

## 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<sup>1</sup>. 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<sup>2</sup>. The outlook is

<sup>1</sup> UN (2004), medium variant projection.

<sup>2</sup> 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”<sup>3</sup>.

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<sup>4</sup>. 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<sup>5</sup>, 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<sup>6</sup> 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<sup>7</sup>, 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

<sup>3</sup> World Bank (2006):15.

<sup>4</sup> 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.

<sup>5</sup> USDA (2006).

<sup>6</sup> Tonnes are metric tonnes throughout this paper; mt = million tonnes.

<sup>7</sup> 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)<sup>8</sup>. 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

<sup>8</sup> 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<sup>9</sup> 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,

<sup>9</sup> 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<sup>10</sup> 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.

<sup>10</sup> 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<sup>11</sup>. 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.

<sup>11</sup> Work is underway in the Global Perspective Studies Unit at FAO.