CHAPTER

3

Prospects for agriculture and major commodity groups

This Chapter deals with the trends and future outlook of world food and agriculture in terms of the main commodity sectors. A brief introduction to the subject is given first presenting trends and prospects for total agriculture (the aggregates of all crops and livestock products).

3.1 Aggregate agriculture: historical trends and prospects

The historical evidence suggests that the growth of the productive potential of global agriculture has so far been more than sufficient to meet the growth of effective demand. This is what the long-term term decline in the real price of food suggests (World Bank, 2000). In practice, world agriculture has been operating in a demand-constrained environment. This situation has co-existed with hundreds of millions of the world population not having enough food to eat. This situation of un-met demand[1] co-existing with actual or potential plenty is not, of course, specific to food and agriculture. It is found in other sectors as well, such as housing, sanitation, health services, etc.

Limits on the demand side at the global level reflected three main factors: (a) the slowdown in population growth from the late sixties onwards (see Chapter 2); (b) the fact that a growing share of world population has been attaining fairly high levels of per capita food consumption, beyond which the scope for further increases is rather limited (Table 2.2), and (c) the fact that those who did not have enough to eat were too poor to afford more food and cause it to be produced, or did not have the resources and other means to produce it themselves.

The first two factors will continue to operate also in the future. Their influence will be expressed as lower growth rates than in the past of demand and, at the global level, also of production. The third factor will also continue to play a role, given that the overall economic outlook indicates that poverty will continue to be widespread in the future (Table 2.6). It follows that for a rather significant part of world population the potential demand for food will not be expressed fully as *effective* demand. Thus, the past trends of decelerating growth of demand will likely continue and perhaps intensify.

However, on the production side, there is no assurance that the past experience, when the world's production potential evolved and proved to be more than

1 The terms "demand" and "consumption" are used interchangeably. Both terms comprise all forms of use, i.e. food, feed, seed and industrial use as well as losses and waste. Demand for as well as supply from stocks, are disregarded in the projections. Given the long time horizon of the study, projections of stock changes would not add much to the main quantifications while unnecessarily complicating the analysis.

sufficient to meet the growth of demand, will continue, even when demand growth will be much lower than in the past. The natural resources per head of the growing population (e.g. land and water resources per person) will certainly continue to decline and the yield growth potential is more limited than in the past. It remains to be seen whether the advances in technology and related factors (e.g. investment, education, institutions and improved farm management) that underpinned the past growth of production will continue to more than make up for the declining resources per person. The future may be different if we are now nearer critical thresholds, e.g. yield ceilings imposed by plant physiology, or availability of water resources for maintaining and/or expanding irrigation. On the positive side, there are those who think that biotechnology has the potential of helping to overcome constraints to further increases in production (Lipton, 1999; Evenson, 2002).

We present in this section a brief overview of what we can expect in terms of increases of aggregate demand for, and production of, agricultural products. The figures we use refer to the aggregate volume of demand and production of the crop and livestock sectors. They are obtained by multiplying physical quantities of demand or production times price for each commodity and summing up over all commodities (each commodity is valued at the same average international price[2] in all countries in all years). The resulting time series is an index of volume changes over time of aggregate demand and production, when the latter are aggregated as indicated above (see Box 3.1 for more discussion on what these growth rates signify). The movements in this aggregate indicator are rarely sufficient for us to analyze and understand the forces that shape the evolution of agricultural variables in their different dimensions. The commodities included (see list in the Appendix) are very diverse from the standpoint of what determines their production, demand and trade. For this reason, the subsequent sections of this Chapter analyze and present the historical experience and prospects of world agriculture in terms of the main commodity sectors. Sections 3.2-3.6 deal with the basic food commodities: cereals, livestock products, oilcrops, the group roots, tubers and plantains, and sugar.

The overall picture for total agriculture is presented in Table 3.1. At the world level, the growth of demand for all crop and livestock products is projected to be lower than in the past, 1.5 percent p.a. in the period 1999/01-2030 and 0.9 percent for 2030-50 compared with rates in the area 2.1-2.3 percent p.a. in the preceding four decades. The difference is in part due to the lower population growth of the future compared with the past. This can be seen when the growth is expressed in terms of demand per capita (middle section of Table 3.1). It is mainly the slowdown in the growth of demand in the developing countries, and in particular in China, that accounts for a large part of the global deceleration. Why this should be so is shown

Box 3.1 Measuring change in agricultural aggregates

When speaking of growth rates of aggregate agricultural production or consumption, it matters what units are used in the measurement of change, in particular whether quantities of the different commodities are just aggregated in physical units (e.g. tonnes – which can be done for commodity groups like cereals but not for summing up heterogeneous products such cereals, meat, oranges, pumpkins, coffee, cotton, etc.) or aggregated in terms of value after multiplying each of them by their respective prices (which makes it possible to aggregate them). With shifts in the commodity structure of production and consumption away from staples and towards higher value commodities, the price-based index of the volume of production or consumption grows faster than the aggregate in physical units (e.g. tonnes) or the index obtained when the same quantities are aggregated using as weights their calorie content. For example, China's production of cereals grew in 1991-01 at 0.7 percent p.a., that of meat at 7.3 percent. Both together in tonnage terms grew at 1.5 percent, but they grew at 3.7 percent when aggregated on the basis of their prices – given that the price of meat is six times that of cereals in the price weights we use. Therefore, we should be aware that statements like "food production growth exceeded that of population" do not necessarily imply that the quantities available for consumption increased but that the aggregate value of production per capita increased. Similar considerations apply when food consumption quantities are aggregated using their calorie contents as weights. For example, China's food consumption per capita measured by the price-based volume index increased 64 percent in the 1990s but by only 11 percent in terms of calories. Analogous, though less pronounced, developments have characterized food consumption changes in other countries, Brazil among them. In contrast, in countries with little (e.g. India) or virtually no (e.g. sub-Saharan Africa) diet diversification, the volume of consumption has grown at roughly the same rates in both measures.

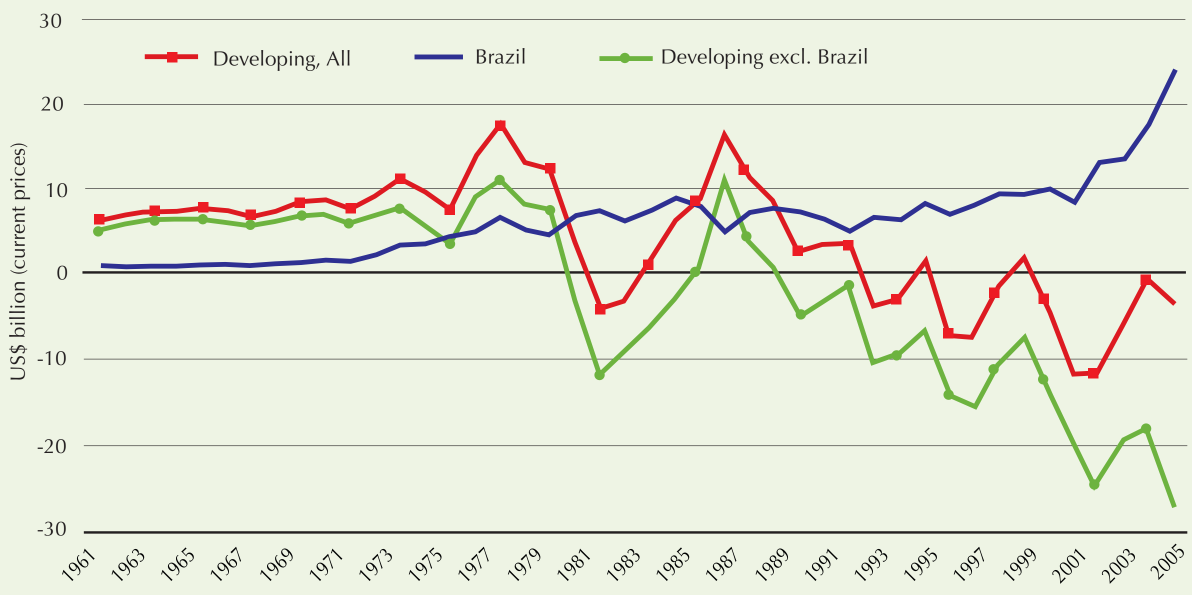
2 International dollar prices, averages for 1989/91.

in the more detailed regional numbers of Table 3.1. They show that the deceleration of the growth of demand per capita in the developing countries outside China is only slight (from 0.8-0.9 percent p.a. in the past to 0.7 percent p.a. in the three decades to 2030), an expected outcome given the operation of the factors mentioned earlier. A better idea about the roles of the above-mentioned factors making for deceleration, in particular the slowdown as higher consumption levels are attained, can be had from the data and projections presented in the memo item in Table 3.1. In it the developing countries are grouped into two sets: those that start in 1999/01 with fairly high per capita food consumption (over 2700 kcal/person/day) and, therefore, face less scope than before for increasing consumption, and all the rest, that is those with 1999/01 kcal under 2700.

China carries a large weight in the former group, so its example can be used to illustrate why a drastic deceleration is foreseen for that group and the developing countries as a whole. China has already attained a fairly high level of per capita food consumption of the main commodities, a total of 2960 kcal/person/day in 1999/01. In the projections, it increases further to 3300 kcal. This is nearly the level of the industrial countries. The increase of 11 percent in 30 years contrasts with that of 50 percent in the preceding 30 years. This explains the drastic slowdown in the growth rate when the aggregates are measured in terms of calorie content. However, the trend for consumption structure to change towards higher value products will continue and this will make for the price-based volume of consumption to grow faster (36 percent) than the 11 percent when measured in calories. This 36 percent in the next 30 years is still much lower than the 170 percent increase of the past 30 years, given that diet diversification towards the higher-value products has much less scope compared with the past when China's food consumption was heavily concentrated in cereals and sweet potatoes and had little by way of livestock products. In conclusion, when such deceleration occurs in China and in a few other large developing countries, the whole aggregate of the developing countries, and indeed the world, will be affected downwards.

In contrast, the growth of per capita demand in the other developing countries, those with under 2700 kcal/person/day in 1999/01, is projected not to decelerate and actually be higher in the future compared with the past (Table 3.1, memo item). This group of countries includes India with its one billion population out of the group's 2.3 billion. The prospect that India will not move much towards meat consumption (see section 3.3) contributes to limit the growth rate of total demand for both food and feed. In the past, the aggregate demand of the developing countries was greatly influenced by the rapid growth of apparent meat consumption in China (see, however, section 3.3 for possible overestimation of meat production and consumption in China). The prospect that

Figure 3.1 Net agricultural trade balance: developing countries, 1961-2004



* all crop and livestock products, primary and processed, excl. fish and forestry products

Table 3.1 Growth rates of demand and production, percent p.a.

	1961 -2001	1971 -2001	1981 -2001	1991 -2001	1999/01 -2030	2030 -2050
			Demand (all commodities - all uses), Total			
World	2.3	2.2	2.1	2.2	1.5	0.9
Developing countries	3.6	3.7	3.7	3.8	2.0	1.1
idem, excl. China	3.2	3.2	3.0	2.8	2.2	1.3
sub-Saharan Africa	2.8	2.9	3.2	3.2	2.8	2.0
idem, excl. Nigeria	2.6	2.5	2.6	3.0	2.8	2.1
Near East/North Africa	3.8	3.6	2.7	2.7	2.2	1.4
Latin America and Caribbean	3.0	2.9	2.8	2.9	1.8	1.0
idem, excl. Brazil	2.6	2.4	2.2	2.8	1.9	1.0
South Asia	3.0	3.2	3.2	3.0	2.3	1.3
East Asia	4.3	4.6	4.7	4.9	1.7	0.6
idem, excl. China	3.6	3.4	3.1	2.4	1.9	1.1
Industrial countries	1.2	1.1	1.0	1.1	0.7	0.4
Transition countries	0.5	-0.7	-2.1	-2.9	0.5	0.1
			Demand (all commodities - all uses), per capita			
World	0.5	0.5	0.5	0.8	0.6	0.4
Developing countries	1.4	1.7	1.8	2.1	0.8	0.5
idem, excl. China	0.8	0.9	0.8	0.8	0.7	0.6
sub-Saharan Africa	0.0	0.1	0.4	0.6	0.7	0.5
idem, excl. Nigeria	-0.2	-0.3	-0.2	0.4	0.7	0.6
Near East/North Africa	1.1	0.9	0.2	0.5	0.5	0.4
Latin America and Caribbean	0.8	0.9	1.0	1.2	0.8	0.6
idem, excl. Brazil	0.4	0.4	0.4	1.0	0.7	0.6
South Asia	0.7	1.0	1.1	1.1	1.0	0.7
East Asia	2.5	3.0	3.3	3.7	1.1	0.6
idem, excl. China	1.5	1.5	1.3	0.9	0.9	0.8
Industrial countries	0.4	0.4	0.3	0.4	0.3	0.4
Transition countries	-0.2	-1.2	-2.4	-2.8	0.7	0.6
Memo items						
Developing countries with over 2700 kcal/person/day in 1999/01	*0.5*	*0.6*	*0.6*	*0.8*	*0.9*	*0.7*
idem, excl. China	*2.1*	*2.4*	*2.6*	*2.9*	*0.9*	*0.6*
Developing countries with under 2700 kcal/person/day in 1999/01	*1.2*	*1.3*	*1.2*	*1.0*	*0.7*	*0.6*
			Production (all food and non-food commodities)			
World	2.3	2.2	2.1	2.3	1.5	0.9
Developing countries	3.4	3.6	3.7	3.8	1.9	1.1
idem, excl. China	2.9	3.0	2.9	2.8	2.2	1.4
sub-Saharan Africa	2.3	2.5	3.1	3.0	2.7	1.9
idem, excl. Nigeria	2.1	2.1	2.3	2.8	2.7	2.1
Near East/North Africa	3.0	3.0	2.8	2.4	2.2	1.4
Latin America and Caribbean	2.9	2.9	2.8	3.2	2.2	1.2
idem, excl. Brazil	2.4	2.3	2.2	2.9	2.1	1.2
South Asia	2.9	3.2	3.2	2.8	2.1	1.3
East Asia	4.2	4.5	4.6	4.8	1.6	0.6
idem, excl. China	3.3	3.2	2.8	2.4	1.9	1.2
Industrial countries	1.5	1.2	1.1	1.4	0.6	0.3
Transition countries	0.3	-0.8	-2.1	-3.1	0.5	0.2

this influence of China will be much weaker in the future and that it will not be replaced by a similar boom in other large countries, is one of the major factors making for the projected deceleration in the aggregate demand of the developing countries.

At the world level, production equals consumption, so the preceding discussion about global demand growth prospects applies also to that of global production. For the individual countries and country groups, however, the two growth rates can differ depending on movements in their net agricultural trade positions. In general, the growth rates of production in the developing regions have been a little below those of demand, as their agricultural imports have been growing faster than their exports, leading to gradual erosion of their traditional surplus in agricultural trade (crop and livestock products, primary and processed, not including fishery and forestry products). The trend has been for this surplus to diminish and to turn into a net deficit in most years in the 1990s. In the last fifteen years, the net balance reached a peak of US$ 16 billion surplus in 1986 and troughs of US$ 12 billion deficits in 2000 and 2001, before recovery in the subsequent years to 2004. The recent recovery reflected above all the extraordinary performance of Brazil's exports (mainly oilseeds and livestock products) which generated a net agricultural surplus of US$ 23.6 billion in 2004, up from an average of US$ 9.2 billion in the late 1990s. Excluding Brazil, the net balance of the other developing countries as a whole continued to precipitate from nearly zero in the late 1980s to reach a deficit of US$ 27 billion in 2004 (Figure 3.1). This prospect had been foreshadowed in our earlier projections to 2010 from base year 1988/90 (Alexandratos, 1995, p. 121).

Behind these trends in the value of the net trade balance of agriculture have been movements in both quantities and prices of the traded commodities and the policies that influenced them. Several factors, often widely differing among commodities, played a role in these developments. The commodity structure of the net trade balances of the developing countries other than Brazil is shown in Figure 3.2. Growing net imports of cereal and livestock products have been the dominant elements shaping this deficit, while imports of oilcrops and products by several major developing countries (China, India, Mexico, Pakistan) have also assumed growing importance in shaping the growing deficit of agriculture notwithstanding rapidly rising net exports of these products from other developing countries, e.g. Malaysia, Brazil, Argentina, Indonesia (see Table 3.11). On the other side, net exports of fruit and vegetables are virtually the only significant item which has shown consistent improvements. For sugar, the traditional large trade surplus (in value terms) of the developing countries as a whole diminished quickly after

Figure 3.2 Developing countries excluding Brazil, net trade balances by major commodity groups, 1984-2004

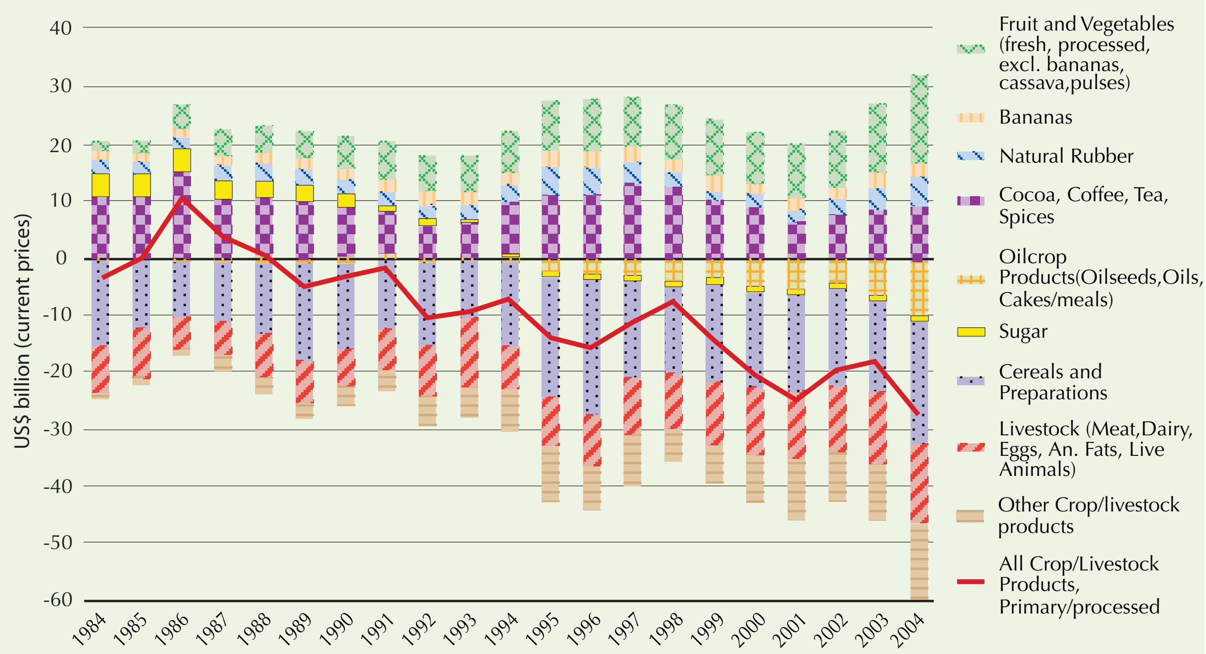
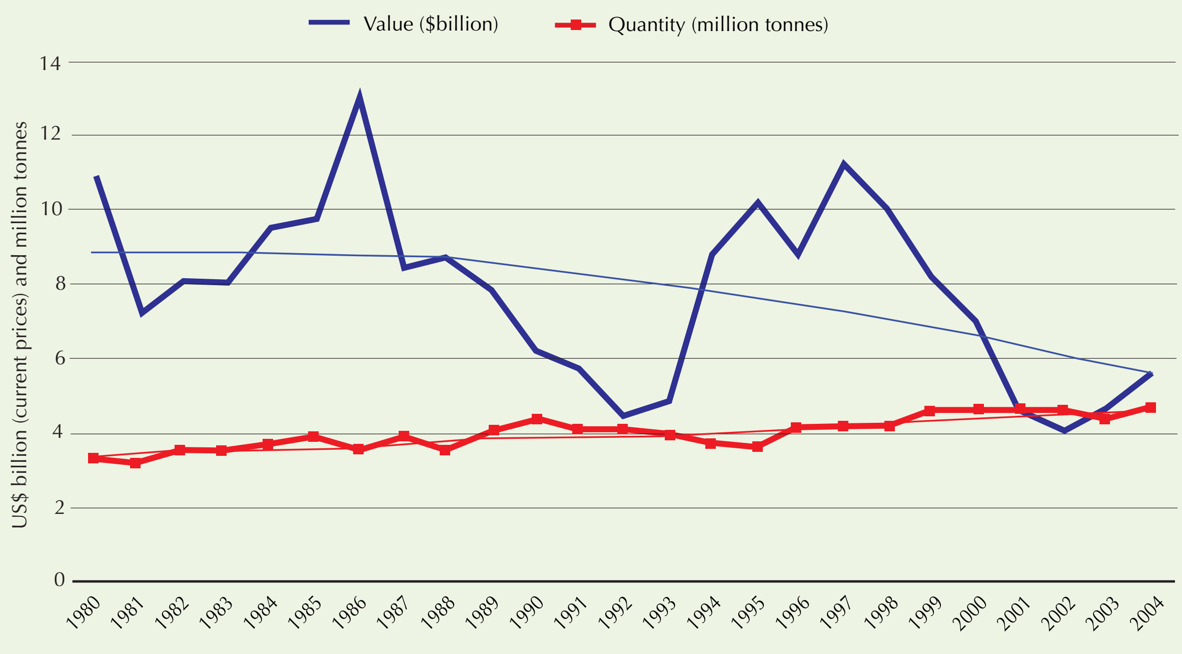


Figure 3.3 Developing countries, net exports of coffee



the early 1990s despite a surge in exports from Brazil, as several developing countries became major importers (Table 3.13, Figure 3.11). The shrinkage also reflects the effects of the heavy domestic support and trade protection in major sugar importing countries like the USA and Japan, or in formerly net importing countries, like the European Union (EU) which became a significant net exporter as a result of these policies. The traditional net surplus of the developing countries in tropical beverages has been fluctuating widely and on balance on a path of slow decline. This has reflected both very slow growth of consumption in the main importing and consuming countries (the industrial ones) and declines in prices, even in current dollars – much more in constant dollars. The net result has been that the developing countries have been exporting more and more quantities but their net receipts from such sales have fallen. This is vividly illustrated by the case of coffee (Figure 3.3) where catastrophic price falls characterized the early years of the current decade.

The evolution of the overall net agricultural trade balance of the developing countries as a whole does not by itself denote overall improvement or deterioration from a developmental standpoint. The aggregate of the developing countries is a composite of widely differing country and commodity situations. For some countries, a declining agricultural trade balance (or a growing deficit) is an indicator of progress towards improved welfare. This is the case of countries like Korea, Rep. in which the growing agricultural deficit has gone hand in hand with high rates of overall development and growing food consumption. The declining overall balance also reflects the rapid growth in such things as China's growing imports of vegetable oils (a positive development overall as they contribute to improve food consumption and are paid for by growing industrial export earnings); or cotton imports into several developing countries, which sustain their growing exports of textiles. In this latter case, however, the cotton exporting developing countries are not benefiting much as a growing market share of exports has been supplied by subsidized exports from the USA. Needless to say, a declining agricultural balance is a negative developmental outcome in countries which still depend heavily on export earnings from agriculture and/or have to divert scarce foreign exchange resources to pay for growing food imports (eventually building up unsustainable foreign debt). It is an even more negative indicator from the standpoint of human welfare when such food imports are not associated with rising food consumption per capita and improved food security, but are necessary just to sustain minimum levels of food consumption - a not uncommon occurrence.

The projections indicate a continuing deepening of the net trade deficit of the developing countries in volume terms. This is because their net imports of the main commodities in which they are deficit, mainly cereals and dairy products, will continue to rise fairly rapidly. In parallel, their net trade surplus in traditional exports (e.g. tropical beverages, bananas) will likely rise less rapidly. The particulars relating to future trade outcomes for the main commodity groups are discussed in the following sections of this Chapter. The potential of some developing countries to be growing net exporters of products competing with those from the industrial countries (meat, but also palmoil, soybeans and sugar) in an increasingly liberal trading environment may eventually attenuate the broader trend for developing countries as a whole to become growing net importers of food and agricultural products. Such effects may be further strengthened by the support to the prices of commodities like sugar and vegetable oils if their use as feedstocks for the production of biofuels were to become more widespread following rising petroleum prices[3].

Concerning production, at global level sufficient production potential can be developed for meeting the expected increases in effective demand in the course of the next five decades. As noted, the required growth rate of global production will be lower than in the past. Naturally, even this growth may not materialize unless we make it happen. This requires continued support to agricultural research and policies and other conditions (education, credit, infrastructure, etc.) to make it profitable and possible for farmers to expand production capacity. That there is scope for increasing global production is not to say that all people will be food-secure in the future. Far from it, as Chapter 2 has shown. The interaction between food security and food production potential is very much a local problem in poor and agriculture-dependent societies. Many situations exist where production potential is limited (e.g. in the semi-arid areas given existing and accessible technology, infrastructure, etc.) and a good part of the population depends on such poor agricultural resources for food and more general livelihood. Unless local agriculture is developed and/or other income earning opportunities open up, the food insecurity determined by limited local production potential will persist, even in the middle of potential plenty at the world level. The need to develop local agriculture in such situations as the condition *sine qua non* for improved food security cannot be overemphasized. In Chapter 2 (Box 2.3), we signaled the possibility that some of the more agriculturally disadvantaged low-income countries with high population growth may find it extremely difficult to advance by as much as required to improve food security to acceptable levels.

3.2 Cereals

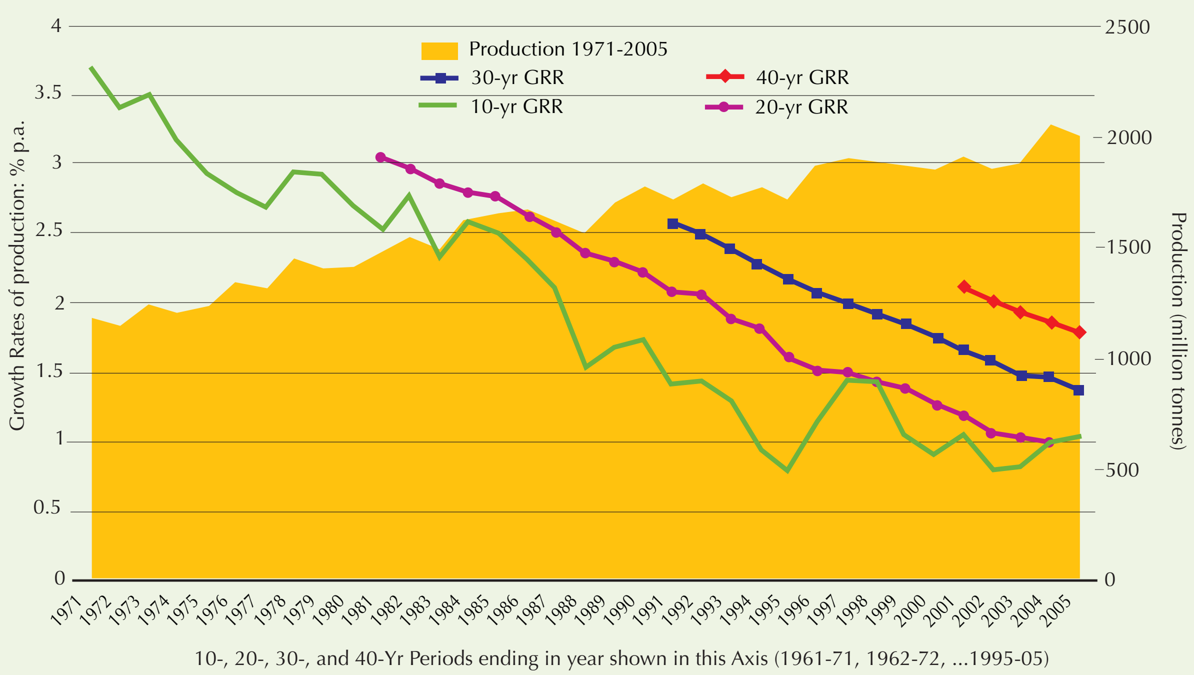
In our previous work (Bruinsma, 2003) we highlighted the historical experience showing that the growth rate of global demand for cereals (for all uses, hence also of world production) has been in long-term decline. Table 3.2 (column 9) shows the progressive fall in the growth rates in the last 40, 30, 20 and 10 years ending in 2001. These trends are seen more clearly in Figure 3.4 using data up to the most recent year 2005 (provisional). Our earlier projections to 2030 concluded that such deceleration would continue, but that the absolute increases in world consumption in prospect still represented a significant quantum jump of some 965 million tonnes (52 percent) over the base year level of 1997/99, leading to total world consumption of 2830 million tonnes by 2030.

There are a number of factors suggesting that the deceleration may be even more pronounced than visualized only 4 years ago and the absolute increments will likely be smaller. They are the following:

- Data revisions showing that world consumption in our old base year 1997/99 was lower than we knew then – by 25 million tonnes;
- Projected world population in 2030 in the most recent demographic projections used here is lower than the one used then, 8130 million vs. 8270 million; and
- Developments in recent years suggest that some structural changes may have occurred making for lower growth in production and consumption of cereals in a number of major consuming countries, foremost among them China and to lesser extent India, which together account for 28 percent of world consumption and for 48 percent of that of the developing countries. In China total cereals consumption peaked at 385 mt in 1996 and had fallen to 314 million tonnes by 2003 according to FAO's FBS data. In India, it grew by only 16 million tonnes over the same period, i.e. 9.1 percent when population had increased

3 On the correlation between sugar prices and those of petroleum via the ethanol link see "Brazil's sugar industry gears up for a new world fuel", *Financial Times*, 8 March 2006. An OECD study concludes that projections suggest "that biodiesel production, in particular, has the potential to boost world vegetable oil prices to levels that have not been observed during the past two decades" (OECD, 2006: 28).

Figure 3.4 World cereals production: growth rates in successive 10-, 20-, 30-, and 40-year periods



12.3 percent. For the world as a whole, cereals production remained practically flat at around 1.9 billion tonnes for the period 1996-2003. These recent developments, if taken into account, as they should to the extent that they are relevant for the future, represent another major factor making for lower world production/consumption in the future.

The resulting lower projection of world cereals consumption for 2030 is 2680 million tonnes, a growth rate of 1.2 percent p.a. measured from the average of 1999/01. This is higher than that of the 1990s (0.9 percent), when per capita consumption (all uses) fell by 20 kg or 6 percent (see Table 3.2, Col. 2), principally because the last decade was the period of the drastic decline in the transition countries following the systemic reforms. The 2030 figure for the developing countries is 1800 million tonnes, which is some 120 million tonnes lower than in our earlier projections. The reduction reflects the three factors mentioned above. For the rest of the developing countries (i.e. excluding China and India, and in per capita terms), projected 2030 consumption of 268 kg is actually slightly higher than that of our earlier projections.

Looking beyond 2030, the growth rate of world consumption and production is expected to fall further in the subsequent 20 years to 0.6 percent p.a. and the aggregate consumption would rise to just over 3 billion tonnes by 2050. Thus, annual world production must rise by some 800 million tonnes in the 30 years to 2030 (not much above the some 770 million tonnes it rose in the preceding 30 years 1969/71 - 1999/01) and by another 330 million tonnes in the subsequent two decades. From the standpoint of mounting pressures on land and water resources, these numbers imply a much more manageable outcome than previously thought. The slowdown in the growth of world consumption is, however, a very mixed blessing. On the positive side we must count the influence of the lower population growth and the gradual approaching of saturation levels in per capita food consumption in a growing number of countries. On the negative side is the prospect that there will still be countries with persistent low overall food consumption levels whose population would consume more if they had access to more food.

Individual cereal commodities and categories of use

For **rice**, the characteristic feature of the historical evolution is that per capita consumption (for all uses, but overwhelmingly for food, though in some countries rice is also used as animal feed) has tended to level off in the last

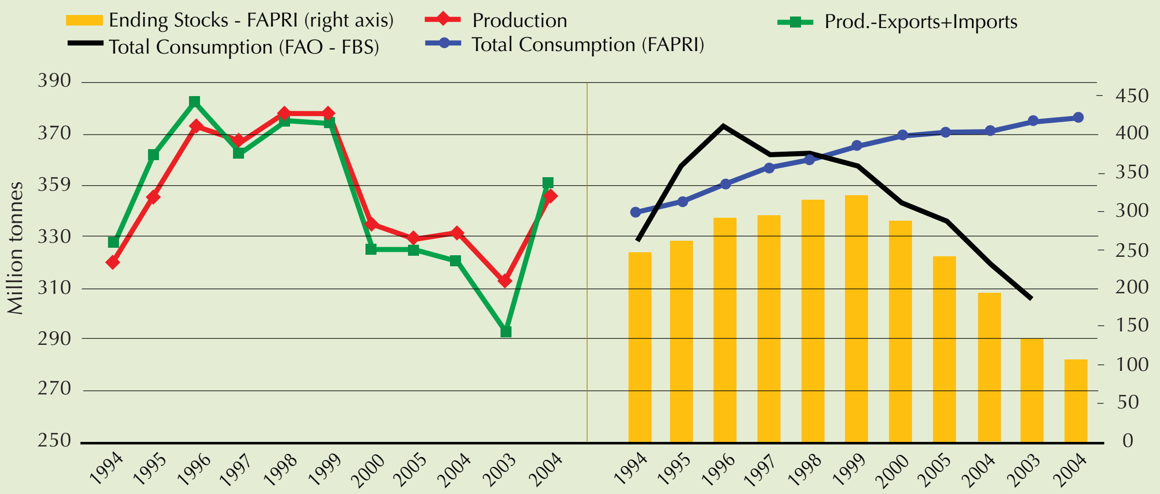
Box 3.2 Uncertainties concerning China's cereals consumption and stocks

Data revisions and the lower projected population growth account for the bulk of the difference between the current projections of cereals consumption in the developing countries and those of the earlier study. In addition lower projections for China also contribute to the difference. China's production of cereals (aggregate of wheat, maize, barley and milled rice – minor cereals are not included in order to make the data comparable with those of FAPRI) peaked in 1998 and 1999 at 380 million tonnes. Thereafter, it fell more or less continuously in the next five years reaching 312 million tonnes in 2003, before rebounding to around 345 million tonnes in 2004 and a provisional estimate of 352 million tonnes in 2005. Notwithstanding these declines in production, domestic prices did not rise until about mid-2003 and China remained a net cereals exporter (maize, rice) up to 2003 (it became a small net importer of 5 million tonnes in 2004). By mid-2003, however, the production shortfalls in combination with rising grain prices in world markets made an impact on the domestic demand-supply balance and led to rapidly increasing grain prices. The production rebound in 2004 is attributed to the response of farmers to these price rises as well as to good weather.

The important thing is to know what happened to consumption of food and feed and whether any significant departures from past patterns are indicative of more fundamental structural changes likely to persist in the future and affect the projections. FAO's Food Balance Sheets data (which are used in this study) suggest that total domestic use of these cereals also fell continuously from a peak of 372 million tonnes in 1996 to 306 million tonnes in 2003 (the last year for which such FBS data are available as of March 2006). These trends are shown in Figure 3.5. However, others consider that total domestic use did not decline but that the shortfall was made up by drawing down China's huge stocks. According to the data used by FAPRI (2005), stocks were reduced from a huge 325 million tonnes in 1999 to 106 million tonnes in 2004 (Figure 3.5). A review of the subject undertaken by FAO highlights the uncertainties concerning both stocks and consumption trends and concludes that "stocks in China must have fallen substantially in recent years" (FAO, 2004c).

The fact that livestock production growth (which depends increasingly on cereals feed) continued unabated in this period (meat production increased 51 percent) would seem to suggest that the second view could be nearer the truth. However, there are two counterarguments: (a) over the same period apparent consumption of protein feeds (mainly soybean meal) seems to have grown very rapidly judging from the increase in soybeans availability from 15 million tonnes to 36 million tonnes, with all of the increase coming from imports. This suggests substitution of oilmeals for cereals in the feed rations; and (b) we should not take for granted the livestock production statistics, as it is widely held that they overstate the growth of livestock production (see Ma *et al*, 2004). In short, the reliability of livestock data is as doubtful as that of changes in cereals consumption, if not more. Such limitations make them a poor guide for resolving the uncertainties as to what happened to the feed consumption of cereals. And, of course, the greater part of the decline in cereals use in the FBS data originated in food (35 million tonnes), not in feed (20 million tonnes). This lends some degree of plausibility to the decline in cereals consumption (see Box 2.1).

Figure 3.5 China: production, stocks and two views on consumption; aggregate of wheat, maize, rice and barley



Source: FAPRI data from FAPRI (2005); Others: FAO STAT decade or so (see Figure 3.6 and Table 3.4). This trend has been most evident in several countries of Asia, both East Asia and South Asia. In the former, per capita consumption of rice declined from a peak of 122 kg in 1984 to 114 kg in 2001. In the latter, it declined from a peak of 89 kg in 1991 to 83 kg ten years later. Given the overwhelming weight of these regions in world rice consumption, these declines are reflected in the aggregate trends of the world and the developing countries. These trends are projected to continue and the average of the developing countries may fall further. In contrast, per capita consumption in the developing countries of both **wheat** (mainly food) and **coarse grains** (increasingly for animal feed) should continue increasing (Table 3.4, Col. 4).

Concerning **wheat**, the growth of consumption in the great majority of the developing countries has depended greatly on the growth of imports: if we exclude Argentina (the major traditional net exporter of wheat among the developing countries) and the two giants China and India from the developing country totals, net imports of the rest increased from 20 million tonnes in 1969/71 to 75 million tonnes in 1999/01, when their consumption grew from 62 million tonnes to 155 million tonnes. That is, some 60 percent of the increment in consumption was met by increments in imports. And, of course, several countries have depended entirely on imports for increasing consumption of wheat. These include both the many tropical non-producing countries as well as those

Table 3.2 Cereal balances, world and major country groups

	Demand						SSR[a] (percent)	Growth rates (percent p.a.)			
	per capita (kg)		total (million tonnes)								
year	food 1	all uses 2	food 3	all uses 4	production 5	net trade 6	7	period 8	demand 9	production 10	population 11
					World						
1969/71	149	303	547	1114	1118	3	100	**1961-2001**	2.1	2.1	1.8
1979/81	160	325	708	1436	1442	3	100	**1971-2001**	1.7	1.7	1.7
1989/91	171	329	897	1727	1732	4	100	**1981-2001**	1.2	1.2	1.6
1999/01	165	309	1000	1865	1884	3	101	**1991-2001**	0.9	1.1	1.4
2030	165	331	1334	2677	2680	3	100	**1999/01-30**	1.2	1.2	1.0
2050	162	339	1439	3010	3012	3	100	**2030-50**	0.6	0.6	0.5
								1999/01-50	1.0	0.9	0.8
					Developing countries						
1969/71	146	192	381	499	483	-20	97	**1961-2001**	3.1	2.9	2.1
1979/81	162	219	526	711	649	-66	91	**1971-2001**	2.8	2.7	2.0
1989/91	174	238	693	951	868	-89	91	**1981-2001**	2.2	2.2	1.9
1999/01	166	238	784	1125	1026	-112	91	**1991-2001**	1.6	1.6	1.7
2030	166	268	1112	1799	1567	-232	87	**1999/01-30**	1.6	1.4	1.2
2050	163	279	1226	2096	1800	-297	86	**2030-50**	0.8	0.7	0.6
								1999/01-50	1.3	1.1	0.9
					Industrial countries						
1969/71	132	531	96	386	409	21	106	**1961-2001**	1.3	1.8	0.8
1979/81	139	542	110	427	551	111	129	**1971-2001**	1.1	1.2	0.7
1989/91	154	543	130	459	581	130	127	**1981-2001**	1.1	0.8	0.7
1999/01	162	592	147	536	647	114	121	**1991-2001**	1.6	1.4	0.6
2030	159	641	160	643	845	203	132	**1999/01-30**	0.6	0.9	0.3
2050	156	665	159	678	926	248	137	**2030-50**	0.3	0.5	0.1
								1999/01-50	0.5	0.7	0.2
					Transition countries						
1969/71	201	653	70	229	226	2	98	**1961-2001**	0.7	0.5	0.7
1979/81	189	778	72	297	242	-41	81	**1971-2001**	-0.7	-0.6	0.5
1989/91	179	769	74	317	282	-37	89	**1981-2001**	-2.3	-1.4	0.3
1999/01	169	499	69	205	211	2	103	**1991-2001**	-3.7	-2.2	-0.1
2030	164	618	62	235	267	32	113	**1999/01-30**	0.5	0.8	-0.3
2050	158	688	54	236	287	51	121	**2030-50**	0.0	0.4	-0.5
								1999/01-50	0.3	0.6	-0.4

[a] SSR =Self-Sufficiency rate = production/domestic demand (in percent)

facing increasingly binding land and water constraints to increasing production (e.g. Yemen).

Growth in per capita wheat consumption of the developing countries should resume, following the exhaustion of the "China effect" (see Box 3.2) which had led to falls in the average of the developing countries in the 1990s. The past pattern of dependence of the growth of consumption on growing imports would continue. Thus, for the same group of developing countries mentioned above (developing excluding Argentina, China and India), some 50 percent of the increment in their projected consumption should be met by increases in imports. Overall, the net wheat imports of all the developing countries except Argentina could grow from the present 74 million tonnes to 150 million tonnes in 2030 and on to 190 million tonnes in 2050. These substantial increases

Table 3.3 Cereal balances, developing regions

	Demand						SSR[a] (percent)	Growth rates (percent p.a.)			
	per capita (kg)		total (million tonnes)								
year	food 1	all uses 2	food 3	all uses 4	production 5	net trade 6	7	period 8	demand 9	production 10	population 11
				Sub-Saharan Africa							
1969/71	115	144	30	38	37	-3	98	**1961-2001**	2.9	2.4	2.8
1979/81	114	137	40	48	41	-8	85	**1971-2001**	3.2	2.7	2.9
1989/91	119	145	55	67	58	-8	86	**1981-2001**	3.3	3.0	2.8
1999/01	123	149	75	90	72	-16	80	**1991-2001**	2.9	2.3	2.6
2030	142	169	161	192	153	-39	81	**1999/01-30**	2.5	2.5	2.1
2050	155	186	234	280	220	-60	79	**2030-50**	1.9	1.8	1.4
								1999/01-50	2.3	2.3	1.8
				Near East/North Africa							
1969/71	179	293	33	53	46	-7	86	**1961-2001**	3.3	2.3	2.7
1979/81	200	332	48	80	58	-24	73	**1971-2001**	3.2	2.2	2.6
1989/91	212	354	67	111	77	-39	69	**1981-2001**	2.3	2.0	2.5
1999/01	204	343	80	135	80	-54	59	**1991-2001**	2.1	-0.4	2.2
2030	199	387	128	249	142	-106	57	**1999/01-30**	2.1	1.9	1.7
2050	193	408	150	316	173	-142	55	**2030-50**	1.2	1.0	0.9
								1999/01-50	1.7	1.6	1.4
				South Asia							
1969/71	150	169	106	120	116	-5	97	**1961-2001**	2.6	2.9	2.2
1979/81	151	170	134	150	147	-2	98	**1971-2001**	2.6	2.8	2.2
1989/91	164	185	181	204	203	-3	99	**1981-2001**	2.4	2.6	2.1
1999/01	157	180	210	241	254	-1	105	**1991-2001**	1.7	2.5	1.9
2030	167	198	328	390	370	-20	96	**1999/01-30**	1.6	1.3	1.3
2050	169	208	372	459	428	-31	95	**2030-50**	0.8	0.7	0.6
								1999/01-50	1.3	1.0	1.0
				East Asia							
1969/71	152	192	178	225	219	-8	97	**1961-2001**	3.3	3.3	1.8
1979/81	181	239	258	340	316	-24	93	**1971-2001**	2.8	2.8	1.5
1989/91	200	273	333	455	433	-27	95	**1981-2001**	1.9	2.0	1.4
1999/01	187	271	350	509	487	-21	96	**1991-2001**	1.0	1.1	1.1
2030	176	318	396	718	656	-62	91	**1999/01-30**	1.2	1.0	0.6
2050	162	332	365	749	682	-68	90	**2030-50**	0.2	0.2	0.0
								1999/01-50	0.8	0.7	0.4
				Latin America and Caribbean							
1969/71	119	224	33	63	66	3	104	**1961-2001**	3.2	2.6	2.2
1979/81	130	262	46	94	87	-8	93	**1971-2001**	2.8	2.2	2.0
1989/91	130	257	57	112	97	-12	86	**1981-2001**	2.3	1.7	1.8
1999/01	133	291	68	150	133	-20	89	**1991-2001**	2.7	3.0	1.6
2030	140	357	99	252	246	-5	97	**1999/01-30**	1.7	2.1	1.1
2050	139	383	106	292	296	4	100	**2030-50**	0.7	0.9	0.4
								1999/01-50	1.3	1.6	0.8

[a] SSR = Self-Sufficiency rate = production/domestic demand (in percent)

in the import requirements reflect, *inter alia*, the prospect that China and India will revert to being medium-sized net importers again after the recent trends which saw net imports decline drastically and the emergence of India as a net wheat exporter (see discussion of trade below).

Consumption of **coarse grains** should continue to grow, mainly for non-food uses (essentially animal feed, though use for the production of biofuels may assume some importance in the future) but also for food in the many countries of sub-Saharan Africa where coarse grains (maize, millet, sorghum, but also tef in Ethiopia) are the mainstay of food cereals consumption. The next three decades will probably see a higher increase in the global totals than the preceding three decades which witnessed the drastic contraction of feed use in the formerly centrally planned economies of Europe.

Table 3.4 Wheat, rice and coarse grains: Demand and production

Demand								Production	Growth rates			
per capita (kg)						total (million tonnes)			(percent p.a.)			
year	food	all uses				food	all uses	production	period	demand	production	population
	World		Dev.ping	Dev.ping excl. China	World excl. Transition	World						
1	2	3	4	5	6	7	8	9	10	11	12	13
						Wheat						
1969/71	57	89	47	50	64	210	327	322	**1961-2001**	2.4	2.4	1.8
1979/81	65	99	63	59	74	289	438	438	**1971-2001**	2.0	1.9	1.7
1989/91	72	105	73	64	84	375	551	559	**1981-2001**	1.2	1.2	1.6
1999/01	69	96	70	65	85	419	578	588	**1991-2001**	0.7	0.9	1.4
2030	71	100	80	77	92	578	813	818	**1999/01-30**	1.1	1.1	1.0
2050	72	102	83	83	94	636	903	908	**2030-50**	0.5	0.5	0.5
									1999/01-50	0.9	0.9	0.8
						Rice (Milled)						
1969/71	49	55	72	67	61	182	203	207	**1961-2001**	2.5	2.5	1.8
1979/81	54	59	76	67	64	237	263	263	**1971-2001**	2.2	2.3	1.7
1989/91	58	65	82	72	70	306	341	345	**1981-2001**	1.8	1.9	1.6
1999/01	57	64	78	71	68	347	387	403	**1991-2001**	1.3	1.7	1.4
2030	55	62	72	67	64	441	503	505	**1999/01-30**	0.9	0.8	1.0
2050	51	59	67	64	61	449	522	524	**2030-50**	0.2	0.2	0.5
									1999/01-50	0.6	0.5	0.8
						Coarse grains						
1969/71	42	159	72	73	141	156	584	589	**1961-2001**	1.8	1.8	1.8
1979/81	41	166	80	78	143	182	735	742	**1971-2001**	1.3	1.2	1.7
1989/91	41	159	84	82	137	216	834	828	**1981-2001**	0.9	0.9	1.6
1999/01	39	149	90	85	142	234	901	894	**1991-2001**	0.8	0.9	1.4
2030	39	168	116	105	164	314	1360	1356	**1999/01-30**	1.4	1.4	1.0
2050	40	179	129	117	174	354	1584	1580	**2030-50**	0.8	0.8	0.5
									1999/01-50	1.1	1.1	0.8
						Total cereals						
1969/71	149	303	192	189	266	547	1114	1118	**1961-2001**	2.1	2.1	1.8
1979/81	160	325	219	204	282	708	1436	1442	**1971-2001**	1.7	1.7	1.7
1989/91	171	329	238	217	292	897	1727	1732	**1981-2001**	1.2	1.2	1.6
1999/01	165	309	238	221	295	1000	1865	1884	**1991-2001**	0.9	1.1	1.4
2030	165	331	268	249	321	1334	2677	2680	**1999/01-30**	1.2	1.2	1.0
2050	162	339	279	263	329	1439	3010	3012	**2030-50**	0.6	0.6	0.5
									1999/01-50	1.0	0.9	0.8

Figure 3.6 Per capita consumption (all uses) of individual cereals

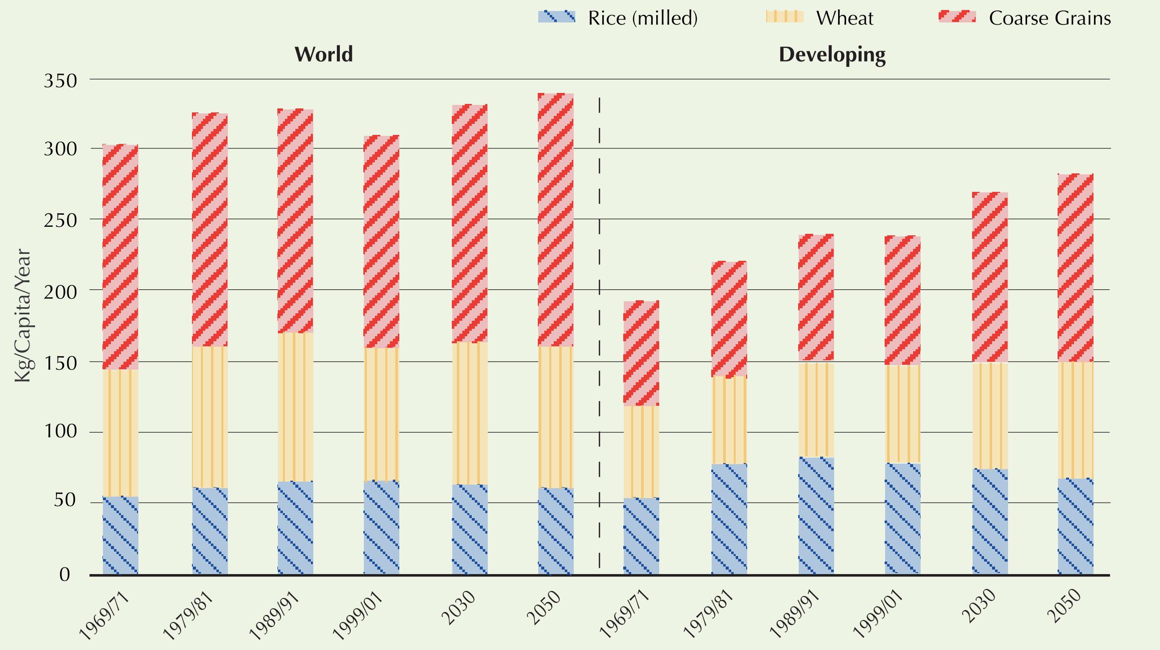
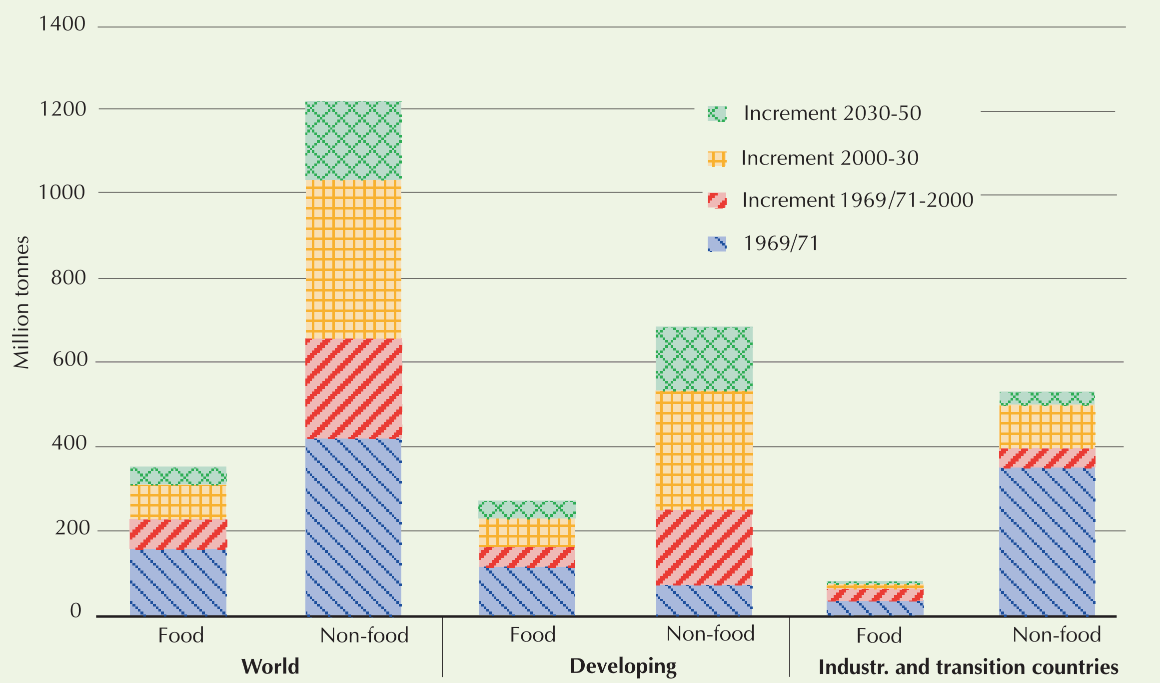


Figure 3.7 Coarse grains: food and non-food use



The relevant data are depicted in Figure 3.7. It is seen that the developing countries will increase their share in world non-food consumption of coarse grains and surpass the rest of the world by 2030. They now account for 39 percent of the world non-food use of coarse grains, up from only 17 percent three decades ago. The share may increase to 52 in 2030 and on to 56 percent in 2050.

Imports and Exports

The lower projected demand for cereals in the developing countries discussed above will also influence their import demand which, although continuing to grow, it should lead to somewhat lower net imports in 2030 (230 million tonnes rather than the 265 million tonnes we had earlier) and on to some 300 million tonnes in 2050[4] (Table 3.2, data and projections for the individual developing regions are in Table 3.3). This is a just over doubling of net imports in the next three decades compared with the 5.7-fold increase of the preceding three decades. However, the growth of net imports has been slowing down, and the just over doubling over the next three decades represents some recovery in the growth of net imports. This outcome reflects above all the prospect that countries like India and China, which in recent years reduced net imports and became modest net exporters, will eventually revert to net importer status (Figure 3.8).

Producing the export surplus. To explore how these growing import requirements of the developing countries may be matched by increases on the part of the exporters we need some rearrangement and more detailed setting out of the data and projections. This is attempted in Table 3.6. The following comments refer mainly to the contents of this table.

The net imports of the developing importers (shown at the bottom of Table 3.5 and repeated in Table 3.6) plus those of the traditional industrial country net importers (essentially Japan, Israel, and the other industrial countries except the EU, North America and Australia) went from 47 million tonnes in 1969/71 to 177 million tonnes in 1999/01, an increment of 130 million tonnes in three decades. It was met by increases of the net trade balances of the following country groups which were traditional exporters or became such during that period: the EU-15 46 million tonnes (from net imports of 21 million tonnes to net exports of 25 million tonnes), North America 50 million tonnes, Australia 12 million tonnes, combined Argentina, Thailand and Viet Nam 20 million tonnes.

In the projections, the net import requirements of the developing importers and the industrial importers increase by 155 million tonnes to 2030 and by another 84 million tonnes by 2050. These quantities must be generated as additional export surplus by the rest of the world. Where will they come from? The novel element in the projections is that part of the required increase may come from the transition countries, while the rest should come from the traditional exporters, developing ones - mainly Argentina, Thailand and Vietnam – and, in time honoured fashion, the lion's share of the additional net exports would originate in the traditional industrial grain exporting countries - North America, Australia and, but on a declining path as net exporter, also the EU (European Commission, 2005b).

The prospective role of the transition countries as a novel additional source of grain exports to the rest of the world must be underlined in any debate on the potential of world agriculture to meet the growing demand of the developing countries. These countries as a group had become large net importers from about the mid-70s until the early 1990s, with their net imports having reached 43 million tonnes in 1993. Following the reform process they emerged as net exporters in most years after the mid-90s, reaching peak net exports of 31 million tonnes in 2002, following the extraordinary weather-induced reduction of harvests in Western Europe. The shift of the transition countries from large net importers to net exporters and the prospect that they will be growing net exporters in the future are clearly seen in Figure 3.8. These prospective developments should help relax often expressed concerns that the traditional industrial exporters of cereals would find it difficult to increase export surpluses in pace with the growing import requirements of the developing country importers. In practice, and given the little scope for increases in their domestic consumption, the production of cereals in the traditional industrial exporter need only increase at rates that will be lower than in the past (see Table 3.6, bottom row).

[4] It is noted that our projections made in the mid-eighties from base year 1982/84, when net imports of the developing countries were 72 mt, indicated that they could rise to 112 million by 2000 (Alexandratos, 1988, p. 106), which is precisely the actual outcome for 1999/01 (Table 3.5), no doubt a lucky coincidence.

Table 3.5 Wheat, rice and coarse grains: Net trade balances

	1969/71	1979/81	1989/91	1991/2001	2030	2050
Developing Countries						
All cereals	-20	-66	-89	-112	-232	-297
Wheat	-25	-49	-59	-63	-127	-163
Rice	-1	-2	0	2	5	6
Coarse grains	6	-16	-30	-51	-110	-139
Industrial countries						
All cereals	21	111	130	114	203	248
Wheat	24	66	76	66	110	132
Rice	2	3	2	1	-2	-3
Coarse grains	-5	42	52	47	95	118
Transition countries						
All cereals	2	-41	-37	2	32	51
Wheat	3	-16	-15	2	22	36
Rice	-1	-1	-1	-1	-1	-1
Coarse grains	0	-25	-21	1	11	16
Memo item: : Developing countries minus developing net exporters*						
All cereals	-30	-85	-106	-144	-295	-380
Wheat	-26	-51	-64	-72	-145	-188
Rice	-1	-5	-6	-9	-16	-20
Coarse grains	-3	-28	-36	-62	-134	-172

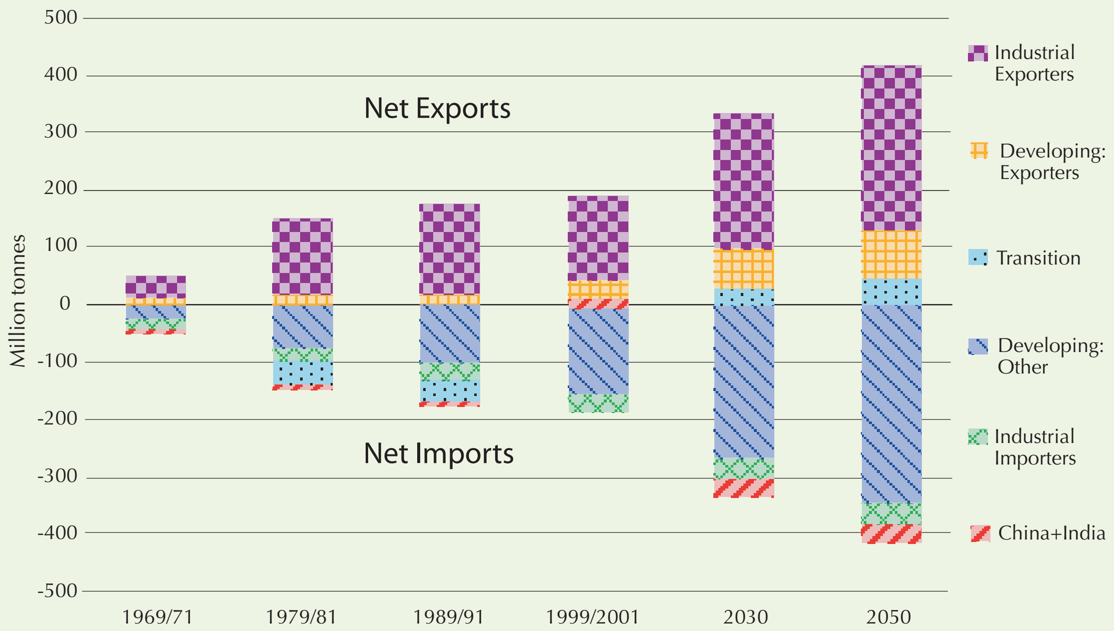
* Developing net exporters: those with net cereal exports over 1 million tonnes in 1999/01 (Argentina, Thailand and Viet Nam). India and China, although they met this criterion, are not included in the net exporter category as they are only occasional net exporters and may not be exporters in the future.

Table 3.6 World cereals trade: matching net balances of importers and exporters

	Net imports (-) or exports (+) (million tonnes)				Increment		
	1969/71	1999/01	2030	2050	1969/71-1999/01	1999/01-2030	2030-50
Importers	**-47**	**-177**	**-332**	**-416**	**130**	**155**	**84**
Developing Importers[1]	-30	-144	-295	-380	113	152	84
Industrial Importers	-17	-33	-36	-36	16	3	0
Exporters	**50**	**180**	**334**	**418**	**130**	**154**	**84**
Developing Exporters	11	31	63	83	21	32	20
Transition Countries	2	2	32	51	0	30	19
Industrial Exporters[2]	38	147	239	284	110	92	45
World imbalance	**3**	**3**	**3**	**3**			
Memo item:	***million tonnes***				***percent p.a.***		
Production of industrial exporters	**386**	**624**	**820**	**900**	**1.3**	**0.9**	**0.5**

[1] All developing countries minus developing exporters (Argentina, Thailand, Viet Nam).
[2] North America, Australia, EU15

Figure 3.8 Cereals: importers and exporters



3.3 Livestock commodities

Past and present

Livestock, a major factor in the growth of world agriculture. The world food economy is being increasingly driven by the shift of diets and food consumption patterns towards livestock products. Some use the term "food revolution" to refer to these trends (Delgado *et al*., 1999). In the developing countries, where almost all world population increases take place, consumption of meat has been growing at over 5 percent p.a., that of milk and dairy products at 3.5 – 4.0 percent p.a. in the last few decades. Aggregate agricultural output is being affected by these trends, not only through the growth of livestock production proper, but also through the linkages of livestock production to the crop sector which supplies the feeding stuffs, mainly cereals and oilseeds. In addition, the shift of aggregate agricultural output towards the higher-value livestock products makes the growth rate of agriculture to be higher than would result from a mere aggregation of tonnes or calorie equivalents (Box 3.1).

On the negative side, and in association with policy distortions or market failures, there are environmental implications associated with the expansion of livestock production. For example, through the expansion of land for livestock development, livestock sector growth has been a prime force in deforestation in some countries such as Brazil, and in overgrazing in other countries. Intensive livestock operations on industrial scale, mostly in the industrial countries but increasingly in the developing ones, are a major source of environmental problems through the production of point-source pollution (effluents, etc.). In parallel, growth in the ruminant sector contributes to greenhouse gas concentrations in the atmosphere through methane emissions and nitrous oxide from the waste of grazing animals.

Important exceptions and qualifications. The strength of the livestock sector as the major driving force of global agriculture can be easily exaggerated. Many developing countries and regions, where the need to increase protein consumption is the greatest, are not participating in the process. There are 26 developing countries having under 10 kg per capita consumption of meat and another 30 with between 10 and 20 kg (the industrial countries have an average of 90 kg). Of these 56 countries 23 have currently consumption levels lower than 10 years earlier. Therefore, the phenomenon of rising meat consumption in the world is less widespread than first impressions from the aggregates would lead one to believe. It is just that per capita consumption has been growing rapidly in a number of large countries, China and Brazil among them, and this has pulled up the average of the developing countries and the world (see Tables 2.7 and 2.8 and discussion in Chapter 2). As noted (Box 3.2), China's meat production statistics are thought to overstate the real growth of the sector in this country, hence also of the world. Thus, the growth rate of world meat consumption of 2.7 percent p.a. in the 1990s is halved if China is excluded from the world totals. This is not to deny that meat and other livestock products are preferred foods in most countries and that demand grows rapidly when incomes increase. It is just that there is less of a meat revolution than commonly asserted, mainly because of lack of development and income growth in many countries. In addition, cultural and religious factors have also stood in the way of wider diffusion of consumption of meat in general in some countries (India) or of particular meats (beef in India, pork in the Muslim countries).

For milk and dairy products, there has been no 'China effect' on the world totals, given the small weight of these products in China's food consumption, no matter that its per capita consumption grew rapidly from a small base and it doubled in the last decade to some 10 kg. There has, however, been a strong negative impact on the growth of world consumption from the slump in the transition countries in the 1990s which reduced the growth rate from 2.0 percent p.a. (world without the transition countries) to 1.0 percent (world total).

Rapid growth of the poultry sector. Perhaps the perception of revolutionary change in the meat sector reflects the extraordinary performance of world production and consumption of poultry meat. It has been growing at more than 5 percent p.a. (Table 3.7) and its share in world meat production increased from 15 percent three decades ago to 30 percent currently. Per capita consumption increased nearly three-fold over the same period. That of pork also increased from 9.7 kg to 14.7 kg (China's statistics helping, but hardly at all for the world without China). In contrast, per capita consumption of ruminant meat (from cattle, sheep and goats) actually declined a little. The growth of poultry meat consumption reflected in part substitution for other meats, essentially beef, in the countries with already medium-high levels of total meat consumption, e.g. several major producers and often exporters of beef in Latin America, North America, Oceania and the EU. For other countries, it was part of the more general thrust towards rapidly growing consumption of meat, e.g. several countries in the regions East Asia and Near East/ North Africa. Significant increases in beef consumption were rare. They occurred in Korea Rep., Japan, Malaysia, Kuwait, Saudi Arabia, Mexico, Taiwan Province of China, (all of them somehow linked to increased beef imports, often the result of more liberal trade policies), and China. Brazil is an example of fast growth in all aspects of the meat economy, with significant increases in production, consumption and exports of beef, poultry and pork.

Buoyancy of meat trade in recent years. The rapid growth in consumption of several countries was supported by even faster growth in trade. Some drastic changes occurred in the sources of exports and destination of imports. For example, Japan increased per capita meat consumption from 29 kg in 1979/81 to 43 kg in 1999/01, an increase of 2.1 million tonnes. All this increase was met by imports (which grew more than 5-fold over the period), while production remained essentially constant. At the global level, trade (world exports, including the meat equivalent of live animal exports) increased from 9.2 percent of world consumption in 1979/81 to 12.8 percent in 1999/01, with poultry increasing from 7 percent to 14 percent, beef from 12.5 percent to 16 percent and pork from 6.5 to 10 percent. The major actors on the side of the importers include Japan which tops the list, followed by the Russian Federation, Mexico, Hong Kong (China SAR), Saudi Arabia and the Rep. of Korea. On the export side, the combined exports of beef and mutton of Australia and New Zealand put them at the top of world meat exporters until 2001, when Brazil became the world's largest exporter. Brazil's skyrocketing exports led to the developing countries as a whole turning into net exporters of meat in 2004 for the first time since the late 1970s. The other major development of the 1990s has been the turn around of the USA from a sizeable net importer of meat to a sizeable net exporter, a result reflecting its declining net imports of beef and pigmeat and skyrocketing exports of poultry meat. In a sense, though the policies are different, the USA is replicating the earlier experience of the EU, which turned from a big net importer of meat up to the late 1970s to a large and, until 1999, growing net exporter.

Figure 3.9 shows the net trade balances of meat by major country groups. On the importer side the lion's share is accounted for by Japan (net imports of 2750 thousand tonnes in 1999/01), while an equal amount is accounted for by a few developing countries (major developing importers in the figure, i.e. those with over 100 thousand tonnes net imports in 1999/01: Mexico, Hong Kong, Korea Rep., Philippines, Taiwan, Malaysia, and Cuba), followed by the region Near

Table 3.7 Meat: aggregate production and demand

	Production							Consumption						
	1999/ 2001	1961/ 2001	1971 -2001	1981 -2001	1991 -2001	1999/01 -2030	2030 -2050	1999/ 2001	1961 -2001	1971 -2001	1981 -2001	1991 -2001	1999/01 -2030	2030 -2050
	Thousand tonnes	Growth rates, percent p.a.						Thousand tonnes	Growth rates, percent p.a.					
World														
Bovine	59378	1.7	1.3	1.1	0.7	1.3	0.9	58549	1.7	1.3	1.1	0.7	1.4	0.9
Ovine	11337	1.7	2.0	2.1	1.6	1.7	1.2	11187	1.7	2.0	2.1	1.6	1.7	1.2
Pigmeat	90666	3.3	3.1	2.9	2.5	1.2	0.4	90818	3.3	3.1	2.9	2.6	1.2	0.4
Poultrymeat	68331	5.4	5.2	5.2	5.3	2.5	1.5	67447	5.3	5.1	5.1	5.1	2.6	1.5
Total meat	**229713**	**3.0**	**2.9**	**2.9**	**2.7**	**1.7**	**1.0**	**228000**	**3.0**	**2.9**	**2.8**	**2.7**	**1.7**	**1.0**
World excl Transition	*213026*	*3.4*	*3.5*	*3.7*	*3.6*	*1.8*	*1.0*	*209574*	*3.3*	*3.4*	*3.6*	*3.6*	*1.9*	*1.0*
Developing countries														
Bovine	29364	2.9	3.2	3.4	3.5	2.2	1.4	29239	3.2	3.5	3.6	3.6	2.2	1.3
Ovine	7865	3.0	3.5	3.8	3.7	2.1	1.4	8102	3.2	3.6	3.7	3.6	2.2	1.4
Pigmeat	52646	6.0	6.1	5.8	4.5	1.7	0.6	53053	6.0	6.1	5.9	4.7	1.7	0.6
-excl. China	*12133*	*4.0*	*4.0*	*3.7*	*2.0*	*2.4*	*1.5*	*12777*	*3.9*	*4.0*	*3.8*	*2.4*	*2.3*	*1.4*
Poultrymeat	35591	7.6	8.0	8.4	8.2	3.4	1.8	36053	7.6	7.9	8.2	8.2	3.4	1.8
Total meat	**125466**	**4.9**	**5.3**	**5.6**	**5.1**	**2.4**	**1.3**	**126447**	**5.1**	**5.5**	**5.6**	**5.3**	**2.4**	**1.3**
-excl. China	*65168*	*3.7*	*3.9*	*3.9*	*3.5*	*2.8*	*1.8*	*66857*	*3.9*	*4.1*	*3.9*	*3.6*	*2.8*	*1.8*
-excl.China and Brazil	*49805*	*3.3*	*3.5*	*3.3*	*3.0*	*3.0*	*2.0*	*53314*	*3.7*	*3.8*	*3.4*	*3.3*	*3.0*	*1.9*
Developing Countries: Total meat by region														
sub-Saharan Africa	5564	2.4	2.3	2.1	2.4	3.3	2.8	5742	2.7	2.6	2.2	2.4	3.3	2.8
NearEast/North Africa	7382	4.1	4.4	4.0	4.3	3.3	2.1	8582	4.6	4.4	2.9	3.7	3.3	2.0
Lat. Amer. and Caribb.	31608	3.6	3.8	4.0	4.1	2.2	1.1	30657	3.8	4.0	4.2	4.1	2.0	1.1
-excl. Brazil	*16244*	*2.6*	*2.6*	*2.4*	*3.1*	*2.4*	*1.4*	*17114*	*3.0*	*3.1*	*3.0*	*3.8*	*2.3*	*1.3*
South Asia	7662	3.4	3.8	3.9	2.7	3.9	2.5	7419	3.3	3.7	3.7	2.5	4.0	2.5
East Asia	73251	6.7	7.1	7.4	6.3	2.1	0.9	74734	6.8	7.2	7.5	6.5	2.1	0.9
-excl. China	*12953*	*4.7*	*5.0*	*4.6*	*2.6*	*2.9*	*1.7*	*14459*	*4.9*	*5.0*	*4.8*	*3.3*	*2.8*	*1.6*
Memo Items														
World livestock production (meat, milk, eggs)[1]		2.3	2.2	2.1	2.1	1.6	0.9							
World cereals feed demand (million tonnes)	666	2.0	1.2	0.6	0.8	1.6	0.8							

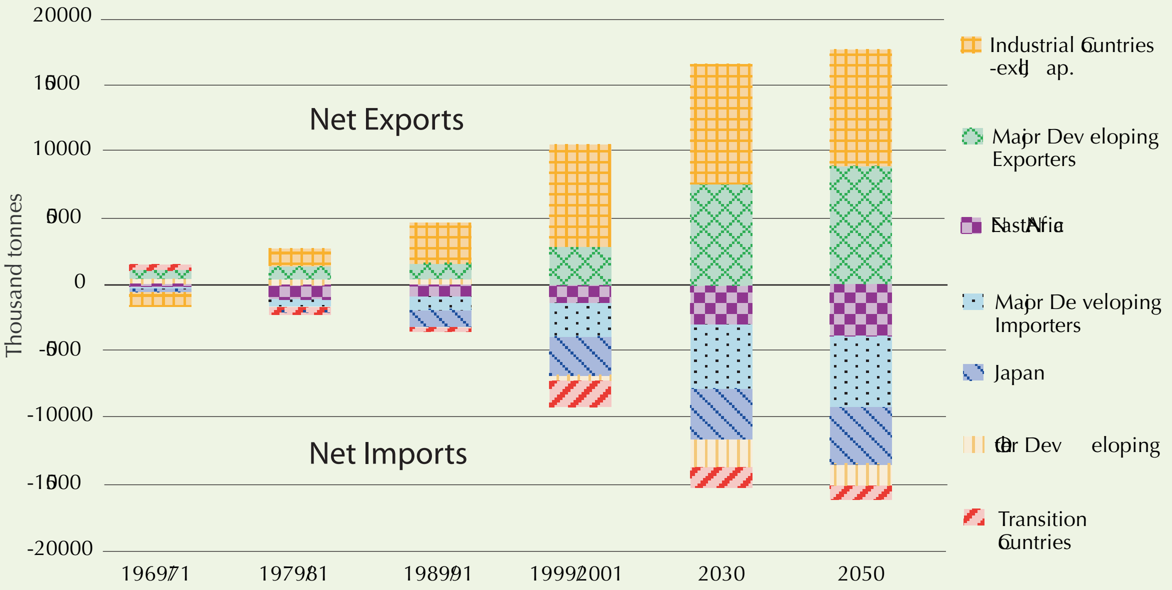
[1] Growth rates of aggregate production derived by valuing all products at 1989/91 international prices (see Box 3.1)

East/North Africa, the transition countries and the rest of the developing countries, excl. the major developing exporters (Brazil, Argentina, Uruguay, Thailand and India). On the exporter side, the picture is dominated by the industrial countries excluding Japan (6 million tonnes net exports in 2004). However, as noted, the exporting developing countries have been playing a growing role in world exports, particularly Brazil whose net meat exports increased to 4.6 million tonnes in 2004, an eight-fold increase in the period 1997-2004.

Milk and dairy products. The growth of world milk production and consumption[5] has been less buoyant than

5 In our data system all dairy products (e.g. cheese, milk powder, etc, but excluding butter which is part of the animal fats in the food balance sheets) are converted into liquid milk equivalent. Perhaps these conversions of data for so many final products are partly responsible for the large statistical discrepancy in the world trade data.

Figure 3.9 Meat: net trade, major importer/exporter country groups*



*Country groups defined in text

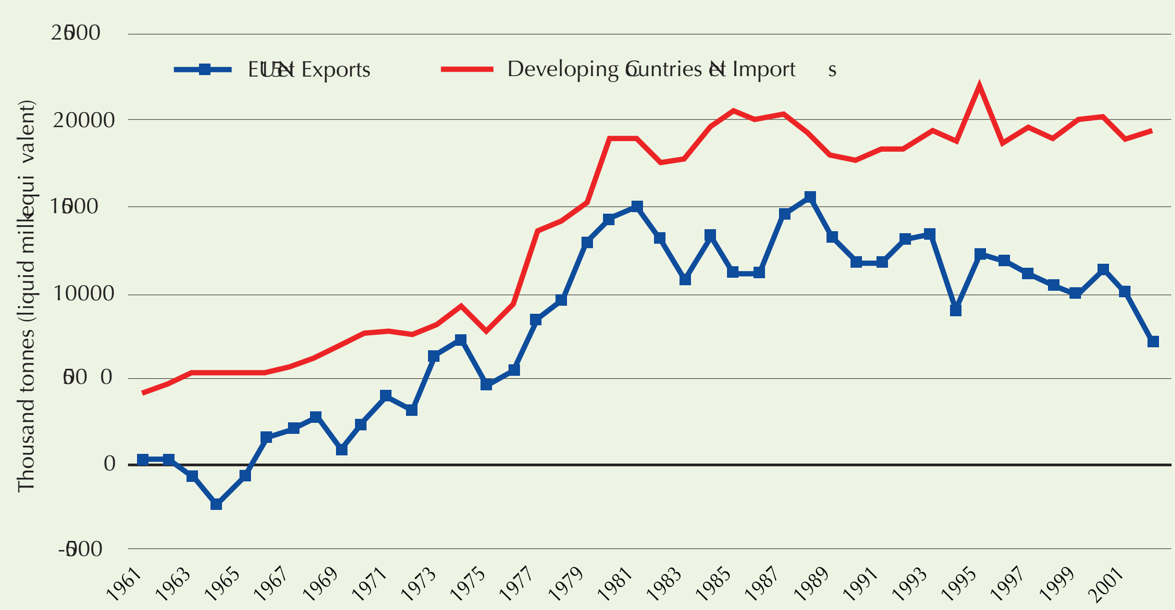
that of meat. In practice, the world per capita consumption is currently not much above that of 10 or 20 years ago. This is explained in large part by the decline in the transition countries. Such declines affected much more the world milk sector than that of meat, because these countries at the inception of the declines had a much larger weight in world milk output (27 percent) than in that of meat (17 percent). The growth rate of world consumption in the 1990s was only 1 percent p.a., but it was 2.1 percent p.a. for the world without the transition countries. The developing countries continue to have per capita consumption well below that of the industrial countries (partly reflecting the consumption habits of East Asia as well as low incomes and poverty in many other countries), but they are gradually reducing the distance, although not all countries/regions are participating in these increases (Tables 2.7 and 2.8). Consumption in South Asia grew the fastest and accounts for a good part of the gains in the developing countries (Table 3.8). Per capita consumption declined in both sub-Saharan Africa and the Near East/North Africa regions from the early 1980s onwards. This development is partly associated with the levelling off in the eighties and subsequent reduction of subsidized exports from the EU. The near stationary net imports of the developing countries largely parallel the pattern of net exports from the EU (Figure 3.10)

The livestock sector in the future

Slower growth in world meat consumption. The forces that shaped the rapid growth of meat demand in the past are expected to weaken considerably in the future. Slower population growth compared with the past is an important factor. Perhaps more important is the natural deceleration of growth because fairly high consumption levels have already been attained in the few major countries that dominated past increases. As noted, China went from 13 kg 20 years ago to 48 kg currently, according to its statistics. If it were to continue at the same rate, it would soon surpass the industrial countries in per capita consumption of meat, an unreasonable prospect given that China will still be a middle income country with significant parts of its population rural and in the low-income category for some time to come. As another example and for similar reasons, Brazil's current average meat consumption of 79 kg suggests that the scope is rather limited for the rapid increases of the past to continue unabated through the coming decades.

The next question is whether any new major developing countries with presently low meat consumption will emerge as major growth poles in the world meat economy. India with its huge population and very low meat consumption could in theory dominate developments if it shifted massively to consuming meat. It is recalled

Figure 3.10 Dairy net trade: developing countries and EU15



that India is expected to rival China in population size by 2030 (both 1.42 billion) and surpass it by a good margin by 2050 (1.53 billion vs. 1.37 billion). It is also recalled that South Asia's projected growth rate of GDP per capita (overwhelmingly reflecting that for India) is, in the latest World Bank assessment, a respectable 4.5 percent p.a. for 2000-2006 and 4.2 percent p.a. after that until 2015 (World Bank, 2006: Table 1.2). India's meat consumption is very low - currently 4.9 kg per capita: it has grown by only 0.6 kg in the 1990s, all of it in poultry meat, when its per capita household consumption expenditure grew 3.0 percent p.a. (see Box 2.1).

Can India play the role China has had so far in raising world meat demand? The recent high growth rates of production (10 percent p.a. in the 1990s) and per capita consumption of poultry meat in India are likely to continue unabated in the coming decades. That is, India's participation in the global upsurge of the poultry sector, being at its incipient stage, has still a long way to go[6]. Consumption of other meats will probably grow by much less, with beef and pork being subject to cultural constraints for significant parts of the population of India and indeed the whole of South Asia. In parallel, consumption of the preferred mutton/goat meat faces production constraints, implying rising real relative prices compared with poultry meat (Landes *et al.*, 2004). Overall, the force of the growth of poultry meat consumption has the potential of raising India's average consumption of all meat to more than double present levels by 2030 and more by 2050. Notwithstanding the possibility that this kind of growth will perhaps be viewed as revolutionary in a national context, India would still be for several decades a predominantly vegetarian society by international standards[7]. Such increases in India's livestock sector will be far from having an impact on world averages and those of the developing countries anywhere near that which was exerted in the historical period by developments in China.

In conclusion, the per capita meat consumption in the developing countries is likely to grow at much slower rates than in the past, mainly because the great push given to consumption growth in the past by China and Brazil will not be playing the same role in the future. The result is that the aggregate meat consumption of the developing may grow in the next thirty years half as rapidly as in the preceding three decades (Table 3.7). However, per capita

6 "Information from industry sources suggests that production and consumption of poultry meat in India has grown by as much as 15 percent annually since the mid-1990s, far faster than indicated by official data. ….Poultry will likely grow in importance to the Indian diet" (Landes *et al.*, 2004).

7 "Fortunately, ours is largely a vegetarian society and thus dependence on meat as a source of protein is much less compared to other nations including China. Hence, comparatively, our food-feed competition will always be moderate" (Paroda, 2001).

Table 3.8 Milk and dairy products

	1999/ 2001	1961 -2001	1971 -2001	1981 -2001	1991 -2001	1999/01 -2030	2030 -2050
	'000 tonnes	Growth rates, percent p.a.					
				Production			
World	577494	1.4	1.2	0.8	1.1	1.4	0.9
Developing	231385	3.4	3.6	3.7	4.0	2.5	1.4
sub-Saharan Africa	16722	2.6	2.6	2.2	2.7	2.6	2.1
Near East/North Africa	29278	2.2	2.3	2.4	2.8	2.3	1.5
Latin America and Caribbean	58203	2.8	2.6	2.9	3.4	1.9	1.0
South Asia	109533	4.0	4.6	4.6	4.8	2.8	1.5
East Asia	17652	5.9	6.9	6.4	5.2	3.0	0.6
Industrial countries	250681	0.8	0.7	0.3	0.8	0.5	0.2
Transition countries	95426	0.3	-0.7	-2.1	-3.3	0.1	-0.2
World excl. transition countries	*482118*	*1.7*	*1.8*	*1.7*	*2.2*	*1.7*	*0.9*
				Consumption			
World	572025	1.4	1.2	0.8	1.0	1.4	0.9
Developing	251097	3.4	3.5	3.4	3.7	2.5	1.3
sub-Saharan Africa	18593	2.7	2.4	1.5	2.4	2.6	2.0
Near East/North Africa	34692	2.7	2.5	1.6	2.3	2.3	1.5
Latin America and Caribbean	63025	2.9	2.6	2.7	2.9	1.8	0.9
South Asia	110246	3.9	4.5	4.5	4.8	2.8	1.5
East Asia	24546	5.4	5.9	5.5	4.7	2.7	0.7
Industrial countries	228583	0.6	0.6	0.3	0.5	0.4	0.2
Transition countries	92342	0.2	-0.9	-2.3	-3.4	0.1	-0.2
World excl. transition countries	*479789*	*1.7*	*1.9*	*1.7*	*2.1*	*1.7*	*1.0*

Net Trade (thousand tonnes)

	1969/71	1979/81	1989/91	1999/01	2030	2050
World (Stat. discrepancy)	2388	1625	-1163	4652	4084	4050
Developing	-7379	-17647	-18028	-19716	-32700	-38750
sub-Saharan Africa	-927	-2541	-1836	-1882	-3760	-4300
Near East/North Africa	-1215	-5193	-5958	-5446	-10200	-13600
Latin America and Caribbean	-2456	-5131	-5140	-4780	-4620	-2160
South Asia	-603	-1044	-874	-713	-2240	-4630
East Asia	-2177	-3739	-4221	-6894	-11900	-14100
Industrial countries	9659	18545	15031	21288	33800	39800
Transition countries	109	729	1837	3083	3000	3050

consumption in the rest of the developing countries should continue rising and even accelerate, as shown in Table 2.7.

Per capita meat consumption in the *transition countries* has already started recovering from its precipitous fall in the 1990s (having fallen from 71 kg in 1989/91 to 44 kg in 1999/01). It may eventually revert by 2050 to the high levels it had achieved before the systemic reforms of the 1990s (Table 2.7). In the *industrial countries*, per capita consumption of meat is fairly high at 90 kg. A few countries with high fish consumption (Japan, Norway) have much lower, though rising, levels. In principle, the achievement of near-saturation levels of overall food consumption, as well as concerns about health, suggest that there is little scope for further increases. Yet the data indicate that such increases do take place even in countries which have passed the 100-kg mark, probably reflecting a mix of overconsumption and growing post-retail waste or feeding of pets. For example, the USA increased consumption by some 10 kg (to 121 kg) in the last ten years and the latest FAPRI projections foresee an increase (all of it in poultry meat) of 7 percent from the average of 1999/01 to 2014, (FAPRI, 2005). The latest USDA baseline projections to 2015 provide a largely similar outlook (slight decline in beef and pork, increase in poultry - USDA, 2006: Table 21). The latest projections of the EU foresee a 6-kg increase in the 10 new member states (to 82 kg by 2012), while per capita consumption should remain stable at 90 kg in the EU-15[8]. (European Commission, 2005b, Table A13). These trends have to be taken into account, even if nutritional and health considerations would suggest otherwise. As shown in Table 2.7, our projection of per capita meat consumption in the industrial countries grows 10 percent in the three decades to 2030 and another 4 percent in the subsequent two decades to 2050.

In conclusion, the projected slowdown in the world meat economy is based on the following assumptions: (a) relatively modest further increases in per capita consumption in the industrial countries, (b) growth rates in per capita consumption in China and Brazil well below those of the past, (c) persistence of relatively low levels of per capita consumption in India, and (d) persistence of low incomes and poverty in many developing countries. If these assumptions are accepted, the projected slowdown follows inevitably. Naturally, a slower growth rate applied to a large base year world consumption (228 million tonnes in 1999/01) will still produce large absolute increases (some 465 million tonnes must be produced annually by 2050, the great bulk of which in the developing countries). These quantitative increases will accentuate environmental and other problems associated with such large livestock sectors.

No slowdown in the consumption of dairy products. Given the still low consumption levels in the developing countries, the potential for growth is there. Few developing countries have per capita consumption exceeding 150 kg (Argentina, Uruguay, some pastoral countries in the Sudano-Sahelian zone of Africa). Among the most populous countries, only Pakistan has such a level. In South Asia, where milk and dairy products are preferred foods, India has only 64 kg and Bangladesh 14 kg. East Asia has only 11 kg. In this latter region, however, food consumption preferences do not favour milk and dairy products, but the potential for growth is still there with growing urbanization. The region's per capita consumption has been rising fast and should continue to do so (Table 2.8). Overall, therefore, there is considerable scope for further growth in consumption of milk and dairy products. In the projections, the growth rate of world consumption is higher than in the recent past despite the lower population growth (Table 3.8), an outcome reflecting above all the reversal of declines in the transition countries.

Meat trade expansion will likely continue, but more of the imports may be supplied by the developing exporters: Despite the projected slowdown in meat demand growth, some of the forces that made for the above discussed buoyancy in world meat trade in the recent past are likely to continue to operate. The net trade positions are shown in Figure 3.9. Overall, the trend for the developing countries to become growing net importers of meat (1680 thousand tonnes in 1999/01, compared with net exports of 1100 thousand tonnes three decades ago) may not continue, mainly because the group of the developing net exporters listed earlier, foremost among them Brazil, have the potential to continue increasing exports.

Trade in dairy products will also likely recover, with the net imports of the developing countries resuming growth after a period of stagnation from the mid-80s onwards (Table 3.8). This would reflect continuation of the growth of imports of East Asia, as well as the resumption of import growth into the major deficit region, the Near East/North Africa, following recovery in the growth of demand.

Livestock Production and the Use of Cereals for Animal Feed. We referred earlier to the importance of the livestock sector in creating demand for grains and oilseeds. Estimates put the total feed use of cereals at 666 million tonnes, or 35 percent of world total cereal use. Feed demand for cereals is often considered as the dynamic element that conditions the growth of the cereals sector. However, in the last two decades or so it has not been dynamic at all. Feed use of cereals grew 2.4 percent p.a. in the 1970s (when livestock production was growing at 2.5 percent), but then the growth rate fell to 0.9 percent in the subsequent two decades while world livestock production kept growing at over 2.0 percent p.a.

It appears, therefore, that the world has been getting on the average more meat, milk and eggs per kg of cereals used as feed, a *prima facie* case of productivity gains in livestock production. No doubt, there have been such gains reflecting in part the above mentioned growing share of the poultry sector in total meat production (poultry requires much smaller quantities of cereals feed per kg of meat than beef). However, other forces have also been at work leading to the reduced grain/meat ratios. Principal among them is the relative shift of world livestock production out

8 To note that in the country classification used here 9 out the 10 new member states are still included in the group of the transition countries, not in the group industrial countries, because of lack of historical data for a number of them.

of the regions that use grain-intensive feeding systems to the developing countries that have lower grain/meat ratios on average. The developing countries account now for 55 percent of world meat output, up from 34 percent two decades ago. The relative shift in the geographical distribution of world meat output reflected not only their faster growth of consumption but also the drastic decline in the 1990s in the output of the transition countries which had high and often inefficient use of cereals feed per unit of output.

Other factors that contributed to these trends include the high cereals support prices in the EU which provided incentives to livestock producers to substitute others feeds for cereals, including imported oilmeals and cassava. Cereals feed use in the EU15 peaked at about 1980, remained nearly flat until the mid-eighties, and declined continuously until 1992, when the MacSharry reform of the EU's Common Agricultural Policy reduced domestic cereal prices and the livestock sector has since increased feed use (by 50 percent in the ten years after 1992). This boost to feed demand from the lower policy prices of cereals has largely run its course and growth will much weaker in the future (European Commission, 2005b). Then in the second half of the 1990s the above described decline in cereals use in China set in and this was another important factor leading to the current "low" share of feed in the aggregate cereals use in the world (35 percent, down from 40 percent two decades earlier). Finally, the slow growth of cereals feed use reflected also the growing use of oilmeals in livestock feeding. World output of soybeans, which is mainly processed into oil and high protein oilmeal, grew at 5 percent p.a. in the last decade. By implication so has the production and consumption as feed of soybean meal. This implies a relative increase in the feed rations of oilmeals at the expense of cereals.

Concerning the future, some of the forces responsible for the slowdown in the demand for cereals feed have been exhausted and, therefore, will not have a depressing influence in the future. As noted, the decline in cereals feed use in the EU was reversed already from the early 1990s and such use should keep growing, albeit at much slower rates than in the period after the price reforms. In parallel, the declines in the Transition countries of both livestock production and cereals feed use have levelled off in the last couple of years and such use will revert to growing again. The increase of the share of poultry in total meat production will continue, but it will not be as pronounced as in the past and the implicit productivity gains (viewed at the level of the entire livestock sector) from this source will not be as pronounced as in the past. Then China's decline in feed use of cereals cannot continue for much longer if livestock production growth is to proceed even at much lower growth rates than in the past.

We noted earlier that the relative shift of world livestock output from the developed to the developing countries contributed to the decline in the growth of cereals feed use to well below the growth of livestock production. It is possible to visualize that this same phenomenon could work in the opposite direction in the future: the continued growth of the developing countries' share in world livestock output will be associated with a gradual shift of their production from grazing and 'backyard' systems to stall-fed systems using concentrate feedstuffs. This will be an additional factor making for higher growth than in the past in the feed use of cereals. Such structural change in the production systems will tend to raise the average grain-meat ratios of the developing countries and perhaps compensate for opposite trends resulting from improvements in productivity. A strong case for this prospect is made in a recent analysis by the Dutch Centre for World Food Studies (Keyzer *et al*., 2001).

In conclusion, all these deviations from past trends suggest that the growth of feed demand for cereals should in the future be more in unison with the growth of livestock production. This is what we have projected with the result that the past declines in the growth of demand for cereals for feed should be reversed and the growth rate to 2030 is projected to be 1.6 percent p.a. (up from 0.8 percent p.a. in the 1990s) and 0.8 percent p.a. in the subsequent two decades (Table 3.7).

3.4 Oilcrops, vegetable oils and products

Past and present

Fastest growth of all sub-sectors of global agriculture. The oilcrops sector has been one of the most dynamic parts of world agriculture in recent decades. In the 20 years to 2001 it grew at 4.1 percent p.a. (Table 3.9), compared with an average of 2.1 percent p.a. for all agriculture[9]. Its growth rate exceeded by a good margin

[9] For the derivation of the growth rates of the entire oilcrops sector, the different crops are added together with weights equal to their oil content. This is what the expression 'oil equivalent', used here, means.

even that of livestock products. The major driving force on the demand side has been the growth of food consumption in developing countries, mostly in the form of oil but also direct consumption of soybeans, groundnuts, etc., as well as in the form of derived products other than oil. Food demand in the developing countries accounted for one half of the increases in world output of the last two decades, with output measured in oil content equivalent (Table 3.10). China, India and a few other countries represented the bulk of this increase. No doubt, the strong growth of demand for protein products for animal feed was also a major supporting factor in the buoyancy of the oilcrops sector. The rapid growth of the oilcrops sector reflects the synergy of the two fastest rising components of the demand for food - food demand for oils favouring all oilcrops that had the potential for rapid expansion of production, e.g. the oil palm, and that for livestock products favouring oilcrops with high protein oilmeals for feed, e.g. soybeans (see below). The oilpalm and soybeans provided 57 percent of the total increment in world oilcrop production in the last two decades (Table 3.10).

Growing contribution to food supplies and food security. World production, consumption and trade in this sector have been increasingly dominated by a small number of crops (soybeans, oil palm, sunflower, and rapeseed) and countries. However, the more traditional and less glamorous oilcrops continue to be very important as major elements in the food supply and food security situation in many countries, e.g. groundnuts and sesame seed in the Sudan and Myanmar, coconuts in the Philippines and Sri Lanka, olive oil in the Mediterranean countries, cottonneseed oil in the countries of Central Asia and those in the Sahel, etc.

Rapid growth of food demand in the developing countries, in conjunction with the high calorie content of oil products, have been a major component of the increases achieved in food consumption (kcal/person/day) in these countries. As noted in Chapter 2, this trend is set to continue, as vegetable oils still have significant scope for consumption increases in most developing countries.

Non-food uses. The second major driving force on the demand side has been the non-food industrial use of vegetable oils, with China and the EU being major contributors to this growth (Table 3.10). In terms of actual oil produced and used (rather than of oil equivalent of oilcrops) the world is apparently using some

Table 3.9 Oilcrops, vegetable oils and products, production and demand

	1999/ 2001	1961 -2001	1971 -2001	1981 -2001	1991 -2001	1999/01 -2030	2030 -2050
	'000 tonnes	Growth rates, percent p.a.					
		Aggregate consumption (all uses)					
World	105.7	3.9	4.0	3.8	3.8	2.3	1.6
Developing	67.2	4.8	5.0	4.6	4.6	2.5	1.5
sub-Saharan Africa	7.0	3.2	3.3	3.6	3.2	2.9	2.1
Near East/North Africa	6.0	5.1	4.5	3.5	2.0	2.3	1.4
Latin America and Caribbean	9.7	4.8	4.5	3.6	3.4	2.6	1.9
South Asia	15.5	4.2	4.5	4.4	4.8	2.7	1.6
East Asia	29.1	5.6	6.2	5.6	5.8	2.4	1.3
Industrial countries	31.9	3.2	3.2	3.3	2.8	2.0	1.7
Transition countries	6.6	1.5	0.9	-0.4	2.3	1.7	1.1
		Production (oilcrops in oil equiv.)					
World	111.6	4.0	4.1	4.1	4.4	2.2	1.6
Developing	75.0	4.4	4.9	4.8	4.9	2.5	1.6
sub-Saharan Africa	6.1	1.2	1.8	3.1	2.5	2.6	2
Near East/North Africa	1.8	2.2	1.8	2.2	2.0	1.7	1.1
Latin America and Caribbean	16.8	5.7	5.6	5.2	6.9	3.7	1.9
South Asia	8.7	2.9	3.4	3.4	0.2	1.8	1.4
East Asia	41.5	5.8	6.2	5.6	5.9	2.1	1.4
Industrial countries	30.4	4.0	3.5	3.3	3.9	1.5	1.3
Transition countries	6.2	1.0	0.7	0.7	1.7	1.6	1.4

25 million tonnes for non-food industrial uses out of a total use of 91 million tonnes. Two decades earlier, the comparable figures were 8 and 41 million tonnes, respectively. The existing data do not permit us to draw even a partial balance sheet of the non-food industrial products for which significant quantities of vegetable oil products are used as inputs[10]. The main industrial products involved (paints, detergents, lubricants, oleochemicals in general and, increasingly, biodiesel) are commodities for which world demand can be expected to grow much faster than the demand for food. If petroleum prices remained high, the biofuels sector will likely keep growing in importance as a market outlet for oils and fats, just as the growing market for bioethanol provides outlets for sugar cane (mainly in Brazil), maize (mainly in the USA) and to a much smaller extent for other crops (sugar beet, wheat, sorghum, eventually cassava, etc). The EU has a target of achieving a 5.75 percent market share of biofuels in the petrol and diesel market in 2010 (European Commission, 2005c: 38).

Concentration of growth in a small number of crops and countries. The demand for protein meals for animal feed also contributed to change the geographical distribution of oilseeds production. The latter shifted towards countries that could produce and export oilseeds of high protein content, in which oilmeals are not by-products but rather joint products with oil, e.g. soybeans in South America. In addition, support policies of the European Union (EU) also helped to shift world production of oilseeds in favour of rapeseed and sunflowerseed. Overall, four oilcrops (oilpalm, soybeans, rapeseed and sunflowerseed) account for 74 percent of world production. Three decades ago they accounted for only 51 percent (Table 3.12). Moreover, a good part of these increases came from a small number of countries: palm oil mainly from Malaysia and Indonesia; soybeans from the USA, Brazil, Argentina, China and India; rapeseed from the EU, China, Canada, India and Australia; and sunflowerseed from Argentina, the EU, China and India. For several countries, including some major producers, these fast expanding oilcrops are new crops that were hardly cultivated at all, or in only insignificant amounts 20 or even 10 years ago.

Growing role of trade. The rapid growth of demand in the developing countries was accompanied by the emergence of several of them as major importers of oils and/or oilseeds, with net imports rising by leaps and bounds. Thus, in 1999/01 there were eleven developing countries, each with net imports of over 0.6 million tonnes (China, Pakistan, Mexico, India, etc.; see Table 3.11). These eleven together had net imports of 17 million tonnes, a five-fold increase in two decades. Numerous other developing countries are smaller net importers, but still account for another 5 million tonnes of net imports, a three-fold increase in two decades. This group includes a number of countries that turned from net exporters to net importers over this period, e.g. Senegal, Sri Lanka. With these rates of increase of imports, the traditional

Table 3.10 Sources of increases in world production and consumption of oilcrops (oil eq.)

Increase in world consumption by use, 1979/81-1999/01		**Increase in world production by oilcrop, 1979/81-1999/01**	
Total world increase (=100), of which:	**100.0**	**Total world increase (=100), of which:**	**100.0**
Developing countries, food	49.4	*Oil palm (palm oil and palm kernel oil)*	*33.0*
Of which :China	*15.2*	*Soybeans*	*24.3*
India	*11.0*	*Rapeseed*	*18.2*
Developed countries, food	13.6	*Sunflower seed*	*7.4*
Non-food industrial uses, world	30.2	*Groundnuts*	*7.5*
Of which :EU15	*7.2*	*All other oilcrops**	*9.5*
China	*4.8*		
USA	*2.6*		
Brazil	*1.9*		
Other uses (feed, seed, waste), world	6.7		

* Includes cotton seed (in oil equivalent); more details on production in Table 3.12

10 One should be careful with these numbers as statisticians often use this category of demand as the dumping ground for unexplained residuals of domestic disappearance and statistical discrepancies. There is no doubt, however, that non-food industrial uses are a dynamic element of demand.

net trade surplus of the vegetable oils/oilseeds complex (oils, oilmeals, oilseeds) of the developing countries was progressively reduced and turned into a deficit in 2001 (it recovered back to positive in the subsequent three years 2002-4). This happened despite the spectacular growth of exports of a few developing countries that came to dominate the world export scene, viz. Malaysia and Indonesia for palm oil and Brazil and Argentina for soybeans. Indeed, if Brazil is excluded from the totals, the deficit of the rest of the developing countries kept growing to reach US$ 9.4 billion in 2004 (Figure 3.2). As happened with the livestock sector, the overall evolution of trade of oilseeds and products has contributed to the agricultural trade balance of the developing countries diminishing rapidly and turning negative (Figure 3.1).

Oilcrops responsible for a good part of agricultural land expansion. On the production side, the fast growth of oilcrops expanded mainly, though not exclusively, in land-abundant countries (Brazil, Argentina, Indonesia, Malaysia, the USA, Canada). The oil palm and the three annual oilcrops which grew the fastest (soybeans, rapeseed, and sunflower) have been responsible for a good part of the expansion of cultivated land under all crops in the developing countries and the world as

Table 3.11 Net trade balances for oilseeds, oils and products

	1969/71	1979/81	1989/91	1991/01	2030	2050
			million tonnes (oil equivalent)			
Developing countries	**2.3**	**1.5**	**4.0**	**5.7**	**15.4**	**24.6**
Malaysia	0.5	2.6	6.4	11.0		
Argentina	0.3	1.1	3.0	5.8		
Indonesia	0.3	0.4	1.3	5.6		
Brazil	0.3	1.2	1.4	3.4		
Philippines	0.7	1.1	1.0	0.9		
sub-total, 5 major exporters	**2.0**	**6.4**	**13.1**	**26.8**	**68.1**	**93.2**
Other developing exporters	**0.4**	**0.4**	**0.7**	**1.5**	**4.6**	**6.6**
China	0.1	-0.1	-1.3	-4.3		
India	-0.1	-1.3	-0.2	-4.3		
Mexico	0.0	-0.3	-0.9	-1.7		
Pakistan	-0.1	-0.4	-1.0	-1.5		
Bangladesh	-0.1	-0.1	-0.3	-1.1		
Korea, Rep.	0.0	-0.2	-0.5	-0.9		
Iran	-0.1	-0.3	-0.7	-0.8		
Taiwan Province of China	-0.1	-0.2	-0.6	-0.7		
Egypt	-0.1	-0.3	-0.7	-0.7		
Turkey	0.0	-0.1	-0.4	-0.6		
Hong Kong	-0.1	-0.1	-0.1	-0.6		
sub-total, 11 major importers	**-0.6**	**-3.4**	**-6.8**	**-17.2**	**-44.6**	**-57.4**
Other developing Importers	**0.5**	**-1.9**	**-3.0**	**-5.3**	**-12.7**	**-17.7**
Industrial countries	**-2.8**	**-0.4**	**-3.1**	**-2.2**	**-10.9**	**-20.9**
USA	2.2	5.4	2.9	5.1		
Canada	0.3	0.9	1.0	2.3		
Japan	-1.0	-1.7	-2.3	-2.6		
EU-15	-4.1	-4.7	-4.1	-6.6		
Other Industrial countries	-0.3	-0.3	-0.6	-0.3		
Transition countries	**0.5**	**-0.9**	**-0.7**	**-0.1**	**-0.9**	**-0.3**
World balance (stat. discrep.)	**-0.1**	**0.2**	**0.2**	**3.4**	**3.5**	**3.4**

* Trade in oils and products derived from oils plus the oil equivalent of trade in oilseeds; trade in oilmeals not included in order to avoid double counting in the equation: production + net trade = consumption expressed in oil equivalent. Importer-exporter status as of 1999/01

a whole. In the developing countries, the harvested area[11] under the main crops (cereals, roots and tubers, pulses, fibres, sugar crops and oilcrops) expanded by 96 million ha while that in the rest of the world declined by 65 million ha in the two decades to 2000, of which more than one half (50 million ha) was for oilcrops.

These numbers clearly demonstrate that land expansion continues to play an important role in the growth of crop production. The 160 percent increase in oilcrop output between 1979/81 and 1999/01 in the developing countries was brought about by a 62 percent (50 million ha) expansion of land under these crops, at the same time as land under their other crops also increased by an almost equal amount (47 million ha).

The oilcrops sector in the future

Food demand. As noted, the growth of food demand in the developing countries was the major driving force behind the rapid growth of the oilcrops sector in the historical period. The most populous countries played a major role in these developments (Table 3.10). Will these trends continue in the future? In the first place, slower population growth, particularly in the developing countries, will be reflected in slower growth rates of their aggregate demand for food, *ceteris paribus*. Naturally, others things will not be equal: in particular, the per capita consumption of the developing countries was only 4.9 kg three decades ago. This afforded great scope for the increases in consumption which took place.

Table 3.12 Major oilcrops, world production

	Production of oilcrops in oil content equivalent (million tonnes)						Actual oil production
	1969/71	1979/81	1989/91	1999/01	2030	2050	1999/01
Soybeans	8.1	15.9	19.6	30.5	67.9	96.4	25.7
Oil palm	2.6	5.7	13.0	25.6	54.2	77.2	25.5
Rapeseed	2.6	4.4	9.7	15.3	29.8	41.4	13.0
Sunflowerseed	4.1	5.9	9.2	10.4	17.5	22.4	9.4
Groundnuts	5.2	5.4	6.8	9.9	16.7	21.4	5.0
Coconuts	3.4	4.1	5.2	6.5	10.8	12.6	3.2
Cotton seed	3.5	4.2	5.4	5.4	7.7	8.9	3.8
Sesame seed	0.9	0.9	1.0	1.3	2.4	3.1	0.8
Other oilcrops	4.0	4.3	4.8	5.9	8.5	9.8	6.2
Total	**34.2**	**50.8**	**74.8**	**110.9**	**215.5**	**293.2**	**92.6**
Oils from non-oilcrops (maize, rice bran)							2.9
	Growth rates, percent p.a.						
	1961-01	1971-01	1981-01	1991-01	1999/01-2030	2030-50	1999/01-50
Soybeans	4.7	4.0	3.6	5.1	2.7	1.8	2.3
Oil palm	7.5	8.1	7.6	7.0	2.5	1.8	2.2
Rapeseed	6.7	6.6	5.6	4.4	2.2	1.7	2.0
Sunflowerseed	3.5	3.4	2.4	1.3	1.8	1.3	1.5
Groundnuts	2.0	2.5	3.3	4.0	1.8	1.3	1.5
Coconuts	2.0	2.3	2.7	2.2	1.7	0.7	1.3
Cotton seed	1.7	1.5	1.0	0.3	1.2	0.7	1.0
Sesame seed	1.5	1.7	1.9	2.9	2.0	1.4	1.7
Other oilcrops	1.2	1.4	1.8	2.4	1.1	0.6	1.0
Total	**4.0**	**4.1**	**4.1**	**4.4**	**2.2**	**1.6**	**2.0**

[11] The increase of harvested area implies not only expansion of the cultivated land in a physical sense (also referred to as arable area in the original study – Bruinsma, 2003) but also expansion of the land under multiple cropping (in the harvested or sown area definition, a hectare of arable land is counted as two if it is cropped twice in a year). Therefore, the harvested area expansion under the different crops discussed here could overstate the extent to which physical area in cultivation has increased. This overstatement is likely to be more pronounced for cereals (where the arable area has probably declined even in the developing countries) than for oilcrops, as the latter include also tree crops (oil and coconut palms, olive trees).

However, in the process per capita consumption grew to 10.4 kg in 1999/01. Within this average, India doubled its per capita consumption and China increased it 3.5-fold. As shown in Table 3.10, food demand in these two countries accounted for over one half of the increment in the food demand of the developing countries. While oils will remain a food item with high income elasticity in most developing countries in the short and medium term-future, the higher levels that will be achieved gradually will lead to slower growth in the longer term future. Thus, per capita consumption will likely rise at much slower rates compared with the past (Tables 2.7-2.8). This slowdown must be seen in the context of rising food demand for all commodities and the implied levels of kcal/person/day. We noted in Chapter 2 (Table 2.2) that 68 percent of the population of the developing countries will be in countries with over 3000 kcal/person/day in 2050. Inevitably, consumption of these calorie-rich foods (oils and products) cannot continue growing at the fast rates of the past. This prospect notwithstanding, there will still be many low income countries which in 2050 will have per capita consumption of fats and oils totally inadequate for good nutrition, the result of persistent low incomes and poverty.

Non-food industrial uses. We noted earlier the inadequacy of the statistics on oilcrop products used for non-food industrial purposes. We also noted that some of the industrial products resulting from such use have high income elasticities of demand. In addition, vegetable oils may be increasingly used as feedstocks for production of biofuels. Palmoil from the main producing countries (Malaysia and Indonesia) could be for the biodiesel sector what sugar cane is proving to be for bioethanol[12]. The latest projections of the European Commission foresee that some 10 million tonnes of oilseeds (20 percent of total consumption in the EU25 of both domestically produced and imported oilseeds) may be used to produce bioenergy in 2012, up from 3.6 million tonnes in 2003. In addition, some 1.5 million tonnes of grains may be so used (European Commission, 2005b: Tables A.1, A.8). There is, therefore, a *prima facie* case to believe that the share of total vegetable oil production going to non-food industrial uses will continue to grow fairly rapidly. In the projections, we make an allowance for this category of demand to grow at rates above those of the demand for food (3.2 percent p.a. versus 1.5 percent p.a. over the entire projection period to 2050). By 2050 such uses may account for some 42 percent of total use compared with 24 percent at present and only 16 percent 30 years ago.

Trade. The projected fairly buoyant growth in demand, and the still considerable potential for expansion of production in some of the major exporters (see below), suggest that past trade patterns will continue for some time - that is, rapidly growing imports in most developing countries, matched by continued export growth of the main exporters. The projections are shown in Table 3.11. The potential for further production and export increases of several developing countries, and the continued growth of demand (mainly for non-food uses, including oilmeals for feed) in the industrial countries together with the limitation in their potential to expand production (particularly under policy reforms limiting the use of subsidies) would likely lead to the net export surplus of the developing countries rising again[13], with Brazil playing an ever growing role in such developments.

Production. The production analysis of the oilcrops sector is conducted separately in terms of the individual crops listed in Table 3.12. Cotton is included among these crops because it contributes some 4 percent of world oil production, though projected production is determined in the context of world demand-supply balance of cotton fibre rather than oil. The production projections for these major oilcrops are shown in Table 3.12. We noted earlier that oilcrop production has been responsible for a good part of the area expansion under crops in, mainly, the developing countries. The relatively land-intensive nature of oilcrop production growth reflects in large part the fact that they are predominantly rainfed crops (less than ten percent irrigated, compared with about 40 percent for cereals).

In the period to 2050 oilcrop production is required to continue growing albeit at rates significantly below those of the past (Table 3.12). Even at those lower rates, the absolute increments involved are very large for some of these crops, e.g. more than tripling for soybeans and the

[12] See: “High hopes for palm oil push up share prices. Malaysia and Indonesia are benefiting from interest in a new energy source”, *Financial Times*, 17 October 2005. Note that the oilpalm, while benefiting from high petroleum prices via the biofuels link, it competes for land (often forest land for expansion) with natural rubber, a crop that is also gaining in competitiveness vis-à-vis synthetic rubber which is produced from the higher-priced petroleum.

[13] The trade numbers in Table 3.12 comprise the oils traded as well as the oil equivalent of the trade in oilseeds and products made from vegetable oils. They do not include trade in oilmeals in order to avoid double counting when we express all numbers in oil equivalent.

oil palm. Given their land-intensive nature, the question whether there is enough land for such expansion without seriously threatening forest areas must be posed[14]. We illustrate what is involved on the basis of the example of soybeans. The three main soybean exporting countries (the USA, Brazil and Argentina) account for 80 percent of world output, with the two South American countries having increased their share from 20 percent twenty years ago to 34 percent in 1999/01, while the share of the USA correspondingly declined from 64 percent to 45 percent[15]. The soybeans harvested area in these three countries is currently 52 million ha[16] (having increased 37 percent in the last two decades) and the average yield is 2.53 t/ha, having grown 33 percent over the same period. Assuming they maintain their share in the world total, a tripling of their production - it had quadrupled in the preceding 30 years - would be required by 2050, with South America, particularly Brazil, accounting for an ever growing share[17]. A near doubling of the area under cultivation would be probably required, even assuming future yields matched the highest yield encountered currently in rainfed cultivation under high input technology in the USA. How much land suitable for growing soybeans under high input technology[18] do these countries have?

According to the FAO/IIASA *Global Agroecological Zones Study* (GAEZ, Fischer *et al.*, 2002) Brazil has some 21 million ha of land suitable for soybeans (classes *Very Suitable* and *Suitable* - not including land in closed forest and in protected areas) or some 66 million ha if we include also the *Medium Suitable* class. It uses currently (2005) 23 million ha, up from only 14 million ha only 5 years earlier. Argentina has some 27 million ha land suitable for soybeans (classes *VS, S* – 39 million ha including class *MS*) and it uses currently 14 million ha, up from 8.6 million ha five years earlier. The USA has some 11 million ha in classes *VS-S* and another 12 million ha in class *MS*. It uses currently 29 million ha for soybeans, the same as five years earlier, which is above the land given as suitable for soybeans in the GAEZ. Naturally, not all of the land shown as suitable for soybeans in the GAEZ estimates will be available for this crop, as other crops also compete for it. Clearly the potential is not unlimited. The expansion rates of the past cannot be continued and even at the lower rates of increase projected here expansion of soybeans area will be pressing against land resources.

3.5 Roots, tubers and plantains

Food consumption of roots, tubers and plantains. Average world food consumption is 69 kg per capita, providing 6 percent of total food calories. As noted in Chapter 2, these products represent the mainstay of diets in several countries, many of which are characterized by low overall food consumption levels and food insecurity. The great majority of these countries are in sub-Saharan Africa. The region's per capita consumption is some 190 kg which provide 23 percent of total calories, but some countries depend overwhelmingly on these products for food (see Chapter 2).

The high dependence on roots, tubers and plantains reflects the agroecological conditions of these countries, which make these products suitable subsistence crops, and to a large extent also the persistence of poverty and lack of progress towards diet diversification. There are significant differences as to which of these starchy foods provide the mainstay of diets in the 19 countries dependent on this family of products. Cassava predominates in most of them (the two Congos, Angola, Mozambique, Tanzania, the Central African Republic, Liberia and Madagascar). In contrast it is mostly plantains in Rwanda and Uganda, and cassava and sweet potatoes in Benin, Togo, Nigeria and Burundi, while there is more balance among the different products (cassava, plantains, sweet potatoes and other roots and tubers – mostly yams) in the other countries (Ghana, Cote d'Ivoire, Guinea, Gabon).

Some studies highlight the high income elasticity of demand for potatoes in the developing countries, the

14 It is said that the expansion of soybean production in Brazil is contributing to deforestation in the Amazon, not so much because forest land is converted for soybean cultivation but rather because it drives expansion into the forest for grazing and rice cultivation ("Exports blamed for Amazon deforestation", *Financial Times*, 14-01-05). Environmental groups also claim that expansion of the oilpalm is destroying rainforest and threatens the habitat of apes (BBC, "Shoppers 'threat to orang-utans'" 23-09-05; also "Worse than Fossil Fuel" *Guardian*, 6th December 2005).

15 Provisional production data for 2005 suggest that the share of Argentina and Brazil increased further to 42 percent and that of the USA declined to 39 percent.

16 Provisional 2005 data: 66 million ha.

17 FAPRI, 2005, projects that Brazil will have overtaken the USA as the World's largest producer of soybeans by 2010.

18 We use the estimates of land suitable for soybeans as evaluated by the GAEZ for the "*high input rainfed*" variant, given that the yields these countries achieve currently are close to or above the 2.5-2.8 tonnes/ha generated by the GAEZ for this variant for land classes VS-S on the average.

majority of which have very low levels of per capita consumption[19]. This contrasts with the position of the other starchy foods (particularly sweet potatoes but also cassava), whose per capita food consumption in the developing countries has apparently stagnated or declined[20]. However, caution is required in drawing firm inferences from these numbers because of the particularly poor quality of data as regards the production and consumption of several of these crops.

Efforts to improve the cassava data in Africa in the context of COSCA[21] suggest that cassava is far from being the inferior good put forward in traditional thinking. "The COSCA study found that the income elasticities of demand for cassava products were positive at all income levels" (Nweke *et al.*, 2002). Indeed, cassava played an important role in the nutrition gains made by a number of countries which faced severe food insecurity problems. For example, gains in per capita food consumption in Ghana (from 1700 calories in 1979/81 to 2580 calories in 1999/01) and in Nigeria (from 2050 to 2720) came largely from increases in the production and consumption of cassava and sweet potatoes – 65 percent and 45 percent of the total calorie increases, respectively. Indeed, these two countries are presented in FAO's 2000 *State of Food Insecurity in the World* (FAO, 2000) as success cases in improving food security based on the diffusion of improved high-yielding cassava cultivars, largely developed by IITA (see also Nweke, 2004; Nweke *et al.*, 2002).

However, such gains were the exception rather than the rule in the many countries with food insecurity problems and high dependence on starchy foods. Only a few of them (Ghana, Nigeria, Malawi, Benin, Rwanda, Angola, Guinea and Peru) registered significant increases in the per capita food consumption of these products. The others had no gains, indeed some of them suffered outright declines according to the reported production statistics. In conclusion, the experiences of the "success" countries indicate that these crops have a promising potential to contribute to improved food security. Analyzing why most countries with high dependence on these crops (over 20 percent of calories) failed to benefit from such potential can throw some light on the more general issue of conditions that must be met if progress in food security is to be made. The fact that some of these countries have been experiencing unsettled political conditions and war is certainly part of the problem.

Feed uses of root crops. Significant quantities of roots are used as feed, mostly potatoes (14 percent of world production goes to feed), sweet potatoes (36 percent) and cassava (27 percent). A small number of countries or country groups account for the bulk of such use. For potatoes, it is mostly the countries of the former Soviet Union and Eastern Europe, and China. Potato feed use has declined in recent years in absolute tonnage as well as percentage terms, mainly as a result of the decline of the livestock sector in the transition countries. For sweet potatoes, China accounts for almost the totality of world feed use and for about two thirds of world production. Feed use in China expanded rapidly up to the late 1990s following the fast growth of its livestock sector and the shift of human consumption to potatoes and other preferred foods.

For cassava, a few countries account for the bulk world feed use (Brazil, China, Nigeria, the EU15, Paraguay, Vietnam, Uganda, Ghana and Angola). Up to a few years ago the EU15 was by far the largest user. Its feed use of imported cassava peaked at some 25 million tonnes (fresh cassava equivalent) in 1990 and has fallen precipitously since then to the current some 5 million tonnes. As noted, the rise and subsequent collapse followed the movements of the cereal prices set by policy in the EU. The vicissitudes of cassava imports and feed use in the EU provide an interesting story of the power of policies (in this case the EU's support prices for cereals) to change radically feeding patterns and exert significant impacts on trade as well as on production, land use and the environment in far away countries (in this case mainly Thailand, see Bruinsma, 2003, Ch. 3).

These products will continue to play an important role in sustaining food consumption levels in the many

19 "Whereas potatoes are typically considered a cheap, starchy staple in industrialized countries, they tend to be high-priced and sometimes are luxury vegetables in the developing world….. Consumption of potato increases as income increases. The relationships for cassava and sweet potato are different. As per capita incomes increase, per capita consumption declines" (Scott *et al.*, 2000).

20 "Outside of Kerala (India) and isolated mountain areas of Viet Nam and China, most cassava in Asia for direct food purposes is first processed. As incomes increase over time, also these areas will reduce their non-processed cassava intake in favour of the preferred rice. On-farm cassava flour consumption, seems to behave in a similar way to non-processed cassava in Asia, as it is also substituted for rice as economic conditions improve. Nonetheless, on-farm, in the poorer Asian rural areas (Indonesia, Viet Nam and China) cassava may remain as an emergency or buffer crop in times of rice scarcity. However, this is not the primary nor the preferred use" (Henry et al., 1998). Also, "the general tendency is that cereals are preferred to root crops" (FAO, 1990: 24) and "In general, cassava is not well regarded as a food, and in fact there is often a considerable stigma against it" (Plucknett *et al.*, 2001).

21 Collaborative study of cassava in Africa (COSCA), initiated in 1989.

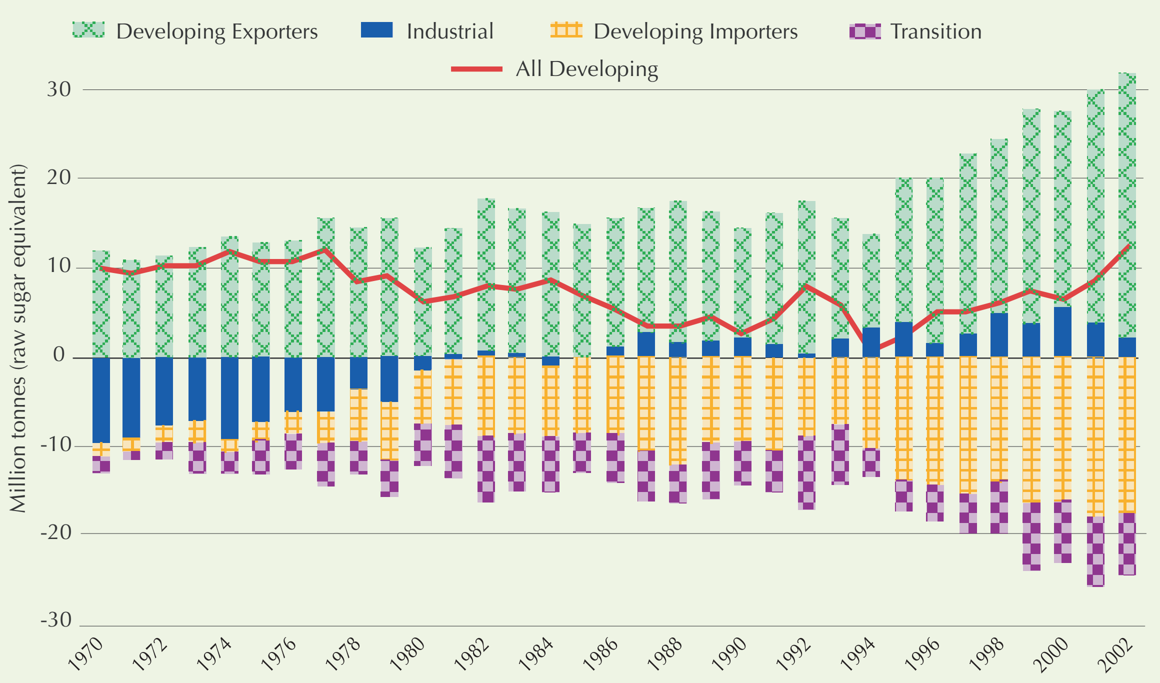
countries that have a high dependence on them and low food consumption levels overall. The possible evolution in food consumption per capita is shown in Tables 2.7 and 2.8. The main factor that made for the decline in the average of the developing countries (precipitous decline of sweet potato food consumption in China) will be much weaker, as the scope for further declines is much more limited than in the past. In parallel, the two factors that make for increases in the average - the positive income elasticities of the demand for potatoes and the potential offered by productivity increases in the other roots (cassava, yams) - will continue to operate. It will be possible for more countries in sub-Saharan Africa to replicate the experiences of countries like Nigeria, Ghana and Malawi, and increase their food consumption. Thus, the recent upturn in per capita consumption of the developing countries is projected to continue (Table 2.7), while the declining trend in sub-Saharan Africa (excluding Nigeria and Ghana, Table 2.8) may be reversed.

Industrial non-food uses of cassava can benefit from the prospect that the crop can become a major feedstock (along with sugar cane and maize) for the production of ethanol (see section on sugar below). Thailand is apparently moving in this direction[22] and other countries with significant cassava production potentials may do so if petroleum prices were to be kept at levels making remunerative the use of cassava feedstocks for biofuels. In our projections of non-food industrial uses of cassava we made some allowance for increased demand originating in the biofuels sector.

3.6 Sugar

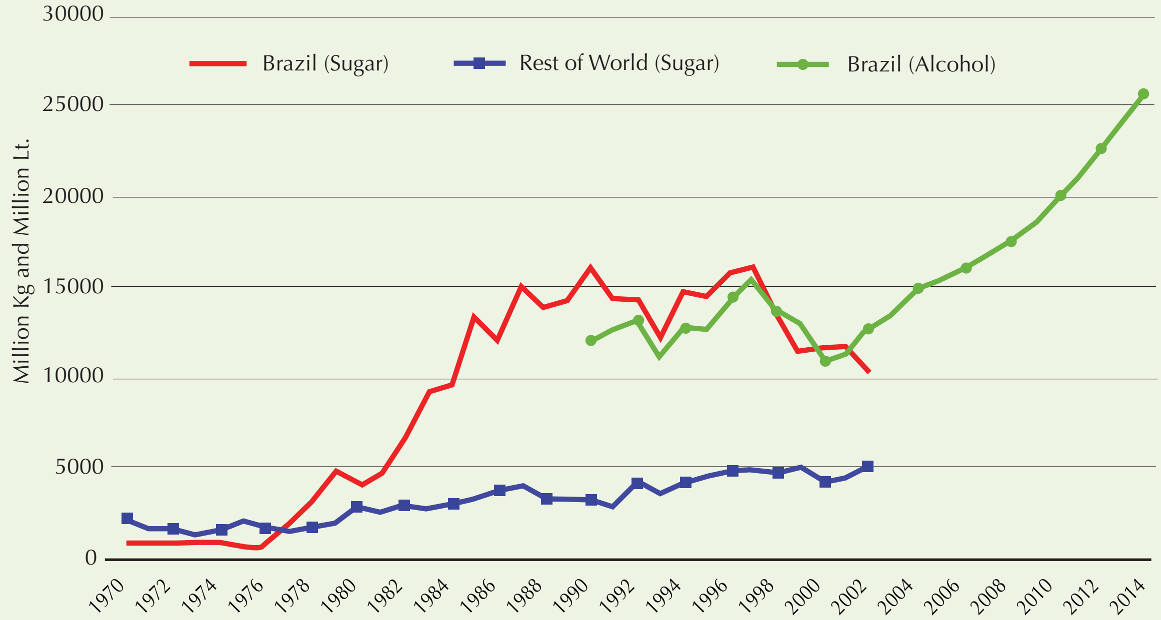
Consumption has been growing fast in the developing countries, which now account for 72 percent of world consumption (up from 49 percent 30 years ago), including the sugar equivalent of sugar crops used in non-food industrial uses (mainly Brazil's sugar cane used in ethanol production - see below). In contrast, food consumption has grown very little in the industrial countries, and has declined in the transition countries in the 1990s. An important factor in the stagnation of sugar consumption in the industrial countries has been the rapid expansion of corn-based sweeteners in the USA, where they now exceed consumption of sugar[23]. Sugar

Figure 3.11 Sugar: net trade positions, 1970-2002



22 http://earth-policy.org/Updates/2005/update49 ; see also "Thai 'Biofuel' Sector Takes off as Region's Energy Needs Rise", Wall Street Journal, Sep 22, 2005
23 Data in http://www.ers.usda.gov/briefing/sugar/Data/data.htm

Figure 3.12 Industrial use of sugar (Brazil and rest of world) and (Brazil only) alcohol production



Sources: Sugar: Faostat; Alcohol with Projections: OECD (2005)

is produced under heavy protection in the industrial countries, with the exception of the traditional exporters among them (Australia and South Africa – OECD, 2002). Under this shelter, their production grew at 1.4 percent p.a. in the last three decades, at a time when their total consumption was not growing. The result has been that these countries turned from net importers of 8.9 million tonnes 30 years ago to net exporters of 4.4 million tonnes in 1999/01 (Figure 3.11). This reflected partly the growing exports of Australia, declining imports of the USA and to a smaller extent Japan, but above all it reflected the shifting of the EU from a net importer of 2.4 million tonnes to a net exporter of 4.2 million tonnes. The net exports of the developing exporters did not decline because over the same period the decline of their exports to the industrial countries was compensated by rising imports into the transition countries and the importing developing countries. The latter, particularly several countries in the Near East/North Africa region but also countries like Indonesia and Nigeria, played a major role in the expansion of world trade as their imports shot up in the second half of the nineties.

A major characteristic of these developments is that the low prices prevailing in world markets acted as a disincentive to production in countries which failed to improve productivity and, together with the rapid growth of their own consumption, contributed to turning several traditional exporting developing countries into net importers. These include countries like the Philippines, Peru, Mozambique and Taiwan (province of China). Collectively, they were net exporters of 2.3 million tonnes in the early-seventies. They now have net imports of 0.8 million tonnes.

Concerning the future, food consumption of sugar in the developing countries is projected to continue to grow (Tables 2.7, 3.13). Growth could be higher than indicated in the Tables if China's policy to limit saccharin consumption succeeded (Baron, 2001, p. 4). Much of the growth would occur in Asia, as Latin America and the Near East / North Africa have already attained fairly high levels of consumption (Table 2.8). Per capita consumption will probably remain constant in the industrial countries, compared with declines in part of the historical period during which corn sweeteners were substituting for sugar in the USA. This process, very pronounced up to the mid-eighties, has by now run its course. It could be reversed if sugar prices were not to be supported at the high levels set by policy and/or maize prices were to rise following its growing use for ethanol production (USDA, 2006:21). Some increases are expected in the transition countries,

Table 3.13 Sugar (raw sugar equivalent)

	Thousand tonnes	percent p.a.						
	1999/01	1961 -2001	1971 -2001	1981 -2001	1991 -2001	1999/01 -2030	2030 -2050	1999/01 -2050
Production								
Developing Countries	130846	3.2	3.1	2.5	2.2	2.2	1.6	1.9
Industrial Countries	35097	1.8	1.4	1.0	1.4	-0.1	-0.4	-0.2
Transition Countries	8330	-0.8	-1.6	-3.1	-3.6	0.0	-1.5	-0.6
World	174271	2.4	2.3	1.7	1.7	1.7	1.3	1.6
Food Use								
Developing Countries	98042	3.4	3.2	2.7	2.7	1.7	0.9	1.4
Industrial Countries	29929	0.2	-0.1	0.5	0.8	0.2	0.0	0.2
Transition Countries	15004	0.6	-0.6	-1.8	0.3	-0.1	-0.2	-0.1
World	142978	2.1	1.8	1.6	2.0	1.3	0.7	1.1
Industrial Non-Food								
World	16193	7.9	8.2	2.7	-0.8	4.6	3.2	4.0
Brazil	11545	11.4	11.2	2.7	-1.9			

	1969/71	1979/81	1989/91	1999/01	2030	2050
	Food Consumption (kg/person/year)					
Developing Countries	15	18	19	21	24	26
Industrial Countries	41	37	33	33	32	32
Transition Countries	42	46	43	37	39	41
World	22	23	23	24	26	27
	Net Trade (Thousand tonnes)					
Industrial Countries	**-8886**	**-1983**	**1851**	**4448**	**-2000**	**-6450**
Australia	1672	2198	2739	3965		
EU15	-2356	2481	3184	4235		
South Africa	628	754	894	1402		
Japan	-2529	-2181	-1902	-1551		
USA	-4646	-3663	-1372	-1579		
Other Industrial	-1655	-1572	-1692	-2024		
Transition Countries	**-935**	**-4813**	**-5006**	**-7510**	**-7600**	**-9300**
Russia				-5350		
Developing Countries	**9269**	**7329**	**3745**	**7353**	**13900**	**20000**
Exporters in 1999/01	**10893**	**14171**	**13752**	**24129**	**43150**	**54800**
Brazil	1162	2653	1093	10515		
Thailand	82	893	2812	3703		
Cuba	5739	6718	6992	3099		
Guatemala	62	189	477	1195		
Colombia	147	239	347	997		
Turkey	77	-83	-206	733		
Swaziland	150	283	440	549		
Other	3473	3278	1798	3338		
Importers in 1999/01	**-1623**	**-6842**	**-10007**	**-16780**	**-29200**	**-34800**
Indonesia	-132	-515	-323	-1758		
Korea, Rep.	-226	-444	-812	-1078		
Iran	-80	-816	-806	-1019		
Nigeria	-110	-716	-412	-954		
Algeria	-198	-554	-827	-950		
Malaysia	-354	-424	-570	-874		
Egypt	90	-477	-703	-746		
Saudi Arabia	-86	-308	-447	-622		
Syria	-146	-209	-372	-557		
Sri Lanka	-308	-253	-333	-539		
Morocco	-244	-311	-268	-506		
Other	171	-1815	-4133	-7178		
World (imbalance)	**-556**	**527**	**584**	**4285**	**4300**	**4250**

making up for some of the declines suffered during the 1990s. Given the lower population growth in the future, these developments suggest a further deceleration in the aggregate world food demand for sugar. As explained below, the impact on the world sugar sector may be compensated by the growing use of sugar crops for biofuel production.

An important influence on the sector may be exerted by the wider use of biofuels. As noted, the rise in the price of petroleum has prompted greatly renewed interest in biofuels as substitutes for gasoline and diesel in motor vehicles. Brazil, using sugar cane as the feedstock for producing ethanol, leads the way[24]: the country's alcohol production increased from 11.3 billion litres (lt.) in the 2001/02 crop year to 15 billion lt. in 2004/05 taking one half of the country's sugar cane production. Given Brazil's large cane production potential, this has not dented significantly its capacity to produce sugar to meet the growing demand for exports: over the same period Brazil's sugar production increased from 17 million tonnes (million tonnes) to 28 million tonnes and exports from 8 million tonnes to 18 million tonnes[25]. Other countries have plans to produce ethanol from sugar cane[26]. More countries with abundant land resources suitable for producing low-cost biofuel crops (e.g. vegetable oils, cassava, in addition to sugar cane) can be expected to join the list if developments in the energy markets so dictate. Notwithstanding the very weak data availability in this field, some provision must be made in the projections for the prospect that the future of the sugar sector may be influenced significantly by the biofuel factor.

FAO's data on non-food industrial uses of sugar can be utilised as a rough guide, though it is not known to what extent such use reflects fuel alcohol production. Brazil accounts for the bulk of the FAO data on industrial uses (70-80 percent of the world total). The FAO data on Brazil track fairly closely the data from independent sources of the country's alcohol production[27] (Figure 3.12). Therefore, the existing FAO data (indicating such use of sugar of 16 million tonnes in 1999/01 – some 10 percent of world total sugar use) can be taken as a starting point for looking into the future. The OECD/FAO sugar projections for Brazil to 2014 (OECD, 2005b) indicate a doubling of alcohol production from 2002-14 to some 26 billion lt. taking into account preliminary data showing a 20 percent recorded rise to 15 billion lt. from 2002-04 (of which some 2.4 billion lt. exported). Conservatively we project further growth at 3.5 percent p.a. (roughly that of Brazil's GDP). For the rest of the world we project analogous increases for the above mentioned countries with plans to produce alcohol from sugar cane. The result is that the trend towards decline in world use of sugar for industrial purposes in the 1990s (-0.8 percent p.a.) is reversed in these conservative assumptions and is projected to grow at 4.0 percent p.a. (Table 3.13). As noted, this upturn would contribute to keeping the growth rate of world aggregate demand (for all uses) and production from declining as the growth of the world food demand for sugar decelerates.

Another factor that may make for deviations of the future in relation to the past in the sugar sector is the growing pressure on the industrial countries to reduce sugar protectionism. Such pressures may bear some fruit in the not too distant future and lead to some shrinkage of sugar production in the industrial countries to the benefit of higher exports from the developing countries. The EU has been promoting reforms in this direction. If adopted and implemented they would have the result that the region would turn again into a net importer. The latest assessment by the EU Commission (2005a – Table 4) indicates that with the proposed reforms the EU-25 could turn into a net importer to the tune of 3.5 million tonnes in 2012/13. This compares with the net exports of 1.6 million tonnes in 2004 and the higher levels of earlier years. Such development, eventually reinforced by more liberal trade policies of other major industrial importers, would lead to the industrial countries as a whole reverting to their "natural" status of being again net importers of sugar, a trend already foreshadowed by the virtual disappearance of their net surplus in 2004.

24 It is said that Brazil's ethanol is competitive with petroleum when the latter's price is US$ 35-40 / barrel (Kojima and Johnson, 2005; OECD, 2005a: Lebre la Rovere, 2004) or even less according to others (see, for example, "The Next Petroleum", Newsweek, 18 August 2005). These figures compare with the current petroleum price of US$60+. Eventually, the competitiveness may be further enhanced (though not by much – Kojima and Johnson, 2005) if the savings of greenhouse gas (GHG) emissions resulting from substituting ethanol for gasoline were to be monetized in the form of tradable carbon credits (Certified Emission Reductions of greenhouse gases) through the Clean Development Mechanism under the provisions of the Kyoto Protocol. Naturally, the dollar exchange rate plays a decisive role here and competitiveness would be reduced if the dollar were to fall vis-à-vis the currency of the biofuel-producing countries.

25 Data from USDA Foreign Agricultural Service, *Brazil, Sugar Reports 2002 and 2005*, GAIN Reports Numbers BR2008 and BR5020 (http://www.fas.usda.gov/htp/news/news05/2005percent20archive.htm).

26 Peru, Colombia, Central America, India, Thailand, Australia, South Africa, Zimbabwe: http://earth-policy.org/Updates/2005/update49

27 http://www.portalunica.com.br/referencia/estatisticas.jsp

The real boost to world trade will likely continue to come from the growing import requirements of the importing developing countries, both the major importers (see list in Table 3.13) and others that will be becoming such. The transition countries will continue to increase their imports though not as fast as in the past, in particular because Russia, the world's largest importer (net imports 5.4 million tonnes in 1999/01, 73 percent of consumption), will likely move towards higher self-sufficiency (Gudosnikov, 2001), given also some decline in aggregate consumption reflecting its already high per capita consumption and falling projected population.

3.7 Concluding remarks

The future may see some drastic decline in the growth of world agriculture. 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 which fuelled much of the growth in the historical period, foremost among them China. In contrast, developing countries that experienced slow growth in the past (and as result still have low per capita consumption - less than 2700 kcal/person/day and potential for further growth) should not experience any slowdown but rather some acceleration.

Increasingly, world agriculture may have to depend on non-food uses of its produce if growth rates are not to be sharply lower compared with the past. The biofuels sector may provide some scope, perhaps a significant one, for relaxing the constraints represented by the declining growth rates of the demand for human consumption. For the moment, biofuels from different crops in the different countries[28] are not generally competitive without subsidies even at the US$ 60/barrel prices of oil, with the exception of ethanol from sugar cane in Brazil. This is true also for other countries producing sugar cane (or have the potential to do so), as many of them do not have the appropriate combination of land resources and productivity, agricultural practices, infrastructure and technological prowess of Brazil. Still, these conditions are not immutable and "this experience with ethanol in Brazil could be replicated in other developing countries" (UNCTAD, 2005: 17). Africa, with its significant sugar cane production potential, is often cited as a region that could profit from Brazil's experience and technology[29], though obstacles to realizing it (infrastructure, institutional, etc) should not be underestimated. Eventually, the competitiveness of biofuels may be further enhanced (though not by much – Kojima and Johnson, 2005) if the savings of greenhouse gas emissions resulting from substituting biofuels for petroleum-based fuels were to be monetized in the form of tradable carbon credits (Certified Emission Reductions of greenhouse gases) through the Clean Development Mechanism under the provisions of the Kyoto Protocol.

Notwithstanding the uncertainties about the future of biofuels, the issue of alternative energy sources is very alive and questions are increasingly asked about the potential of world agriculture to become a significant source of biomass feedstocks (Kojima and Johnson, 2005; Smeets *et al*., 2004). Although at present the promotion of biofuels in several industrialized countries serves the additional (perhaps the principal) objective of supporting their agricultures (hence restrictions in imports of biofuels are usually an integral part of such policies), in the future it can have significant effects on world agriculture as it can offer novel development opportunities for countries with ample land resources, e.g. several countries in sub-Saharan Africa, Latin America and South-East Asia, if barriers to trade of biofuels were eased.

At the same time as offering novel development opportunities, the issue of possible competition between uses of agricultural resources for energy vs. food will be becoming increasingly relevant. Traditional food and fibre use of land may lose out in this competition simply because, on the margin, the potential market for energy is huge in relation to that for food, eventually leading to rising food prices. The latter may not dent the welfare of

[28] Other crops currently used as feedstocks for ethanol production include sugar beets and cereals (mainly in Europe – the latest EU projections make an allowance for 1.5 million tonnes of cereals to be used for bioenergy production in 2012 - European Commission, 2005b) and maize (mainly in the USA, where strong growth is foreseen for the next 10 years when maize use for ethanol may reach 23 percent of production, i.e. more that twice present levels and surpassing exports as a major outlet for the crop– USDA, 2006), while cassava is a promising candidate in countries like Thailand. Vegetable oils (mainly soybean oil in the USA and rapeseed oil in Europe) are also used in the production of biodiesel, while palm oil is considered to have a competitive edge over other oils. Among these crops, sugar cane has the advantage that its main by-product (bagasse) is used in the production of electricity thus making the ethanol distilleries virtually self-sufficient in energy.

[29] Feature story on the World Bank President's visit to Brazil, 20 December 2005 (http://web.worldbank.org/wbsite/external/news/0,,contentMDK:20764365~menuPK:34457~pagePK:34370~piPK:34424~theSitePK:4607,00.html)

those who can afford to pay higher prices for both food and fuel, including the population groups that benefit from the development of biofuels. However, low income consumers that do not participate in such gains may be adversely affected in their access to food. And, of course, the environmental implications, e.g. deforestation, of further expansion of agriculture for the production of the feedstock crops have to be accounted for in the drawing up of the balance sheet of the pros and cons of the energy sector demands spilling over into agriculture. Pressures from the expansion of biofuels on foodcrop agriculture may be somewhat mitigated by the prospect that eventually the advancement of technology would make possible economic production of "cellulosic" ethanol. The latter uses as feedstock lignocellulosic biomass (grasses, wood, but also crop residues) that could be grown on land with limited food crop production potential.

It is too early to deal fully with this important subject, particularly in the light of uncertainties concerning the oil price levels at which alternative energy sources other than biofuels (e.g. nuclear, solar, wind, etc) become competitive[30]. However, the issues of alternative energy sources and the potential of agriculture as a source of the biomass feedstocks for the production of liquid fuels will continue to draw interest. Our conventional projections to 2050 are a first and necessary step in addressing it: they can help establish how much more food and related agricultural resources the world may need in the longer term future and in which countries – a valuable input into any evaluation of the potential for diverting agricultural resources to other uses and what this may imply for food security.

30 Work is underway in the Global Perspective Studies Unit at FAO.