Executive summary

In recent years the growth rates of world agricultural production and crop yields have slowed. This has raised fears that the world may not be able to grow enough food and other commodities to ensure that future populations are adequately fed.

However, the slowdown has occurred not because of shortages of land or water but rather because demand for agricultural products has also slowed. This is mainly because world population growth rates have been declining since the late 1960s, and fairly high levels of food consumption per person are now being reached in many countries, beyond which further rises will be limited. But it is also the case that a stubbornly high share of the world's population remains in absolute poverty and so lacks the necessary income to translate its needs into effective demand.

As a result, the growth in world demand for agricultural products is expected to fall from an average 2.2 percent a year over the past 30 years to 1.5 percent a year for the next 30. In developing countries the slowdown will be more dramatic, from 3.7 percent to 2 percent, partly as a result of China having passed the phase of rapid growth in its demand for food.

This study suggests that world agricultural production can grow in line with demand, provided that the necessary national and international policies to promote agriculture are put in place. Global shortages are unlikely, but serious problems already exist at national and local levels and may worsen unless focused efforts are made.

Food and nutrition

Massive strides have been made in improving food security. The proportion of people living in developing countries with average food intakes below 2 200 kcal per day fell from 57 percent in 1964-66 to just 10 percent in 1997-99. Yet 776 million people in developing countries remain undernourished — about one person in six.

Global progress in nutrition is expected to continue, in parallel with a reduction in poverty as projected by the World Bank. The incidence of undernourishment should fall from 17 percent of the population of developing countries at present to 11 percent in 2015 and just 6 percent in 2030. By 2030, three-quarters of the population of the developing world could be living in countries where less than 5 percent of people are undernourished. Less than 8 percent live in such countries at present.

Despite impressive reductions in the *proportion* of undernourished, continuing population growth means that progress in reducing the total

number will be slower. The World Food Summit of 1996 set a target of halving the number of undernourished people to about 410 million by 2015. This study's projections suggest that this may be difficult to achieve: some 610 million people could still be undernourished in that year, and even by 2030 about 440 million undernourished may remain. Priority for local food production and reduced inequality of access to food could improve this performance. The problem of undernourishment will tend to become more tractable and easier to address through policy interventions, both national and international, as the number of countries with high incidence declines.

Agriculture, poverty and international trade

Undernourishment is a central manifestation of poverty. It also deepens other aspects of poverty, by reducing the capacity for work and resistance to disease, and by affecting children's mental development and educational achievements.

Currently, one in four people in developing countries are living in extreme poverty, subsisting on less than US$1 a day. This proportion is down from almost one-third in 1990. But because of population growth the fall in numbers has been slower, from 1269 million to 1134 million. The latest World Bank assessment to 2015 suggests that such reductions in global poverty could continue. Sub-Saharan Africa is the exception, however. Here the numbers of poor rose steeply during the 1990s and seem likely to continue to do so. Seven out of ten of the world's poor still live in rural areas. Growth in the agricultural sector has a crucial role to play in improving the incomes of poor people, by providing farm jobs and stimulating off-farm employment. Some direct nutritional interventions may also be needed — such as vitamin and mineral supplementation of basic foods — while health, water and sanitation measures to reduce the effects of illness on food absorption will also be important.

Trade has an important role to play in improving food security and fostering agriculture. Some estimates put the potential annual increase in global welfare from freer trade in agriculture as high as US$165 billion. But the progress made in the current round of trade negotiations has been limited and the benefits so far remain modest. If future reforms focus too narrowly on the removal of subsidies in the countries of the Organisation for Economic Co-operation and Development (OECD), most of the gains will probably be reaped by consumers in developed countries. Developing countries should benefit more from the removal of trade barriers for products in which they have a comparative advantage (such as sugar, fruits and vegetables), from reduced tariffs for processed agricultural commodities, and from deeper preferential access to markets for the least developed countries.

Internal reforms are also needed within developing countries if free trade is to contribute to poverty reduction. Such reforms include: a reduction of the bias against agriculture in national policy making; the opening of borders for long-term foreign investments; the introduction of schemes to improve food quality and safety; investments in roads, irrigation, seeds and skills; improved quality standards; and safety nets for the poor who face higher food prices.

Globalization in food and agriculture holds promise as well as presenting problems. It has generally led to progress in reducing poverty in Asia. But it has also led to the rise of multinational food companies with the potential to disempower farmers in many countries. Developing countries need the legal and administrative frameworks to ward off the threats while reaping the benefits.

Crop production

The annual growth rate of world demand for cereals has declined from 2.5 percent a year in the 1970s and 1.9 percent a year in the 1980s to only 1 percent a year in the 1990s. Annual cereal use per person (including animal feeds) peaked in the mid-1980s at 334 kg and has since fallen to 317 kg.

The decline is not cause for alarm: it was above all the natural result of slower population growth and shifts in human diets and animal feeds. However, in the 1990s it was accentuated by a number of temporary factors, including serious recessions in the transition countries and some East and Southeast Asian countries.

The growth rate of demand for cereals is expected to rise again to 1.4 percent a year to 2015, slowing to 1.2 percent per year thereafter. In developing countries overall, cereal production is not expected to keep pace with demand. The net cereal deficits of these countries, which amounted to 103 million tonnes or 9 percent of consumption in 1997-99, could rise to 265 million tonnes by 2030, when they will be 14 percent of consumption. This gap can be bridged by increased surpluses from traditional grain exporters, and by new exports from the transition countries, which are expected to shift from being net importers to being net exporters.

Oilcrops have seen the fastest increase in area of any crop sector, expanding by 75 million ha from the mid-1970s until the end of the 1990s, while cereal area fell by 28 million ha over the same period. Future per capita consumption of oilcrops is expected to rise more rapidly than that of cereals. These crops will account for 45 out of every 100 extra kilocalories added to average diets in developing countries between now and 2030.

Sources of growth in crop production

There are three main sources of growth in crop production: expanding the land area, increasing the frequency with which it is cropped (often through irrigation), and boosting yields. It has been suggested that we may be approaching the ceiling of what is possible for all three sources.

A detailed examination of production potentials does not support this view at the global level, although in some countries, and even in whole regions, serious problems already exist and could deepen.

Land. Less new agricultural land will be opened up than in the past. In the coming 30 years, developing countries will need an extra 120 million ha for crops, an overall increase of 12.5 percent. This is only half the rate of increase observed between 1961-63 and 1997-99.

At global level there is adequate unused potential farmland. A comparison of soils, terrains and climates with the needs of major crops suggests that an extra 2.8 billion ha are suitable in varying degrees for the rainfed production of arable and permanent crops. This is almost twice as much as is currently farmed. However, only a fraction of this extra land is realistically available for agricultural expansion in the foreseeable future, as much is needed to preserve forest cover and to support infrastructural development. Accessibility and other constraints also stand in the way of any substantial expansion.

More than half the land that could be opened up is in just seven countries of tropical Latin America and sub-Saharan Africa, whereas other regions and countries face a shortage of suitable land. In the Near East and North Africa, 87 percent of suitable land was already being farmed in 1997-99, while in South Asia the figure is no less than 94 percent. In these regions, intensification through improved management and technologies will be the main, indeed virtually the only, source of production growth. In many places land degradation threatens the productivity of existing farmland and pasture.

Water. Irrigation is crucial to the world's food supplies. In 1997-99, irrigated land made up only about one-fifth of the total arable area in developing countries but produced two-fifths of all crops and close to three-fifths of cereal production.

The role of irrigation is expected to increase still further. The developing countries as a whole are likely to expand their irrigated area from 202 million ha in 1997-99 to 242 million ha by 2030. Most of this expansion will occur in land-scarce areas where irrigation is already crucial.

The net increase in irrigated land is predicted to be less than 40 percent of that achieved since the early 1960s. There appears to be enough unused irrigable land to meet future needs: FAO studies suggest a total irrigation potential of some 402 million ha in developing countries, of which only half is currently in use. However, water resources will be a major factor constraining expansion in South Asia, which will be using 41 percent of its renewable freshwater resources by 2030, and in the Near East and North Africa, which will be using 58 percent. These regions will need to achieve greater efficiency in water use.

Yields. In the past four decades, rising yields accounted for about 70 percent of the increase in crop production in the developing countries. The 1990s saw a slowdown in the growth of yields. Wheat yields, for example, grew at an average 3.8 percent a year between 1961 and 1989, but at only 2 percent a year between 1989 and 1999. For rice the respective rates fell by more than half, from 2.3 percent to 1.1 percent.

Yield growth will continue to be the dominant factor underlying increases in crop production in the future. In developing countries, it will account for about 70 percent of growth in crop production to 2030. To meet production projections, future yield growth will not need to be as rapid as in the past. For wheat yields, an annual rise of only 1.2 percent a year is needed over the next 30 years. The picture for other crops is similar. Growth in fertilizer use in developing countries is expected to slow to 1.1 percent per year over the next three decades, a continuation of the slowdown already under way.

Overall, it is estimated that some 80 percent of future increases in crop production in developing countries will have to come from intensification: higher yields, increased multiple cropping and shorter fallow periods.

Improved technology

New technology is needed for areas with shortages of land or water, or with particular problems of soil or climate. These are frequently areas with a high concentration of poor people, where such technology could play a key role in improving food security.

Agricultural production could probably meet expected demand over the period to 2030 even without major advances in modern biotechnology. However, the new techniques of molecular analysis could give a welcome boost to productivity, particularly in areas with special difficulties, thereby improving the incomes of the poor, just as the green revolution did in large parts of Asia during the 1960s to 1980s.

Needed for the twenty-first century is a second, doubly green revolution in agricultural technology. Productivity increases are still vital, but must be combined with environmental protection or restoration, while new technologies must be both affordable by, and geared to the needs of, the poor and undernourished.

Biotechnology offers promise as a means of improving food security and reducing pressures on the environment, provided the perceived environmental threats from biotechnology itself are addressed. Genetically modified crop varieties — resistant to drought, waterlogging, soil acidity, salinity and extreme temperatures — could help to sustain farming in marginal areas and to restore degraded lands to production. Pest-resistant varieties can reduce the need for pesticides.

However, the widespread use of genetically modified varieties will depend on whether or not food safety and environmental concerns can be adequately addressed. Indeed, the spread of these varieties, in the developed countries at least, has recently slowed somewhat in response to these concerns, which must be addressed through improved testing and safety protocols if progress is to resume.

Meanwhile, other promising technologies have emerged that combine increased production with improved environmental protection. These include no-till or conservation agriculture, and the lower-input approaches of integrated pest or nutrient management and organic agriculture.

Livestock

Diets in developing countries are changing as incomes rise. The share of staples, such as cereals, roots and tubers, is declining, while that of meat, dairy products and oilcrops is rising.

Between 1964-66 and 1997-99, per capita meat consumption in developing countries rose by 150 percent, and that of milk and dairy products by 60 percent. By 2030, per capita consumption of livestock products could rise by a further 44 percent. As in the past, poultry consumption will grow fastest.

Productivity improvements are likely to be a major source of growth. Milk yields should improve, while breeding and improved management will increase average carcass weights and offtake rates. This will allow increased production with lower growth in animal numbers, and a corresponding slowdown in the growth of environmental damage from grazing or wastes.

In developing countries, demand will grow faster than production, producing a growing trade deficit. In meat products this will rise steeply, from 1.2 million tonnes a year in 1997-99 to 5.9 million tonnes in 2030 (despite growing meat exports from Latin America), while in milk and dairy products the rise will be less steep but still considerable, from 20 million to 39 million tonnes a year.

An increasing share of livestock production will probably come from industrial enterprises. In recent years production from this sector has grown twice as fast as that from more traditional mixed farming systems and more than six times faster than from grazing systems.

Forestry

During the 1990s the world's total forest area shrank by 9.4 million ha — about three times the size of Belgium — each year. However, the rate of deforestation was slower in the 1990s than in the 1980s. Industrial and transition countries expanded their forest areas, and many developing countries — including Bangladesh, China, India, Turkey and Viet Nam — are now planting more forest area than they cut.

The crop projections suggest that cropland will need to expand by an extra 120 million ha by 2030, while urban land areas will continue to grow by a considerable amount. Much of this extra land will have to come from forest clearance. In addition, by 2030 annual world consumption of industrial roundwood is expected to rise by 60 percent over current levels, to around 2 400 million m^3.

Even so, deforestation is expected to slow further in the coming decades and the world is unlikely to face a wood supply crisis. Production of wood-based materials is continually increasing in efficiency. The area of plantations is also growing rapidly: production of industrial roundwood from plantations is expected to double by 2030, from 400 million m^3 today, to around 800 million m^3. In addition, a big increase in tree-growing outside forests and plantations — along roads, in towns, around homes and on farms — will boost the supply of wood and other tree products.

The central challenges for the forestry sector are to find ways of managing natural and cultivated tree resources so as to increase production, improve the food security and energy supply of the poor, and safeguard the environmental services and biodiversity provided by forests.

Fisheries

World fisheries production has kept ahead of population growth over the past three decades. Total fish production almost doubled, from 65 million tonnes in 1970 to 125 million tonnes in 1999, when world average intake of fish, crustaceans and molluscs reached 16.3 kg per person. By 2030, annual fish

consumption is likely to rise to some 150 to160 million tonnes, or between 19 and 20 kg per person.

This amount is significantly lower than the potential demand, because environmental factors are expected to limit supply. By the turn of the century, three-quarters of ocean fish stocks were overfished, depleted or exploited up to their maximum sustainable yield. Further growth in the marine catch can be only modest. During the 1990s the marine catch levelled out at 80 to 85 million tonnes a year, not far from its maximum sustainable yield.

Aquaculture compensated for this marine slowdown, doubling its share of world fish production during the 1990s. It will continue to grow rapidly, at rates of 5 to 7 percent a year up to 2015. In all sectors of fishing it will be essential to pursue forms of management conducive to sustainable exploitation, especially for resources under common ownership or no ownership.

Environment and climate

Over the next 30 years, many of the environmental problems associated with agriculture will remain serious. Loss of biodiversity caused by the expansion and intensification of production often continues unabated even in the developed countries, where nature is highly valued and, supposedly, protected.

Nitrogen fertilizers are a major source of water and air pollution. The crop projections imply slower growth in the use of these fertilizers than in the past, but the increase could still be significant for pollution. Projections also suggest a 60 percent increase in emissions of ammonia and methane from the livestock sector. Comprehensive measures will be needed to control and reduce air and water pollution from these sources.

Global warming is not expected to depress food availability at the global level, but at the regional and local levels there may be significant impacts. Current projections suggest that the potential for crop production will increase in temperate and northerly latitudes, while in parts of the tropics and subtropics it may decline. This may further deepen the dependence of developing countries on food imports, though at the same time it may improve the ability of temperate exporters to fill the gap. Rising sea levels will threaten crop production and livelihoods in countries with large areas of low-lying land, such as Bangladesh and Egypt.

Food insecurity for some vulnerable rural groups in developing countries may well worsen. By 2030, climate change is projected to depress cereal production in Africa by 2 to 3 percent. Improved seeds and increased fertilizer use should more than compensate, but this factor will still weigh heavily on efforts to make progress.

Forestry and agriculture both contribute to human impact on climate. The burning of biomass — in deforestation, savannah fires, the disposal of crop residues and cooking with firewood or dung — is a major source of atmospheric carbon dioxide, while fertilizers and animal wastes create large emissions of nitrous oxide and ammonia.

Forestry can help to soak up some of the carbon released by human activities. Between 1995 and 2050, slower deforestation, together with

regeneration and plantation development, could reduce carbon dioxide emissions by the equivalent of 12 to 15 percent of all fossil fuel emissions.

Farming also has a positive role to play. By 2030 the amount of carbon locked up in cropland soils, as soil organic matter from crop residues and manure, could rise by 50 percent if better management practices are introduced.

The projections at a glance

Population (millions)	1979-81	1997-99	2015	2030	2050
World	4 430	5 900	7 207	8 270	9 322
Developing countries	3 259	4 595	5 858	6 910	7 987
Industrial countries	789	892	951	979	986
Transition countries	382	413	398	381	349

Population growth (% per annum)	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030	2030 to 2050
World	1.6	1.5	1.2	0.9	0.6
Developing countries	1.9	1.7	1.4	1.1	0.7
Industrial countries	0.7	0.7	0.4	0.2	0.0
Transition countries	0.5	0.1	- 0.2	- 0.3	- 0.4

GDP growth (% per annum)	1997-99 to 2015 total	2015 to 2030 total	1997-99 to 2015 per capita	2015 to 2030 per capita
World	3.5	3.8	2.3	2.9
Developing countries	5.1	5.5	3.7	4.4
Industrial countries	3.0	3.0	2.6	2.8
Transition countries	3.7	4.0	4.0	4.3

Growth in demand for agricultural products (% per annum)	1969 to 1999	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World	2.2	2.1	2.0	1.6	1.4
Developing countries	3.7	3.7	4.0	2.2	1.7
Industrial countries	1.1	1.0	1.0	0.7	0.6
Transition countries	- 0.2	- 1.7	- 4.4	0.5	0.4

Growth in agricultural production (% per annum)	1969 to 1999	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World	2.2	2.1	2.0	1.6	1.3
Developing countries	3.5	3.7	3.9	2.0	1.7
Industrial countries	1.3	1.0	1.4	0.8	0.6
Transition countries	- 0.4	- 1.7	- 4.7	0.6	0.6

Calorie consumption (kcal/capita/day)	1961-63	1979-81	1997-99	2015	2030
World	2 283	2 552	2 803	2 940	3 050
Developing countries	1 960	2 312	2 681	2 850	2 980
Industrial countries	2 891	3 135	3 380	3 440	3 500
Transition countries	3 154	3 389	2 906	3 060	3 180

Undernourishment	Million people				% of population			
	1990-92	1997-99	2015	2030	1990-92	1997-99	2015	2030
World		815				14		
Developing countries	816	777	610	443	20	17	11	6
Industrial countries		11				1		
Transition countries		27				6		

The projections at a glance (continued)

Cereals	Million tonnes				% per annum			
	1979-81	1997-99	2015	2030	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World								
Production	1 442	1 889	2 387	2 838	1.4	1.0	1.4	1.2
Food	706	1 003	1 227	1 406	1.9	1.4	1.2	0.9
Feed	575	657	911	1 148	0.6	0.6	1.9	1.5
Developing countries								
Production	649	1 026	1 354	1 652	2.5	2.1	1.6	1.3
Food	524	790	1 007	1 185	2.2	1.7	1.4	1.1
Feed	113	222	397	573	3.8	4.4	3.5	2.5
Net trade	- 66	- 103	- 190	- 265				

Meat	Million tonnes				% per annum			
	1979-81	1997-99	2015	2030	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World								
Production	132	218	300	376	2.8	2.7	1.9	1.5
Food	130	214	297	373	2.8	2.7	1.9	1.5
Developing countries								
Production	45	116	181	247	5.5	5.9	2.7	2.1
Food	44	116	184	252	5.6	6.1	2.7	2.1
Net trade	- 0.2	- 1.2	- 3.9	- 5.9				

Vegetable oils and oilseeds (oil equivalent)	Million tonnes				% per annum			
	1979-81	1997-99	2015	2030	1979 to 1999	1989 to 1999	1997-99 to 2015	2015 to 2030
World								
Production	50	104	157	217	4.1	4.3	2.5	2.2
Food	37	67	98	130	3.3	2.8	2.3	1.9
Industrial use	8	23	45	71	6.1	6.9	3.9	3.1
Developing countries								
Production	29	68	109	156	5.0	4.7	2.8	2.4
Food	21	45	73	102	4.3	3.6	2.9	2.2
Industrial use	3	13	26	41	8.2	10.2	4.4	3.1
Net trade	1.5	4.0	3.4	3.5				

Arable land (million ha)	Total			Irrigated			
	1997-99	2015	2030	1979-81	1997-99	2015	2030
World	1 608			210	271		
Developing countries	956	1017	1076	151	202	221	242
Industrial countries	387			37	42		
Transition countries	265			22	25		

Crop land and yields in developing countries	Harvested land (million ha)				Yield (tonnes/ha)			
	1979-81	1997-99	2015	2030	1979-81	1997-99	2015	2030
Wheat	96	111	113	118	1.6	2.5	3.1	3.5
Rice (paddy)	138	157	162	164	2.7	3.6	4.2	4.7
Maize	76	97	118	136	2.0	2.8	3.4	4.0
All cereals	408	465	497	528	1.9	2.6	3.2	3.6
% of total	60	55	53	51				