, R.B. 1998. Regionality of food consumption. *Agribusiness*, 14(3): 213–226.

Leipämaa-Leskinen, H. 2007. Contradictions in food consumption. *International Journal of Consumer Studies*, 31: 597–602.

Lin, C.T.J. & Milon, J.W. 1993. Attribute and safety perceptions in a double-hurdle model of shellfish consumption. *American Journal of Agricultural Economics*, 75(3): 724–729.

Lippincott Mercer. 2006. *Serving the climate-change-conscious consumer*. Summary report based on consumer research in the UK and U.S.

Loureiro, M.L. & McCluskey, J.J. 2000. Assessing consumer response to protected geographical identification labeling. *Agribusiness*, 16(3): 309–320.

Loureiro, M.L. & Hine, S. 2004. Preference and willingness to pay for GM labeling policies. *Food Policy*, 29: 467–483.

Lutz, W. & Samir, K.C. 2010. *Review. Global population projections*. The Royal Society Publishing.

Lutz, W., Crespo Cuaresma, J. & Sanderson, W. 2008. The demography of educational attainment and economic growth. *Science*, 319: 1047–1048.

Magnusson, M, Arvola A, Hursti U, Aberg L & Sjoden, P. 2001. Attitudes towards organic foods among Swedish consumers. *British Food Journal*, 103(3), 209–226.

Marette, S., Roosen, J. & Blanchemanche, S. 2008. Health information and substitution between fish: lessons from a laboratory and field experiments. *Food Policy*, 33: 197–208.

MarketLine. 2012. Organic food: world market overview (market size, segmentation and trends analysis). In: *ReportLinker* [online]. [Cited 31 December 2013]. www.reportlinker.com/p0188829/Organic-Food-Global-Industry-Guide.html

Mata no Peito. 2013. *Mata no Peito* [online]. [Cited 31 December 2013]. http://matanopeito.org/

McKean, J.D. 2001. The importance of traceability for public health and consumer protection. Revue Scientifique et technique de l'Office International des Epizooties 20, 363–371

Minten, B. 2008. The food retail revolution in poor countries: is it coming or is it over? *Development and Cultural Change*, 56(4): 767–789.

Mittaine, J. F. 2012. World fishmeal and oil supply/demand and outlook for market trends. In: 7th JCI Spring Conference on Chinese feed raw materials market. Hainan, China. March 22–23, 2012.

Muhammad, A., Seale, J.L., Meade, B. & Regmi, A. 2013. *International evidence on food consumption patterns: an update using 2005 international program data.* TB-1929. U.S. Dept. of Agriculture, Econ. Res. Serv. March 2011. Revised February 2013.

Nayga, R.M. 1999. Toward an understanding of consumer's perceptions of food labels. *International Food and Agribusiness Management Review*, 2(1): 29–45.

Nayga, R.M. 2000, Nutrition knowledge, gender and food label use. *Journal of Consumer Affairs*, 34(1): 97–112.

Organisation for Economic Co-operation and Development (OECD). 2012. *Obesity update 2012* [online]. [Cited 30 December 2013]. www.oecd.org/health/49716427.pdf

OECD–FAO. 2011. *OECD–FAO Agricultural Outlook 2011-2020*. OECD Publishing and FAO. (also available at http://dx.doi.org/10.1787/agr_outlook-2011-en).

OECD/FAO. 2012. *OECD–FAO Agricultural Outlook 2012-2021*. OECD Publishing and FAO. (also available at http://dx.doi.org/10.1787/agr_outlook-2012-en).

OECD–FAO. 2013. *OECD–FAO Agricultural Outlook 2013-2022*. OECD Publishing and FAO. (also available at http://dx.doi.org/10.1787/agr_outlook-2013-en).

Orth, U.R. & Firbasová, Z. 2003. The role of consumer ethnocentrism in food product evaluation. *Agribusiness*, 19(2): 137–153.

Pascal, G. and S. Mahé 2001. Identity, traceability, acceptability and substantial equivalence of food. Cellular and Molecular Biology 47, 1329–1342.

Quagrainie, K., Hart, S. & Brown, P. 2008. Consumer acceptance of locally grown food: the case of Indiana aquaculture products. *Aquaculture Economics & Management*, 12(1): 54–70.

Reardon, T. & Barrett, C. 2000. Agroindustrialization, globalization, and international development: an overview of issues, patterns, and determinants. *Agricultural Economics*, 23(3): 195–205.

Reardon, T. & Timmer, C.P. 2012. The economics of the food system revolution. *The Annual Review of Resource Economics*, 4: 225–264.

Reardon, T., Chen, K., Minten, B. & Adriano, L. 2012. *The quiet revolution in staple food value chains: Enter the dragon, the elephant and the tiger*. Mandaluyong City, Philippines, Asian Development Bank.

Roheim C. A. 2008. The economics of ecolabeling. *In* T. Ward & B. Phillips, eds. *Seafood ecolabelling principles and practice*. Oxford, UK, Wiley - Blackwell.

Roheim, A.C, Asche, F. & Santos, J.I. 2011. The elusive price premium for ecolabelled products: evidence from seafood in the UK market *Journal of Agricultural Economics.* (also available at http://dx.doi: 10.1111/j.1477-9552.2011.00299.x).

Sanjuan, A. I., Sánchez, M., Gil, J. M., Gracia, A. & F. Soler. 2003. Brakes to organic market enlargement in Spain: consumers' and retailers' attitudes and willing to pay. *International Journal of Consumer Studies*, 27, 2, 134–144.

Sapp, S.G. 2003. A comparison of alternative theoretical explanations of consumer food safety assessments. *International Journal of Consumer Studies*, 27, 1, 34–39.

Scarpa, R., Philippidis, G. & Spalatro, F. 2005. Product-country images and preference heterogeneity for Mediterranean food products: a discrete choice framework. *Agribusiness*, 21(3): 329–349.

Sharma, S., Shimp, T.A. & Shin, J. 1995. Consumer ethnocentrism: a test of antecedents and moderators. *Journal of the Academy of Marketing Science*, 23(1): 26–37.

Schipmann, C. & Qaim, M. 2010. Spillovers from modern supply chains to traditional markets: product innovation and adoption by smallholders. *Agricultural Economics*, 41(3/4): 361–371.

Shepherd, C.J. 2013. Aquaculture: are the criticisms justified? Feeding fish to fish. *World Agriculture* (mimeo).

Shepherd, C.J. & Jackson, A.J. 2013. Global fishmeal and fish oil supply - inputs, outputs and markets. *Journal of Fish Biology*. Manuscript number SIWFC 12-001R1.

Shimp, T.A. & Sharma, S. 1987. Consumer ethnocentrism: construction and validation of the CETSCALE. *Journal of Marketing Research*, 24: 280–289.

Siegrist, M., Stampfli, N. & Kastenholz, H. 2009. Acceptance of nanotechnology foods: a conjoint study examining consumers' willingness to buy. *British Food Journal*, 111(7): 660–668.

Singh, K., Dey, M.M. and Surathkal, P. 2012. Analysis of a Demand System for Unbreaded Frozen Seafood in the United States Using Store-level Scanner Data. Marine Resource Economics 27: 371-387.

Skytte, H. & Bove, K. 2004. The concept of retailer value: a means-end chain analysis. *Agribusiness*, 20(3): 323–345.

Smith, M.D., Roheim, C.A., Crowder, L.B., Halpern, B.S., Turnipseed, M., Anderson, J.L., Asche, F., Bourillón, L., Guttormsen, A.G., Kahn, A., Liguori, L.A., McNevin, A., O'Connor, M., Squires, D., Tyedemers, P., Brownstein, C., Carden, K., Klinger, D., Sagarin, R. & Selkoe, K.A. 2010. Sustainability and global seafood. *Science*, 327: 784–786.

Tacon, A.G. & Metian, M. 2008. Global overview on the use of fishmeal and fish oil in industrially compounded aquafeeds: trends and future prospects. *Aquaculture*, 285: 146–158.

Thogersen, J. 2000. Psychological determinants of paying attention to eco-labels in purchase decisions: model development and multinational validation. *Journal of Consumer Policy*, 23(3): 285–313.

Timmer, C.P. 1981. Is there curvature in the Slutsky matric? Review of Economics and Statistics 63: 395-402.

Trench, P.C., Narrod, C., Roy, D. & Tiongco, M. 2012. Responding to health risks along the value chain. *In* S. Fan & R. Pandya-Lorch, eds. *Reshaping agriculture for nutrition and health*, pp. 93–102. Washington, DC, International Food Policy Research Institute.

United Nations. 2011. *World Population Prospects: The 2010 Revision, Highlights and Advance Tables.* Working Paper No. ESA/P/WP.220. Department of Economic and Social Affairs, Population Division.

United Nations. 2013. *A new global partnership: eradicate poverty and transform economies through sustainable development.* The Report of the High Level Panel of Eminent Persons on the Post-2015 Development Agenda.

UN-HABITAT. 2008. State of the World's Cities 2008/2009. UN-HABITAT.

UNPD. 2007. World urbanisation prospects, the 2007 revision. New York, NY: United Nations Population Division

Washington S. 2008. Ecolabels and marinne capture fiheries: current practice and emerging issues. Globefish Research Programme, Vol.91 Rome, FAO. p. 52

Wanyoike, F., Kaitibie, S., Kuria, S., Bruntse, A., Thendiu, I.N., Mwangi, D.M. & Omore, A. 2010. Consumer preferences and willingness to pay for improved quality and safety: the case of fresh camel milk and dried camel meat (nyir nyir) in Kenya. *In* M.A. Jabbar, D. Baker & M.L. Fadiga, eds. *Demand for livestock products in developing countries with a focus on quality and safety attributes: evidence from Asia and Africa*, pp. 93–102. ILRI Research Report 24. Nairobi, International Livestock Research Institute.

Wessells, C.R., Johnston, R.J. & Donath, H. 1999. Assessing consumer preferences for ecolabeled seafood: The influence of species, certifier, and household attributes. *American Journal of Agricultural Economics*, 81(5): 1084–1089.**Worldwatch Institute.** 2013. *Local food: a holiday recipe that's better for you, for farmers, and for homeland security* [online]. [Cited 31 December 2013]. www.worldwatch.org/local-food-holiday-recipe-thats-better-you-farmers-and-homeland-security

Yeung, R.M.W. & Morris, J. 2006. An empirical study of the impact of consumer perceived risk on purchase likelihood: a modeling approach. *International Journal of Consumer Studies*, 30: 294–305.

Yeung, R.M.W. & Yee, W.M.S. 2003. Risk reduction: an insight of the UK poultry industry. *Nutrition and Food Science*, 32: 219–226.

14. APPENDIX

14.1 Demand elasticities for scenario 5

Country	Own price elasticity	Notes	Alternative own price elasticity	Income elasticity	Notes	Alternative income elasticity
Other North Africa	–0.7	CP	–0.444	0.65	GDPI	0.605
Argentina	–0.7	CP	–0.389	0.55	GDPI	0.53
Other Asia	–0.55	CP	–0.382	0.5	GDPI	0.521
Australia	–1.5	CP	–0.279	0.65	GDPI	0.38
Bangladesh	–0.86	CP	–0.490	1.31	GDPI	0.667
Brazil	–0.7	CP	–0.419	0.85	GDPI	0.571
Canada	–0.54	CP	–0.271	0.8	GDPI	0.369
Chile	–0.9	CP	–0.402	0.9	GDPI	0.548
China	–0.5	CP	–0.480	0.6	GDPI	0.654
Colombia	–0.7	CP	–0.432	0.65	GDPI	0.589
Algeria	–0.7	CP	–0.444	0.65	GDPI	0.605
Egypt	–0.7	CP	–0.434	0.65	GDPI	0.592
Other Eastern Europe	–0.7	CP	–0.382	0.4	GDPI	0.521
Other Western Europe	–0.7	CP	–0.254	0.65	GDPI	0.346
Indonesia	–0.87	CP	–0.456	1.1	GDPI	0.621
India	–0.88	CP	–0.484	1.1	GDPI	0.66
Iran (Islamic Republic of)	–0.7	CP	–0.395	0.65	GDPI	0.539
Israel	–0.2	CP	–0.328	0.1	GDPI	0.447
Japan	–0.55	CP	–0.279	0.5	GDPI	0.38
Kazakhstan	–0.7	CP	–0.403	0.65	GDPI	0.55
Republic of Korea	–0.7	CP	–0.351	0.65	GDPI	0.479
Mexico	–0.7	CP	–0.371	0.65	GDPI	0.506
Other Near East	–0.7	CP	–0.382	0.65	GDPI	0.521
Malaysia	–0.98	CP	–0.422	0.65	GDPI	0.576
Norway	–0.5	CP	–0.267	0.5	GDPI	0.364
New Zealand	–0.5	CP	–0.299	0.5	GDPI	0.407
Pakistan	–0.5	CP	–0.463	0.45	GDPI	0.632
Peru	–0.9	CP	–0.425	0.65	GDPI	0.579
Philippines	–1.41	CP	–0.455	1.09	GDPI	0.62
Russian Federation	–0.55	CP	–0.390	0.45	GDPI	0.532
Other South America and Caribbean	–0.7	CP	–0.382	0.65	GDPI	0.521
Saudi Arabia	–0.7	CP	–0.401	0.65	GDPI	0.546
Thailand	–0.73	CP	–0.433	0.45	GDPI	0.591
Turkey	–0.7	CP	–0.409	0.65	GDPI	0.558
Ukraine	–0.7	CP	–0.418	0.65	GDPI	0.57
South Africa	–0.7	CP	–0.415	0.5	GDPI	0.566
EU27	–0.5	CPI	–0.278	0.5	GDPI	0.379
United States of America	–0.5	CPI	–0.191	0.5	GDPI	0.26
LDC sub-Saharan Africa	–0.7	PP	–0.480	0.35	GDPI	0.654
Other sub-Saharan Africa	–0.7	PP	–0.480	0.65	GDPI	0.654
LDC Asia	–0.6	PP	–0.480	0.65	GDPI	0.654
Ghana	–0.7	PP	–0.500	0.65	GDPI	0.682
Nigeria	–0.7	PP	–0.489	0.55	GDPI	0.667
United Republic of Tanzania	–0.35	PP	–0.504	0.3	GDPI	0.687
Viet Nam	–0.6	PP	–0.484	0.65	GDPI	0.659

Source: Muhammad *et al.* (2013), appendix Table 6 for own price elasticity and appendix Table 5 for income elasticity.

The country specification in Muhammad *et al.* (2013) is not the same as in OECD–FAO (2013). The following assumptions have been made:

- For “other North Africa”, average elasticities for Tunisia and Morocco have been used.
- As Muhammad *et al.* (2013) do not report elasticities for Algeria, the values for “other North Africa” have been used.
- For “other Western Europe”, elasticities for Switzerland have been used.
- For LDC sub-Saharan Africa, other sub-Saharan Africa and LDC Asia, averages for low-income countries have been used.
- For other Asia, other Eastern Europe, other Near East and other South America and Caribbean, average for middle-income countries has been used.
- For EU27, average for high-income countries has been used.

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