Prospects for food, nutrition, agriculture and major commodity groups

World agriculture: towards 2030/2050

Interim report

Global Perspective Studies Unit
Food and Agriculture Organization of the United Nations
Rome, June 2006

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This interim report presents an update, revision and extension to 2050 of Chapters 2 and 3 of the *FAO Study World agriculture: towards 2015/2030, an FAO Perspective,* published in 2003 (Bruinsma, 2003). It is mainly meant to disseminate interim results and to solicit comments, as an intermediate step in the preparation of a more complete report.

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CHAPTER 1

Overview

1.1 Why the new outlook to 2050

This is an updated version, with extension of projections to 2050, of two of the key chapters (Chapters 2 and 3) of the study *World Agriculture: Towards 2015/30* completed in 2002 and published in 2003 (Bruinsma, 2003). Chapter 2 presents prospective developments in food demand and consumption and possible implications for nutrition and undernourishment. Chapter 3 deals with production, consumption and trade, in terms of the main commodity sectors and aggregate agriculture.

This updating and extension is undertaken for a number of reasons, in addition to the need to take on board more recent data and historical ones that have been revised.

The **first** has to do with demography. Future world population may be lower than the projections available at the time of the earlier study indicated. For this reason, food requirements in the future may be lower than projected in the earlier study. In addition, longer-term projections suggest that the end of world population growth may be within sight by the middle of this century, as world population may peak at 9.2 billion around the year 2075[1]. In practice, much of the increase between the 6.1 billion of 2000 and the peak will have occurred by 2050 when world population may reach 8.9 billion. It follows that over the next 50 years world agriculture may be transiting to a future when global population growth will no longer be the major driving force for further growth in world food demand and production. This has consequences for the rate at which further pressures on land and water resources and the wider environment will be building up.

In this context, of particular interest is the question: will the eventual cessation of world population growth imply that the classical Malthusian concerns (the prospect that population growth will run ahead of the potential of agriculture to increase food production, and its corollary – food insecurity attributed predominantly to production constraints), will no longer be relevant? We attempt to estimate the magnitudes involved, but the short answer is that these concerns will probably retain their full relevance well beyond 2050, as explained in Section 1.2 below.

The **second** reason is that the growing tightness of energy markets and associated rising oil prices may exert some important effects on food and agriculture that have to be taken into account. At the time of the earlier projections, the World Bank's price outlook for oil was that it could decline from the US$ 28/barrel of 2000 to US$ 21/barrel in 2015 in current dollars and even more in constant dollars of 1990[2]. The outlook is

1 UN (2004), medium variant projection.
2 From US$ 29 to US$ 17, World Bank (2002): Tables A2.12-A2.13.

quite different in the Bank's latest assessment in view of the recent sharp price rises – to a 2005 average of US$ 53.4/barrel. Thus, "the World Bank has adopted a technical assumption for the future path of oil prices based on a slow decline toward US$ 40 per barrel by 2010"[3].

High energy prices affect the food and agriculture sector in several ways. Besides the classical ones (via macroeconomic effects affecting all aspects of production, consumption and trade, and the more direct ones on production agriculture via the effects on the costs of the energy-intensive inputs like fertilizer and fuel) they can impact agriculture by creating new markets for those products which can be used as biomass feedstocks for the production of biofuels as substitutes for the petroleum-based fuels (petrol, diesel) in transport[4]. The case of Brazil which, after a period of shrinkage during the 1990s when oil prices were low, has now reverted to using some 50 percent of its sugar cane output to produce fuel ethanol, both for domestic use and export, is telling. Ethanol in Brazil is considered to be competitive vis-à-vis traditional fossil fuels at oil prices of US$ 35-40/barrel, although this figure will vary with the dollar exchange rate. Also well known is the growing use of maize in the USA (in this case with subsidies) to produce fuel ethanol. The renewable fuel provisions in the Energy Policy Act of 2005 will further promote such use: by 2015, it may become more important than exports and could account for some 23 percent of the country's maize output[5], with important impacts on world markets.

Again with subsidies, the use of vegetable oils to produce biodiesel is expanding in certain EU countries, while the EU has a target of a 5.75 percent market share of biofuels in the petrol and diesel market in 2010. The latest projections of the European Commission foresee that 1.5 million tonnes[6] of grain and some 10 million tonnes of oilseeds may be used to produce bioenergy in 2012. There is growing interest in the countries with abundant, or potentially so, production potential of suitable feedstocks (like palm oil for biodiesel in Malaysia and Indonesia, cassava and sugar cane for ethanol in Thailand) for going the way of producing biofuels, both for domestic use and export.

Although at present the promotion of biofuels is often used in several industrialized countries as a means to relax the demand constraints facing agriculture, in the future it can have far-reaching effects on world agriculture as it can offer novel development opportunities for countries with significant agricultural resources, if barriers to trade of biofuels were eased or removed. Africa, with its significant sugar cane production potential, is often cited as a region that could profit from Brazil's experience and technology[7], though obstacles to realizing it (infrastructure, institutional, etc.) should not be underestimated. Eventually, the competitiveness of biofuels may be further enhanced if the savings of greenhouse gas 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.

It is too early to deal fully with this important subject, given the uncertainties about future oil prices. However, 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 feedstocks and in particular the food security and environmental implications, e.g. further deforestation from the eventual expansion of land under the feedstock crops (oil palm, soybeans, sugar cane, etc). Our conventional projections to 2050 are a first and necessary step in addressing this issue: they can help establish how much more food and related agricultural resources the world may need 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. The advancement of technology in converting lignocellulosic biomass (from crop residues, grasses and wood) to produce "cellulosic" ethanol may contribute to mitigating eventual pressures on the land with food crop production potential.

A third reason is that nearly ten years into the period to 2015, the date by which the international community committed itself in the 1996 World Food Summit to halving hunger and undernutrition (halving the numbers undernourished), not much progress has been made

3 World Bank (2006):15.
4 They can also raise the competitiveness of agricultural products, e.g. cotton or natural rubber, that compete with oil-based synthetics whose cost rises with the price of oil.
5 USDA (2006).
6 Tonnes are metric tonnes throughout this paper; mt = million tonnes.
7 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).

and the prospects that the target will be attained are not encouraging. The significant progress made by some countries is being compensated by severe setbacks suffered by other countries. The latter tend to be those with high population growth rates, hence failures to increase food consumption per capita are translated into increases of the numbers undernourished. For those among them with poor agricultural resources and high dependence on them for their food security and overall development, the task of achieving in the foreseeable future the quantum jumps in food consumption required for meeting the target may prove very arduous indeed. Longer term projections can help drive home the issue that even if the global target for reducing undernutrition were achieved, there will still be several countries with unacceptably high incidence. The need to plan ahead interventions to cope with the persistence of high undernutrition will likely remain a live issue for many years to come.

1.2 Main findings

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

The main reason is that zero population growth at the global level will be the net result of continuing increases in some countries (e.g. by some 31 million annually in 2050 in Africa and South and Western Asia together) compensated by declines in others (e.g. by some 10 million annually in China, Japan and Europe together)[8]. Nearly all the further population increases will be occurring in countries several of which even in 2050 may still have inadequate food consumption levels, hence significant scope for further increases in demand. The pressures for further increases of food supplies in these countries will continue. Much of it will have to be met by growing local production or, as it happened in the past and is still happening currently, it may not be fully met – a typical case of production-constrained food insecurity. The creation of slack in some countries with declining population (e.g. the transition economies, when growth of aggregate demand will have been reduced to a trickle - .01 percent p.a. in the final two decades 2030-50) will not necessarily be made available to meet the still growing demand in countries with rising population, e.g. demand growth at 2.0 percent p.a. in sub-Saharan Africa.

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

Food and nutrition

The historical trend towards increased food consumption per capita as a world average and particularly in the developing countries will likely continue, but at slower rates than in the past as more and more countries approach medium-high levels. The average of the developing countries, that rose from 2110 kcal/person/day 30 years ago to the present 2650 kcal, may rise further to 2960 kcal in the next 30 years and on to 3070 kcal by 2050. By the middle of the century the great bulk of their population (90 percent) may live in countries with over 2700 kcal, up from 51 percent at present and only 4 percent three decades ago. As in the past, the great improvements in China and a few other populous countries will continue to carry a significant weight in these developments.

However, not all countries may achieve food consumption levels consonant with requirements for good nutrition. This may be the case of some of the countries which start with very low consumption (under 2200 kcal/person/day in 1999/01), high rates of undernourishment, high population growth rates, poor prospects for rapid economic growth and often meagre agricultural resources. There are 32 countries in this category, with rates of undernourishment between 29 percent and 72 percent, an average of 42 percent, Yemen and Niger among them. Their present population of 580 million is projected to grow to 1.39 billion by 2050, that of Yemen from 18 million to 84 million and

8 Other reasons include the likely continuation of changes in the structure of consumption towards more livestock products following growth in incomes and urbanization, particularly in the developing countries.

that of Niger from 11 million to 53 million. Their current average food consumption of 2000 kcal/person/day is actually a little below that of 30 years ago. Despite the dismal historical record, the potential exists for several of these countries to make gains by assigning priority to the development of local food production, as other countries have done in the past. Under this fairly optimistic assumption, the average of the group may grow to 2450 kcal in the next 30 years, though this would still not be sufficient for good nutrition in several of them. Hence the conclusion that reducing undernourishment may be a very slow process in these countries.

Notwithstanding the several countries with poor prospects for making sufficient progress, the developing countries as a whole would record significant reductions in the relative prevalence of undernourishment (percent of population affected). However, these will not be translated into commensurate declines in the numbers undernourished because of population growth. Reduction in the absolute numbers is likely to be a slow process. Numbers could decline from the 810 million in 1999/01 to 580 million in 2015, to 460 million in 2030 and to just over 290 million by 2050. This means that the number of undernourished in developing countries, which stood at 823 million in 1990/92 (the 3-year average used as the basis for defining the World Food Summit target), is not likely to be halved by 2015. However, the proportion of the population undernourished could be halved by 2015 – from 20.3 percent in 1990/92 to 10.1 percent in 2015 and on to 6.9 in 2030 and to 3.9 by 2050. It is noted that the UN Millennium Development Goals (MDG) refer not to halving the numbers undernourished but rather to a target to "halve, between 1990 and 2015, the proportion of people who suffer from hunger". In this sense, the MDG goal may be achieved.

Despite this slow pace of progress in reducing the prevalence of undernourishment, the projections do imply considerable overall improvement. In the developing countries the numbers well-fed (i.e. not classified as undernourished according to the criteria used here) could increase from 3.9 billion in 1999/01 (83 percent of their population) to 5.2 billion in 2015 (90 percent of the population), to 6.2 billion (93 percent) in 2030 and to 7.2 billion (96 percent) by 2050. That would be no mean achievement. Fewer countries than at present will have high incidence of undernourishment, none of them in the most populous class. The problem of undernourishment will tend to become smaller in terms of both absolute numbers affected and, even more, in relative terms (proportion of the population), hence it will become more tractable through policy interventions, both national and international.

The progress in raising per capita food consumption to 3000+ kcal/person/day in several developing countries is not always an unmixed blessing. The related diet transitions often imply changes towards energy-dense diets high in fat, particularly saturated fat, sugar and salt and low in unrefined carbohydrates. In combination with lifestyle changes, largely associated with rapid urbanization, such transitions, while beneficent in many countries with still inadequate diets, are often accompanied by a corresponding increase in diet-related chronic Non-Communicable Diseases (NCDs). In many countries undergoing this transition, obesity-related NCDs tend to appear when health problems related to undernutrition of significant parts of their populations are still widely prevalent. The two problems co-exist and these countries are confronted with a "double burden of malnutrition" resulting in novel challenges and strains in their health systems.

Growth of agriculture and main commodity sectors

Aggregate agriculture: World agriculture (*aggregate value of production*, all food and non-food crop and livestock commodities) has been growing at rates of 2.1-2.3 percent p.a. in the last four decades, with much of the growth originating in the developing countries (3.4-3.8 percent p.a.). The high growth rates of the latter reflected, among other things, developments in some large countries - foremost among them China. Without China, the rest of the developing countries grew at 2.8-3.0 percent p.a. They also reflected the rising share of high value commodities like livestock products in the total value of production: in terms of quantities (whether measured in tonnage or calorie content), the growth rates have been lower (see Box 3.1).

The future may see some drastic decline in the growth of aggregate world production, to 1.5 percent p.a. in the next three decades and on to 0.9 percent p.a. in the subsequent 20 years to 2050. The slowdown reflects the lower population growth and the gradual attainment of medium-high levels of per capita consumption in a growing number of countries. The latter factor restricts the scope for further growth in demand per capita in several countries which had very high growth in the past, 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 will have to depend on non-food uses of commodities if growth rates are not to be sharply lower compared with the past. As noted, the biofuels sector may provide some scope, perhaps a significant one, for relaxing the demand constraints represented by the declining rates of increase in human consumption.

Cereals: All the major commodity sectors should participate in the deceleration of agricultural growth. The cereals sector (sum of wheat, milled rice and coarse grains) has already been in such downward trend for some time now, with the growth rate having fallen from 3.7 percent p.a. in sixties, to 2.5 percent, 1.4 percent and 1.1 percent p.a. in the subsequent three decades to 2001. In this latter year world production stood at just under 1.9 billion tonnes. It has grown further since then to some 2 billion tonnes in 2005 (preliminary estimate). We project increases to some 3 billion tonnes by 2050 and this would afford some increase in world per capita availability to around 340 kg (for all food and non-food uses), some 10 percent over present levels. It is noted that the current level of per capita consumption (309 kg in 1999/01) is lower than what was achieved in the past mainly due to the sharp declines in the transition economies (the former socialist countries of the USSR and Eastern Europe) in the 1990s. Recovery in their consumption as well as continued growth in the developing countries should raise the world average to levels it had attained in the past (in the mid-80s). A good part of the increase in world cereals consumption should be for animal feed (mostly coarse grains), with the bulk of such consumption increases originating in the developing countries to support the expansion of their livestock production.

The decline in the growth rate notwithstanding, the absolute increases involved should not be underestimated: an increase of world production by another 1.1 billion tonnes annually will be required by 2050 over the 1.9 billion tonnes of 1999/01 (or 1 billion tonnes over the 2 billion of 2005). Achieving it should not be taken for granted, as land and water resources are now more stretched than in the past and the potential for continued growth of yield is more limited.

Not all countries will be able to increase cereals production *pari passu* with their consumption. Therefore, past trends of ever growing net cereal imports of the developing countries should continue and grow to some 300 million tonnes[9] by 2050 a 2.7-fold increase over the 112 million tonnes of 1999/01. This is a much lower rate of increase compared with the past when they had grown more than 5-fold in 40 years. The novel element in the projections is that transition economies are transforming themselves from the large net importers of cereals they were up to the early 1990s (net imports of 43 million tonnes in 1993) to net exporters (18 million tonnes net exports annual average in 2002-04). Such net exports could increase further in the future and, therefore, the traditional cereal exporters (North America, Australia, the EU and the developing exporters) would not have to produce the full surplus needed to cover this growing deficit.

Livestock: Production and consumption of meat will also experience a growth deceleration compared with the high growth rates of the past, though the milk sector should accelerate, mainly because of growth in the developing countries demand. The growth of the meat sector had been decisively influenced upwards by the rapid growth of production and consumption in China, and to a smaller extent also Brazil. This upward influence on the world totals was counterbalanced in the 1990s by the drastic shrinkage of the livestock sector in the transition economies, leading to a growth rate in the decade of 2.1 percent p.a. vs. 3.1 percent if the transition economies data are excluded from the world totals. These influences will not be present with the same force in the future - with the exception of continued rapid growth of production in Brazil (mainly for export). The decline in the transition economies has already been reversed while the growth of meat consumption in China, which grew from 9 kg per capita to more than 50 kg in the last three decades, cannot obviously continue at the same high rates for much longer (see, however, Chapter 3 for uncertainties concerning the reliability of the livestock data of China).

The rest of the developing countries still has significant scope for growth, given that their annual per capita meat consumption is still a modest 16 kg. Some of this growth potential will materialize as effective demand and their per capita consumption could double by 2050, i.e. faster than in the past. It is unlikely that other major developing countries will replicate the role played by China in the past in boosting the world meat sector. In particular,

9 To 380 million tonnes if we exclude from the developing countries the traditional exporters among them - Argentina, Thailand and Vietnam.

India's meat consumption growth may not exert anything like the impact China had in the past, notwithstanding its huge population and good income growth prospects. The country may still have low levels of consumption (though significantly above the current 5 kg) for the foreseeable future.

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

Sugar: There are a number of features that characterize the evolution of the sector and determine future prospects: (a) rapidly rising food consumption in the developing countries (3.2 percent p.a. in the last 30 years); (b) the emergence of several of them as major net importers (net imports of the deficit developing countries rose from 10 million tonnes to 29 million tonnes over the same period); (c) the growing dominance of Brazil as the major low-cost producer and exporter (production rose from 7.5 million tonnes to 32 million tonnes[10] and net exports from 1 million tonnes to 11 million tonnes over the same period); (d) the growing use of sugar cane as feedstock for the production of biofuels (ethanol, mainly in Brazil, which now uses some 50 percent of cane production for this purpose); and (e) the prospect that after many years of heavy protectionism of the sugar sector and declining net imports in the industrial countries (which turned into net exporters from the mid-80s, mainly due to the protection of the sector in the EU and the substitution of corn-based sweeteners for sugar in the USA), the stage may be set for a reversal of such trends and the resumption of growth in their imports.

Many developing countries, including China, have still low or very low sugar consumption per capita (28 countries have less than 10 kg p.a. and another 18 have 10-20 kg). Therefore, the potential exists for further growth in consumption, though it will not be as vigorous as in the past when 60 developing countries had less than 20 kg in 1969/71. Depending on the evolution of petroleum prices, sugar cane use as feedstock for the production of biofuels may keep growing in several producing countries (or those that have the resource potential to become major producers). Already several countries have plans to do so. It is possible that this development would contribute to keeping the growth rate of world aggregate demand (for all uses) and production from declining in line with the deceleration in the demand for food uses.

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

10 Raw sugar equivalent of sugar cane production.

Agricultural trade of the developing countries

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

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

1.3 Conclusions

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

The slowdown in the growth of world agriculture may be mitigated if the use of crop biomass for biofuels were to be further increased and consolidated. Were this to happen, the implications for agriculture and development could be significant for countries with abundant land and climate resources that are suitable for the feedstock crops; assuming, of course, that impediments to biofuels trade do not stand on the way. Several countries in Latin America, South-East Asia and sub-Saharan Africa, including some of the most needy and food-insecure ones, could benefit. Whether and to what extent this will happen is very uncertain, but the issue deserves serious analysis and evaluation[11]. Of particular interest are (a) possible adverse effects on the food security of the poor and the food-insecure if food prices were to rise because of resource diversion towards the production of feedstock crops for biofuels; and (b) the environmental implications of cultivated land expansion into pasturelands and forested areas. As noted, this is a typical case of possible trade-offs between different aspects of the environment and sustainability: benefits from the reduction in greenhouse gas emissions when biofuels substitute fossil fuels in transport and adverse effects from the expansion and intensification of agriculture.

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

CHAPTER 2

Prospects for food and nutrition

2.1 The broad picture: historical developments and present situation

2.1.1 Progress made in raising food consumption per person

Food consumption, in terms of kcal/person/day, is the key variable used for measuring and evaluating the evolution of the world food situation[1]. The world has made significant progress in raising food consumption per person. In the three decades to 1999/01, it increased from an average of 2400 kcal/person/day to almost 2800 kcal/person/day (Table 2.1). This growth was accompanied by significant structural change. Diets shifted towards more livestock products, vegetable oils, etc. and away from staples such as roots and tubers (Tables 2.7 and 2.8). The increase in world average kcal/person/day would have been even higher but for the declines in the transition economies in the 1990s.

The gains in the world average reflected predominantly those of the developing countries, given that the industrial countries and the transition economies had fairly high levels of per capita food consumption already in the past.

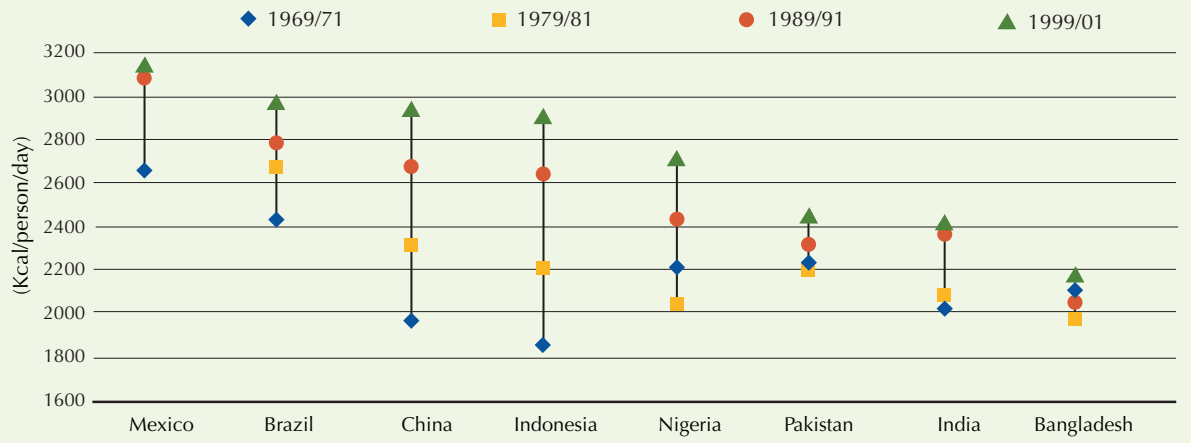
Table 2.1 Per capita food consumption (kcal/person/day)

	1969/71	1979/81	1989/91	1999/01	2015	2030	2050
World	2411	2549	2704	2789	2950	3040	3130
Developing countries	2111	2308	2520	2654	2860	2960	3070
sub-Saharan Africa	2100	2078	2106	2194	2420	2600	2830
- excluding Nigeria	*2073*	*2084*	*2032*	*2072*	*2285*	*2490*	*2740*
Near East / North Africa	2382	2834	3011	2974	3080	3130	3190
Latin America and Caribbean	2465	2698	2689	2836	2990	3120	3200
South Asia	2066	2084	2329	2392	2660	2790	2980
East Asia	2012	2317	2625	2872	3110	3190	3230
Industrial countries	3046	3133	3292	3446	3480	3520	3540
Transition countries	3323	3389	3280	2900	3030	3150	3270

Note: See Appendix for country classifications

[1] The more correct term for this variable would be "national average apparent food consumption or availability", since the data come from the national Food Balance Sheets rather than from food consumption surveys (see Box 2.2). The term "food consumption" is used in this sense in this report.

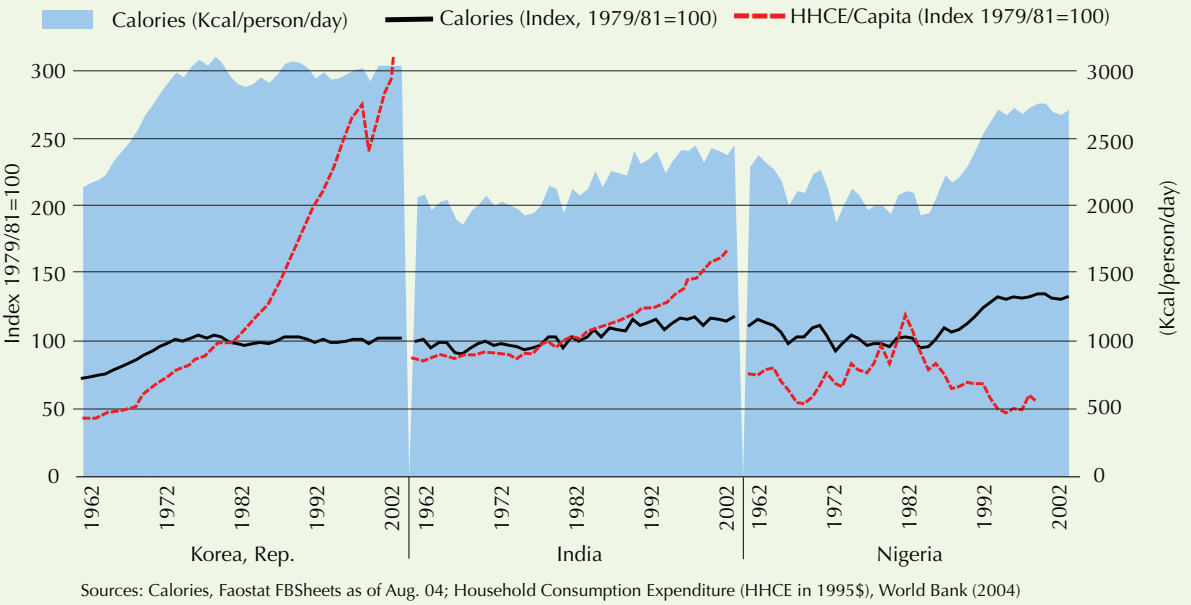
Figure 2.1 Per capita food consumption, developing countries with over 100 million population in 2000



This overall progress of the developing countries has been decisively influenced by the significant gains made by the most populous among them. There are currently 8 developing countries with a population of 100 million or more. Of them, only Bangladesh remains at very low levels of food consumption. China, Indonesia, Brazil and Mexico have made the transition to fairly high levels (in the range 2900-3150 kcal). In more recent years (from the late 1980s) India and Pakistan also made some progress and are now approaching middling levels of per capita food consumption after long periods of near stagnation (Figure 2.1). Nigeria's data show that the country raised per capita food consumption significantly to medium-high levels in the decade starting in the mid-eighties (but see Bruinsma, 2003: 37 for data problems in Nigeria).

However, the data on apparent food consumption in some of these large countries reveal some contradictory evidence when confronted with those depicting the broader economic situation. Precisely, and as Figure 2.1 shows, in India the gradual rise in apparent average consumption came to a virtual standstill in the 1990s and seems to have remained stuck at around 2400 kcal/person/day. Yet it was in the decade of the 1990s that India's economic growth accelerated and per capita incomes, or rather the more

Figure 2.2 Evolution of apparent food consumption/capita in relation to income per capita: three country typologies



Sources: Calories, Faostat FBSheets as of Aug. 04; Household Consumption Expenditure (HHCE in 1995$), World Bank (2004)

relevant Household Consumption Expenditure (HHCE) per capita, grew much faster than before (3.3 percent p.a. in 1992-02, up from 2 percent in the preceding decade and 1.6 percent in the decade before). On the other hand, the data for Nigeria, if correct, would seem to suggest evolution of food consumption in the opposite direction, i.e. fast growth in food consumption per capita in the decade to the early 1990s, precisely when per capita incomes and HHCE were on a path of fast decline. Gains in cassava productivity are often cited as a major factor explaining the gains in food consumption in Nigeria (FAO, 2000; Nweke, 2004). The "paradoxes" for these two countries are shown in Figure 2.2 together with the case of Korea, Rep. which provides a benchmark of what constitutes a more "normal" evolutionary path, i.e. food consumption growing fast with economic growth and subsequently slowing down, and eventually leveling off, as high levels of around 3000 kcal/person/day were achieved. A closer look at the "paradox" of Nigeria was attempted in Bruinsma (2003: 37) and is attempted here for India (Box 2.1).

An alternative way of looking at changes over the historical period is to observe the distribution of the population of the developing world who live in countries having given levels of kcal/person/day. This is a rough and far from perfect approximation to depicting a distribution pattern of world food consumption, using the country averages as the unit of observation in the absence of comprehensive within-country distribution data. The relevant data are shown in Table 2.2. The stark changes that took place in the relatively short period of 30 years are vividly depicted: thirty years ago, some 2 billion, or 75 percent of the 2.6 billion population of the developing countries lived in 47 countries, including both China and India, with under 2200 kcal/person/day, more than one half of them in countries with under 2000 kcal, China among them. Only six developing countries accounting for a mere 100 million population had over 2700 kcal, a level that is roughly near a threshold for not having significant prevalence of undernutrition.

Thirty years on the situation had changed dramatically: "only" some 600 million (12 percent) of the greatly increased population (4.7 billion) of the developing countries lived in the under 2200 kcal category, while a substantial 2.4 billion (51 percent) had shifted into the over 2700 kcal category. The gains made by some of

Table 2.2 Population living in developing countries with given per capita food consumption (million)[1]

kcal/person/day		1969/71	1999/01	2030	2050
Under 2200	Population (m.)	1962	584	29	
Under 2200	Average kcal	1992	2001	2060	
Under 2200	No countries	47	32	2	
2200-2500	Population (m.)	438	1537	785	128
2200-2500	Average kcal	2321	2403	2380	2460
2200-2500	No countries	40	26	17	3
2500-2700	Population (m.)	103	201	510	618
2500-2700	Average kcal	2624	2547	2605	2625
2500-2700	No countries	8	14	23	12
2700-3000	Population (m.)	40	1925	2336	1622
2700-3000	Average kcal	2800	2933	2835	2870
2700-3000	No countries	4	16	31	42
Over 3000	Population (m.)	60	484	3049	5140
Over 3000	Average kcal	3117	3174	3280	3200
Over 3000	No countries	2	14	29	45
All Developing	Population (m.)	2604	4731	6709	7509
All Developing	Average kcal	2111	2654	2960	3070
All Developing	No countries	101	102	102	102

[1] Only countries with Food Balance Sheets

Box 2.1 Indian paradox: Near stagnant average food consumption in midst of rapid economic growth

As discussed later (section 2.3 and Chapter 3), much of the slowdown in global cereals consumption has been the result of developments in per capita food consumption of cereals in China and India, which between themselves account for 38 percent of world population. A major issue for the global projections is the extent to which recent developments in these two large countries are indicative of things to come or if these trends may change in the future. To address this issue we first note the significant differences existing in the historical developments in the two countries.

In China, the leveling off and subsequent decline in per capita cereals consumption occurred when the country had reached nearly 220 kg/person/year and consumption of all foods was providing 2600+ kcal/person/day. In parallel with the declines in cereals, the consumption of other foods was increasing leading to the present nearly 3000 kg/person/day (more on China's cereals in Chapter 3, Box 3.2.). In contrast India's per capita cereals consumption started stagnating/declining when it was still relatively low at around 170 kg and when consumption of all food was also low at around 2400 kcal/person/day (or 2150 kcal rural and 2070-2160 urban according to the national consumer expenditure surveys of 1993-94 and 1999-2000 – (Dev et al., 2004: tables 8-9). Somewhat higher levels are indicated by nutrition surveys proper, though these are measured in terms of consumption units rather than per capita, Shetty, 2002: tables 5-6). Moreover, the stagnation and/or decline in per capita cereals consumption was not accompanied by any significant increases in the consumption of total food calories, so that the national average is still in the area of 2450 kcal/person/day. The reduction of calories from cereals, and to a smaller extent pulses, was made up mainly by increases in the consumption of vegetable oils, milk, sugar and fruit and vegetables.

These developments are assumed to reflect both the influence of standard economic factors (e.g. inadequate growth of incomes of those that would consume more cereals if they could afford them, and prices) but also what goes by the name of "change in tastes and preferences". Several authors emphasize the role of such shifts in tastes, e.g. Dev et al. (2004), Rao (2000), Sen (2005). However, we are still short of explanations why such widespread shifts, that would normally occur when national averages are at levels consonant with significantly reduced undernutrition, seem to occur in India at the very early stages of such nutritional transition when the prevalence of undernutrition is still high. The latter is estimated at 21 percent of the population or 220 million (FAO, 2004a). These estimates are not different from those circulating among national experts, e.g. Paroda (2001): "India still has the world's largest number of poor people (around 250 million) who do not get two square meals a day".

To judge from survey data of food intakes, the situation has been getting worse rather than improving, at least in terms of per capita calories consumed (Shariff and Malik, 1999), and this phenomenon is fairly widespread affecting all classes, rural and urban and those below and above the poverty threshold (Sen, 2005: table 5). Some authors (e.g. Saha, 2000) consider that the decline of cereals consumption is a sign of distress rather than of improving welfare favouring diet diversification, indicating that things are getting worse in the rural areas as people have to pay more than before for things like fuel and other basic necessities of life. Of course, this is saying that rural incomes have not improved at anything near the rates implied by the high overall economic growth rates, if at all. In which case, the near stagnant levels of national average food consumption may not be much of a paradox.

Overall, however, one should be careful in taking at face value the calorie data coming from the surveys (similar reservations apply, of course, to the FAO estimates of apparent food consumption based on the food balance sheets). Such surveys seem to consistently show significant underconsumption of the population groups at the bottom of the income distribution scale. For example, in ten of India's 16 States the poorest (by expenditure) 20 percent of the population had in 1999-2000 calories in the range in the range 1300-1600. Worse, in 1983 the poorest 20 percent are shown as having had calories in the range 850-1360 in 3 States (Tamil Nadu, Kerala, Karnataka - Meenakshi and Vishwanathan, 2003, Table 6). Nutritionists would say these levels are hardly sufficient for survival and minimal activity if persons are permanently subjected to them even after accounting for differences among States in population characteristics (age/sex structures, body weight). Apparently this result reflects, inter alia, exclusion of the food consumed by employees in their employers' households. In India's National Sample Surveys such food is counted as part of the latters' food consumption (Minhas, 1991). In conclusion, we should evaluate carefully the reliability of the survey data before drawing conclusions about developments in India's food consumption levels.

National income data can help us examine the issue in an international context. India's per capita GDP in the year 2000 was 2220 PPP$ of 1995[2] (World Bank, 2004) when per capita apparent food consumption was 2410 kcal/person day. This relationship is not at all "abnormal" in a cross-country comparison: there are 11 developing countries[3] with GDP in the neighbourhood of that of India (PPP$ 2200 plus/minus $500) and they all have kcal/person/day in the range 2000-2600, with India being right in the middle of the range. Going by analogy, in the future India should be somewhere near the middle of the range of countries with incomes in the neighbourhood of what India will have at that time. Assuming the growth rate of per capita GDP of the last 10 years (4.1 percent p.a.) were to apply also to the period to 2030, India's per capita GDP should rise by 2030 to PPP$ 7400 of 1995. Countries that currently have incomes in range PPP$ 7400 plus/minus $1000[4], have kcal/person/day in the range 2700-3150. Therefore, India's average national food consumption rising to around 2800 kcal by 2030 would not be out of place in the projections. Were this to happen, it would imply a significant reduction in undernutrition for the country and the world. To judge from survey data, Indians do move up the calorie scale as incomes increase: in six of India's 16 States the richest (by expenditure) 20 percent of the population had over 3000 kcal/person/day while the bottom 20 percent had calories in the range 1713-2228 (Meenakshi and Vishwanathan, 2003, Table 6). As incomes rise and poverty is reduced[5], those in the less well off segments of the population can be expected to behave vis-à-vis food more like those in the better-off groups currently.

2 PPP= Purchasing Power Parity (definition in: http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/ICPEXT/0,,contentMDK:20118237~menuPK:62002075~pagePK:60002244~piPK:62002388~theSitePK:270065,00.html)
3 Cameroon, Pakistan, Angola, Ghana, Guinea, Vietnam, Lesotho, Bolivia, Nicaragua and Honduras (Zimbabwe is not included because it was in the middle of a severe food crisis).
4 Brazil, Uruguay, Costa Rica, Mexico, Malaysia, Trinidad and Tobago and Chile (Botswana, with income in this range but only 2160 calories, is not included in the sample as being atypical and a clear outlier, probably because of the large weight of the diamond sector in total GDP).
5 See the World Bank's projections of reductions in South Asia's poverty (Table 2.6).

the very populous developing countries mentioned above were largely responsible for this massive upgrading of the food situation of the developing countries.

2.1.2 Failures

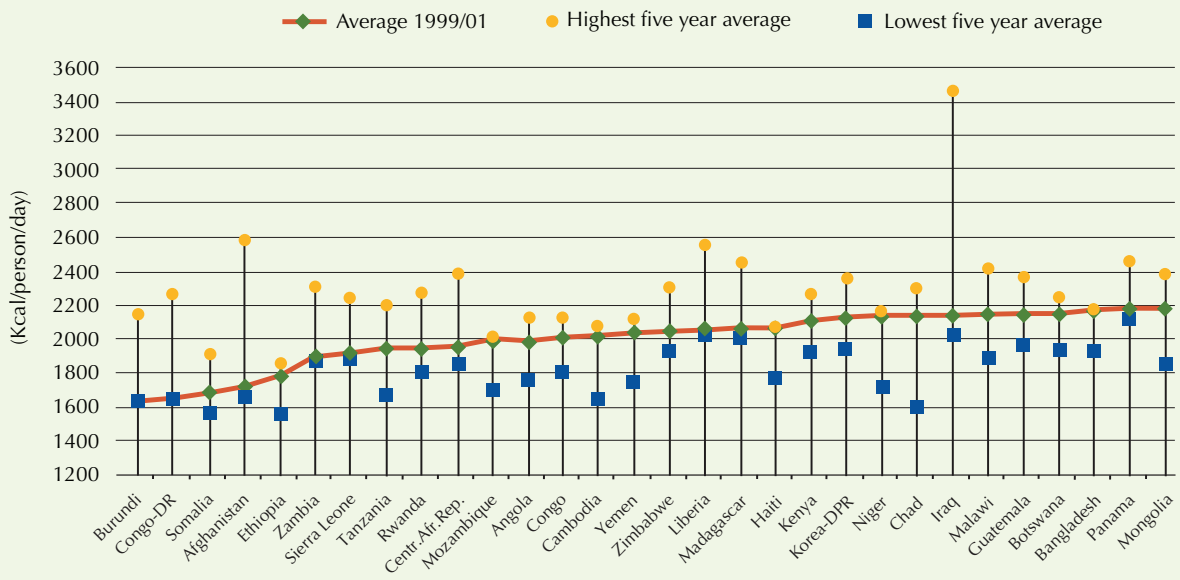
A significant number of countries failed to participate in this general thrust towards increasing average food consumption levels. There are currently 32 developing countries where food consumption is under 2200 kcal/person/day (Table 2.2). Figure 2.3 summarizes their historical experience: present (average 1999/01) levels are compared with the highest and lowest ones recorded in any 5-year average (5-year averages are used to smooth out distortions from yearly fluctuations) in the period 1961-2002. The following comments may be made about these 32 countries:

- Several among them (e.g. Iraq, Afghanistan, the Central African Republic, Panama, Madagascar, Malawi) had achieved middling levels (over 2400 kcal) or even high ones (Iraq) in at least one 5-year average in the past. They were in the under-2200 kcal class in 1999/01 because they suffered declines, some particularly deep ones, Iraq, Afghanistan, Congo DR, Burundi and Liberia. The impact of war or war-like conditions is evident.
- For most other countries in Figure 2.3, the highest level ever achieved was totally inadequate to start with, yet they suffered further declines, some very sharp ones, e.g. Somalia, Burundi, Congo DR, Rwanda, Kenya, Ethiopia-cum-Eritrea[6].
- Finally, a few countries did not suffer declines but have always had very low per capita food consumption. That is, they have never had levels that were significantly above the very low ones they have currently. Here belong Bangladesh, Niger, Haiti and Mozambique.

Looking at the regional picture, sub-Saharan Africa stands out as the only region which failed to make any significant progress in raising per capita food consumption, a stagnation even more pronounced if we exclude Nigeria from the regional averages (Table 2.1). Not all countries of the region are in this dire food security situation. Besides Nigeria, a number of other countries made significant progress to over 2400 kcal/person/day (Mauritius, Mauritania, Ghana, Gabon, Benin, Burkina Faso and Lesotho) but their weight in the region is too small to have much effect on the total. The regional aggregate picture is dominated by the failures suffered by the larger countries. Of the 12 countries with population of over 15 million, six have per capita food consumption

6 The data used in Figure 2.3 refer to the aggregate Ethiopia and Eritrea, because there are no separate data before 1993 for making historical comparisons for the two countries separately.

Figure 2.3 Developing countries with under 2200 kcal in 1999/01. Highest and lowest 5-year average kcal recorded during 1961-2001



levels which are lower than what they attained in the past - some of them much lower, e.g. Congo DR, Madagascar and Tanzania. Only Nigeria and Ghana among these larger countries have shown persistent gains in per capita food consumption, apparently in both countries due to jumps in production of roots and tubers, as discussed later in this Chapter.

2.1.3 The prevalence of undernourishment– past and present

The latest FAO assessment, *The State of Food Insecurity in the World 2004* (FAO, 2004a), estimates the total prevalence of undernourishment in the developing countries at 813 million persons in 2000/02 (17 percent of their population - Table 2.3)[7], when average food consumption reached 2650 kcal/person/day. This estimate is not significantly different from that of ten years earlier, the 3-year average 1990/92 (823 million), although then it represented a higher proportion of their total population (20 percent). The 3-year average 1990/92 was the base used by the 1996 World Food Summit (WFS) in setting the target of halving the numbers undernourished in the developing countries by 2015 at the latest.

This slight decline represents virtually no progress in the first ten years of the 25-year period set by the WFS for attaining the target. In practice, declines achieved in East Asia were compensated by increases in the other two regions with the highest concentrations - sub-Saharan Africa and South Asia. If these trends continue, the halving target will certainly not be achieved and whatever reductions take place will further accentuate the divide between countries making progress and those falling behind.

Changes in the prevalence of undernourishment are close correlates of changes in food consumption levels (kcal/person/day), as explained in Box 2.2. The historical data in Table 2.1 show that food consumption levels have improved greatly for most regions over the last three decades. Such improvement must have been accompanied by a lowering of the prevalence of undernourishment also in the years before 1990/92. By implication, undernourishment must have been much higher in the past, e.g. in 1969/71 when there were only 2110 kcal/person/day on the average in the developing countries. Estimates for that period indicate 960 million which was 37 percent of the population[8].

7 The term "undernourishment" is used to refer to the status of persons whose food intake does not provide enough calories to meet their basic energy requirements. The term "undernutrition" denotes the status of persons whose anthropometric measurements indicate the outcome not only, or not necessarily, of inadequate food intake but also of poor health and sanitation - conditions that may prevent them from deriving full nutritional benefit from what they eat (FAO, 1999: 6).

8 Estimates in http://www.fao.org/faostat/foodsecurity/index_en.htm.

Table 2.3 Prevalence of undernourishment, developing countries

	1990/92	2000/02	1999/01	2015	2030	2050
	Percent of population					
	SOFI 04					
Developing countries	20.3	17.0	17.2	10.1	6.9	3.9
sub-Saharan Africa	35.7	32.7	33.3	21.1	12.4	5.8
excl. Nigeria	*40.8*	*38.3*	*39.0*	*25.2*	*14.7*	*6.8*
Near East / North Africa	7.6	10.1	10.2	7.0	5.7	3.7
Latin America and Caribbean	13.4	10.2	10.7	6.6	3.9	2.6
South Asia	25.9	22.1	22.3	12.1	8.4	4.1
East Asia	16.5	11.5	11.6	5.8	3.9	2.9
	Million					
Developing countries	823	813	811	582	458	290
sub-Saharan Africa	170	203	201	179	140	88
excl. Nigeria	*159*	*192*	*191*	*173*	*135*	*84*
Near East / North Africa	24	40	39	36	36	29
Latin America and Caribbean	60	53	55	41	27	20
South Asia	291	301	299	203	166	90
East Asia	277	217	216	123	88	64

*The absolute numbers differ slightly from those published in FAO (2004a) because the latter include estimates for some small countries.
SOFI 04 = *State of World Food Insecurity in the World 2004 (FAO, 2004a)*

Box 2.2 Measuring the prevalence of undernourishment: the key role of the estimates of food available for direct human consumption[9]

The key data used for estimating the prevalence of undernourishment are those of food available for direct human consumption. These data are derived in the framework of the national Food Balance Sheets (FBS – explanations in http://faostat.fao.org/faostat/agricult/cbcp-e-e.htm). The latter are constructed on the basis of countries' reports on their production and trade of food commodities. The part used as food is derived after deduction of estimates and/or allowances for non-food uses and for losses (excluding losses at the household or individual level[10]. Such losses can be considerable – see estimates for the USA in Kantor, 1998). The population data are used to express these food availabilities into per capita terms (kg/person/year, then converted to kcal/person/day). The resulting numbers are taken as proxies for actual national average food consumption. For many countries the thus estimated per capita food consumption of the different commodities are totally inadequate for good nutrition, hence the relatively high estimates of the prevalence of undernourishment reported for them.

This conclusion is inferred from a comparison of the estimated kcal/person/day shown in the FBS data with what would be required for good nutrition. The parameters for the latter are well known[11], though not devoid of controversy. In the first place, there is the amount of food (or dietary) energy that is needed for the human body to function at rest (breathe, pump blood, etc.) even without allowing for movement or activity. This is the Basal or Resting Metabolic Rate (BMR or RMR). It is in the general range 1300-1700 kcal/day for adults in different physiological conditions (age, sex, height, bodyweight). Taking the age/sex structure and body-weights of the adult populations of the different countries, their national average BMRs for adults are estimated. These refer to the amount of energy as a national average per adult person that must be actually absorbed if all were in a state of rest and inactivity. For children, in addition to the BMR, an additional allowance needs to be made for the requirements for adequate growth and in the case of pregnant and lactating (nursing) mothers for the proper growth of the foetus and for the lactation needs of the growing infant.

9 Reproduced with amendments from FAO (1996a).
10 Work is currently underway to generate estimates for such losses.
11 See discussion in FAO (2004b).

When an allowance for light activity is added, estimated to be about 54 percent of the BMR, there results a range of between 1720 kcal and 1965 kcal person/day for the different developing countries given their population structures in 2000 (average: 1840). This will rise to 1820-1980 kcal by 2050 (average: 1913) when the demographic structure will be different, with a higher proportion of adults. It follows that population groups in which an average individual has habitually an intake below this level (the threshold) are undernourished because they do not eat enough to maintain health, body weight and to engage in light activity. The result is physical and mental impairment. Characteristics for the former are evidenced in nutritional anthropometric surveys. Estimating the prevalence of undernourishment means estimating the proportion of population with food intakes below these thresholds. It is noted that the notion, measurement and definition of thresholds of requirements are not devoid of controversy. For example, Svedberg (2001:12) considers that the thresholds used in the FAO measurement of undernourishment for the tropical countries are too high leading to overestimates of undernourishment[12].

In principle, a country having national average kcal/person/day equal to the threshold would have no undernourishment problem provided all persons engage in only light activity and each person had access to food exactly according to his/her respective requirements. However, this is never the case; some people consume (or have access to) more food than their respective "light activity" requirements (e.g. because they engage in more energy-demanding work or have high household waste or simply overeat) and other people less than their requirement (usually because they cannot afford more). Thus, an allowance must be made for such unequal access. Empirical evidence suggests that the inequality measure used in these estimates – the coefficient of variation (CV) – ranges from 0.2 to 0.36 in the different countries (a CV of 0.2 means, roughly, that the average difference of the food intake of individuals from the national average - the standard deviation - is 20 percent of the national average). Even at the lowest level of inequality generally found in the empirical data (CV=0.2), the national average kcal/person/day must be well above the threshold if the proportion of population undernourished is to be very low. For example, a country with threshold 1800 kcal and CV=0.20, must have a national average of 2700 kcal/person/day if the proportion undernourished is to be only 2.5 percent, or 2900 if it is to be 1 percent. Naturally, if inequality were more pronounced, these requirements would be higher.

These numbers, or norms, are, therefore, a first guide to assessing the adequacy or otherwise of the national average food consumption levels in the FBS data and expressed in kcal/person/day. This latter number is the principal variable used to generate estimates of the prevalence of undernourishment as explained elsewhere (FAO, 1996b; more technical discussion in Naiken, 2003)[13]. Numerous countries fall below the national average energy level (kcal/person/day) required for undernourishment to be very low, in many cases they fall below by considerable margins. Therefore, even if one knew nothing more about the prevalence of undernourishment, the inevitable conclusion for these countries is that it must be significant, ranging from moderate to high or very high, even when inequality of access to food is moderate. It follows that progress towards reducing or eliminating undernourishment must manifest itself, in the first place, in the form of increased per capita food consumption. Naturally, this is not equivalent to saying that the food consumption shown in the FBS data is itself a variable which can be operated upon directly by policy. For it to rise, somebody must consume more food, and the food must come from somewhere – production or imports. The policies to raise national average consumption are those which enhance the purchasing power and more general access to food of those who would consume more if they had the means, for example, access to resources and technologies to improve their own food production capacities, access to non-farm employment, social policies, etc. The point made here is that changes in the national average kcal/person/day recorded in the FBS data do signal the direction and magnitude of movement towards improved or worsened food security status.

How reliable are the FBS data, since in many cases they show very low or very high levels of national average food consumption or sudden spurts or collapses? The answer is: they are as reliable as, mainly, the primary data on production and trade supplied by the countries, as well as the estimates made for non-food uses and losses of food commodities and the population data used to express them in per capita terms[14]. It is these data and estimates that are processed, in the form of the FBS, to derive the indicators of per capita food consumption as national averages used here. Given the primary data, the conclusion that many countries are in a difficult food security situation follows logically and inevitably.

12 Work is currently underway to revise the thresholds used in the estimation of undernourishment.

13 These key variables (kcal/person/day and the CV) are used as parameters of the lognormal statistical distribution (with kcal/person/day as the mean) to estimate the percentage of population undernourished.

14 In some cases the population data themselves are a prime source of errors in the estimates of food consumption per capita (for the case of Nigeria, see Bruinsma, 2003, Box 2.2).

2.2 The outlook for food and nutrition to 2015, 2030 and 2050

2.2.1 Demographics

The population data and projections used here are those of the United Nations *World Population Prospects-the 2002 Revision* (UN, 2003). The projections indicate that a rather drastic slowdown in world demographic growth is in prospect. The data and projections are shown in Table 2.4. The world population of 6071 billion of 2000 is projected to grow to 8130 million in 2030 and to 8920 million in 2050. The growth rate of world population peaked in the second half of the 1960s at 2.04 percent p.a. and had fallen to 1.35 percent p.a. by the second half of the 1990s. Further deceleration will bring it down to 0.7 percent in 2025-30 and to 0.33 percent by 2045-50.

Despite the drastic fall in the growth rate, the absolute annual increments continue to be large. Seventy nine million persons were added to world population every year in the second half of the 1990s and the number will remain at over 50 million p.a. until the mid-2030s. More rapid declines after 2035 should bring the annual increment down to 26 million by 2050. Practically all these increases will be in the developing countries. Within the developing countries themselves, there will be increasing differentiation. East Asia will have shifted to negative demographic growth (-0.2 percent p.a.) in the last five years of the projection period. At the other extreme, sub-Saharan Africa's population will still be growing at 1.2 percent p.a. in the same period 2045-50, despite the drastic downward revision made in recent years in the region's population projections. By 2050, 18 million of the 26 million added annually to world population will be in sub-Saharan Africa. Some countries, mostly in Africa, have demographic projections suggesting that their populations in 2050 would be rather sizeable multiples of their current ones. This prospect raises the serious issue whether significant improvements in food consumption and nutrition could be achieved in the foreseeable future (see discussion in Box 2.3). In conclusion, rapid population growth could continue to be an important impediment to achieving improvements in food security in some countries, even when world population ceases growing.

2.1.2 Overall economy and poverty

The latest World Bank assessment of global economic prospects published in late 2005 contains economic growth (GDP per capita) projections for the period 2001-15 (World Bank, 2006: Table 1.2). These medium-term projections of the World Bank are shown in Figure 2.4. Higher growth rates in per capita GDP than in the 1990s are foreseen for all regions and country groups with the exception of East Asia, which however remains the region with the highest rate of over 5.0 percent p.a. in per capita terms. To note in particular: (a) the reversal of declines and robust growth in the low/middle-income Europe and Central Asia (comprising in the World Bank's classification the transition economies plus Turkey), and (b) the great contrast in the prospects of the two

Table 2.4 Population data and projections

	Population (million)					growth rates, percent per annum			
	1970	2000	2015	2030	2050	1970-2000	2000-2030	2030-2050	2000-2050
World (UN)	3692	6071	7197	8130	8919				
World (countries with FBS)	3682	6048	7166	8091	8871	1.7	1.0	0.5	0.8
Developing countries	2603	4731	5802	6709	7509	2.0	1.2	0.6	0.9
sub-Saharan Africa	262	607	853	1134	1509	2.9	2.1	1.4	1.8
Near East/North Africa	183	392	521	643	774	2.6	1.7	0.9	1.4
Latin America and Caribbean	281	515	623	705	762	2.0	1.1	0.4	0.8
South Asia	708	1340	1685	1972	2208	2.2	1.3	0.6	1.0
East Asia	1169	1877	2119	2256	2256	1.5	0.6	0.0	0.4
Industrial Countries	727	905	965	1003	1019	0.7	0.3	0.1	0.2
Transition Countries	351	411	399	380	343	0.5	-0.3	-0.5	-0.4

Table 2.5 Income growth assumptions

	World Bank Region*	GNI per Capita $		growth rates, percent per annum					
		WB Atlas 2002	PPP 2002	Total GDP at market prices		Per capita GDP at market prices			
				2000 -2030	2030 -2050	1980 -1990	1990 -2000	2000 -2030	2030 -2050
		1	2	3	4	5	6	7	8
World	World total	5121	7848	3.1	3.2	1.3	1.2	2.1	2.7
Developing countries		1077	3755	4.8	4.6			3.6	4.0
Sub-Saharan Africa	Sub Saharan Africa	450	1700	3.8	4.3	-1.1	-0.5	1.6	2.8
Near East/North Africa	Middle East and North Africa	2240	5670	4.1	4.1	-1.1	1.0	2.4	3.1
Latin America and the Caribbean	Latin America and the Caribbean	3280	6950	3.4	3.5	-0.9	1.6	2.3	3.1
South Asia	South Asia	460	2460	6.0	5.5	3.3	3.2	4.7	4.9
East Asia	East Asia and Pacific	960	4280	6.0	5.0	5.8	6.3	5.3	5.0
Industrial countries	High income countries	26490	28480	2.5	2.5	2.5	1.8	2.2	2.4
Transition countries	Europe and Central Asia	2160	6900	4.3	3.8	0.9	-1.8	4.5	4.3

Notes: Cols 1, 2, from World Bank (2004). GNI=Gross National Income, formerly named Gross National Product (GNP); Col. 3, based largely on World Bank projections to 2030 for World Bank (2005); Col. 4, Own assumptions. Cols 5-6 from World Bank (2006): Table 1.2; Cols 7-8, computed from Cols 1, 3, 4 and population projections in Table 2.4

*The country coverage of the World Bank groups is similar, though not identical to that in this study, e.g. Turkey is included in the group (low and middle income) Europe and Central Asia, South Africa in sub-Saharan Africa, while Korea Rep., Hong Kong and Taiwan (Province of China) are in the High-Income Countries (World Bank classification from World Bank, 2005: Table A.51).

Box 2.3 Countries with high population growth for 50 years and limited agricultural resources: An untenable combination?[15]

A key characteristic of the demographic outlook, which is not so evident in medium term projections but leaps to the eye in projections of 50 years ahead, is the prospect that a number of countries could have in 2050 populations which are large multiples of present ones. As shown in Table 2.4 world population is projected to be in 2050 47 percent above that of 2000 and that of the developing countries 59 percent. In contrast, the population of Niger (the country with the highest total fertility rate in the world of 8 children per woman at present and projected to still hold this record with 3.85 children in 2050) is projected to grow from 10.7 million in 2000 to 53 million in 2050, an almost 5-fold increase. In like manner, Yemen's population would grow from 18 million to 84 million, Ethiopia's from 65 to 170 million, Uganda's from 23.5 to 103 million, and so on for a number of other countries. Almost all of these countries have been in nearly perennial food insecurity for several decades. The issue is therefore raised if and to what extent significant progress in development and food security can be achieved under the rapidly mounting population pressure implied by the demographic projections.

The issue is of paramount importance for those countries with large and growing rural populations and heavy dependence of their economies on their own agriculture for income, employment, food supplies and for providing the basis for their overall development. Countries falling in this category which also have agricultural resources that are limited in quantity and/or quality (e.g. predominantly semi-arid, little irrigation potential) and are not endowed with other resources (e.g. oil, mining) will find it much more difficult than other low-income countries to reduce poverty and make adequate progress in food security. The food and agriculture projections cannot avoid recognizing this prospect and highlight the possibility that food insecurity could continue to be a dominant characteristic in a number of countries for several decades to come. More generally, the demographic projections themselves (i.e. the underlying assumptions about fertility, mortality and migration) may have to be revisited and re-assessed in the light of prima facie incompatibilities between population growth and agricultural potentials in countries where the latter are of crucial importance for development. The just released (in early 2005) 2004 revision of the UN demographic projections (UN, 2005a) did modify the projections of the 2002 revision (used here) for some of these countries, but not always in the direction of making them more compatible with agricultural potentials. For example, Yemen's 2050 population is now projected to be 59 million rather 84 million, but for Uganda the revision is in the opposite direction: 127 million in 2050, up from the 103 million of the 2002 projection; and Niger's projection remains almost unchanged at 50 million in 2050.

15 A more complete discussion of the issues in this Box can be found in Alexandratos (2005).

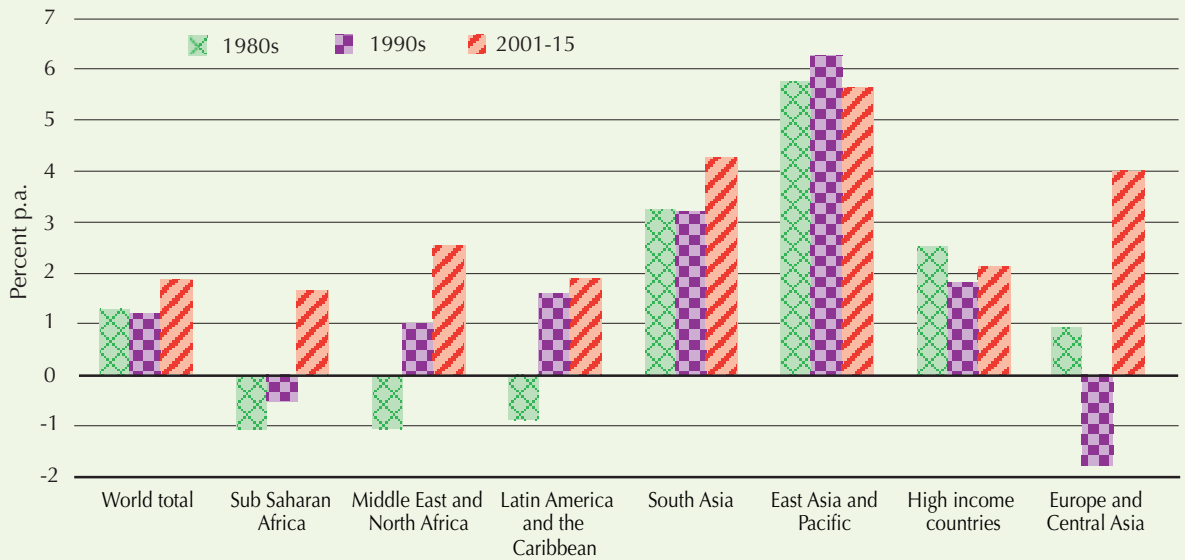
regions with high relative concentrations of poverty and food insecurity, South Asia and sub-Saharan Africa. In the former, a further acceleration of the relatively high growth rates of the past holds promise of positive impact on poverty alleviation (see below). However, progress may be very limited in sub-Saharan Africa, with per capita incomes growing at only 1.7 percent p.a. in the period to 2015. This is certainly much better than the past which was characterized by declining incomes. However, it will be far from sufficient to make a significant dent on poverty and food insecurity in the medium term future.

These World Bank projections and extensions to 2030 have provided the basis for defining the GDP projections used as exogenous assumptions in the present study. Projections for the period 2030-50 were formulated by the authors of this study, largely on the assumption of continuation of the growth of the period to 2030, but with some important exceptions. They are shown in Table 2.5. The exogenous economic growth assumptions used here, together with the growth of population, are the major determinants of projected food consumption, though by no means are they the only ones. Many other factors besides population and average GDP growth influence the apparent levels and commodity composition of food consumption and have to be taken into account in the process of all phases of analytical and evaluation work concerning consumption, production and trade (see methodological notes in Bruinsma, 2003, Appendix 2). As noted (Figure 2.2), there are several countries where the evolution of average per capita income (as recorded in the national accounts data) seems to bear little relationship to the evolution of the average apparent food consumption as revealed in the Food Balance Sheets. For some countries, particularly those with severe food insecurity problems, it is often the evolution of local food production that dominates developments in food consumption (Bruinsma, 2003: 45-47).

One of the important questions we shall be asking below is the extent to which such projected food demand will be associated with reductions in undernourishment. Since undernourishment is more often than not closely correlated with poverty, it is relevant to ask to what extent the economic growth and development outlook we use as exogenous assumptions are compatible with poverty reduction. We have no way of exploring poverty implications for the long term horizon we use in this study. However, the empirical evidence that economic growth is correlated with reduction of poverty (defined as numbers of people, or population proportions, living on e.g. US$ 1 or US$ 2 a day or less) suggests that the positive growth rates assumed here (Table 2.5) do imply poverty reductions, though we cannot say by how much. Some idea of the magnitudes involved in this relationship between economic growth and poverty reduction can be had from the World Bank's projections of poverty associated with those of the per capita GDPs to 2015 in Figure 2.4.

Their poverty estimates are shown in Table 2.6. They refer to what is commonly known as US$ 1/day poverty,

Figure 2.4 Growth rates of per capita GDP, 1980s, 1990s and 2001-15



Source, World Bank (2006), Table 1.2 (see note in Table 2.5 for country coverage)

i.e. number of persons living in households with per capita expenditure under US$ 1/day, with US$ defined in units of Purchasing Power Parity - PPP. These poverty projections imply that:

- The Target set by the Millennium Development Goals of halving by 2015 *the proportion* (not the absolute numbers) of the population of the developing countries as a whole living in poverty from that prevailing in 1990 may be achieved (the proportion falls from 31 percent in 1990 to 12.3 percent in 2015);
- The absolute numbers in poverty may also be halved. They are projected to decline from 1216 million in 1990 to 614 million in 2015;
- Much of the decline is due to prospective developments in East Asia, where the halving of poverty (from 1990 levels) had already being achieved by 2002. Further declines would practically eliminate poverty (of the US$1/day definition) in the region by 2015;
- South Asia is also projected to make great strides in reducing significantly (though by no means eliminating) poverty by 2015. Indeed these two regions of Asia will account for the totality of further reductions in poverty between 2002 and 2015 (200 million each);
- In contrast, the absolute numbers in poverty in sub-Saharan Africa kept increasing in the 1990s and are projected to continue to do so until 2015, though not as fast as in the past. The trend for the percentage of population in poverty in this region to also increase may be reversed, but at 38 percent this percentage will still be very high in 2015.

There is a parallel between these foreseen developments in the prevalence of poverty and those projected here for the prevalence of undernourishment, which are the subject of the following section. It is noted, however, that poverty and undernourishment are not identical concepts, in particular as concerns the settings of threshold levels for defining them (for discussion, see FAO, 2001: 10).

2.2.3 Food security outcomes

Higher per capita food consumption in the future, but with significant exceptions

By 2015, and even more by 2030, the key variable we use to track developments in food security - per capita food consumption as defined above - will have grown significantly. The world average will be approaching 3000 kcal/person/day in 2015, will be just over 3000 by 2030 and higher in 2050 (Table 2.1). These changes in world averages will reflect above all the rising consumption of the developing countries, whose average will have risen from the present 2650 kcal to over 3000 kcal in 2050. More and more people will be living in countries with medium to high levels of per capita food consumption. For example, by 2050 some 90 percent of the increased population of the developing countries will be living in countries with values of this variable exceeding 2700 kcal/person/day, up from 51 percent at present and the only 4 percent three decades ago. Indeed, some 5 billion could be in countries exceeding 3000 kcal (Table 2.2).

Table 2.6 Estimates and projections US$1 poverty, World Bank, baseline scenario

	Million			Percent of population		
	1990	2002	2015	1990	2002	2015
Developing countries	1216	1001	614	31.0	24.2	12.3
sub-Saharan Africa	227	303	336	44.6	46.4	38.4
Middle East and North Africa	6	5	3	2.3	2.4	0.9
Latin America and Caribbean	49	42	29	11.3	9.5	6.9
South Asia	462	437	232	41.3	31.3	12.8
East Asia and Pacific	472	214	14	29.6	14.9	0.9
Memo Items						
East Asia and Pacific, excl. China	97	34	2	21.1	10.8	0.4
Developing countries, excl. China	841	821	603	30.2	26.9	14.8

Source: Adapted from World Bank (2006), Table 1.3. See Table 2.5 for country coverage

These rises are not always an unmixed blessing as the diet transitions experienced by many countries imply changes in diets towards energy-dense ones high in fat, particularly saturated fat, sugar and salt and low in unrefined carbohydrates. In combination with lifestyle changes, largely associated with rapid urbanization, such transitions, while beneficent in many countries with still inadequate diets, are often accompanied by a corresponding increase in diet-related chronic Non-Communicable Diseases (NCDs – WHO, 2003; Schmidhuber and Shetty, 2005; Alexandratos, 2006). In many countries undergoing this transition, obesity-related NCDs appear when health problems related to undernutrition of significant parts of their populations are still widely prevalent. The two problems co-exist and these countries are confronted with a "double burden of malnutrition" resulting in novel challenges and strains in their health systems.

These gains notwithstanding, there will still be several countries in which the per capita food consumption will not increase to levels allowing significant reductions in the numbers undernourished from the very high levels currently prevailing (see below). As shown in Table 2.2, in 2030 12 percent of the developing country population (810 million people) will still be living in countries with low levels of food consumption (under 2500 kcal), and the number will still be 130 million in 2050. As noted (Box 2.2), at these levels of national average consumption the prevalence of undernourishment is bound to be significant.

At the regional level, in 2030 sub-Saharan Africa will still have only 2600 kcal/person/day. The disparity between sub-Saharan Africa and the other regions is even more pronounced if Nigeria is excluded from the regional total (Table 2.1). Of the 19 countries still remaining in 2030 in the under 2500 kcal category (Table 2.2), 14 will be in sub-Saharan Africa.

Modest reductions in the numbers undernourished

The relatively high average consumption levels that the developing countries may attain in the future (Table 2.1) could lead one to expect that the problem of undernourishment will be solved or be well on its way to solution, in the sense that the numbers undernourished should show significant declines. This would be the corollary of what was said earlier about the importance of the per capita food consumption as the major variable that is a close correlate of the level of undernourishment. Yet the estimates presented in Table 2.3 show that reductions would be rather modest: the 810 million of 1999/01 (17.2 percent of the population) may become 580 million in 2015 (10.1 percent), 460 million in 2030 (6.9 percent) and 290 million (3.9 percent) by 2050. For the developing countries as a whole, we may have to wait until after 2030 before the numbers of undernourished are reduced to the target set for 2015 by the WFS, i.e. one half of the 823 million estimated for the base period of 1990/92. It is noted that the UN Millennium Development Target refers not to halving the numbers undernourished but rather to "halve, between 1990 and 2015, the *proportion* of people who suffer from hunger" (UN, 2005b). In this sense, the Target may be achieved in 2015, as the proportion falls from the 20.3 percent in 1990/92 to the projected 10.1 percent in 2015.

These findings indicate that achieving significant declines in the prevalence of undernourishment may prove to be more arduous than commonly thought. A combination of higher national average food consumption and reduced inequality (see below for assumptions) can have a significant impact on the *proportion* of the population undernourished. However, when population growth is added in, such gains do not necessarily translate into commensurate declines in the absolute numbers, because the population of the developing countries will have grown from 4.7 billion in 2000 to 5.8 billion in 2015 and 7.5 billion in 2050 (Table 2.4).

The numbers of undernourished are expected to decrease little by 2015 in sub-Saharan Africa and they will still be above those of the WFS base in 1990/92. A small decline is no doubt an improvement over the historical trend of nearly stagnant food consumption per capita in the region and rising numbers of undernourished. It is, however, far from what is needed to meet the World Food Summit target of reducing the numbers by half by no later than 2015. In contrast, rather significant reductions are expected for East Asia and to a smaller extent for South Asia, the two regions that contain the bulk of the world's undernourished population. East Asia is expected to have more than halved undernourishment by 2015 from base 1990/92 (it had already reduced it by 22 percent in the period 1990/92-2000/02) and South Asia could achieve this target shortly after 2030.

In order to appreciate why these prospects emerge, let us recall briefly that future estimates are generated by applying the same method FAO uses for estimating present undernourishment. The only difference is that we use the future values for those variables for each country that we project, or can assume, to be different from the

present ones. As noted (Box 2.2), the variables which, in our method, determine the numbers undernourished are the following:

- The projected population;
- The per capita food consumption in kcal/person/day, taken as a proxy for actual average national consumption. Future values are derived from the projections of per capita food consumption for each commodity discussed in detail elsewhere (Chapter 3) and summarized in Tables 2.7 and 2.8 (major commodities) as well as in Table 2.1 (kcal/person/day);
- The threshold (or cut-off level) of food energy (kcal/day) a person must have in order not to be undernourished. This varies by country depending on age/sex structure of the population. The range of values applicable to different developing countries was given in Box 2.2. It was noted that due to the changing demographic structures (growing share of adults in total population) the levels will be higher in the projection years than at present[16]. Therefore, this factor would tend to raise the prevalence of undernourishment, *ceteris paribus*;
- The coefficient of inequality, as described in Box 2.2. We have no way of knowing how this variable may change in each country in the future. If we applied in the future the same values used for the current undernourishment estimates, we would be ignoring the prospect that declining poverty and rising national averages of food consumption are normally associated with more equal access to food. The World Bank projections of declines in the prevalence of poverty (Table 2.6) imply that the share of population below the poverty line (hence also of persons with low food consumption levels) will be smaller in the future compared with the present. Given the nature of food consumption (it increases fast from low levels as incomes rise but then tends to level off as higher levels are attained) it is reasonable to assume that the reduced poverty projected by the Bank and the rising national averages of food consumption projected here would be accompanied by reduced inequality in food consumption as measured by the coefficient of variation (CV). We take this prospect on board by assuming that countries will have lower inequality in the future. How much lower depends on the progress they make in raising their average kcal/person/day[17]. The net effect of these assumptions is that the coefficients of variation (CV) of the different developing countries which are currently in the range 0.21-0.36 would be in the range 0.20-0.295 in 2050. The estimates of future undernourishment presented in Table 2.3 are based on such assumptions about changes in inequality.

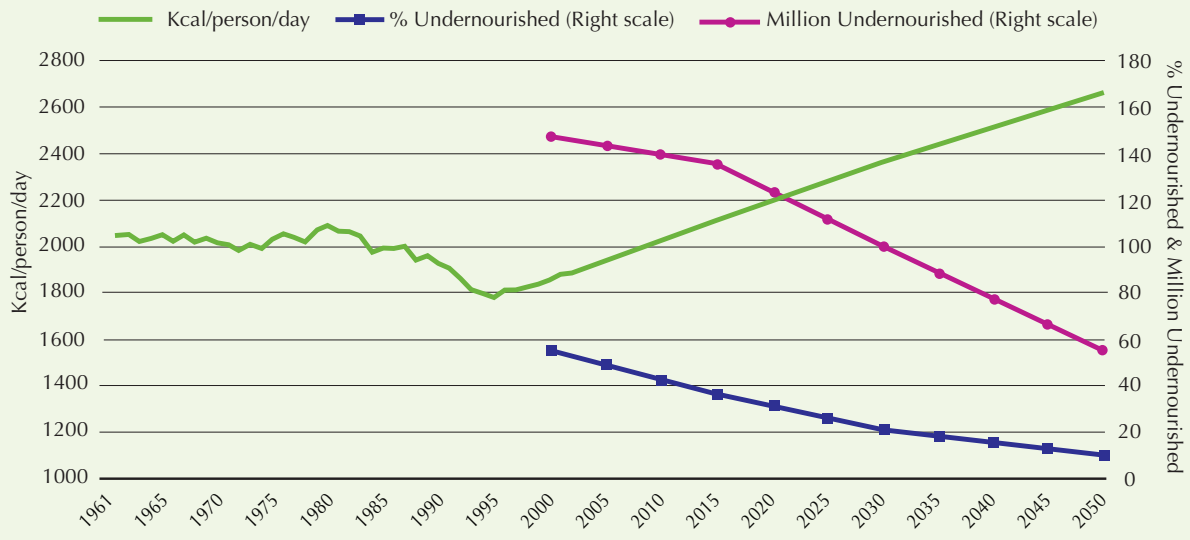
One factor making for the slow decline in the numbers of undernourished is the gradual rise in the threshold for classifying a person as undernourished. As noted, this rise is due to the growing share of adults in the population. The (simple arithmetic) average threshold of the developing countries rises from 1840 kcal in 2000 to 1875 kcal in 2030 and to 1913 kcal in 2050. This rise has important implications for the future prevalence of undernourishment in countries with low average food consumption. It implies that consumption must rise by an equal proportion just to prevent the prevalence of undernourishment (in percent of the population) from increasing, and by more if absolute numbers are not to rise. If this change in the age structure of the population and the associated rise in threshold requirements had not intervened, the numbers undernourished estimated for 2030 would be 15 percent lower than shown in Table 2.3 – 390 million rather than 460 million.

A second factor is to be found in the very adverse initial conditions several countries start with. For example, 17 developing countries start with estimated base year undernourishment of over 40 percent[18]. The group's average per capita food consumption is 1835 kcal and undernourishment is 54 percent of the population or 146 million. The food consumption projections imply (according to the method used here) that the *proportion* of the population affected will fall to 35 percent by 2015. This is a significant decline. However, the *absolute numbers* affected will fall little – to 134 million in 2015, because of the relatively high growth rate of the group's population, 2.4 percent p.a. in 2000-2015. The undernourished may still be some 100 million (19 percent of the population) in 2030.

Are we perhaps too pessimistic? Readers may judge for themselves on the basis of the following considerations. The per capita food consumption of this group of countries has moved in the range 1760-2070 kcal in the past four decades. In the projections, it grows from the 1835 kcal

16 As noted (Box 2.2) work is currently under way to revise the thresholds.
17 Future CV = (present CV) times (present kcal/future kcal), subject to future CV=> 0.20
18 They are (in descending order of percent undernourished): Eritrea, Congo DR, Burundi, Somalia, Afghanistan, Sierra Leone, Zambia, Ethiopia, Mozambique, Haiti, Tanzania, Rwanda, Central African Republic, Angola, Congo, Liberia and Zimbabwe.

Figure 2.5 Countries with undernourished over 40 percent in 1999/01



in 1999/01 to 2100 kcal in 2015 to 2350 kcal in 2030 and to 2650 kcal in 2050. If achieved, undernourishment may fall to tolerable levels by the final year of the projections, to 7.5 percent. Taking into account population growth, aggregate demand for food (expressed in calories) is projected to grow at 3.3 percent p.a. in the 15 years to 2015. This contrasts with the experience of the past four decades when the highest growth rate achieved in any 15-year period (1961-76, 1962-77, …, 1986-01, 1987-02) was 2.9 percent p.a. (and the lowest 1.6 percent). Overall, therefore, the projections of food consumption and of production, far from being pessimistic, embody a degree of optimism. This projected acceleration is clearly seen in Figure 2.5 which shows the history and projections for this group of countries. The projected improvement is partly justified by the prospect of recovery of agriculture following eventual cessation of war or warlike conditions that are, or were recently, present in several countries in this group. Empirical evidence suggests that in such situations better performance of agriculture is a key factor in making possible rapid increases in food consumption (Bruinsma, 2003: 45-47). Similar considerations apply, *mutatis mutandis*, to other countries which start from low or very low per capita food consumption and high undernourishment and also have fairly high population growth rates.

In conclusion, rapid reductions in the numbers of undernourished require the creation of conditions that will lead to hefty increases in national average food consumption in countries starting with low levels, as well as to lower inequality of access to food. Countries with high population growth rates will need stronger doses of policies in that direction than countries with slower growth rates. The projections of population and the overall economic growth used here, and the derived projections of food demand and consumption, indicate that in many countries the decline in the numbers of undernourished will be a slow process. Moreover, in several countries with high population growth rates the absolute numbers of undernourished are projected to increase rather than decline by 2015. As noted (Box 2.3), the countries which, in addition to high demographic growth, also have limited agricultural resources and high dependence on agriculture, will find it most difficult to achieve significant improvements.

2.3 Structural changes in the commodity composition of food consumption

The growth in per capita food consumption was accompanied by significant change in the commodity composition, at least in the countries that experienced such growth. The relevant data and projections are shown in Tables 2.7 and 2.8.

Much of the structural change in the diets of the developing countries concerned the rapid increases of livestock products (meat, milk, eggs), vegetable oils and, to a smaller extent, sugar, as sources of food calories. These three food groups together now provide 29 percent of total food consumption of the developing countries (in

terms of calories), up from 20 percent three decades ago. Their share is projected to rise further to 35 percent in 2030 and to 37 percent in 2050 (in the industrial countries the share has been around 48 percent for several decades now). However, structural change was not universal and wide inter-country diversity remains in the share of different commodity groups in total food consumption. The major changes, past and projected, are briefly reviewed below. Further discussion of developments in the main commodity sectors is presented in Chapter 3.

Cereals continue to be by far the most important source of total food consumption in the developing countries (their direct food consumption provides 54 percent of total calories) and the world as a whole (50 percent). There is, however, very wide inter-country diversity: direct food consumption of cereals provides only 15-30 percent of total calories in several countries ranging from those with diets based predominantly on roots and tubers (e.g. Rwanda, Burundi, the two Congos, Uganda, Ghana, etc.) to several high income countries with predominantly livestock-based diets (these latter countries consume, of course, large quantities of cereals indirectly in the form of animal feed for the production of the livestock products they consume as food). At the other extreme, countries with rice-based diets like Bangladesh, or those with diets based on coarse grains (e.g. Lesotho, Burkina Faso) continue to derive 70-80 percent of total food calories from cereals.

Per capita *food* use of cereals[19] seems to have peaked in the early 1990s, and this is true for the world as a whole (per capita apparent consumption fell from 171 kg/person/year in 1989/91 to 165 kg in 1999/01) as well as for the aggregate of the developing countries (from 174 kg to 166 kg). This of course raises the question why the average of the developing countries should be leveling off when so many of them are far from having reached adequate levels of food consumption. Addressing this question requires that we look in some more detail at the experiences of the individual countries. In practice, the peak and subsequent decline reflects primarily developments in China and India. Per capita food consumption of cereals declined in China in the last few years while it stagnated and declined somewhat in the 1990s in India. A commentary on India is provided in Box 2.1 and on China in Chapter 3 (Box 3.2)

These two large countries account for 38 percent of world population and for 48 percent of that of the developing countries. Therefore trends in their values influence decisively the global totals. Excluding these two large countries from the totals, the averages for both the world and the developing countries kept increasing in the 1990s, albeit very slowly. This very slow growth in the midst of still significant undernutrition is a composite of both positive and negative factors in operation. On the negative side, there are the experiences of the many countries whose declines in food cereals consumption is part of the broader picture of failures in the food security area discussed in the preceding section. Countries in this class include Iraq, Afghanistan, Rwanda, Burundi, Somalia and several others. On the positive side, there are the experiences of those countries whose declines in food cereals are broadly part and parcel of the well established pattern of diet diversification away from staples like cereals towards more preferred foods. Countries in this class include several of those in the middle and upper middle income classes, e.g. Taiwan (Province of China), Korea, Rep., Turkey, Tunisia, Syria, etc.

Concerning the future, the downward pressure from developments in China and India on the averages of the world and the developing countries will be attenuated and on balance the declines in these averages observed in the last few years may be halted at least in the first sub-period of the projections to 2030 before resuming a slow pace of decline in the two subsequent decades. This likely development will be the net effect of the contrasting trends of, on the one hand, diet diversification away from the direct consumption of cereals in those countries attaining medium-high levels of food consumption, and on the other hand, increases in per capita consumption in those countries remaining at low levels of food consumption and/or diversifying towards cereals and away from other staples, e.g. roots and tubers. The share of cereals in total calories will continue to decline, but very slowly, falling for the developing countries from 54 percent at present to 49 percent in 2030 and to 46 percent in 2050. Naturally, the per capita consumption of cereals for all uses (including food, feed and other non-food uses, e.g. for seed and the production of ethanol or starch) should keep growing again after the reversal of the sharp declines of the 1990s in the feed sector of the transition economies (Table 2.7 and Chapter 3).

Concerning the likely developments in the individual cereals (wheat, rice, coarse grains) much of the slowdown in per capita food consumption will continue

19 Food use of cereals includes the grain equivalent of all cereals-based food products, including products like beer produced from barley and sugar-substitute sweeteners produced from maize, e.g. corn syrups.

to originate in the declines in per capita consumption of rice, a well established trend in the major countries with predominantly rice-based diets, particularly those in the East Asia region. In contrast, *wheat* food consumption grew the fastest of all cereals in the past and will continue to do so in the future. Such growth in consumption will be accompanied by continued growth in wheat imports in many developing countries, particularly those that are non-producers or minor producers for agro-ecological reasons (see Chapter 3).

Food consumption of *coarse grains* has declined on average, but continues to be important mainly in sub-Saharan Africa (where it accounts for 70 percent of food consumption of cereals, with some countries depending overwhelmingly on maize – Zimbabwe, Zambia, etc. – and others mostly on millet and sorghum – mostly the countries in the Sudano-Sahelian zone) and to a smaller extent in Latin America (42 percent, mostly maize). The decline in other regions, particularly in China, has brought down the average for the developing countries. In future, smaller declines in Asia and some recovery in sub-Saharan Africa could halt the trend towards decline of the average of the developing countries. Developments in maize use for the production of sweeteners (which in our data appears as food demand for maize) have boosted the food consumption of coarse grains in the industrial countries, mainly in the USA, where HFCS has replaced a good part of sugar. Aggregate demand for coarse grains will be increasingly influenced by the demand for animal feed and, in some countries, for the production of biofuels. As discussed in Chapter 3, the developing countries will be playing a growing role in the world total demand and trade of coarse grains.

Wide inter-country differences in cereals food consumption will continue to persist. Several countries have per capita food consumption of cereals under 100 kg/year, some below 50 kg (Congo DR, Burundi, Rwanda). These persistently low levels reflect a combination of agroecological factors (favouring dependence of diets on roots and tubers, bananas and plantains, in countries mainly in the humid tropics) as well as prevalence of poverty and depressed levels of food consumption overall. It is worth noting that Africa includes countries at the two extremes of the cereals consumption spectrum: the countries with the highest food consumption of cereals are also in Africa, namely those in North Africa, but also Niger, Burkina Faso and Lesotho, with per capita levels in the range from 200 to 250 kg.

Livestock products: The diversification of diet in developing countries has been most visible in the shift towards meat, milk and eggs. Here again there is very wide diversity between countries as regards both the levels of consumption achieved as well as the speed with which the transformation has been taking place. Several developing countries have traditionally had high meat consumption, comparable to the levels of the industrial countries. They include the traditional meat exporters of Latin America (e.g. Argentina, Uruguay), but also the occasional country with predominantly pastoral economy, e.g. Mongolia. However, developments in these countries are not what caused the structural change in the diets of the developing countries towards more meat. If anything, they slowed it down as the per capita consumption in many of them either remained flat or actually declined. The real force behind the structural change has been rapid growth in consumption of livestock products in countries like China[19] (including Taiwan Province and the Hong Kong SAR), Korea Rep., Malaysia, Chile, Brazil and several countries in the Near East/North Africa region. Indeed, as discussed in Chapter 3, the increase of meat consumption of the developing countries from 11 to 27 kg in the last four decades was decisively influenced by the rapid growth in China and Brazil. Excluding them from the totals, the average of the other developing countries grew much less over the same period, from 11 kg to only 16 kg[20] (Table 2.7). Given the uncertainties surrounding China's meat statistics, it is perhaps a bit exaggerated to speak of a "meat revolution" taking place in the developing countries and the world.

In the future we may witness a significant slowdown in the growth of demand for meat, notwithstanding the prospect that per capita consumption in the latter group of countries (developing minus China and Brazil) could grow somewhat faster than in the past, rising from the present 16 kg to 26 by 2030 and to 32 kg by 2050 (Table 2.7). However the large weight in the world

19 The reliability of the meat sector data in China has been questioned (Ma et al., 2004). If the data actually overstate China's meat production by a considerable margin, the country's impact on the world meat economy and particularly the aggregates of the developing countries would have been more modest in the past, and could be more important in the future, than suggested here.

20 These data for meat consumption refer only to the traditional meats constituting the great bulk of aggregate consumption, i.e. bovine, ovine, pigmeat and poultry. Other meats (horse, camel, rabbit and game) are not included in the estimates given here. They add to the world average of 37.4 kg another 0.8 kg. However, these other meats are significant food sources in a number of countries, e.g. they add 24 kg to the per capita meat consumption in Mongolia, an important 5-10 kg in some African countries which significantly increases the meat consumption from the more traditional animals. For sub-Saharan Africa, this other meat increases the regional average from the 9.5 kg shown in Table 2.8 to 11.1 kg. Several European countries have also significant consumption, e.g. Italy and France (5-6 kg), and an EU15 average of 3.5 kg added to the traditional average of 88 kg.

Table 2.7 Changes in the commodity composition of food by major country groups

kg / person / year	1969/71	1979/81	1989/91	1999/01	2030	2050
			World			
Cereals, food	148.7	160.1	171.0	165.4	165	162
Cereals, all uses	*302.8*	*325.0*	*329.3*	*308.7*	*331*	*339*
Roots and tubers	83.7	73.4	64.5	69.4	75	75
Sugar (raw sugar equiv.)	22.4	23.4	23.3	23.6	26	27
Pulses, dry	7.6	6.5	6.2	5.9	6	6
Vegetable oils, oilseeds and products (oil eq.)	6.8	8.3	10.3	12.0	16	17
Meat (carcass weight)	26.1	29.5	33.0	37.4	47	52
Milk and dairy, excl. butter (fresh milk eq.)	75.3	76.5	76.9	78.3	92	100
Other food (kcal/person/day)	216	224	241	289	325	340
Total food (kcal/person/day)	**2411**	**2549**	**2704**	**2789**	**3040**	**3130**
			Developing countries			
Cereals, food	146.3	161.7	173.7	165.7	166	163
Cereals, all uses	*191.8*	*219.1*	*238.6*	*238.0*	*268*	*279*
Roots and tubers	78.8	69.6	60.1	67.0	75	*77*
(Developing minus China)	*61.8*	*59.0*	*58.4*	*62.8*	*76*	*80*
Sugar (raw sugar eq.)	14.7	17.5	19.2	20.7	25	26
Pulses, dry	9.2	7.8	7.3	6.7	*7*	*7*
Vegetable oils, oilseeds and products (oil eq.)	4.9	6.5	8.6	10.4	14	16
Meat (carcass weight)	10.7	13.7	18.2	26.7	38	44
(Developing minus China & Brazil)	*10.7*	*12.5*	*13.6*	*15.9*	*26*	*32*
Milk and dairy, excl. butter (fresh milk eq.)	28.6	34.0	38.1	45.2	67	78
Other food (kcal/person/day)	123	140	171	242	285	300
Total food (kcal/person/day)	**2111**	**2308**	**2520**	**2654**	**2960**	**3070**
			Industrial countries			
Cereals, food	132.3	139.4	154.4	162.4	159	156
Cereals, all uses	*531.1*	*542.0*	*543.7*	*591.8*	*641*	*665*
Roots and tubers	74.2	67.1	69.4	66.7	61	57
Sugar (raw sugar eq.)	40.5	36.7	32.6	33.1	32	32
Pulses, dry	3.4	2.8	3.2	3.6	4	4
Vegetable oils, oilseeds and products (oil eq.)	13.2	15.7	18.5	21.5	24	24
Meat (carcass weight)	69.7	78.5	84.3	90.2	99	103
Milk and dairy, excl. butter (fresh milk eq.)	189.1	201.0	211.2	214.0	223	227
Other food (kcal/person/day)	486	500	521	525	565	580
Total food (kcal/person/day)	**3046**	**3133**	**3292**	**3446**	**3520**	**3540**
			Transition countries			
Cereals, food	200.5	189.2	179.1	168.7	164	158
Cereals, all uses	*653.0*	*777.6*	*767.8*	*499.1*	*618*	*688*
Roots and tubers	140.2	118.4	97.1	103.3	99	94
Sugar (raw sugar eq.)	41.9	45.9	43.4	36.5	39	41
Pulses, dry	4.1	3.1	2.3	1.6	2	2
Vegetable oils, oilseeds and products (oil eq.)	7.4	9.2	10.2	10.1	15	18
Meat (carcass weight)	49.5	62.9	70.7	44.4	59	68
Milk and dairy, excl. butter (fresh milk eq.)	185.7	181.3	177.2	160.2	179	193
Other food (kcal/person/day)	331	372	333	317	365	390
Total food (kcal/person/day)	**3323**	**3389**	**3280**	**2900**	**3150**	**3270**

Note: Cereals food consumption includes the grain equivalent of beer consumption and of corn sweeteners.

Table 2.8 Changes in the commodity composition of food, developing regions

	1969/71	1979/81	1989/91	1999/01	2030	2050
			sub-Saharan Africa			
Cereals, food	115.3	114.3	118.8	123.3	142	155
Roots and tubers	193.0	175.0	184.3	191.2	211	205
(sub-Sah. Afr. minus Nigeria and Ghana)	*184.3*	*182.6*	*179.5*	*165.9*	*194*	*191*
Sugar (raw sugar eq.)	7.8	9.8	8.6	10.0	12	15
Pulses, dry	11.0	9.7	8.9	9.8	12	14
Vegetable oils, oilseeds and products (oil eq.)	8.0	8.4	8.5	8.9	12	13
Meat (carcass weight)	10.2	10.5	9.8	9.5	14	18
Milk and dairy, excl. butter (fresh milk eq.)	29.6	33.7	29.8	28.3	34	38
Other food (kcal/person/day)	139	141	130	128	170	185
Total food (kcal/person/day)	2100	2078	2106	2194	2600	2830
			Near East / North Africa			
Cereals, food	179.3	199.7	211.8	203.5	199	193
Roots and tubers	16.6	26.5	31.8	33.7	33	33
Sugar (raw sugar eq.)	20.4	28.0	28.2	27.7	29	30
Pulses, dry	6.2	6.3	8.0	6.6	7	7
Vegetable oils, oilseeds and products (oil eq.)	7.5	10.9	12.5	12.1	14	15
Meat (carcass weight)	12.6	17.3	19.6	21.7	35	43
Milk and dairy, excl. butter (fresh milk eq.)	68.1	84.1	75.0	73.2	90	101
Other food (kcal/person/day)	224	277	298	333	370	385
Total food (kcal/person/day)	2382	2834	3011	2974	3130	3190
			Latin America and Caribbean			
Cereals, food	118.7	130.1	130.1	132.6	140	139
Roots and tubers	94.1	74.3	63.9	63.3	62	58
Sugar (raw sugar eq.)	40.5	48.1	46.0	48.5	49	47
Pulses, dry	14.2	12.6	10.5	11.2	11	10
Vegetable oils, oilseeds and products (oil eq.)	6.8	10.1	12.1	11.8	15	16
Meat (carcass weight)	33.5	40.5	42.8	58.5	79	90
Milk and dairy, excl. butter (fresh milk eq.)	84.0	96.9	94.5	108.8	136	150
Other food (kcal/person/day)	240	246	258	272	310	330
Total food (kcal/person/day)	2465	2698	2689	2836	3120	3200
			South Asia			
Cereals, food	150.4	151.1	164.3	157.1	167	169
Roots and tubers	16.9	19.9	18.7	23.5	31	36
Sugar (raw sugar eq.)	20.3	20.6	23.7	25.6	30	32
Pulses, dry	14.5	11.3	12.3	10.1	8	7
Vegetable oils, oilseeds and products (oil eq.)	4.6	5.8	7.2	9.7	15	18
Meat (carcass weight)	3.9	4.1	5.0	5.5	12	18
Milk and dairy, excl. butter (fresh milk eq.)	37.0	41.6	55.1	67.6	106	129
Other food (kcal/person/day)	84	89	104	141	180	200
Total food (kcal/person/day)	2066	2084	2329	2392	2790	2980
			East Asia			
Cereals, food	152.2	181.4	199.5	186.7	176	162
Roots and tubers	96.6	80.8	57.1	65.8	61	53
Sugar (raw sugar eq.)	5.7	8.0	10.5	11.6	17	20
Pulses, dry	4.8	4.3	2.6	2.0	2	2
Vegetable oils, oilseeds and products (oil eq.)	3.5	4.7	7.8	10.6	15	17
Meat (carcass weight)	9.2	13.2	22.6	39.8	62	73
Milk and dairy, excl. butter (fresh milk eq.)	3.7	5.0	7.4	11.3	21	24
Other food (kcal/person/day)	98	121	179	322	405	440
Total food (kcal/person/day)	**2012**	**2317**	**2625**	**2872**	**3190**	**3230**

Note: Cereals food consumption includes the grain equivalent of consumption of beer and of corn sweeteners.

meat totals of the developed countries, as well as some major developing ones (e.g. China and Brazil and some others mid-high income countries with much less growth potential than the rest of the developing countries given the high or medium-high levels already achieved), together with the slower global population growth, means that aggregate world demand would grow at much lower rates than in the past. The prospects are slim that other large developing countries such as India will emerge as major meat consumers, due to a continuation of low incomes and the influence of dietary preferences favouring meat less than in other societies. Thus, the boost given in the past to world meat consumption by the surge in China (but see footnote 19) is unlikely to be replicated by other countries with the same force in the future. The major structural changes that characterized the historical evolution of the world livestock economy, particularly in the 1990s, are likely to continue, though in somewhat attenuated form. These changes are the growing role of the poultry sector in total meat production, and the growing share of trade in world output and consumption (see Chapter 3).

The other major commodity group with very high consumption growth in the developing countries is that of *vegetable oils*. The rapid growth in consumption, in combination with the high calorie content of oils and other oilcrop products[21], have been instrumental in bringing about the increases in apparent food consumption (kcal/person/day) of the developing countries, that characterized the progress in food security achieved in the past. Three decades ago, consumption of oilcrop products (4.9 kg/person/year, in oil equivalent) supplied only 136 kcal/person/day, or 6.5 percent of the total availability of 2110 calories of the developing countries. By 1999/01 consumption per capita had grown to 10.4 kg contributing 272 kcal to total food supplies, or 10 percent of a total which itself had risen to 2650 kcal. In practice, one out of every four calories added to the consumption of the developing countries over this period originated in this group of products (see further discussion of the oilcrops sector in Chapter 3). In the future, vegetable oils are likely to retain, and indeed strengthen, their primacy as major contributors to further increases in food consumption of the developing countries: 38 out of every 100 additional calories may come from these products in the period to 2050.

Some important structural changes of the historical period in the world oilcrops economy are likely to continue (see also Chapter 3). These are:

- the growing share of four oilcrops in the total oilcrops sector (oil palm, soybeans, rape, sunflower);
- the continued dominance of a few countries as major producers and exporters;
- the growing role of imports in meeting the food demand for vegetable oils of many developing countries.
- the growing role of soybeans as a source of high protein feeds for the livestock sector and associated growth in trade (see Chapter 3); and
- the prospect that the biofuels sector may open new avenues for growth of the oilcrops sector (Chapter 3).

Consumption of *pulses* in the developing countries stagnated overall and registered drastic declines in several countries, mainly in Asia and sub-Saharan Africa. These trends reflected not just changing consumer preferences, but also, in several countries, failure to promote production of these crops. Often this was the result of preference for increasing production and self-sufficiency in cereals. As Evenson (2004), referring mostly to Latin America, puts it "Because of limited genetic improvements, beans have effectively been "crowded out" of productive areas by crops with greater genetic improvement, especially corn and soybeans". It is thought that where these declines in protein-rich pulses were not accompanied by increases in the consumption of livestock products, the result has been a deterioration in the overall quality of diets, even where dietary energy (kcal/person/day) increased (for the case of India, see Hopper, 1999). For the future, no major changes are foreseen in per capita consumption of pulses, with the average of the developing countries remaining at about 7 kg.

Roots, tubers and plantains: This category of basic foods comprises a variety of products, the main ones being cassava, sweet potatoes, potatoes, yams, taro and plantains[22]. They have been traditionally the mainstay of food consumption in several countries with low-middle levels of overall food consumption, mainly in sub-Saharan Africa and Latin America. Nineteen countries, all in sub-Saharan Africa, depend on these products for over 20 percent of food consumption in terms of calories. These countries account for 60 percent of the region's

21 The figures given here refer to the consumption of oils as well as that of oilcrops directly (soybeans, groundnuts, etc.) or in the form of derived products other than oil, all measured in oil equivalent. This consumption of oilcrops in forms other than oil is particularly important in some countries.

22 Plantains are included along with the roots and tuber crops because "…Plantains and cooking bananas are grown and utilized as a starchy staple mainly in Africa…" (FAO, 1990).

population. In three of them, the dependence is over 50 percent (Congo DR, Rwanda, Ghana). Most have low overall per capita food consumption (13 of them have under 2200 calories of which six under 2000) and, consequently, high prevalence of undernourishment. Cereals, which in the developing countries as a whole provide 54 percent of total food calories, account in these countries for much smaller proportions, typically 20-45 percent, rising to just over 50 percent only in Tanzania (mostly maize) and Madagascar (rice). At the same time, the region contains countries at the other extreme of the spectrum with only minimal consumption of roots and tubers, e.g. Mali, Mauritania, Niger, Sudan, etc.

The Food Balance Sheets data show that in several of the countries with high dietary dependence on roots and tubers, what happens to the production of these crops is an important determinant of changes in the national average food consumption. As in the case of Nigeria mentioned earlier, other countries (Ghana, Benin, Malawi, Peru) also experienced significant increases in per capita food consumption which originated to a large extent in the increases of roots and tubers production. Despite these country examples, the evolution over time shows declining per capita food consumption of starchy foods for the developing countries and the world as a whole up to about the late 1980s, followed by some recovery in the 1990s (Table 2.7). These developments were due to two main factors:

- the rapid decline in food consumption of sweet potatoes in China (from a peak of some 100 kg three decades ago to the some 40 kg at present), the parallel rise in that of potatoes, in both China (from 14 kg to 36 kg) and the rest of the developing countries (from 9 kg to 16 kg), and
- the rapid rise of food consumption of all these products in a few countries, e.g. Nigeria, Ghana, Malawi, etc, with Nigeria having a major weight in shaping the aggregate for sub-Saharan Africa (Table 2.8).

These trends are expected to continue, as will the high dependence of several countries on roots and tubers as a major source of food. Per capita food consumption of all roots, tubers and plantains in developing countries should increase slowly - from the present 67 kg to 75 kg in 2030 and to 77 kg in 2050 (Table 2.8). Much of the decline in China's per capita food consumption of sweet potatoes has already occurred and in the future it will not have the depressing effect it had in the past on total roots consumption of the developing countries. Potatoes will continue to show relatively high income elasticity in most developing countries, and average food consumption is projected to increase. Another factor that could raise consumption is the potential for productivity increases in the other root crops (cassava, yams). It will be possible for more countries in sub-Saharan Africa to replicate the experiences of countries like Nigeria, Ghana, Benin, Malawi, and increase their food consumption based on rapid production improvements in these crops (Nweke, 2004; Babaleye, 2005).

Sugar shares many of the characteristics of vegetable oils as regards food consumption and trade of the developing countries: it is a fast-rising consumption item and a major export commodity of several countries (Brazil, Cuba, Thailand, etc.). In addition, several developing countries are becoming large and growing net importers (Egypt, Iran, Korea Rep.), making up for the lack of growth of imports into the industrial countries. The developing countries' average consumption is 21 kg/person year, but it is higher (26 kg) if China is excluded - China has only 7 kg as it uses a lot of saccharine. About one half of the developing countries consume less than 20 kg, and a quarter under 10 kg. The scope for consumption growth is still considerable and the average of the developing countries should keep increasing. China's contribution to total growth should be more than in the past since the country could be discouraging the use of saccharine (see also Chapter 3).

2.4 Concluding remarks

Some brief conclusions may be drawn, as follows:

- There will be significant progress in raising food consumption levels and improving nutrition. There will be significant reductions in the relative prevalence of undernourishment (percent of population affected), but these will not be translated into commensurate declines in the numbers undernourished because of population growth. Reduction in the absolute numbers of undernourished is likely to be a slow process.
- The number of undernourished in the developing countries is not likely to be halved by 2015 from the 823 million of 1990/92 (the 3-year average used as the basis for defining the World Food Summit target). However, the *proportion* of the population undernourished may be halved by 2015 and decline further in the rest of the projection period.
- The projected slow progress in reducing undernourishment will reflect the inadequate progress of many countries towards rapid economic development and

poverty reduction. However, empirical evidence suggests that in the countries with high dependence on agriculture, assigning priority to the development of food production holds promise of overcoming the constraint to better nutrition represented by unfavourable overall economic growth prospects. This prospect underlies the projection that the countries with long histories of stagnant food consumption levels and high undernourishment could make some progress in the future. Poor agricultural resources may represent a serious obstacle to such prospects, particularly in countries with high demographic growth.

- Despite this slow pace of progress in reducing the prevalence of undernourishment, the projections imply a considerable overall improvement. In the developing countries the numbers of well-fed (i.e. not classified as undernourished according to the criteria used here) could increase from 3.9 billion in 1999/01 (83 percent of their population) to 5.2 billion in 2015 (90 percent of the population), to 6.2 billion (93 percent) in 2030 and to 7.2 billion (96 percent) by 2050. That would be no mean achievement.
- In conclusion, in many countries, including some of the more populous ones, the relative prevalence of undernourishment (percent of the population) will decline significantly. Fewer countries than at present will have high levels of undernourishment, none of them in the most populous class. The problem of undernourishment will tend to become smaller in terms of both absolute numbers affected and, even more, in relative terms, hence it will become more tractable through policy interventions, both national and international.

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.

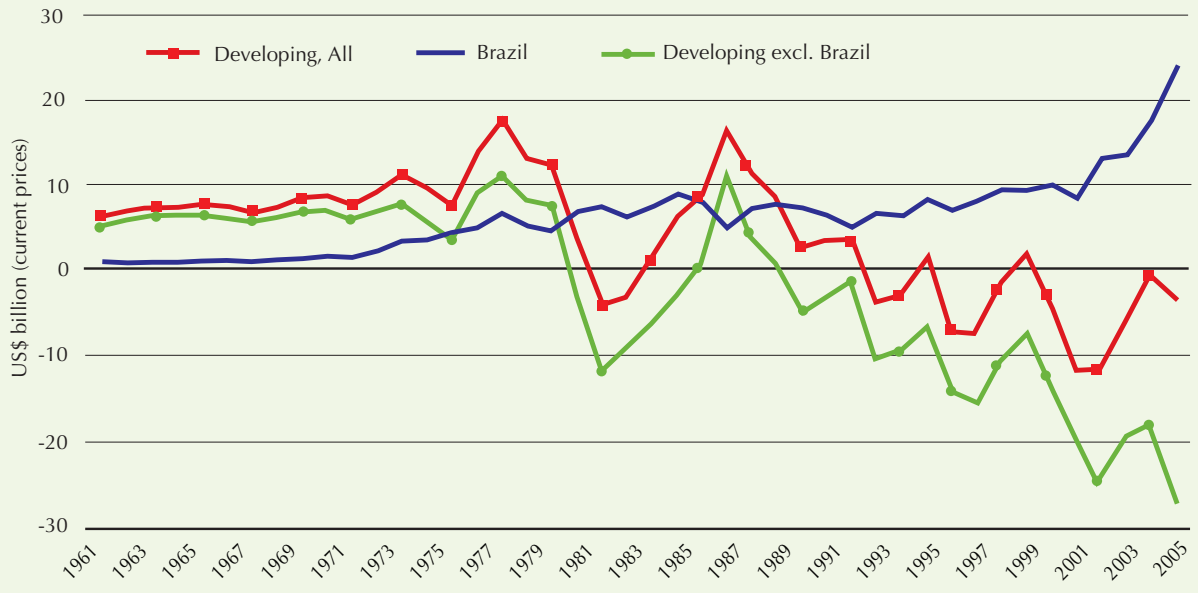
2 International dollar prices, averages for 1989/91.

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

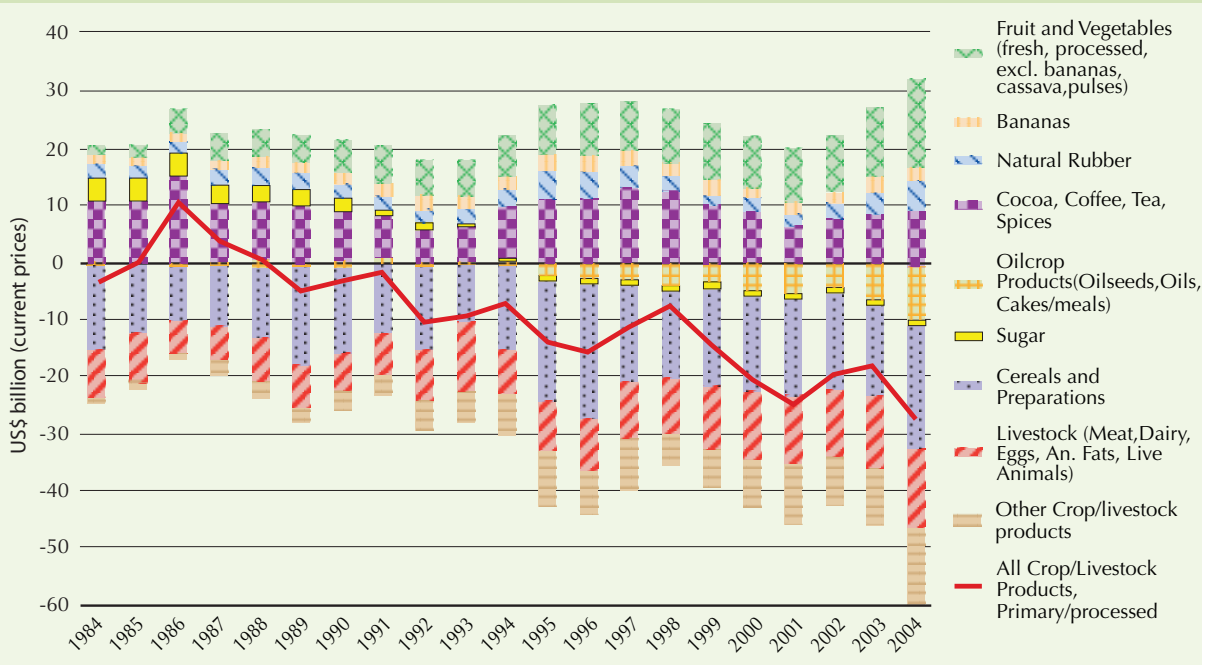
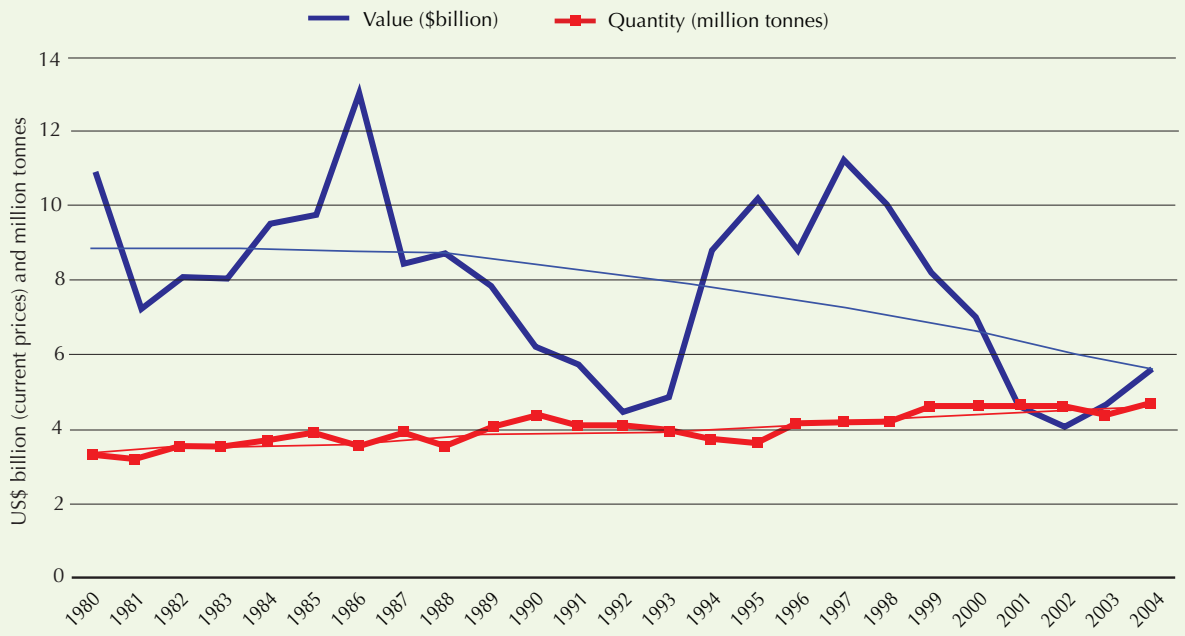


Figure 3.3 Developing countries, net exports of coffee



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

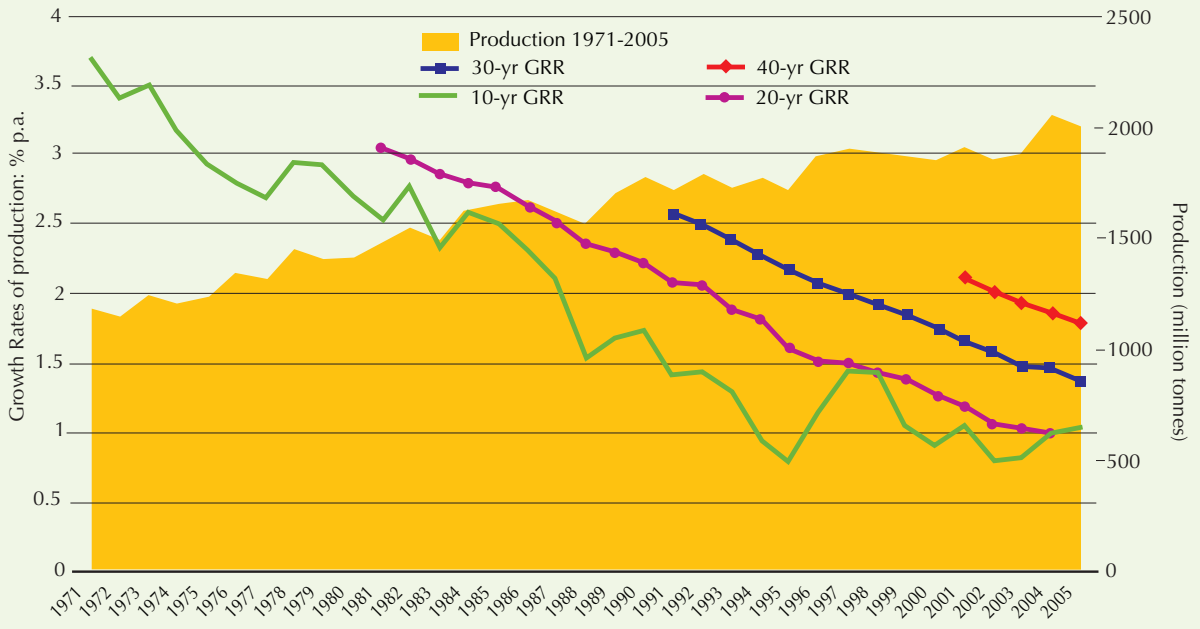
In our previous work (Bruinsma, 2003) we highlighted the historical experience showing that the growth rate of global demand for cereals (for all uses, hence also of world production) has been in long-term decline. Table 3.2 (column 9) shows the progressive fall in the growth rates in the last 40, 30, 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

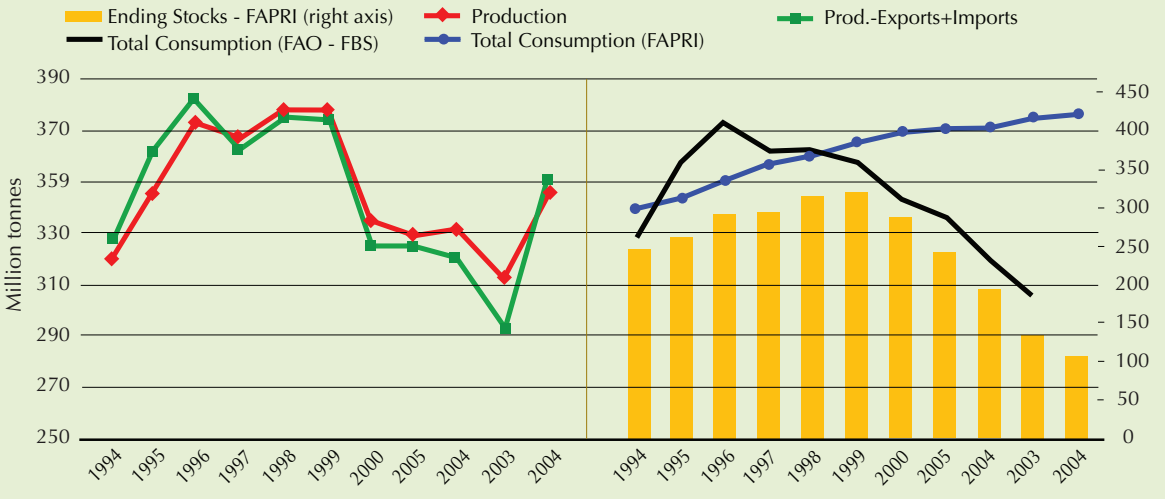
Box 3.2 Uncertainties concerning China's cereals consumption and stocks

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]	Growth rates			
	per capita (kg)		total (million tonnes)				(percent)	(percent p.a.)			
year	food	all uses	food	all uses	production	net trade		period	demand	production	population
	1	2	3	4	5	6	7	8	9	10	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]	Growth rates			
	per capita (kg)		total (million tonnes)				(percent)	(percent p.a.)			
year	food	all uses	food	all uses	production	net trade		period	demand	production	population
	1	2	3	4	5	6	7	8	9	10	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

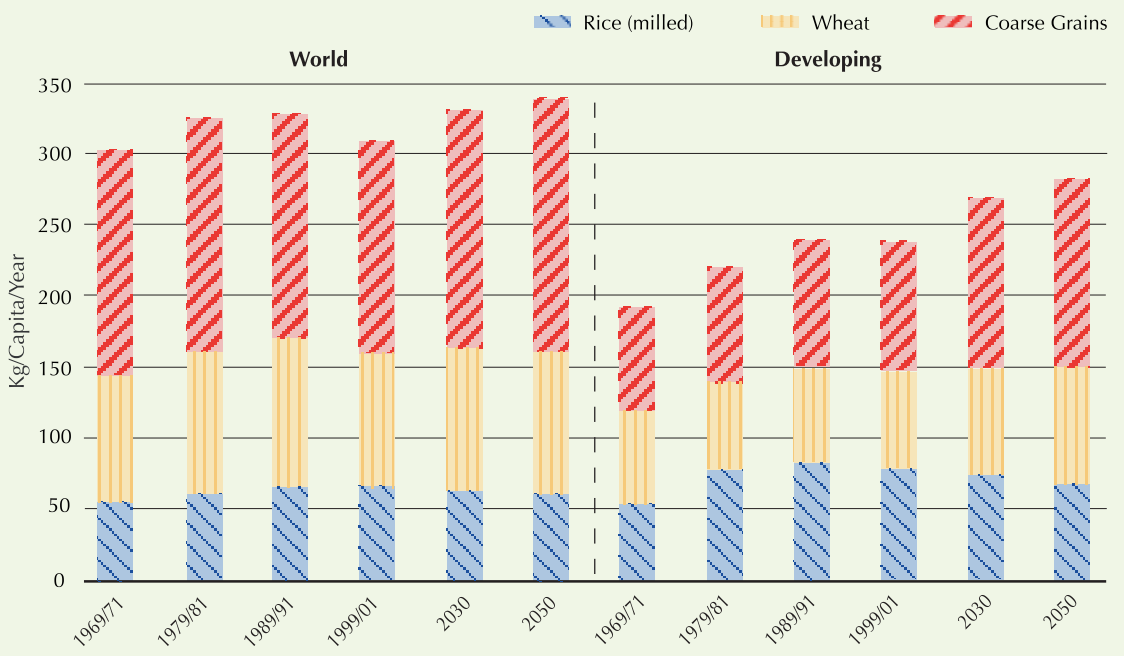
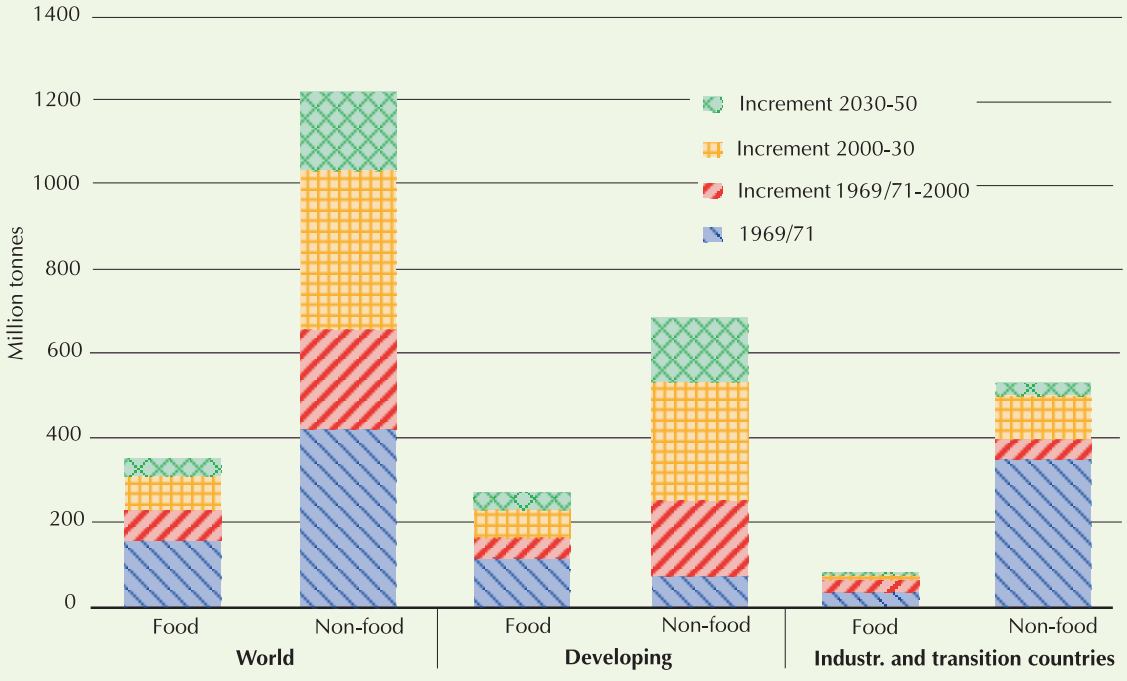


Figure 3.7 Coarse grains: food and non-food use



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

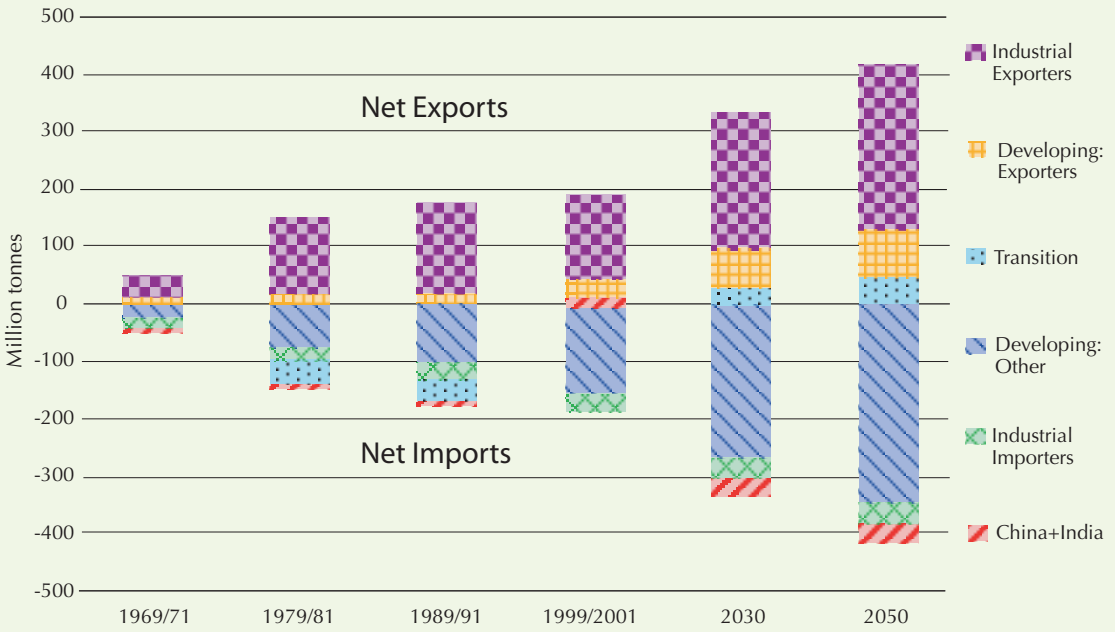
* Developing net exporters: those with net cereal exports over 1 million tonnes in 1999/01 (Argentina, Thailand and Viet Nam). India and China, although they met this criterion, are not included in the net exporter category as they are only occasional net exporters and may not be exporters in the future.

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							

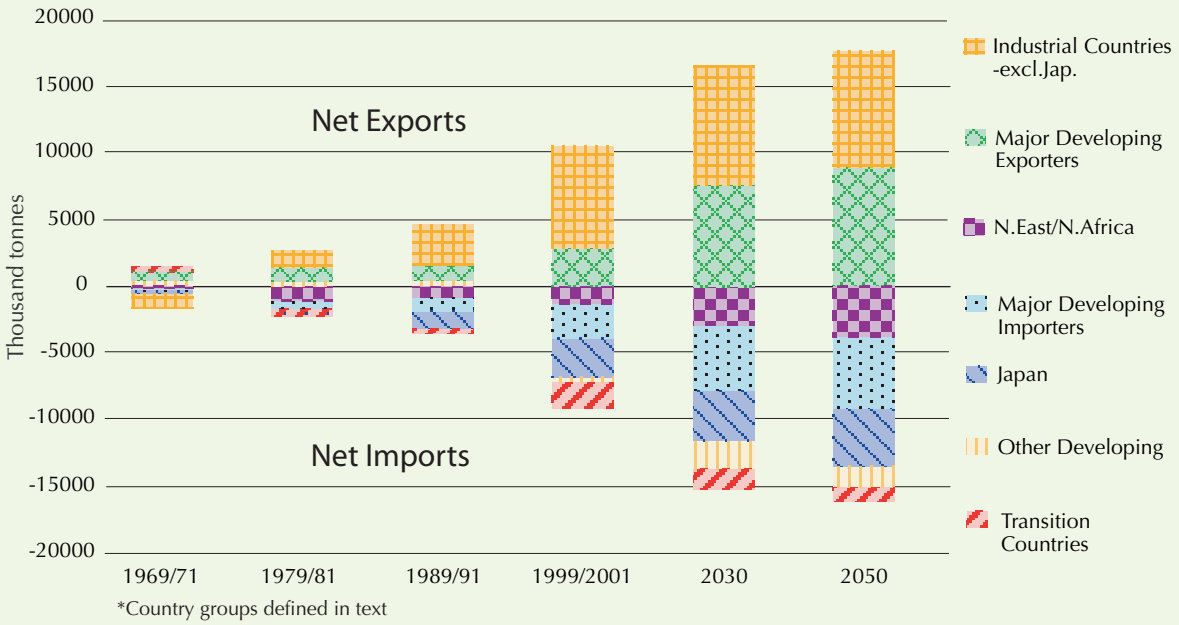
[1] Growth rates of aggregate production derived by valuing all products at 1989/91 international prices (see Box 3.1)

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

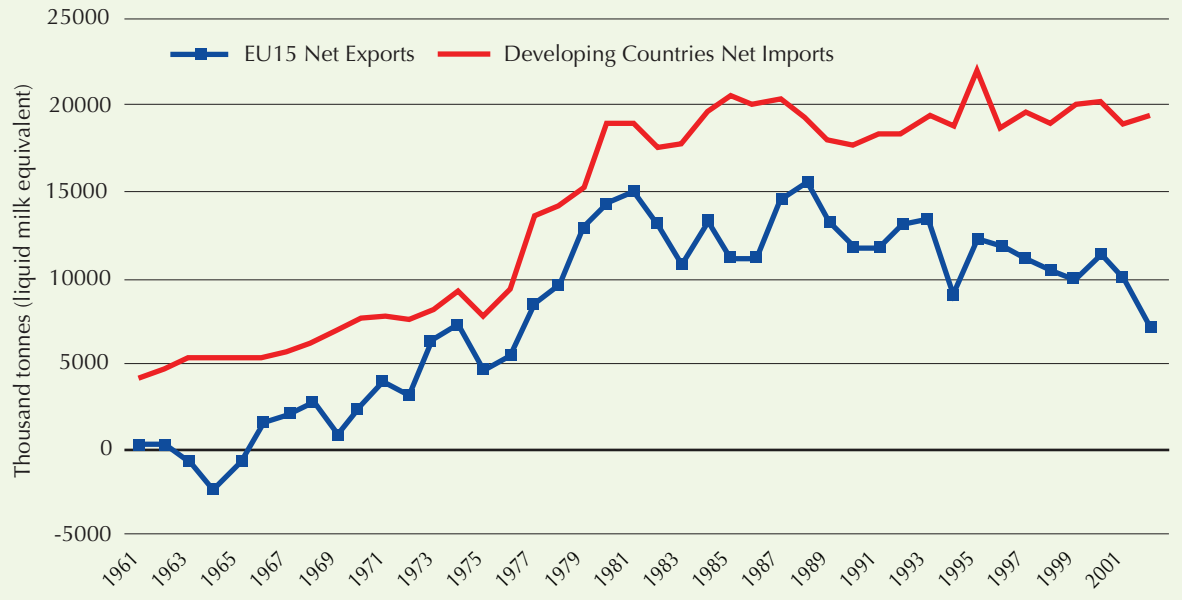
that of meat. In practice, the world per capita consumption is currently not much above that of 10 or 20 years ago. This is explained in large part by the decline in the transition countries. Such declines affected much more the world milk sector than that of meat, because these countries at the inception 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.

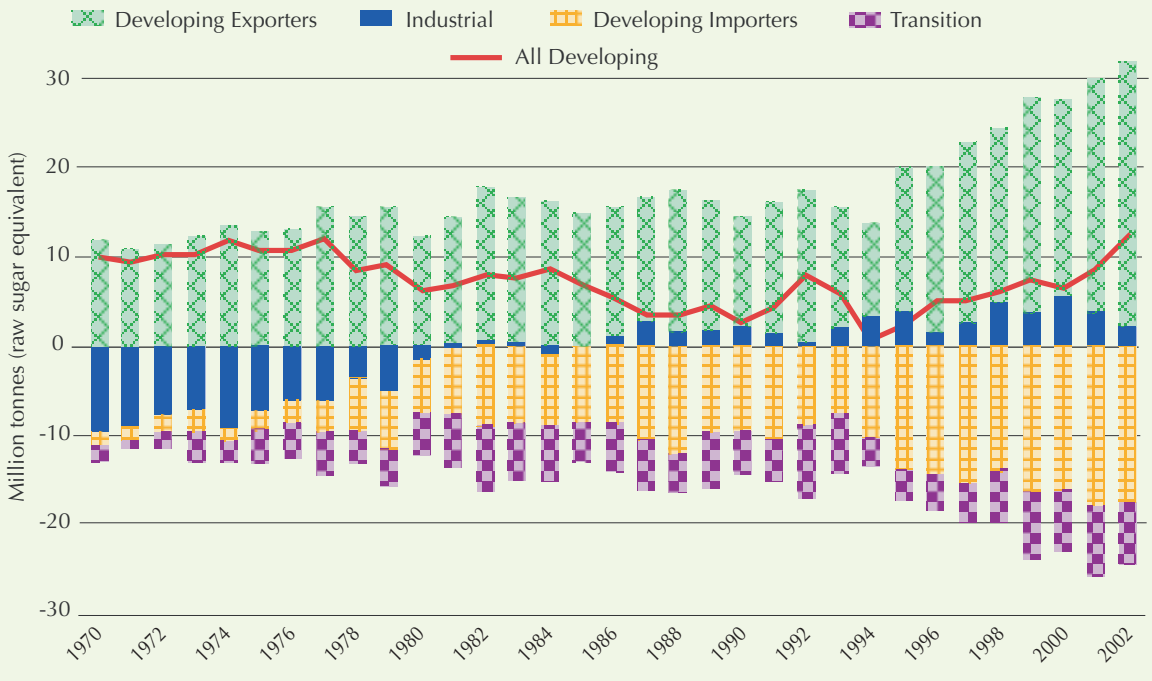
countries that have a high dependence on them and low food consumption levels overall. The possible evolution in food consumption per capita is shown in Tables 2.7 and 2.8. The main factor that made for the decline in the average of the developing countries (precipitous decline of sweet potato food consumption 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

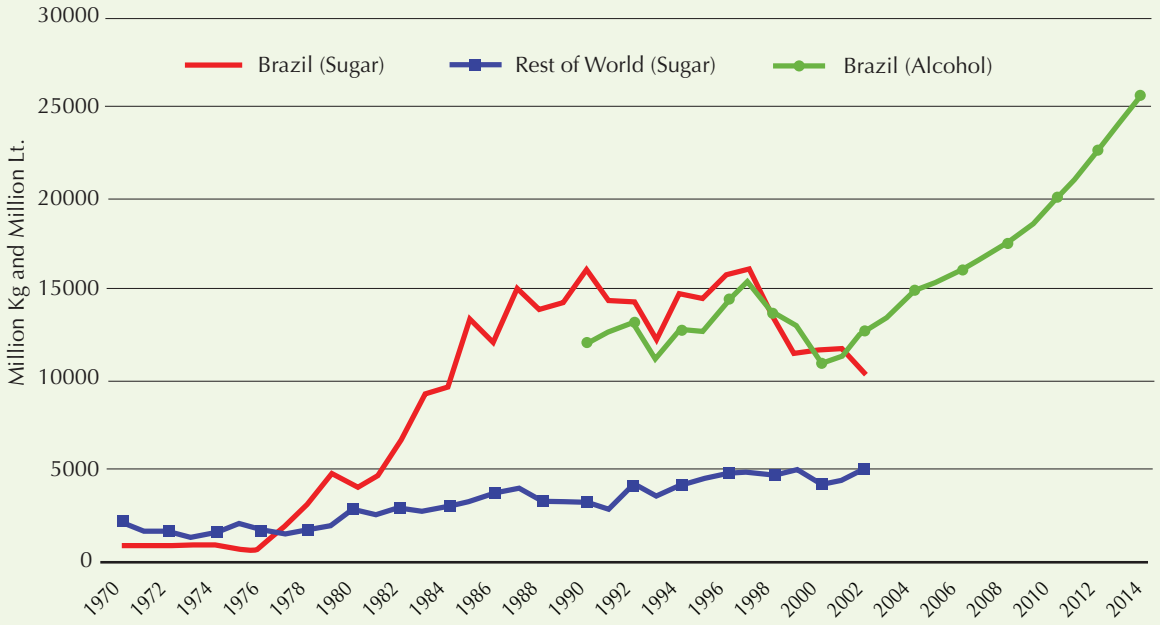
Figure 3.11 Sugar: net trade positions, 1970-2002



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.

Appendix: Countries[1] and commodities

Developing Countries

Africa, sub-Saharan	Latin America and Caribbean	Near East/North Africa	South Asia
Angola	Argentina	Afghanistan	Bangladesh
Benin	Bolivia	Algeria	India
Botswana	Brazil	Egypt	Maldives
Burkina Faso	Chile	Iran, Islamic Rep.	Nepal
Burundi	Colombia	Iraq	Pakistan
Cameroon	Costa Rica	Jordan	Sri Lanka
Central Afr. Rep.	Cuba	Lebanon	
Chad	Dominican Rep.	Libyan Arab Yam.	
Congo	Ecuador	Morocco	
Côte d'Ivoire	El Salvador	Saudi Arabia	
Dem. Rep. of Congo	Guatemala	Syrian Arab Rep.	
Eritrea	Guyana	Tunisia	
Ethiopia	Haiti	Turkey	**East Asia**
Gabon	Honduras	Yemen	
Gambia	Jamaica	Near East, other[4]	Cambodia
Ghana	Mexico		China
Guinea	Nicaragua		Dem. Rep. of Korea
Kenya	Panama		Indonesia
Lesotho	Paraguay		Lao
Liberia	Peru		Malaysia
Madagascar	Suriname		Mongolia
Malawi	Trinidad and Tobago		Myanmar
Mali	Uruguay		Philippines
Mauritania	Venezuela		Rep. of Korea
Mauritius	Latin America, other[3]		Thailand
Mozambique			Viet Nam
Namibia			East Asia, other[5]
Niger			
Nigeria			
Rwanda			
Senegal			
Sierra Leone			
Somalia			
Sudan			
Swaziland			
Togo			
Uganda			
United Rep. of Tanzania			
Zambia			
Zimbabwe			
sub-Saharan Africa, other[2]			

1 Country groups marked with asterisk (*) were treated in the analysis as one aggregate.

2 Cape Verde, Comoros, Djibouti, Guinea Bissau, Sao Tomé and Principe, Seychelles.

3 Antigua, Bahamas, Barbados, Belize, Dominica, Grenada, Netherland Antilles, Saint Kitts and Nevis, Saint Lucia, Saint Vincent/Grenadines, Bermuda.

4 Cyprus, Kuwait, United Arab Emirates.

5 Brunei, Macau, Solomon Islands, Fiji, French Polynesia, New Caledonia, Vanuatu, Papua New Guinea, Kiribati.

Industrial countries

European Union-15*	Other Industrial Countries
Austria	Iceland
Belgium	Malta
Denmark	Norway
Finland	Switzerland
France	Israel
Germany	Japan
Greece	South Africa
Ireland	Australia
Italy	New Zealand
Luxembourg	Canada
Netherlands	United States
Portugal	
Spain	
Sweden	
United Kingdom	

Transition countries

Russian Federation

Countries in the European Union*	Central Asia*	Other Eastern Europe*
Czech Republic	Armenia	Albania
Estonia	Azerbaijan	Bosnia and Herzegovina
Hungary	Georgia	Bulgaria
Latvia	Kazakhstan	Croatia
Lithuania	Kyrgyzstan	Romania
Poland	Tajikistan	Moldova Republic
Slovakia	Turkmenistan	The Former Yugoslav Rep. of Macedonia
Slovenia	Uzbekistan	Serbia and Montenegro
		Belarus
		Ukraine

Commodities covered

Crops	Livestock
Wheat	Beef, veal and buffalo meat
Rice, paddy	Mutton, lamb and goat meat
Maize	Pig meat
Barley	Poultry meat
Millet	Milk and dairy products
Sorghum	(in whole milk equivalent)
Other cereals	Eggs
Potatoes	
Sweet potatoes and yams	
Cassava	
Other roots	
Plantains	
Sugar, raw[1]	
Pulses	
Vegetables	
Bananas	
Citrus fruit	
Other fruit	
Vegetable oil and oilseeds (in vegetable oil equivalent)[2]	
Cocoa beans	
Coffee	
Tea	
Tobacco	
Cotton lint	
Jute and hard fibres	
Rubber	

1 Sugar production in the developing countries analyzed separately for sugar cane and sugar beet.

2 Vegetable oil production in the developing countries analyzed separately for soybeans, groundnuts, sesame seed, coconuts, sunflower seed, palm oil/palm-kernel oil, rapeseed, all other oilseeds.

Note on Commodities

All commodity data and projections in this report are expressed in terms of primary product equivalent unless stated otherwise. Historical commodity balances (Supply Utilization Accounts - SUAs) are available for about 160 primary and 170 processed crop and livestock commodities. To reduce this amount of information to manageable proportions, all the SUA data were converted to the commodity specification given above in the list of commodities, applying appropriate conversion factors (and ignoring joint products to avoid double counting: e.g. wheat flour is converted back into wheat while wheat bran is ignored). In this way, one Supply Utilization Account in homogeneous units is derived for each of the commodities of the study. Meat production refers to indigenous meat production, i.e. production from slaughtered animals plus the meat equivalent of live animal exports minus the meat equivalent of all live animal imports. Cereals demand and trade data include the grain equivalent of beer consumption and trade.

The commodities for which SUAs were constructed are the 26 crops and 6 the livestock products given in the list above. The production analysis for the developing countries was, however, carried out for 34 crops because sugar and vegetable oils are analyzed separately (for production analysis only) for the 10 crops shown in the footnote to the list.

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