Chapter 1

World food and agriculture to 2030/2050 revisited. Highlights and views four years later[1]

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This chapter sketches out the possible evolution of world food and agriculture to 2050 in terms of key variables: production and consumption of the main commodity groups; and the implications for food and nutrition in developing countries. It presents a view of how these variables may evolve over time, not how they should evolve from the normative perspective of solving problems of nutrition and poverty. The chapter's contents are based on food and agriculture projections to 2015, 2030 and 2050, prepared in the years 2003 to 2005 and published in 2006 (FAO, 2006 – hereafter referred to as the Interim Report [IR]). The main findings from Chapter 1 of the IR (Overview) are attached as Annex 1.2. The reader is referred to the full IR for details.

The IR projections were based on historical data from the complete FAO (FAOSTAT) food balance sheets (FBS) available for all countries. The FBS data then available went up to 2001, so the base year for the projections was the three-year average for 1999 to 2001. The projected rainfed and irrigated land use and yield configurations underlying the production projections were not evaluated against the land and water potentials of each country at that time. The latest attempt in this area dates from work carried out in 2000 to 2002, with projections going to 2030 from base year 1997/1999 and published in 2003 (Bruinsma, 2003), using the land potential estimates from an older edition of the Global Agroecological Zones Study (GAEZ) of FAO and the International Institute for Applied Systems Analysis (IIASA) (Fischer *et al.,* 2002). The IR evaluation was delayed by waiting for fresh estimates of such potentials to be produced for the revised GAEZ. These estimates from the new GAEZ are currently being prepared for publication (Fischer, van Velthuizen and Nachtergaele, forthcoming), but are not yet available in the format required for use in analyses of the IR-type. In the

1. The author thanks colleagues in FAO's Markets and Trade Division for making available the preliminary results of their ongoing work on the projections for the 2009 OECD/FAO Agricultural Outlook.

meantime, an attempt has been made to unfold the land-use and yield growth implications of the production projections to 2030/2050 of the IR using the old GAEZ estimates of land potentials. These are presented in Chapter 6.

Naturally, presenting in mid-2009 projections completed in 2005 and based on historical data up to 2001 and on the outlook for key exogenous variables (population and GDP projections) as known at that time presents some problems. The last few years have witnessed upheavals, and these must be taken into account in passing judgement regarding the relevance today of views into the future from four years ago. In the first place, the energy markets have intruded into those for agricultural produce, via high energy prices and the boost these gave to the demand for crops as biofuel feedstocks, helped by government policies favouring such use of crops. It is now widely accepted that this was a key factor explaining the food price surges up to mid-2008. Second, the overall economic outlook is being severely affected by the ongoing economic crisis, although the issue of how important this may prove to be in the longer term is moot. In addition, the latest demographic assessments (from 2006) (UN, 2007) and the just-released assessment for 2008 suggest that projected populations to 2050 may be higher than those of the 2002 assessment (UN, 2003) used in the IR, particularly in several countries of sub-Saharan Africa.[2]

It would be desirable to account for these new circumstances by redoing the entire projections exercise. This proved practically impossible, however, given the great country and commodity detail involved (FAO, 2006: 66–68) and the delay in updating FAO's FBS data (Box 1.1). The second best option is to review the IR projections on the basis of the FAO data set used predominantly for current monitoring, and published (for major countries and aggregates only) in the six-monthly *Food Outlook,* and also for the annual OECD/FAO medium-term projections (hereafter referred to as the country balance sheets [CBS] data).[3] The current round of these medium-term projections for the ten years 2009 to 2018 has just been completed (OECD/FAO, 2009).[4] These projections *ex-hypothesi* incorporate all the information currently available concerning developments in the last few years and views of what may be in store up to the year 2018 in terms of the overall economy, the energy sector and prices. As such, the projections provide a valid benchmark for comparison with those of the IR to draw inferences

2. World population was projected to reach 8.9 billion by 2050 in the 2002 assessment, and 9.2 billion in the latest 2008 assessment. The IR projections for developing countries of sub-Saharan Africa are 1.5 billion and 1.7 billion, respectively.

3. CBS is a database maintained by the Trade and Markets Division of FAO. The CBS data used here were updated on 3 July 2009.

4. Data and projections available at www.agri-outlook.org/document/6/0,3343,en_36774715_36775671_40969158_1_1_1_1,00.html.

about the continued validity, or otherwise, of these IR projections. Comparability is limited by differences in commodity coverage/specifications and in the country groups distinguished (Box 1.1). However, some comparisons at the level of large country aggregates (developing, developed, world) can be made to provide a reality check of the IR projections. Regional-level projections are presented in the section on Food consumption and nutrition in developing countries.

Box 1.1 - The data situation

Before proceeding, a note on the data situation is in order. Projections published in the IR and previous work were based exclusively on FAO's FAOSTAT data sets of production and trade of all commodities, including non-food ones such as cotton and rubber, as they had been standardized and processed into the supply utilization accounts (SUAs) and the FBS. Revisiting these projections in mid-2009, to take account of recent developments, required inspecting them against SUA/FBS data updated to a more recent year, as many changes had occurred owing to the advent of biofuels and the surge in food prices. However, such data were not yet available: at the time of writing (May 2009) FAO's published SUA/FBS data go only to 2003, with provisional unpublished ones to 2005. These estimates include some radical revisions to the historical data, including those for 1999/2001, the base year for the IR, particularly as regards per capita food consumption, which is of key importance in diagnosing the nutrition situation (see the section on Food consumption and nutrition in developing countries). Non-SUA/FBS FAOSTAT data go to 2007 for production and 2006 for trade. It is obvious that the existing updates of the SUA/FBS data do not provide an adequate basis for revisiting the IR projections in light of the new circumstances.

The following analysis resorts to the CBS data set, which covers a more limited number of commodities than the SUA/FBS data; for example, it does not cover key food commodities such as roots and tubers or pulses, which are the mainstay of diets in several countries. It has data up to 2008 (for which year the data are often estimates) for production, trade and stocks (and hence also includes the implicit total domestic disappearance or consumption for all uses). It often, but not always, includes utilization categories (food, feed, etc.). The country coverage and detail in this data set are not always sufficient to generate the country groups used in the IR projections (FAO, 2006: 67). For example, the IR projections include Romania and Bulgaria in the group "Other Eastern Europe". Likewise, the ten countries that entered the European Union (EU) in 2004 are projected as a separate group from the older EU15 countries. For recent years, the CBS data do not generally show data for these countries individually, but only for the EU as a whole. This makes it impossible to generate data suitable for comparing the IR projections for many country groups with actual outcomes to 2007 and with estimates for 2008. In the following discussion, data are therefore compared between developing countries and the rest of the world or developed countries. The latter comprise the "industrial" and "transition" groups in the IR.

Even more serious problems arise from the non-comparability of data resulting from differences in commodity specifications. For example, in the IR the commodity "sugar" includes all sugar crops and derived products (including non-centrifugal sugar, which is important in countries such as India) converted into raw sugar-equivalent quantities.

The CBS do not use the same coverage, so direct comparison is not possible. The same goes for the commodity "vegetable oil": in the IR specification it comprises all oilcrops, oils and derived products converted into oil equivalent. This means that consumption of oilseeds – directly as pulses (e.g., soybeans, groundnuts) or in other forms – is counted as consumption of the oil content equivalent in the IR data and projections but not in those of other databases and projection studies.

This chapter presents such a reality check, together with the IR projections, for a few commodity aggregates, focusing particularly on cereals (sum of wheat, rice and coarse grains) and meat (sum of bovine, pig meat, poultry and ovine, in carcass weight). There were two reasons for selecting these aggregates:

- They do not present major comparability problems with the commodity specifications of the IR.
- They have held centre stage in the debate on food price surges: at the early stages of the price surges, there was quasi-consensus around the view that spurts in food/feed demand, particularly in the fast-growing emerging economies (India, China) with their allegedly voracious appetite for meat, were a key determinant. This is no longer a proposition that many would defend, but it is an idea that is hard to die[5] (Alexandratos, 2008).

In addition, comparisons for the commodity "vegetable oils" are presented. These comparisons are of a more limited nature because of incompatibilities in the commodity specifications.

Interim report projections and reality checks

A major point made in the IR was that the growth of demand in developing countries and the world for both cereals (excluding their use for biofuels, which was not accounted for in the IR) and meat would gradually decelerate. However, as noted, in the debate on the recent food price surges up to mid-2008, it was often stated (or rather assumed, given that food consumption data were scarce) that the spurt in demand for meat and the associated demand for feed cereals in developing countries, particularly China and India, were a major factor explaining why cereals prices surged. The first question is therefore whether the predicted deceleration is actually happening. Attention should then turn to examining

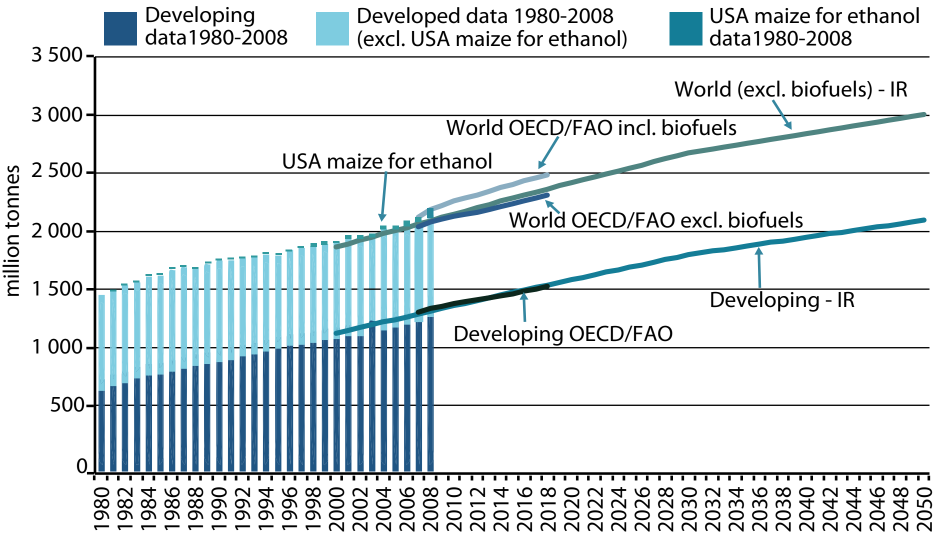
5. For example, see a recent article in the *Economist* ("Green shoots", 21 March 2009) holding that the steady increase in demand from poorer countries is the single largest cause of rising prices. It would be more correct to state that increases in demand in the developing countries represent the major component of global demand growth, but this is nothing new. This phenomenon was present even when prices were not rising, and often when they were falling.

whether or not the OECD/FAO projections sketch out future trajectories that are close enough to those of the IR.

Cereals

Table 1.1 compares the IR's projections with the most recent data for 1999/2001 and the latest three-year average for 2006/2008, with and without cereal use for biofuels. Figure 1.1 illustrates the relevant trajectories.

Figure 1.1
World cereal consumption, with and without United States maize for ethanol



Sources: FAO, 2006; OECD/FAO, 2009.

Consumption, developing countries: A gradual slowdown in the growth of cereals consumption (all uses, not only food) in the developing countries was projected – to 1.8 percent per annum in the first sub-period 1999/2001 to 2015. This is happening. From 1999/2001 to 2006/2008 growth decelerated to 1.8 percent per annum, from 3.0 percent in the 1980s and 2.0 percent in the 1990s, while per capita consumption increased to 244 kg per annum in 2006/2008. Therefore, for this criterion, the IR projections seem to be on the right track. Will they continue to be so in the future? The OECD/FAO medium-term projections to 2018 foresee that aggregate consumption in developing countries will rise to 1 462 million tonnes in 2015 (close enough to the 1 472 million tonnes of the IR, Table 1.1) and on to 1 522 million tonnes by 2018. The IR projections seem to be on the right track for this criterion too.

Table 1.1
Cereals (wheat, rice milled, coarse grains): IR data to 2001 and projections, versus revised CBS data to 2008 and OECD/FAO projections to 2018

	Quantity *(million tonnes)*					
Consumption	1999/ 2001	2006/ 2008	2015	2018	2030	2050
World: IR data and projections (excl. biofuels)	1 866		2 287		2 677	3 010
World: CBS data	1 900	2 130				
USA: maize for ethanol (USDA data)[a]	16	74				
World: CBS data (excl. USA maize ethanol)	1 884	2 056				
World: OECD/FAO projections (incl. biofuels)		2 121	2 407	2 490		
World: OECD/FAO projections biofuels		84	172	175		
World: OECD/FAO projections (excl. biofuels)		2 037	2 235	2 314		
Developing countries: IR data and projections (excl. biofuels)	1 125		1 472		1 799	2 096
Developing: CBS data	1 148	1 301				
Developing: OECD/FAO projections		1 301	1 462	1 522		
Developed countries: IR data and projections (excl. biofuels)	741		815		877	914
Developed: CBS data	752	829				
Developed: CBS data (excl. USA maize ethanol)	736	755				
Developed: OECD/FAO projections (incl. biofuels)		820	945	967		
Developed: OECD/FAO projections biofuels		80	168	172		
Developed: OECD/FAO projections (excl. biofuels)		740	777	796		
Production						
World: AT data and projections	1 885		2 290		2 679	3 012
World: CBS data	1 887	2 147				
World: OECD/FAO projections		2 127	2 416	2 500		
World: OECD/FAO projections (excl. biofuels)		2 043	2 244	2 325		
Developing countries: AT data and projections	1 026		1 304		1 567	1 799
Developing: CBS data	1 026	1 205				
Developing: OECD/FAO projections		1 192	1 327	1 374		
Developed countries: AT data and projections	859		985		1 112	1 212
Developed: CBS data	861	942				
Developed: OECD/FAO projections		935	1 088	1 126		
Developed: OECD/FAO projections (excl. biofuels)		855	920	955		
Net imports						
Developing countries: AT data and projections	112		168		232	297
Developing: CBS data	110	121				
Developing: OECD/FAO projections		122	140	154		

[a] Historical data for cereals use for biofuels going back to 1980 exist for only the United States of America www.ers.usda.gov/data/feedgrains/feedgrainsqueriable.aspx.

USDA = United States Department of Agriculture.

Table 1.1 (*continued*)

	Growth rate *(% per annum)*						
Consumption	1980-1990	1990-2000	1999/2001-2006/2008	2006/2008-2018	1999/2001-2015	2015-2030	2030-2050
World: IR data and projections (excl. biofuels)					1.4	1.1	0.6
World: CBS data	1.9	1.0	1.6				
USA: maize for ethanol (USDA data)	20.2	4.5	24.4				
World: CBS data (excl. USA maize ethanol)	1.9	0.9	1.3				
World: OECD/FAO projections (incl. biofuels)				1.5			
World: OECD/FAO projections biofuels				6.9			
World: OECD/FAO projections (excl. biofuels)				1.2			
Developing countries: IR data and projections (excl. biofuels)					1.8	1.3	0.8
Developing: CBS data	3.0	2.0	1.8				
Developing: OECD/FAO projections				1.4			
Developed countries: IR data and projections (excl. biofuels)					0.6	0.5	0.2
Developed: CBS data	0.8	-0.4	1.4				
Developed: CBS data (excl. USA maize ethanol)	0.7	-0.5	0.4				
Developed: OECD/FAO projections (incl. biofuels)				1.5			
Developed: OECD/FAO projections biofuels				7.1			
Developed: OECD/FAO projections (excl. biofuels)				0.7			
Production							
World: AT data and projections					1.3	1.1	0.6
World: CBS data	1.6	0.9	1.9				
World: OECD/FAO projections				1.5			
World: OECD/FAO projections (excl. biofuels)				1.2			
Developing countries: AT data and projections					1.6	1.2	0.7
Developing: CBS data	2.8	1.8	2.3				
Developing: OECD/FAO projections				1.3			
Developed countries: AT data and projections					0.9	0.8	0.4
Developed: CBS data	0.6	0.0	1.3				
Developed: OECD/FAO projections				1.7			
Developed: OECD/FAO projections (excl. biofuels)				1.0			

Source: Data and projections from FAO, 2006.

Consumption, developed countries: The IR projected a rebound of growth in the early years of the projection period because of the expected recovery of transition countries after the deep declines of the 1990s. Growth did rebound, to 1.4 percent per annum in the period 1999/2001 to 2006/2008, which was more than projected in the IR (0.6 percent for 1999/2001 to 2015). However, much of the rebound was due to the growing use of grains for biofuels (overwhelmingly maize for ethanol in the United States of America)[6] and the associated price rises. Without these, the rebound was a much more modest 0.4 percent per annum – lower than the IR projections. That it was lower than projected can be interpreted as reflecting the fact that not all use of maize for ethanol represented additional consumption: part of it was matched by reductions in, mainly, the use of grain for livestock feed following the higher prices, hence the lower than projected growth of consumption for food and feed (see section on Biofuels: significance for the long-term outlook).[7]

What about the future? The OECD/FAO projections foresee faster growth in developed countries, at an annual 1.5 percent from 2006/2008 to 2018, than the IR projections do. However, the OECD/FAO projections for developed countries *include biofuels* (80 million tonnes in 2006/2008, 172 million tonnes in 2018). Excluding such use from the projections, the growth of consumption for all other uses from 2006/2008 to 2018 is reduced to 0.8 percent per annum. In the end, the IR projection for 2015 of 815 million tonnes compares with the 945 million tonnes (with biofuels) and the 777 million tonnes (without biofuels) of the OECD/FAO projections for the same year. Again, it is implicit that the growth of biofuels will squeeze out some of the IR-projected consumption for food and, predominantly, feed. Overall, therefore, the IR projections for developed countries (excluding biofuels use) seem to be on track.

Consumption, world totals: The sum of the two country groups – developed and developing – shows that for the world as a whole consumption growth was higher (1.6 percent per annum from 1999/2001 to 2006/2008) than the projected 1.4 percent for 1999/2001 to 2015. However, it was lower (1.3 percent per annum) than projected in the IR if the United States of America's maize use for biofuels

6. Use of maize for fuel alcohol in the United States of America had reached 91 million tonnes in 2008 (*www.ers.usda.gov/data/feedgrains/feedgrainsqueriable.aspx*). This is the only source with data of cereals use for biofuels extending back to 1980. Data for more recent years are available for some other countries in the data set used in the OECD/FAO projections: for 2008, they indicate, 6 million tonnes in the EU27, 2 million tonnes in Canada and 4 million tonnes in China.

7. Not all the maize used for biofuels should be subtracted from the supplies available for feed: some 30 percent is returned to the feed sector in the form of by-products (mainly distillers' dry grains).

is excluded from world consumption. The OECD/FAO projections for 2015 are 2 407 million tonnes (with biofuels) and 2 235 million tonnes (without biofuels) versus the 2 287 million tonnes in the IR projection for the same year.

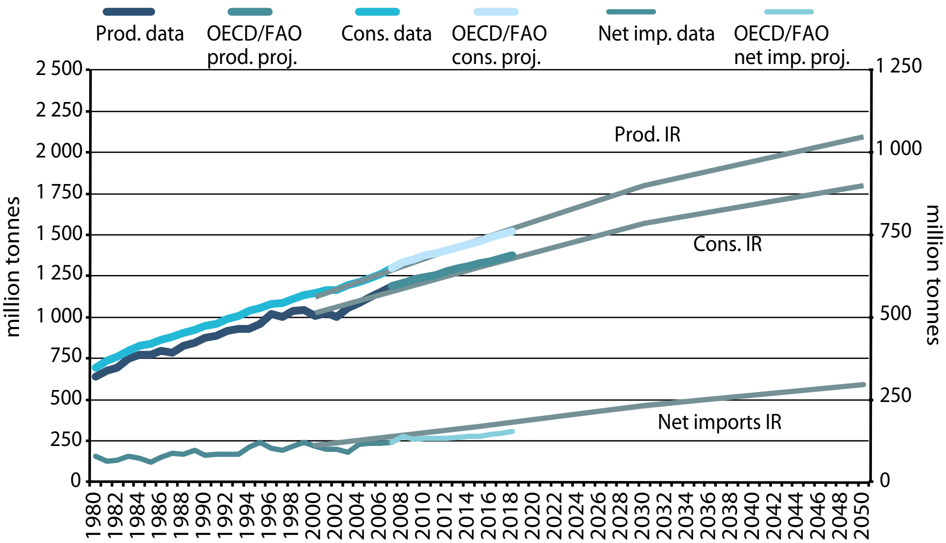
Conclusion: By and large, the trajectories of actual consumption to 2008, for the world as a whole and separately for developing and developed countries (excluding the biofuels component), follow the IR projection paths fairly closely (Figure 1.1), which are for gradually decelerating growth. It would therefore be possible to use the existing IR projections (at least for these large country aggregates and the world as a whole) and add one or more alternative views of future use of cereals for biofuels (this topic is addressed later in this chapter, with deeper coverage in Chapters 2 and 3). This would generate a path of possible developments in the global demand for cereals over the projections' time horizon that would be compatible with the IR projections, the developments to date, the OECD/FAO medium-term outlook and at least one view of cereal use for biofuels. Obviously, updating the study's views of cereal futures for individual countries and small country groups would require considerable work to run similar reality checks at the country level, while also taking on board the drastic revisions of the FBS historical data on food consumption for all commodities (discussed in the section on Food consumption and nutrition in developing countries).

Production and net imports, developing countries: The interface between production historical data and the projections is not as neat as those for consumption, given fluctuations caused by both weather and policies. Data for developing countries production are plotted in Figure 1.2 (and shown in Table 1.1). Production was nearly stagnant over the period 1996 to 2002 (1 023 million tonnes in 1996/1998, 1 030 million tonnes in 2001/2003), while consumption kept growing and stocks were depleted. This was one of the factors that presaged the price spikes in subsequent years (Alexandratos, 2008). During this period, almost all the increases in consumption were met by stocks drawdown. The role of China was particularly important in developments during this period: China started running down the huge stocks it had accumulated in the 1990s, with closing stocks of 309 million tonnes in 1999 (84 percent of annual consumption), falling to 148 million tonnes by 2005 (40 percent of consumption).[8] From 2003 onwards there was a rebound in production (reaching 1 205 million tonnes in 2006/2008),

8. Problems associated with China's huge stocks accumulated by the late 1990s included overflowing granaries with losses due to quality deterioration, and large financial losses from sales (domestic and export) at below-cost prices. These problems prompted policy reforms to reduce stocks, including some relaxation of the policies that obliged farmers to produce cereals (OECD, 2005: 37; USDA, 2001).

and production increases were more than sufficient to meet the growth in consumption. Indeed, part of the increased production went to rebuilding stocks (Figure 1.3). China's role was also important in this second period; without China, the turnaround from stock depletion to stock rebuilding is much less pronounced, although still evident in the data.

Figure 1.2
Cereal production, consumption (left axis) and net imports (right axis), developing countries

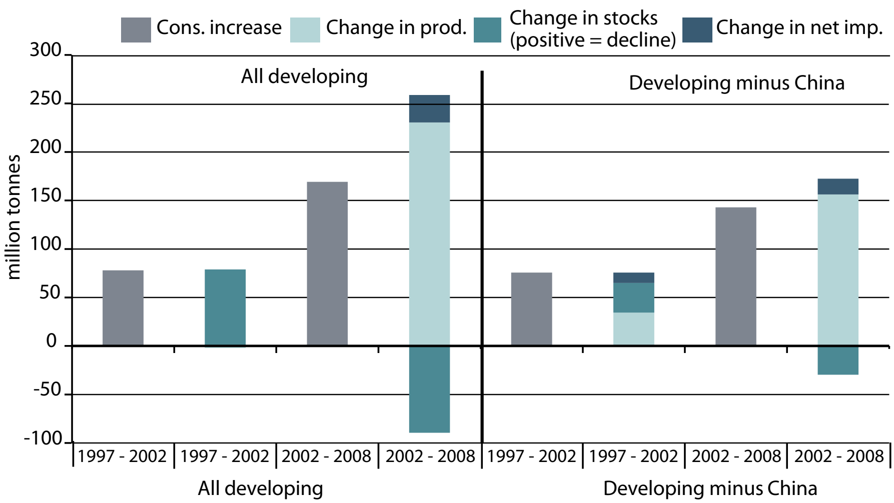


Sources: FAO, 2006; OECD/FAO, 2009.

It is important to note that in both periods, changes in net imports played a minor role as contributors to changes in aggregate consumption. They fluctuated in the range of 91 million tonnes (2003) to 136 million tonnes (2008). The IR had projected that net imports would play a larger role as contributors to the growth of consumption in developing countries. Net imports were projected to rise from the 112 million tonnes of 1999/2001 to 168 million tonnes in 2015, and on to 232 million tonnes in 2030 and 297 million tonnes in 2050. The OECD/FAO projections have 140 million tonnes in 2015 and 154 million tonnes in 2018. If developments in the first half of the current decade are a harbinger of things to come, there may be need for radical rethinking of how the future of developing countries is viewed in terms of growing dependence on imported cereals. Lower imports than projected in the IR mean lower projected consumption and/or higher projected production. As already noted, consumption growth in the developing countries is largely on the projected path. Therefore, if projected imports must be lower, the production projections must be revised upwards. This raises the question: Is the IR projection of 1.6 percent per annum from 1999/2001 to 2015 too low in light of the production growth rebound of recent years (2.3 percent from 1999/2001 to 2006/2008)?

Before jumping to conclusions, there is need to take a closer look at the production increases and examine whether the acceleration of growth is likely to prove durable or is the result of extraordinary circumstances. This requires looking at the data for individual countries. Annex 1.1 lists the 29 developing countries (accounting for 16 percent of developing countries' cereal production in 1999/2001) that in the period 1999/2001 to 2006/2008 achieved cereal production growth rates exceeding 4 percent per annum, with 5.7 percent per annum as a group, up from 1.7 percent in the 1990s. For several of these countries the spurt in growth of the last few years represented recoveries from troughs in the preceding years. Such growth rates are certainly not very informative for judging long-term growth prospects.

Figure 1.3
Growth in cereal demand met by changes in production, stocks and net imports, 1997/2002 versus 2002/2008



Source: FAO CBS data.

Were the IR projections to be redone today, it would certainly be necessary to revisit the production projections of individual countries in the light of developments in the last few years. The key issue is, of course, whether this would affect in any significant way the aggregates for all developing countries and the prospects for growth of their net cereal imports. For this the OECD/FAO projections to 2018 can be referred to. In these projections, the spurt in the growth of production for the period 1999/2001 to 2006/2008 (2.3 percent per annum) is not maintained;[9] they project a growth rate of 1.3 percent per annum from 2006/2008 to 2018, with projected production for 2015 of 1 327 million tonnes, versus 1 304 million tonnes in the IR (Table 1.1). It has also been noted that consumption in developing countries is somewhat lower than that in the IR. By implication, developing countries' projected net imports, being the difference between two much larger numbers, are lower than those of the IR for 2015, at 140 million tonnes versus 168 (Figure 1.3).

Much of the difference in net imports is due to India and China:[10] in the IR they turn into modest (for their size) net importers by 2015, while the OECD/FAO projections have them continuing as small net exporters (6.4 million tonnes in 2015 and 5.1 million tonnes in 2018). Excluding India and China, the two projections of net imports for 2015 are close – 143 million tonnes in the IR, 146 million tonnes in OECD/FAO. China and India have the potential to influence decisively the cereal trade prospects of the developing countries. The two countries together were net importers in the past, but became net exporters after 1999, reaching peak net exports of 26 million tonnes in 2002, which declined to 4 to 6 million tonnes per annum in the four years 2005 to 2008.

A few years ago, these two giants were seen as turning into net importers again over the medium term. Thus, the 2004 issue of the Food and Agricultural Policy Research Institute (FAPRI) projections to 2013 had them as net importers of 11 million tonnes in 2013. The latest edition (FAPRI, 2009) has them as net exporters of only 1 million tonnes in 2018. Similarly, the OECD *Agricultural*

9. The latest cereals production forecast for 2009 for the developing countries indicates virtually no increase over that of 2008 (FAO, *Food Outlook*, June 2009).

10. China's net trade position does not include the situation in Taiwan Province of China and China Hong Kong Special Administrative Region (SAR), both of which have been net importers, to the tune of 7 million tonnes per annum in the last ten years, and are projected to remain so in the future. Thus, all China is really a net importer of cereals, both at present and in the projections.

outlook of 2004 had China becoming a significant net importer.[11] A recent International Food Policy Research Institute (IFPRI) report (Rosegrant *et al.*, 2008: Figure 4.7) has, in its baseline scenario, China's net cereal imports exceeding 50 million tonnes in both 2025 and 2050, while India remains a net exporter in 2025 turning into a net importer in 2050. In conclusion, the net trade position of the developing countries, being the difference between the much larger numbers of production and consumption, remains sensitive to even small variations of these two larger numbers. Views about the future cereal trade positions of China and India can cause any outlook of developing countries' import needs to swing around. As noted, such views tend to change over time. Back in the mid-1990s, Brown (1995) considered the prospect of China's burgeoning cereals imports as a major threat to world food security, a clear exaggeration at the time (see critique in Alexandratos, 1996) and even more so today. Many people seem to be mesmerized by the hugeness and high economic growth rates of China and its apparently voracious appetite for livestock products and food in general. This perception may be accurate (for some time) for things such as energy and metals, but is much less so for food: the income elasticity of the demand for food tends to decline rather rapidly, being limited (as it were) by the elasticity of the human stomach. The IR projection of the status of China and India as modest net importers by 2015 reflected the dominant view of a few years ago. There is no compelling reason for changing the long-term projections just now, but the matter should certainly be kept under constant review.

Production, developed countries: The IR had projected an acceleration of developed country production (not accounting for the effects of biofuels) in the first projection sub-period (to 0.9 percent per annum between 1999/2001 and 2015, up from zero in the 1990s) because of the expected recovery in transition countries. The advent of the additional demand for biofuels led to production increases that were even faster than projected in the IR (1.3 percent per annum in 1999/2001 to 2006/2008; Table 1.1), and that were significantly influenced by a quantum jump of 13 percent in 2008, following the price spikes. The OECD/FAO projections foresee even higher growth in the future (1.7 percent per annum from 2006/2008 to 2018), largely because of growing use for biofuels. The latter

11. "From a net exporter of both wheat and coarse grains at the beginning of the Outlook, China could become a significant importer of cereals assuming that the Tariff Rate Quotas (TRQs), implemented by China under the World Trade Organization (WTO) accession agreement, will be used efficiently. By the end of this decade, China could import more than ten times as much wheat, coarse grains and rice as in the recent past. Both wheat and rice import quotas are projected to become filled at least in some years, and coarse grain imports, already by far the largest part of Chinese cereals imports, could reach levels equivalent to twice the import quota for maize" (OECD, 2004: 52).

Table 1.2
Meat (bovine, ovine, pig, poultry): IR data to 2001 and projections, versus revised CBS data to 2008 and OECD/FAO projections to 2018

	Carcass weight (*million tonnes*)						Growth rate (% *per annum*)						
Consumption	1999/ 2001	2006/ 2008	2015	2018	2030	2050	1981– 1990	1990– 2000	1999/2001– 2006/2008	2006/2008 –2018	1999/2001 –2015	2015– 2030	2030– 2050
World: IR data and projections	228		305		380	463					2.0	1.5	1.0
World: CBS data	230	270					3.3	3.3	2.3				
World: OECD/FAO projections		267	312	328						1.9			
Developing countries: IR data and projections	127		191		258	334					2.8	2.0	1.3
Developing: CBS data	128	159					5.2	6.5	3.1				
Developing: OECD/FAO projections		157	195	208						2.6			
Developed countries: IR data and projections	101		113		123	130					0.8	0.5	0.3
Developed: CBS data	102	112					2.3	0.4	1.3				
Developed: OECD/FAO projections		110	117	120						0.8			
Production													
World: IR data and projections	230		306		382	465					1.9	1.5	1.0
World: CBS data	230	271					3.3	3.2	2.4				
World: OECD/FAO projections		268	312	329						1.9			
Developing countries: IR data and projections	125		190		255	332					2.8	2.0	1.3
Developing: CBS data	126	158					5.1	6.2	3.3				
Developing: OECD/FAO projections		156	192	205						2.5			
Developed countries: IR data and projections	104		116		126	133					0.7	0.6	0.3
Developed: CBS data	104	113					2.3	0.4	1.2				
Developed: OECD/FAO projections		112	120	124						0.9			

Source: Data and projections from FAO, 2006.

are projected to increase by slightly more than 100 percent, with almost all of the increase occurring in developed countries. If it is assumed that all cereals used for biofuels come from home production in the developed countries, when they are excluded, production in 2015 becomes 920 million tonnes versus the 985 million tonnes in the IR. This difference can be attributed in part to the possibility that the use of cereals as biofuels would squeeze out some of the demand for other uses (mostly feed), and in part to the lower net imports required by developing countries in the OECD/FAO projections, as discussed in previous paragraphs.

Production, world: For the world as a whole (the sum of developed and developing countries), the IR projection is 2 287 million tonnes for 2015. This compares with the 2 416 million tonnes (with biofuels) or 2 244 million tonnes (without biofuels) of the OECD/FAO projections for the same year. If it were not for biofuels, the IR projection of 3 012 million tonnes for 2050 would not be in need of major revision. However, the advent of biofuels requires at least speculation on possible upwards revisions, perhaps to some 3 150 million tonnes, as discussed in the section on Biofuels: significance for the long-term outlook.

Meat

Consumption, developing countries: The IR emphasized that the fast growth of meat consumption in the developing countries in the 1980s and 1990s reflected predominantly developments in China and a few other countries (e.g., Brazil) (FAO, 2006: Table 3.7). It projected that such growth was bound to slow as these countries reached medium to high levels of per capita consumption. Other developing countries would experience faster growth than in the past, but that would not be sufficient to sustain the growth of consumption in the developing countries and the world as a whole at the high rates of the preceding two decades. Is this forecast slowdown happening?

Table 1.2 shows that deceleration is taking place in developing countries: from growth of more than 5 percent per annum in the 1980s and 1990s to 3.1 percent in the first seven years of the projection period – more or less on target to meet the 2.8 percent per annum projected for the period to 2015. The OECD/FAO projections foresee a growth rate of 2.6 percent per annum from 2006/2008 to 2018, in line with the IR's 2.8 percent for 1999/2001 to 2015. OECD/FAO projects a slow rise in per capita consumption, from 29 kg in 2006/2008 to 33 kg in 2015, the same as the IR projects for that year.

Consumption, developed countries: In contrast, meat consumption in developed countries has been growing faster than anticipated in the IR. Per capita consumption rose from 75 kg in 1999/2001 to 80 kg in 2006/2008. In the OECD/FAO projections it rises further to 85 kg in 2015 and on to 87 kg in 2018. This contrasts with the IR projections of 83 kg for 2015 and 95 kg in 2050. The overshooting is wholly due to the strong rebound of consumption in transition countries (the former Soviet Union and Eastern Europe) in the early years of the projection period after the slump of the 1990s. Their per capita consumption rose from 46 kg per annum in 1999/2001 to 57 kg in 2006/2008, a level that the IR had projected would be reached in a later year. Clearly, this must be taken into account in any further discussion of livestock sector prospects. Needed revisions would raise the transition countries' consumption in the medium term, but the key issue is whether this would alter in any significant way the longer-term prospects as depicted in the IR: these countries' consumption of 23 million tonnes of meat in 2006/2008 accounts for 8.5 percent of the world total; their population is on the decline (from 404 million people in 2007 to 346 million in 2050); therefore, even if they continue their rapid growth of meat consumption to reach the developed countries' average (some 95 kg per capita in 2050), they will add only another 9 million tonnes (or 2 percent) to the 465 million tonnes world consumption the IR had projected for 2050 – not a significant change. The key issue therefore remains whether or not the developing countries, with their growing weight in world population and meat consumption, are likely to make faster progress than projected (from 26.7 kg per capita per annum in 1999/2001 to 44 kg in 2050). So far growth is on the projected trajectory, with per capita consumption reaching 29 kg per annum in 2006/2008. As noted, the OECD/FAO projections indicate 33 kg for 2015 and 34 kg in 2018.

Consumption, world: The growth of world meat consumption has been slowing, from 3.3 percent per annum in the 1980s and 1990s to 2.3 percent per annum for the period 1999/2001 to 2006/2008. The IR projects 2.0 percent per annum for 1999/2001 to 2015 and further declines in growth in subsequent projection periods. OECD/FAO projects 1.9 percent per annum from 2006/2008 to 2018, i.e., the acceleration caused by the rebound of consumption in the transition countries in recent years is not maintained. Overall, therefore, the IR projections of world meat consumption can be considered an acceptable longer-term outlook in the light of developments to date, at least in global totals.

Production: Production projections mirror those of consumption, given that net trade is a very small fraction (less than 1 percent) of production/consumption for the large country aggregates considered here. The commentary on consumption magnitudes therefore also applies to those of production.

Vegetable oils

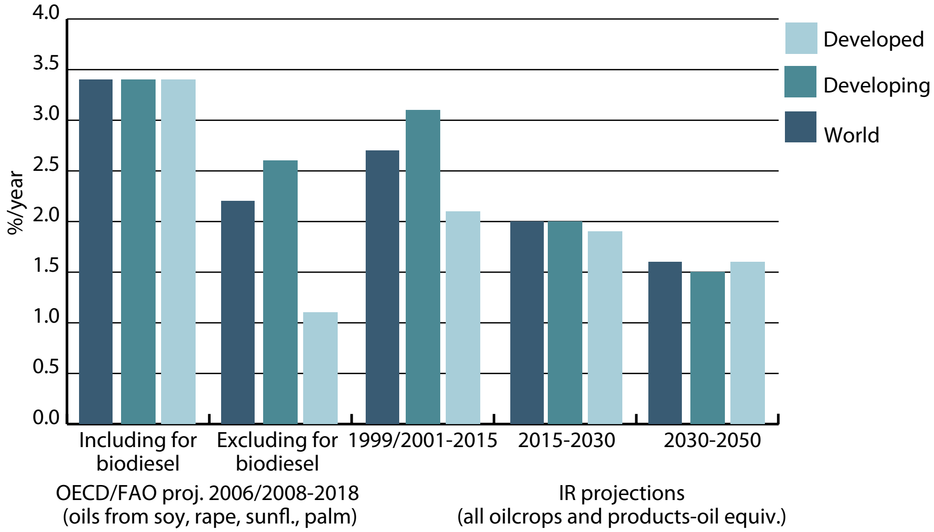
The IR (FAO, 2006: 27, 52–58) highlighted the importance of vegetable oils as a fast-growing item in the food consumption growth of developing countries. It projected that such growth would continue for some time (FAO, 2006: Tables 2.7 and 3.9). It also highlighted the growing weight of non-food uses of oils in industry (paints, detergents, lubricants, oleochemicals in general and, increasingly, biodiesel). It projected that world consumption for both food and non-food uses would continue to grow at high rates, although not as high as those of the recent past. As the historical data on non-food uses included biodiesel, the IR projections must be considered as containing an allowance for biodiesel, albeit of unknown magnitude. How do the IR projections compare with developments in the current decade and with the OECD/FAO projections?

Straightforward comparisons of quantities such as those shown earlier for cereals cannot be made for vegetable oils. This is because the CBS data are not of the same specification as those used in the IR analyses (Box 1.1). In addition, the OECD/FAO projections treat the oilseeds-oils complex as two commodities: "vegetable oil" (the sum of only the four major oils – soybean, rapeseed, sunflower seed and palm) and "oilseeds" (the sum of rapeseed, soybeans and sunflower seed). They do not cover other oils and oilseeds (coconut, groundnut, sesame, cottonseed, olive, etc.), some of which are important in several countries. Therefore, the IR data and projections cannot be compared directly (in terms of quantities of production and consumption) with the data in CBS or with the OECD/FAO projections. At best, comparisons can be made between the IR's projected growth rates of consumption of vegetable oil only (not oilseeds) and the OECD/FAO projections, which are not affected significantly by the differences in commodity coverage and specification.

Comparisons of the consumption growth rates are shown in Figure 1.4. The growth rates in the IR projections for the period 1999/2001 to 2015 are generally lower than those of the OECD/FAO projections for 2006/2008 to 2018. However, the latter include an allowance for biodiesel. Without this, the OECD/FAO growth rates of consumption are lower than the IR's. In practice, the IR growth rates are halfway between the OECD/FAO projections of growth rates with biodiesel and those without biodiesel; for example, the IR world growth rate of 2.7 percent per annum is halfway between OECD/FAO's 3.4 percent with biodiesel and 2.2 percent without biodiesel.

As noted, the IR projections contain a component for biodiesel, which is unknown but must be small: the use of oils for biodiesel really shot up in the last few years, from less than 1 million tonnes in 1999/2001 to 10 million tonnes in 2006/2008 (mostly in the EU and to a lesser extent the United States of America and several developing countries – Argentina, Brazil, Malaysia, Indonesia and Thailand), according to the data used in OECD/FAO projections. It is noted that the four oils included in the OECD/FAO definition of vegetable oils are the fastest growing ones. It is therefore to be expected that the growth rate is higher in the OECD/FAO projections than in those of the IR, which also include the slower-growing oils. By and large, therefore, the IR projections can be considered an acceptable basis for generating a long-term outlook for the sector after adding one or more alternatives for biodiesel use of vegetable oils.

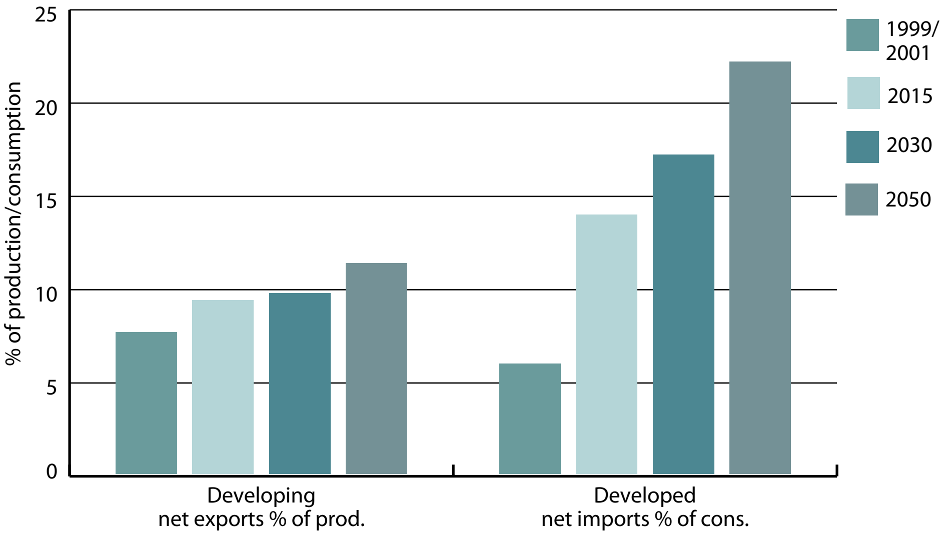
Figure 1.4
Growth of vegetable oil consumption



Sources: FAO, 2006; OECD/FAO, 2009.

The IR projections indicate a growing export orientation for the vegetable oil sector in developing countries (a growing share of total production going to exports), and a growing import dependence in developed countries (a growing share of consumption coming from net imports from developing countries, Figure 1.5). The OECD/FAO projections confirm these prospects, although direct comparability of quantities is not possible. Developed countries are increasing their net imports of oils from 8.1 million tonnes (20.4 percent of consumption) in 2006/2008 to 16 million tonnes (28.2 percent of consumption) in 2018. At the same time, they continue to be net exporters of oilseeds, predominantly soybeans from the United States of America, to the tune of 20.5 million tonnes in 2018, up from 15.5 million tonnes in 2006/2008. These net oilseed exports correspond to roughly 4 to 5 million tonnes of oil equivalent,[12] so developed countries' net imports of all oils and oilseeds (in oil equivalent) would be some 11 to 12 million tonnes in 2018 (16 million tonnes minus 4 to 5 million tonnes). This is higher than the IR projection for 2015, of 7.2 million tonnes. The difference can be attributed to higher oil and oilseed imports following growth of the biodiesel industry in developed countries.

Figure 1.5
Oilseeds, vegetable oils and products (oil equivalent), IR projections



Source: FAO, 2006.

Biofuels: significance for the long-term outlook

The potential for using crops to produce biofuels had its moment of glory during the recent price surges of both energy and food commodities. At one extreme, biofuels were vilified as causing the food price surges and, occasionally, as destroying the environment and land and water resources. At the other extreme,

12. The bulk of developed countries' oilseed exports are soybeans from the United States of America, and rapeseed and sunflower seed (mainly from Canada, Eastern Europe and Ukraine). Therefore, if developed countries' net oilseed exports were converted into oil equivalent (to obtain a number that can be compared with the definition used in the IR), they would correspond to some 4 to 5 million tonnes of oil (using an average oil extraction rate near that of soybean's 18 to 19 percent, increased to 20 to 25 percent to account for the higher extraction rates of rapeseed and sunflower seed, of 41 to 43 percent).

they were seen as offering great opportunities for boosting farm incomes and energy independence, and for mitigating adverse environmental effects by reducing the burning of fossil fuels.

The debate subsided with the collapse of oil prices. These days, headlines are usually concerned with the woes of the biofuels industry following its rapid expansion during the boom years. The industry is now largely kept alive by mandates and subsidies, with the possible exception of sugar ethanol, mainly in Brazil.

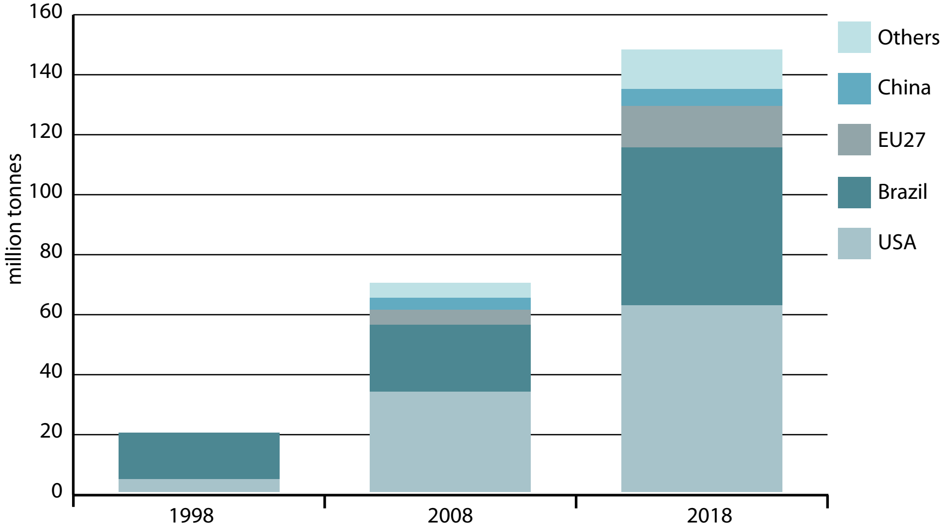
However, the issue is not dead. High energy prices are likely to return (IEA, 2008; Stevens, 2008; McKinsey Global Institute, 2009), and the geopolitical causes driving the quest for energy security are not going away. Add the strength of the farm and biofuel industry lobbies, the continuing relevance of environmental concerns and the prospects for technological change in converting biomass to liquid fuels, and the debate can be expected to reignite. It follows that any assessment of long-term food prospects cannot ignore the possibility that the expected "normal" slowdown in the growth of demand for agricultural produce (and the underlying claims on agricultural resources and technology development) may not materialize. There is therefore need for one or more projection alternatives to account for biofuel effects. Such projections are not easily made. The fact that mandates and subsidies drive much of the use of grains and vegetable oils for biofuels (with the possible exception of Brazil's sugar ethanol) means that the historical data do not provide an adequate basis from which to glean valid information concerning the role of energy-to-crop relative prices as triggers of demand growth.

Currently, biofuel projections are commonly an integral part of most food and agriculture projections. In this area, the latest attempts that contain (to varying degrees) sufficient detail of the biofuels modules are all medium-term (ten years), not long-term.[13] They include the latest annual issues of ten-year outlooks by USDA (2009), FAPRI (2009) and OECD/FAO (2009). The last of these provides the most detail, so it is used to illustrate the orders of magnitude involved; Figures 1.6 and 1.7 show the volumes of biofuels (ethanol and biodiesel, respectively) projected to be produced by 2018.

World production of ethanol is projected to increase by slightly more than 100 percent from 2008 to 2018, with the United States of America, Brazil and the EU27 as the major players. Both Brazil and the EU are projected to increase their shares in the world total. The United States of America's share will be somewhat reduced (from 43 to 37 percent) and will lose its top position to Brazil's

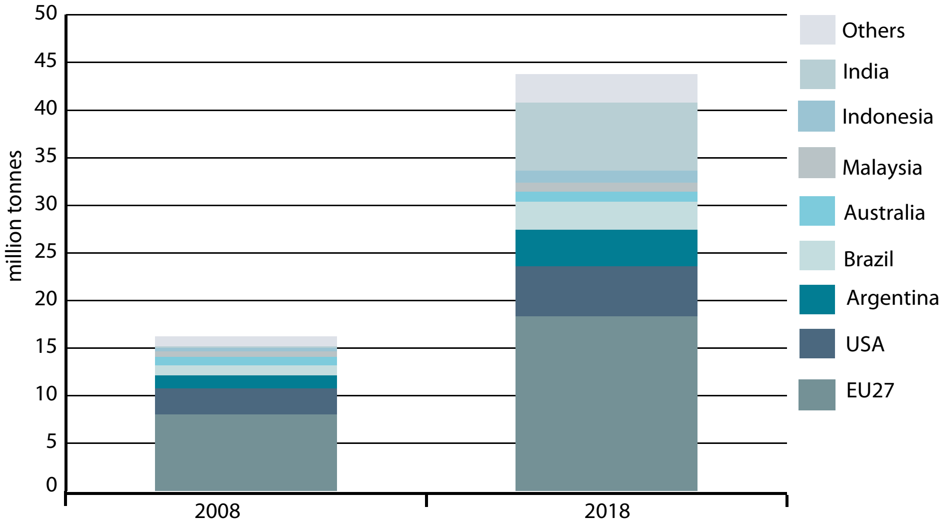
13. The IIASA work (Chapter 3), which contains long-term biofuels projections, was not available at the time of writing this chapter.

Figure 1.6
Ethanol production, OECD/FAO projections



Source: OECD/FAO, 2009.

Figure 1.7
Biodiesel production, OECD/FAO projections



Source: OECD/FAO, 2009.

share, which will increase from 34 to 39 percent. Biodiesel production is seen as growing even faster than ethanol, by 170 percent in the ten-year period. The EU will continue to hold top place, with 42 percent of world production (down from the current 50 percent). The great revelation (according to these projections) could be India, with biodiesel production going from very little today to some 7 million tonnes in ten years, all of it from *jatropha*, making India the world's second largest producer, with a 16 percent share. This reflects the mandate for having a 20 percent biofuels blend in gasoline and diesel by 2017.

The key issue is what all this may imply for food security and nutrition. Would food consumption be lower with the use of food crops for biofuel production than it would be without it? It is difficult to provide a concrete answer to this question without running counterfactual scenarios, which is not practicable at the moment. It is not just a question of whether world food and feed consumption would be lower because of the price rises caused by, mainly, biofuels. This can be taken for granted, as the diversion of grain to biofuels most directly affects the feed/livestock sector in developed countries, which is more sensitive to price changes than other components of the food system. However, food security and nutrition issues are related to the food consumption in countries where large proportions of the population are undernourished or just above the threshold for undernourished (in terms of minimum daily energy requirements [MDERs] – see section on Food consumption and nutrition in developing countries). In such countries, food price rises could aggravate the situation of those below the threshold and push some of those above it into the class of undernourished.

None of the ten-year projection studies offers scenarios with and without biofuels.[14] Developments in the last few years of price surges embody information that can help to answer the question: Do the ten-year projections provide information about the impact of biofuels on per capita food consumption, and in which country groups? As seen in Table 1.1, some 84 million tonnes of cereals were used for biofuels in the three-year average for 2006/2008, and 105 million tonnes in 2008 alone. Has this led to a reduction in per capita consumption? In the absence of FBS data beyond 2005, it is not known what happened to the per capita food consumption of all commodities expressed in kilocalories per person per day (kcal/person/day). The CBS data can be used to figure out only how per capita consumption of cereals for all uses evolved over the last few years. Figure 1.8

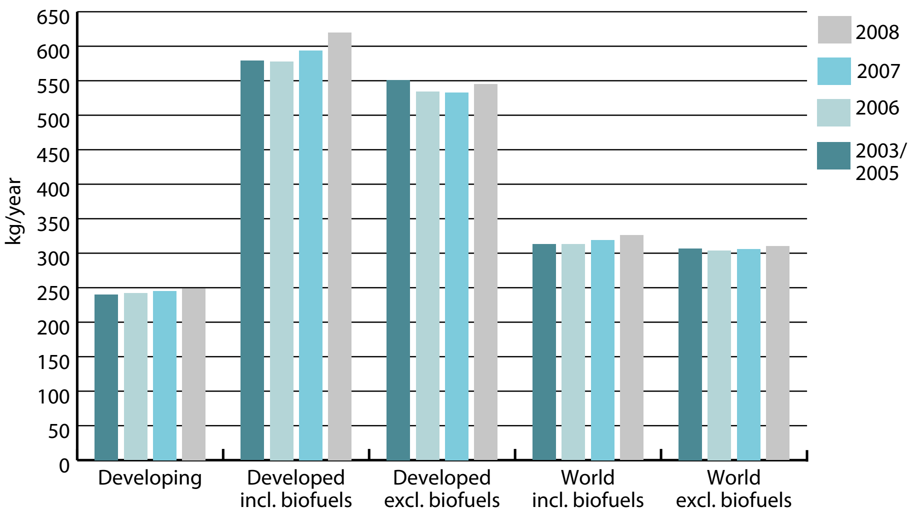
14. A recent IIASA study for the Organization of the Petroleum Exporting Countries (OPEC) Fund for International Development (OFID) (IIASA, 2009: Part III, Box 3.4-1) indicates that in 2020, 66 percent of the additional demand for cereals generated by scenarios with growing biofuels use (over and above use in 2008) would be met by increased production, and the rest by reduced consumption of feed (24 percent) and food (10 percent).

plots consumption in kilograms per capita (all uses, with and without cereals use for biofuels). It is seen that:

- there have been no declines, but rather small increases, in per capita consumption in developing countries (cereals use for biofuels in these countries – some 4 million tonnes in China – is very small, so the entire change can be attributed to non-biofuel uses);
- the only declines occurred in developed countries, from 2006 to 2007 in food and feed consumption (i.e., all consumption minus the part going to biofuels); with biofuels, developed countries' per capita consumption rose significantly.

Does this mean that the diversion of cereals to biofuels, and the associated price increases did not lead to reduced per capita food consumption and/or increases in the numbers undernourished in countries with nutrition problems?[15] In the

Figure 1.8
Cereal consumption, all uses including and excluding use for biofuels



Developing countries are those with estimates of undernourishment in FAO, 2008; developed countries are the rest of the world

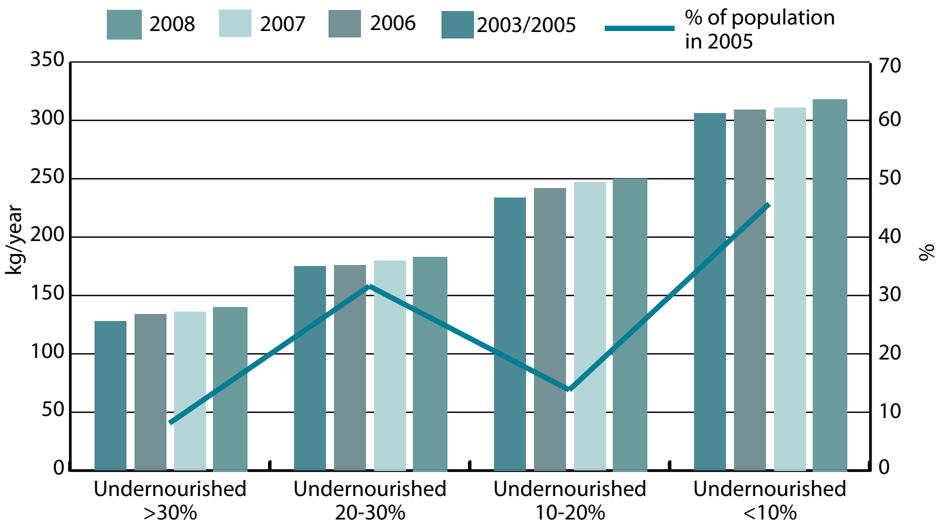
Sources: Cereals consumption from CBS data, 3 July 2009; population from UN, 2007.

15. The relevant question is whether or not per capita consumption is less than it would have been in the absence of the price surges. It is also noted that the number (but not the percentage of population) undernourished may increase even when per capita consumption does not decline, or even increases a little. This can happen because of population growth.

absence of updated FBS data covering all food products, this question cannot be answered.

As noted, the risk of the nutritional situation deteriorating in the wake of price surges is highest and most relevant in countries with low food consumption levels and significant proportions of their populations undernourished. To shed light on this, Figure 1.9 unfolds developments in the per capita consumption of cereals by developing country sub-groups, according to their nutrition status in 2003/2005 (as given in FAO, 2008). Again, it is seen that no country group suffered a decline. On the contrary, per capita consumption increased in all groups.

Figure 1.9
Developing countries cereal consumption: all uses, by proportion of population undernourished in 2003/2005



Developing countries are those with estimates of undernourishment in FAO, 2008; developed countries are the rest of the world.

Sources: Undernourishment status from FAO, 2008; cereal consumption from CBS data 3 July 2009; population from UN, 2007.

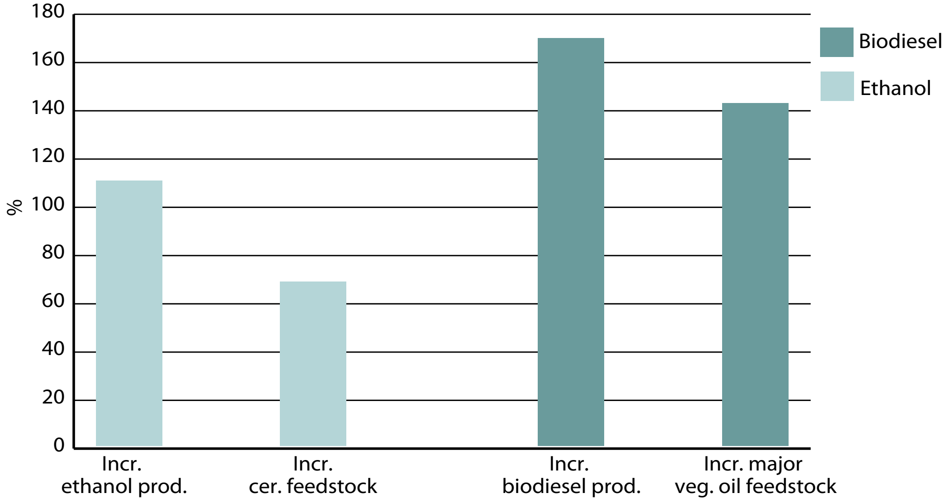
This is not equivalent to saying that the diversion of grain to biofuels and the associated price rises had no impact on the numbers undernourished: it is possible that were it not for biofuels, the per capita consumption of cereals would have improved by more than shown in Figures 1.8 and 1.9. Naturally, not all the amount devoted to biofuels would have been available for food and feed: part would simply not have been produced, as the high prices were to a large measure responsible for the rebound in world cereals production in both 2007 (+ 5.4 percent) and 2008 (+ 7.3 percent). As noted, the IIASA analysis (2009) suggests that in the projection period to 2020, some two-thirds of the cereals going to biofuels could come from increased production, and the balance from reduced consumption of food and, mainly, feed.

The increases of biofuel production in the OECD/FAO ten-year projections (Figures 1.6 and 1.7) imply further increases in the demand for feedstock crops (presented earlier in the sections on Cereals and Vegetable oils). Naturally, not all additional ethanol will be produced from cereals, and not all biodiesel will come from the four major vegetable oils covered in the OECD/FAO analyses. Even without resorting to feedstocks of non-food crop biomass (second-generation biofuels), by-products (e.g., molasses), food crops other than cereals (mainly sugar cane, sugar beet, cassava, etc.) and fats other than the major oils (e.g., tallow, coconut oil) will contribute a share to biofuels, which may grow – as implied by, for example, Brazil's increasing share in world ethanol production and India's ascendancy in biodiesel based on *jatropha*. The increases in biofuel production will therefore require less than proportional increases in feedstocks from cereals and the major edible vegetable oils (Figure 1.10). Nevertheless, in the projections, growing shares of world cereals and vegetable oils consumption will be for biofuels, as shown in Figure 1.11.

What about projections beyond 2018? The IFPRI study with projections to 2050 addresses this issue in the following assumption: "We hold the volume of biofuel feedstock demand constant starting in 2025, in order to represent the relaxation in the demand for food-based feedstock crops created by the rise of the new technologies that convert non-food grasses and forest products" (Rosegrant *et al.*, 2008:, 11). This assumption implies that some 200 million tonnes of cereals will be going to biofuels by 2050 (up from the 105 million tonnes in 2008 and 175 million tonnes in 2018 of the OECD/FAO projections). Assuming that two-thirds of this additional demand would come from increased production (as in the estimate in IIASA, 2009), the original projection of 3 010 million tonnes in 2050 (Table 1.1) would need to be raised to some 3 150 million tonnes, and food/feed consumption lowered by some 60 million tonnes, to 2 950 million tonnes.

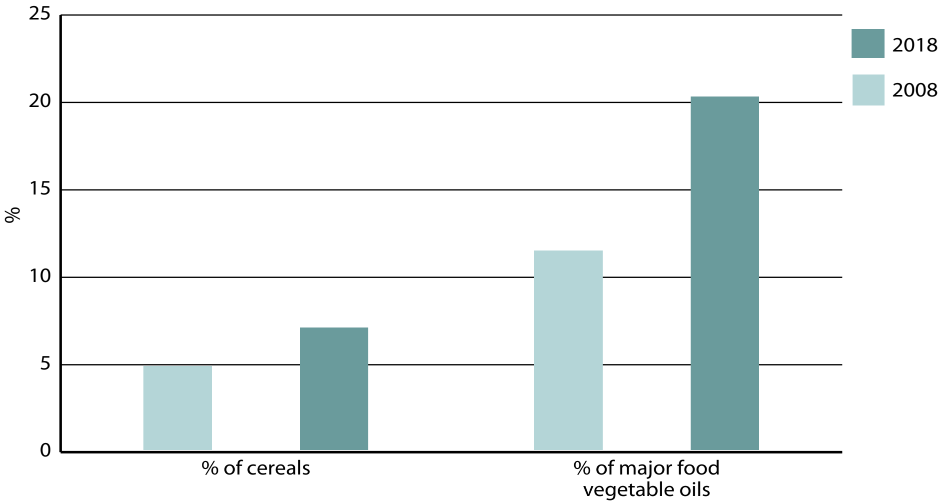
These are all speculative ballpark numbers and are offered to provide some orders of magnitude. If they turn out to be approximately correct, world agriculture could perhaps cope with the problem without incurring significantly higher stress over that implied by the need to increase cereals production by some 900 million tonnes projected in the IR, in terms of the required land-irrigation-yield configurations shown in Chapter 6.

Figure 1.10
Increases in biofuel production versus increases in cereal and vegetable oil feedstocks, 2008 to 2018



Source: OECD/FAO, 2009.

Figure 1.11
Cereal and vegetable oil biofuel feedstocks as shares of aggregate world consumption



Vegetable oils include those from soybeans, rapeseed, sunflower seed and oil-palm, but not *jatropha*.
Source: OECD/FAO, 2009.

However, things may turn out quite differently if energy prices were to explode and make the conversion of food crops to biofuels profitable, even without subsidies and mandates. The investment frenzy that underpinned expansion of the biofuels industry during the recent price surges for petroleum is telling. It may happen again, and the energy sector must be seen as competing with the food sector for supplies when it is profitable for it to do so. The latest McKinsey (2009: 63) report forecasts an annual biofuels growth rate of 14.4 percent for the period 2006 to 2020. This is higher than the 10 percent implied by the OECD/FAO projections for the period 2006 to 2018 (the sum of ethanol and biodiesel). The latest United States Government energy outlook to 2030 (EIA, 2009) has world biofuels growth rates in the range of 10 percent (low oil price case) to 14 percent (high oil price case) per annum from 2006 to 2020. Annual growth declines drastically in the subsequent decade, to between 3.7 and 4.6 percent.

In conclusion, food-fuel competition is likely to continue into the future. Any analysis must address the eventuality of such competition intensifying, with adverse effects on the food security of some countries and population segments: if this happens, the purchasing power of those demanding more energy could easily overwhelm that of the poor demanding food (see further discussion in Schmidhuber, 2006; Alexandratos, 2008). Among the major tasks of any remake of FAO's long-term projections would be addressing this issue, unfolding the implications for food security and exploring the alternatives.

Food consumption and nutrition in developing countries

Revisiting current estimates and possible future outcomes

The IR (FAO, 2006: Table 2.3) projected a gradual rise in per capita food consumption in developing countries. As a result, the number of undernourished people would gradually fall, from 811 million in 1999/2001 to 582 million in 2015. Further declines were projected for 2030 and 2050, with the 1996 World Food Summit target of halving the numbers undernourished by 2015 being within sight shortly after 2030. Is this still the case? What do the more recent data show?

As noted, the latest food consumption data from FBS go to 2005. They indicate that per capita consumption in developing countries increased between 1999/2001 and 2003/2005, from 2 580 to 2 620 kcal/person/day (Table 1.3). It would have been expected that the number undernourished in 2003/2005 would be lower than in 1999/2001. However, FAO's *The State of Food Insecurity in the World 2008* (FAO, 2008, hereafter referred to as SOFI 2008) estimates the number undernourished in developing countries at 823 million in 2003/2005, i.e., an increase, although food consumption per capita also increased. This seems to be going against the grain of the arguments made in the IR: that rising per capita consumption and the accompanying slight improvement in the equality of distribution would lead to declining undernourishment. Of course, it is quite possible for the number undernourished to increase because of population growth, if the increase in per capita calorie intake is small, as is the case here (see previous paragraph and Table 1.3). However, the question arises: Do the most recent estimates indicate a real reversal of the trend towards gradual and slow declines in the numbers of undernourished, or is this just data noise?

Table 1.3
Per capita food consumption (kcal/person/day)

	IR Table 2.1				New data and adjusted projections				
Country group	1999/ 2001	2015	2030	2050	1999/2001 new	2003/ 2005	2015	2030	2050
World	2 789	2 950	3 040	3 130	2 725	2 771	2 884	2 963	3 047
Developing countries	2 654	2 860	2 960	3 070	2 579	2 622	2 770	2 864	2 966
Sub-Saharan Africa	2 194	2 420	2 600	2 830	2 128	2 167	2 319	2 494	2 708
- excluding Nigeria	2 072	2 285	2 490	2 740	2 016	2 061	2 206	2 406	2 643
Near East and North Africa	2 974	3 080	3 130	3 190	2 991	2 995	3 072	3 134	3 197
Latin America and Caribbean	2 836	2 990	3 120	3 200	2 798	2 899	2 953	3 084	3 151
South Asia	2 392	2 660	2 790	2 980	2 334	2 344	2 532	2 656	2 843
East Asia	2 872	3 110	3 190	3 230	2 764	2 839	3 034	3 112	3 144
- excluding China	2 698	2 835	2 965	3 100	2 475	2 538	2 614	2 740	2 870
Industrial countries	3 446	3 480	3 520	3 540	3 429	3 462	3 501	3 548	3 569
Transition countries	2 900	3 030	3 150	3 270	2 884	3 045	3 043	3 159	3 283

Source: Author.

To understand what is happening, it should be noted that the data for per capita consumption, population, MDERs (the threshold for classifying people as undernourished) and the measure of inequality (the coefficient of variation [CV]) have all been revised rather drastically. These are the key data and parameters used to estimate undernourishment. They are now different from those in SOFI 2004, which were used to prepare the IR.

For example, the average kcal/person/day in developing countries for 1999/2001 is now 2 580 kcal, down from the 2 654 used in the IR and SOFI 2004. The decline is particularly sharp for some countries, such as Myanmar (from 2 840 to 2 160), Ecuador (from 2 720 to 2 220), Indonesia (from 2 910 to 2 420) and Benin (from 2 500 to 2 190). Such declines cannot but take a heavy toll of the estimates of undernourished, *ceteris paribus*.

If these revised kcal figures had been used in the computation on the IR estimates, with all the other data (population, MDERs and CVs) as they were known then, the undernourished would have been 920 million, not 811 million, in the starting three-year average 1999/2001 of the IR. Again, using the new kcal for 2003/2005 with the population data from the United Nations (UN) 2002 assessment (UN, 2003) – to be compatible with that of the IR for 1999/2001 – and unchanged MDERs and CVs, the undernourished for 2003/2005 would have been 910 million, a small decline from the estimate for 1999/2001, not an increase.

The revisions of the other data (population, MDERs and CVs) explain why the estimates of undernourishment in SOFI 2008 imply a small increase rather than a small decline between 1999/2001 and 2003/2005. To appreciate what is involved, it is necessary to examine how and why the data were so drastically revised:

- Regarding population data, the UN assessment of 2006 (UN, 2007) had revised estimates for several countries, which had to be taken on board. This concerned particularly several African countries, such as Togo (the new estimate for 2000 is 18 percent higher than the old one), Benin (16 percent higher), Angola (12 percent higher), Senegal (10 percent higher), Nigeria (9 percent higher) and Mali (16 percent lower).
- The reasons why the MDERs and the CVs were revised are explained elsewhere (FAO, 2004). The IR (FAO, 2006: Box 2.2) provides a more general discussion of the estimation of numbers undernourished.
- Concerning data on food consumption per capita, for some countries the change was predominantly the direct consequence of the population revisions: approximately the same amount of food was now divided by a larger population (e.g., in Togo, Benin, Angola, Senegal). In other countries, changes in both population and total food supplies were responsible for the changes in per capita consumption (e.g., in Nigeria, Mali). At the other extreme, for some countries the change in per capita consumption was almost entirely due to revised estimates of total food consumption in the FBS (e.g., in Indonesia, Myanmar, Ecuador). Such changes in the total food consumption data are not necessarily (or only) the result of changed total national availabilities of food commodities (production + imports – exports + stock changes). They also reflect changes introduced in the final-use allocations of total availabilities in the course of preparing the revised FBS (allocations among food, feed, stock changes, etc.).

Generating a revised base year data set

The preceding discussion suggests that the IR projections of per capita food consumption (kcal/person/day, given in FAO, 2006: Table 2.1) and the derived projections of undernourishment (FAO, 2006: Table 2.3) need to be adjusted before they can be compared with the latest situation presented in SOFI 2008 and provide a basis for making statements about the future course of undernourishment in relation to the present. This assumes that the SOFI 2008 depiction is accepted as representing the reality for the latest year with estimates, 2003/2005. The SOFI 2008 estimates are based on: i) the revised kcal/person/day data; ii) the new population data from the UN 2006 assessment; and iii) the new MDERs and CVs. These are used to create new estimates of undernourishment in the starting situation of the IR (the base year 1999/2001) and are shown in Table 1.4, columns 3 and 9. It is seen that use of the revised data generates a total estimate of 810 million undernourished people in the developing countries in 1999/2001.

Table 1.4
Incidence of undernourishment, developing countries, from SOFI 2008

Country group	1990/1992	2003/2005	1999/2001	2015	2030	2050
	Share of population *(%)*					
	(1)	(2)	(3)	(4)	(5)	(6)
Developing countries	n/a	16.3	17.0	11.3	8.1	4.8
Sub-Saharan Africa	n/a	30.5	32.0	22.3	13.9	7.0
- excluding Nigeria	n/a	35.8	37.6	26.5	16.1	7.9
Near East and North Africa	n/a	7.9	8.1	6.1	5.0	3.2
Latin America and the Caribbean	n/a	8.3	9.7	6.9	4.4	3.1
South Asia	n/a	21.3	21.1	13.8	10.2	5.2
East Asia	n/a	11.3	12.7	7.1	5.1	3.9
- excluding China	n/a	15.0	17.0	12.8	8.8	5.3
	Number of people[a] *(millions)*					
	(7)	(8)	(9)	(10)	(11)	(12)
Developing countries	813	823	810	664	556	370
Sub-Saharan Africa	169	213	202	204	174	118
- excluding Nigeria	154	200	190	196	165	110
Near East and North Africa	19	33	31	31	31	24
Latin America and Caribbean	53	45	50	43	31	24
South Asia	283	313	289	238	206	118
East Asia	290	219	237	149	115	87
- excluding China	112	97	105	93	72	46

[a] The absolute numbers differ from those published in SOFI 2008 because the latter includes Central and Western Asian countries of the former Soviet Union in the developing countries.

Source: FAO, 2008.

This is practically identical to that of the IR (based on SOFI 2004 estimates), although regional estimates are somewhat different, even though the underlying kcal and parameters have been revised – some of them drastically. Obviously, the impacts of the revisions of the key data and parameters used in the estimation have cancelled one another.

Adjusting the projected food consumption

Obviously, if the SOFI 2008 estimates for 2003/2005 are taken as representing the actual undernourishment situation, the projections must be adjusted before statements can be made about how the situation may evolve in the future compared with the present, i.e., 2003/2005. Adjustments must be made to the projected values of: i) kcal/person/day (to take into account the new starting data for 2003/2005); ii) the population in the projection years from the UN 2006 assessment of population prospects, which was used to generate the SOFI 2008 estimates (the IR population projections used those of the UN 2002 assessment); and iii) the revised MDERs and CVs.

Ideally, the new historical FBS data (available in unpublished form up to 2005) would be used, and the whole projections exercise redone by country and commodity to generate the new projected values for kcal/person/day. This is not practically possible at this stage, so shortcuts have to be devised to make adjustments. Box 1.2 describes the rules used to make the adjustments. These rules were applied directly for each country at the level of kcal/person/day (not by commodity). It is noted again that these adjustments are necessary to account for the fact that food consumption levels and the estimates of undernourishment depicted in SOFI 2008 differ from those that formed the basis for the IR food consumption and undernourishment projections.

The revised projections of kcal/person/day resulting from these adjustments are shown in Table 1.3 (reproducing Table 2.1 of the IR [FAO, 2006] for comparison). The following comments apply:

- With the exception of the Near East and North Africa region, the revised base year data for kcal/person/day in all other developing regions are lower than the data used in the IR. The difference is very marked in the East Asia region, particularly when China is excluded from the regional totals (see earlier discussion on the data for Myanmar and Indonesia).
- These lower starting levels have an impact on the projected values when the latter are adjusted as indicated. Although projected per capita levels in developing countries are lower than in the IR (by an average of 3.4 percent in 2050), the aggregate projected consumption in 2050 is virtually the same as that of the IR. This is because the new projected population of

UN 2006 is higher than that of UN 2002 (used in the IR), by 3.2 percent. That the new projections of per capita consumption combined with the new population values generate aggregate food demand equal to that of the IR is important: the aggregate food demand of the IR was derived as an integral component of the entire configuration of production, consumption (all uses, not only food) and trade. However, although this feature applies to the developing countries aggregate, it may not apply at the level of individual countries.

- The result is that in 2050 fewer developing countries than reported in the IR will have reached medium to high levels of per capita food consumption (more than 2 700 kcal/person/day): 73 countries in these revised estimates account for 80 percent of the developing country population in 2050, versus 85 countries and 90 percent of the population in the IR (Table 1.5).

Table 1.5
Developing country populations with given per capita food consumption[a]

		IR Table 2.2			Revised		
kcal/person/day		1999/ 2001	2030	2050	2003/ 2005	2030	2050
< 2 200	Population (million)	584	29		515	217	
< 2 200	Average kcal	2 001	2 060		1 928	2 087	
< 2 200	Countries (number)	32	2		32	6	
2 200–2 500	Population (million)	1 537	785	128	2 087	785	381
2 200–2 500	Average kcal	2 403	2 380	2 460	2 365	2 368	2 367
2 200–2 500	Countries (number)	26	17	3	26	20	9
2 500–2 700	Population (million)	201	510	618	368	2 575	1 148
2 500–2 700	Average kcal	2 547	2 605	2 625	2 616	2 653	2 632
2 500–2 700	Countries (number)	14	23	12	13	26	20
2 700–3 000	Population (million)	1 925	2 336	1 622	1 372	801	3 035
2 700–3 000	Average kcal	2 933	2 835	2 870	2 987	2 854	2 856
2 700–3 000	Countries (number)	16	31	42	14	25	35
> 3 000	Population (million)	484	3 049	5 140	735	2 495	3 185
> 3 000	Average kcal	3 174	3 280	3 200	3 163	3 309	3 262
> 3 000	Countries (number)	14	29	45	17	25	38
All developing	Population (million)	4 731	6 709	7 509	5 077	6 873	7 748
All developing	Average kcal	2 654	2 960	3 070	2 622	2 864	2 966
All developing	Countries (number)	102	102	102	102	102	102

[a] Only countries with FBS.
Source: Author.

Box 1.2 - Rules for adjusting the IR food (kcal/person/day) projections

If the FBS kcal for 2003/2005 is lower than that of the IR base year (i.e., $kcal_{2003/2005} < IR\text{-}kcal_{1999/2001}$), the $kcal_{2003/2005}$ is taken as the base year and the projected values are derived by applying the growth rates of kcal in the IR projections (49 of the 97 developing countries in the IR are in this category). Thus, for these countries:

$Revkcal_{2015} = kcal_{2003/2005}$ x (2 + g)11

where g is the annual growth rate between 1999/2001 and 2015 of the kcal in the IR. $Revkcal_{2030}$ and $Revkcal_{2050}$ are derived applying the same rule, i.e., applying the respective growth rates of the IR projections to the $Revkcal_{2015}$.

If the FBS kcal for 2003/2005 is higher than that of the IR base year, but lower than the kcal for 2015 in the IR projections (i.e., $IRkcal_{2015} > Newkcal_{2003/2005} > IRkcal_{1999/2001}$), the $IRkcal_{2015}$ remains unchanged and so do the IR projected kcals for 2030 and 2050 (38 countries in this category).

If the FBS kcal for 2003/2005 is higher than the IR kcal projected for 2015, then $Revkcal_{2015} = Newkcal_{2003/2005}$ (ten countries in this category). An upper limit of 3 500 kcal is imposed to prevent countries with very drastic upward revisions in their kcal from exploding towards unrealistically high levels of consumption in the projection years. Cuba is an example: it had 2 833 kcal in the IR base year 1999/2001; in the revised data used in SOFI 2008 it has 3 022 kcal for the same year and 3 276 kcal for 2003/2005.

Revised estimates of undernourishment in the future

The implications of the changes for undernourishment in the future are unfolded in Table 1.4. The following comments apply:

- SOFI 2008 indicates that the numbers undernourished in the developing countries increased between 1990/1992 and 2003/2005, although the percentages of the population affected declined. As described previously, the same applies to changes in the period 1999/2001 to 2003/2005. However, it was noted that revisions in the kcal/person/day data alone would have produced a small decline, not an increase. It is the application of the whole package of data and parameter revisions that generates a small increase. Does this indicate that the problem is getting worse, rather than improving towards the World Food Summit target of halving absolute numbers by 2015 (from those of 1990/1992)? It can only be noted that the increase in the estimate of absolute numbers is small and may not be significant, given the data noise.
- Comparing the new projected numbers of undernourished in Table 1.4 with those in Table 2.3 of the IR (FAO, 2006), it is evident that projected

undernourishment is now higher, both in absolute numbers and as percentages of the population. The higher percentages of the population result from lower projected per capita kcal (Table 1.4). This impact is reinforced in the absolute numbers because the projected population of developing countries is higher (UN, 2006) (Table 1.5).

- The revised projections indicate a slow decline in undernourishment. However, the rate of decline in the IR was such that the World Food Summit target could be within reach shortly after 2030. In the revised estimates, achievement of this target is shifting further into the future – to just before 2050.

Conclusions

This chapter examined whether the long-term projections to 2050 in the IR study (FAO, 2006, prepared between 2003 and 2005 from historical data to 2001 and base year 1999/2001) were still valid as predictions (for selected broad country and commodity aggregates) of what may be in store in world food and agriculture to mid-century. The projections were tested against: i) actual outcomes, as far as data permitted, in the first eight years of the projection period (to 2008); and ii) the ten-year projections for 2009 to 2018 that OECD/FAO had just completed, both with and without the quantities used as biofuel feedstocks. It was concluded that on both counts, and disregarding biofuels, the IR's projections are still broadly valid at the level of the aggregates considered.

The advent of biofuels requires a fresh look at the long-term picture. The existing medium-term projections of biofuel production and, in some cases, of the corresponding crop quantities to be used as feedstocks indicate that further growth is in prospect, although not at the very high rates of the last few years. In these projections, the quantities of cereals by which world aggregate consumption would be higher because of biofuels are still relatively modest (7 percent of world consumption in 2018, up from the current 4.8 percent; Figure 1.11), and much of the increase would likely come from increased production over and above what it would have been without biofuels. However, biofuels have the potential to be a major disruptive force, conditioning agricultural futures because of growing integration of the energy and agriculture markets. This theme, together with the possible impact of climate change, must inform all future attempts to speculate about long-term futures of world food and agriculture.

The chapter also examined the IR's projections of food consumption and numbers undernourished in developing countries in the light of some drastic revisions of the historical data and parameters used to compute such numbers, as well as in the projected populations. The projected food consumption levels had to be adjusted to account for these revisions and make it possible to compare the projections with the latest published estimates (in SOFI 2008) of per capita consumption and numbers undernourished. These adjustments indicate that the rate at which the numbers undernourished were projected to decline – slow and inadequate though it was in the IR projections – may turn out to be even slower. Achievement of the 1996 World Food Summit target of halving the number undernourished in the developing countries by 2015 (from that of 1990/1992) may well recede further into the future.

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Annex 1.1

Cereal production in developing countries

Developing countries with cereal production growth > 4.0 percent per annum[a]

	Amount (*'000 tonnes*)			Growth (*% per annum*)		
	1989/1991	1999/2001	2006/2008	1980-1990	1990-2000	1999/2001-2006/2008
Sierra Leone	353	181	913	0.2	-7.2	26.0
Iraq	2 456	1 379	3 471	2.8	-9.0	14.1
Paraguay	787	1 236	2 531	6.8	4.1	10.8
Guinea	521	955	1 888	0.0	7.9	10.2
Afghanistan	2 645	2 311	4 493	-3.8	0.8	10.0
Algeria	2 481	1 871	3 337	-1.2	-4.4	8.6
Chad	647	1 103	1 952	4.6	5.0	8.5
Ethiopia and Eritrea	6 370	8 858	15 378	1.7	4.0	8.2
Cambodia	1 649	2 740	4 663	8.6	6.3	7.9
Madagascar	1 779	1 910	3 183	1.9	0.4	7.6
Uruguay	1 101	1 568	2 600	2.1	5.8	7.5
Morocco	7 452	3 478	5 649	8.7	-5.1	7.2
Mali	1 999	2 350	3 578	7.1	2.3	6.2
Niger	1 898	2 690	4 093	0.4	2.9	6.2
Myanmar	9 110	14 002	20 934	-0.2	3.8	5.9
Sudan	2 918	3 988	5 818	-1.3	2.0	5.5
Venezuela	1 834	2 565	3 722	5.6	2.6	5.5
Iran, Islamic Republic	12 248	13 224	19 139	3.8	0.0	5.4
Zambia	1 461	1 137	1 615	6.6	0.3	5.1
Brazil	34 910	46 873	65 483	2.8	2.5	4.9
Yemen	700	689	958	0.4	0.3	4.8
Tanzania, United Republic	3 897	3 826	5 311	3.8	0.8	4.8
Angola	297	546	754	-2.5	7.1	4.7
Philippines	10 781	12 732	17 312	3.3	1.0	4.5
Burkina Faso	1 961	2 660	3 613	6.2	1.9	4.5
Nigeria	16 896	20 045	27 223	10.4	2.1	4.5
El Salvador	764	781	1 055	2.1	-0.4	4.4
Bolivia, Plurinational State	801	1 142	1 541	2.4	3.3	4.4
Malawi	1 543	2 347	3 096	1.1	7.1	4.0
Total	132 257	159 187	235 303	3.4	1.7	5.7
Other developing	737 239	866 952	969 742	2.7	1.8	1.6
All developing	869 496	1 026 138	1 205 045	2.8	1.8	2.3

[a] Only countries with 2006/2008 production > 500 000 tonnes.

Annex 1.2

World agriculture: towards 2030/2050 – interim report: excerpt from Chapter 1– Overview

Main findings

Continued growth of world agriculture even after the end of world population growth

The main reason is that zero population growth at the global level will be the net result of continuing increases in some countries (e.g., by some 31 million annually in 2050 in Africa and South and Western Asia together) compensated by declines in others (e.g., by some 10 million annually in China, Japan and Europe together). Nearly all the further population increases will be occurring in countries several of which even in 2050 may still have inadequate food consumption levels, hence significant scope for further increases in demand. The pressures for further increases of food supplies in these countries will continue. Much of it will have to be met by growing local production or, as it happened in the past and is still happening currently, it may not be fully met – a typical case of production-constrained food insecurity. The creation of slack in some countries with declining population (e.g., the transition economies, when growth of aggregate demand will have been reduced to a trickle -.01 percent per annum in the final two decades 2030 to 2050) will not necessarily be made available to meet the still growing demand in countries with rising population, e.g., demand growth at 2.0 percent per annum in sub-Saharan Africa.

In conclusion, zero population growth at the global level will not automatically translate into zero growth in demand and cessation of the building-up of pressures on resources and the wider environment. The need for production to keep growing in several countries will continue to condition their prospects for improved nutrition. In those among them that have limited agricultural potential, the problem of production-constrained food insecurity and significant incidence of undernourishment may persist, even in a world with stationary population and plentiful food supplies (or potential to increase production) at the global level. Nothing new here: this situation prevails at present and it will not go away simply because population stops growing at the global level. Projections to 2050 provide a basis for thinking about this possible outcome.

Food and nutrition

The historical trend towards increased food consumption per capita as a world average and particularly in the developing countries will likely continue, but at slower rates than in the past as more and more countries approach medium-high levels. The average of the developing countries that rose from 2 110 kcal/person/day 30 years ago to the present 2 650 kcal, may rise further to 2 960 kcal in the next 30 years and on to 3 070 kcal by 2050. By the middle of the century the great bulk of their population (90 percent) may live in countries with over 2 700 kcal, up from 51 percent at present and only 4 percent three decades ago. As in the past, the great improvements in China and a few other populous countries will continue to carry a significant weight in these developments.

However, not all countries may achieve food consumption levels consonant with requirements for good nutrition. This may be the case of some of the countries which start with very low consumption (under 2 200 kcal/person/day in 1999/2001), high rates of undernourishment, high population growth rates, poor prospects for rapid economic growth and often meagre agricultural resources. There are 32 countries in this category, with rates of undernourishment between 29 percent and 72 percent, an average of 42 percent, Yemen and Niger among them. Their present population of 580 million is projected to grow to 1.39 billion by 2050, that of Yemen from 18 million to 84 million and that of Niger from 11 million to 53 million. Their current average food consumption of 2 000 kcal/person/day is actually a little below that of 30 years ago. Despite the dismal historical record, the potential exists for several of these countries to make gains by assigning priority to the development of local food production, as other countries have done in the past. Under this fairly optimistic assumption, the average of the group may grow to 2 450 kcal in the next 30 years, although this would still not be sufficient for good nutrition in several of them. Hence the conclusion that reducing undernourishment may be a very slow process in these countries.

Notwithstanding the several countries with poor prospects for making sufficient progress, the developing countries as a whole would record significant reductions in the relative prevalence of undernourishment (percent of population affected). However, these will not be translated into commensurate declines in the numbers undernourished because of population growth. Reduction in the absolute numbers is likely to be a slow process. Numbers could decline from the 810 million in 1999/2001 to 580 million in 2015, to 460 million in 2030 and to just over 290 million by 2050. This means that the number of undernourished in developing countries, which stood at 823 million in 1990/1992 (the three-year average used as the basis for defining the World Food Summit target), is not likely to be halved by 2015. However, the proportion of the population undernourished could be halved by 2015 – from 20.3 percent in 1990/1992 to 10.1 percent in 2015 and on to 6.9 in 2030 and to 3.9 by 2050. It is noted that the UN Millennium Development Goals (MDGs) refer not to halving the numbers undernourished but rather to a target to "halve, between 1990 and 2015, the proportion of people who suffer from hunger". In this sense, the MDG goal may be achieved.

Despite this slow pace of progress in reducing the prevalence of undernourishment, the projections do imply considerable overall improvement. In the developing countries the numbers well-fed (i.e., not classified as undernourished according to the criteria used here) could increase from 3.9 billion in 1999/2001 (83 percent of their population) to 5.2 billion in 2015 (90 percent of the population), to 6.2 billion (93 percent) in 2030 and to 7.2 billion (96 percent) by 2050. That would be no mean achievement. Fewer countries than at present will have high incidence of undernourishment, none of them in the most populous class. The problem of undernourishment will tend to become smaller both in terms of absolute numbers affected and, even more, in relative terms (proportion of the population), hence it will become more tractable through policy interventions, both national and international.

The progress in raising per capita food consumption to 3 000+ kcal/person/day in several developing countries is not always an unmixed blessing. The related diet transitions often imply changes towards energy-dense diets high in fat, particularly saturated fat, sugar and salt, and low in unrefined carbohydrates. In combination with lifestyle changes, largely associated with rapid urbanization, such transitions, while beneficent in many countries with still inadequate diets, are often accompanied by a corresponding increase in diet-related chronic non-communicable diseases (NCDs). In many countries undergoing this transition, obesity-related NCDs tend to appear when health problems related to undernutrition of significant parts of their populations are still widely prevalent. The two problems coexist and these countries are confronted with a "double burden of malnutrition" resulting in novel challenges and strains in their health systems.

Growth of agriculture and main commodity sectors

Aggregate agriculture: World agriculture (aggregate value of production, all food and non-food crop and livestock commodities) has been growing at rates of 2.1 to 2.3 percent per annum in the last four decades, with much of the growth originating in the developing countries (3.4 to 3.8 percent per annum). The high growth rates of the latter reflected, among other things, developments in some large countries – foremost among them China. Without China, the rest of the developing countries grew at 2.8 to 3.0 percent per annum. They also reflected the rising share of high-value commodities like livestock products in the total value of production: in terms of quantities (whether measured in tonnage or calorie content), the growth rates have been lower.

The future may see some drastic decline in the growth of aggregate world production, to 1.5 percent per annum in the next three decades and down to 0.9 percent in the subsequent 20 years to 2050. The slowdown reflects the lower population growth and the gradual attainment of medium-high levels of per capita consumption in a growing number of countries. The latter factor restricts the scope for further growth in demand per capita in several countries that had very high growth in the past, foremost among them China. In contrast, developing countries that experienced slow growth in the past (and as a result still have low per capita consumption – less than 2 700 kcal/person/day) and potential for further growth should not experience any slowdown but rather some acceleration. Increasingly, world agriculture will have to depend on non-food uses of commodities if growth rates are not to be sharply lower compared with the past. As noted, the biofuels sector may provide some scope, perhaps a significant one, for relaxing the demand constraints represented by the declining rates of increase in human consumption.

Cereals: All the major commodity sectors should participate in the deceleration of agricultural growth. The cereals sector (sum of wheat, milled rice and coarse grains) has already been in such downward trend for some time now, with the growth rate having fallen from 3.7 percent per annum in the 1960s, to 2.5 percent, 1.4 percent and 1.1 percent in the subsequent three decades to 2001. In this latter year world production stood at just under 1.9 billion tonnes. It has grown further since then to some 2 billion tonnes in 2005 (preliminary estimate). We project increases to some 3 billion tonnes by 2050 and this would afford some increase in world per capita availability to around 340 kg (for all food and non-food uses), some 10 percent over present levels. It is noted that the current level of per capita consumption (309 kg in 1999/2001) is lower than what was achieved in the past mainly due to the sharp declines in the transition economies (the former socialist countries of the Soviet Union and Eastern Europe) in the 1990s. Recovery in their consumption as well as continued growth in the developing countries should raise the world average to levels it had attained in the past (in the mid-1980s). A good part of the increase in world cereals consumption should be for animal feed (mostly coarse grains), with the bulk of such consumption increases originating in the developing countries to support the expansion of their livestock production.

The decline in the growth rate notwithstanding, the absolute increases involved should not be underestimated: an increase of world production by another 1.1 billion tonnes annually will be required by 2050 over the 1.9 billion tonnes of

1999/2001 (or 1 billion tonnes over the 2 billion of 2005). Achieving it should not be taken for granted, as land and water resources are now more stretched than in the past and the potential for continued growth of yield is more limited.

Not all countries will be able to increase cereals production *pari passu* with their consumption. Therefore, past trends of ever-growing net cereals imports of the developing countries should continue and grow to some 300 million tonnes by 2050, a 2.7-fold increase over the 112 million tonnes of 1999/2001. This is a much lower rate of increase compared with the past when they had grown more than fivefold in 40 years. The novel element in the projections is that transition economies are transforming themselves from the large net importers of cereals they were up to the early 1990s (net imports of 43 million tonnes in 1993) to net exporters (18 million tonnes net exports annual average in 2002 to 2004). Such net exports could increase further in the future and, therefore, the traditional cereals exporters (North America, Australia, the EU and the developing exporters) would not have to produce the full surplus needed to cover this growing deficit.

Livestock: Production and consumption of meat will also experience a growth deceleration compared with the high growth rates of the past, although the milk sector should accelerate, mainly because of growth in the developing countries demand. The growth of the meat sector had been decisively influenced upwards by the rapid growth of production and consumption in China, and to a smaller extent also Brazil. This upward influence on the world totals was counterbalanced in the 1990s by the drastic shrinkage of the livestock sector in the transition economies, leading to a growth rate in the decade of 2.1 percent per annum versus 3.1 percent if the transition economies data are excluded from the world totals. These influences will not be present with the same force in the future – with the exception of continued rapid growth of production in Brazil (mainly for export). The decline in the transition economies has already been reversed, while the growth of meat consumption in China, which grew from 9 kg per capita to more than 50 kg in the last three decades, cannot obviously continue at the same high rates for much longer.

The rest of the developing countries still have significant scope for growth, given that their annual per capita meat consumption is still a modest 16 kg. Some of this growth potential will materialize as effective demand, and their per capita consumption could double by 2050, i.e., faster than in the past. It is unlikely that other major developing countries will replicate the role played by China in the past in boosting the world meat sector. In particular, India's meat consumption growth may not exert anything like the impact China had in the past, notwithstanding its huge population and good income growth prospects. The country may still have low levels of consumption (although significantly above the current 5 kg) for the foreseeable future.

Vegetable oils: The sector has been in rapid expansion, fuelled by the growth of food consumption and imports of the developing countries. The growth of the non-food uses (including in recent years for the production of biofuels in some countries) was also a major factor in the buoyancy of the sector, as was the availability of ample expansion potential of land suitable for the major oil crops – mainly soybeans in South America and the oilpalm in Southeast Asia. Indeed, oil crops have been responsible for a good part of the increases in total cultivated land in the developing countries and the world as a whole. These trends are likely to continue as the food consumption levels of the developing countries are still fairly low and the income elasticity of demand for vegetable oils is still high in most countries. In parallel, the growing interest in using vegetable oils in the production of biofuels may provide a significant boost. In this respect, concerns have been expressed that the rapid expansion of land areas under oil crops can have significant adverse impacts on the environment, mainly by favouring deforestation. This is just another example of the trade-offs between different aspects of sustainability that often accompany development: benefits in terms of reduced emissions of greenhouse gases when biofuels substitute petroleum-based fuels in transport versus the adverse impacts of land expansion.

Sugar: There are a number of features that characterize the evolution of the sector and determine future prospects: (a) rapidly rising food consumption in the developing countries (3.2 percent per annum in the last 30 years); (b) the emergence of several of them as major net importers (net imports of the deficit developing countries rose from 10 million tonnes to 29 million tonnes over the same period); (c) the growing dominance of Brazil as the major low-cost producer and exporter (production rose from 7.5 million tonnes to 32 million tonnes and net exports from 1 million tonnes to 11 million tonnes over the same period); (d) the growing use of sugar cane as feedstock for the production of biofuels (ethanol, mainly in Brazil, which now uses some 50 percent of cane production for this purpose); and (e) the prospect that after many years of heavy protectionism of the sugar sector and declining net imports in the industrial countries (which turned into net exporters from the mid-1980s, mainly owing to the protection of the sector in the EU and the substitution of maize-based sweeteners for sugar in the United States of America), the stage may be set for a reversal of such trends and the resumption of growth in their imports.

Many developing countries, including China, still have low or very low sugar consumption per capita (28 countries have less than 10 kg per annum and another 18 have 10 to 20 kg). Therefore, the potential exists for further growth in consumption, although it will not be as vigorous as in the past, when 60 developing countries had less than 20 kg in 1969/1971. Depending on the evolution of petroleum prices, sugar cane use as feedstock for the production of biofuels may keep growing in several producing countries (or those that have the resource potential to become major producers). Already several countries have plans to do so. It is possible that this development would contribute to keeping the growth rate of world aggregate demand (for all uses) and production from declining in line with the deceleration in the demand for food uses.

Roots, tubers and plantains: These products play an important role in sustaining food consumption levels in the many countries that have a high dependence on them and low food consumption levels overall. Many of these countries are in sub-Saharan Africa. In some countries (e.g., Nigeria, Ghana, Benin, Malawi) gains in production following the introduction of improved cultivars have been instrumental in raising the per capita food consumption levels. There is scope for other countries in similar conditions to replicate this experience. This prospect, together with the growing consumption of potatoes in many developing countries, should lead to a reversal of the trend for per capita food consumption of these products to decline – a trend that reflected largely the decline of food consumption of sweet potatoes in China. In addition, the potential use of cassava in the production of biofuels (actively pursued in Thailand) would further sustain the demand growth for this sector.

Agricultural trade of the developing countries

The growing imports of, mainly, cereals, livestock products, vegetable oils and sugar of many developing countries have resulted in the group of the developing countries as a whole turning from net agricultural exporters to net importers in most years after the early 1990s, reaching a deficit of USD 12 billion in 2000, before recovering in subsequent years to 2004. The recovery of recent years reflected above all the explosive growth of Brazil's agricultural exports, including oilseeds and products, meat, sugar, etc. Without Brazil, the deficit of the rest of the developing countries, already present from the late 1980s onwards, grew further from USD 20 billion in 2000 to USD 27 billion in 2004. Their traditional export commodities (tropical beverages, bananas, natural rubber, etc.) did not exhibit similar dynamism and for long periods stagnated or outright declined (in value terms), with the exception of the group fruit and vegetables.

The structural factors underlying these trends are likely to continue. The growing food demand in the developing countries will continue to fuel the growth of import requirements of basic foods in many of them, while the scope is limited for growth of consumption and imports of their traditional exportables to the developed countries. If anything, the growing competition among the developing exporters to supply those nearly saturated markets will continue to put pressure on prices (levels and instability) and lead to shifts in market shares at the expense of the weakest exporters among them, as happened with coffee in recent years. It may happen with sugar if the preferences protecting the weakest developing exporters were to be diminished or outright removed under the thrust of trade reforms. What will be somewhat different from the past is that the traditional dichotomy between developed (net importers) and developing (net exporters) will be further blurred: the markets facing the major developing exporters will be increasingly those of the importer developing countries, as is already happening with commodities such as sugar and vegetable oils.

Conclusions

The slowdown in world population growth and the attainment of a peak of total population shortly after the middle of this century will certainly contribute to easing the rate at which pressures are mounting on resources and the broader environment from the expansion and intensification of agriculture. However, getting from here to there still involves quantum jumps in the production of several commodities. Moreover, the mounting pressures will be increasingly concentrated in countries with persisting low food consumption levels, high population growth rates and often poor agricultural resource endowments. The result could well be enhanced risk of persistent food insecurity for a long time to come in a number of countries, in the midst of a world with adequate food supplies and the potential to produce more.

The slowdown in the growth of world agriculture may be mitigated if the use of crop biomass for biofuels were to be further increased and consolidated. Were this to happen, the implications for agriculture and development could be significant for countries with abundant land and climate resources that are suitable for the feedstock crops – assuming, of course, that impediments to biofuels trade do not stand on the way. Several countries in Latin America, Southeast Asia and sub-Saharan Africa, including some of the most needy and food-insecure ones, could benefit. Whether and to what extent this will happen is very uncertain, but the issue deserves serious analysis and evaluation. Of particular interest are: (a) possible adverse effects on the food security of the poor and the food-insecure if food prices were to rise because of resource diversion towards the production of feedstock crops for biofuels; and (b) the environmental implications of cultivated land expansion into pasturelands and forested areas. As noted, this is a typical case of possible trade-offs between different aspects of the environment and sustainability: benefits from the reduction in greenhouse gas emissions when biofuels substitute fossil fuels in transport and adverse effects from the expansion and intensification of agriculture.