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Global food security:
facts, issues and implications

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- The challenge of food security is to ensure that all people have physical and economic access to food that meets their dietary needs and food preferences for an active and healthy lifestyle.
- Growth in global food consumption is expected to slow significantly over the next 40 years, from an average rate of 2.2 per cent a year (1970 to 2000) to 1.3 per cent a year (2000 to 2030) and then to 0.6 per cent a year (2030 to 2050).
- Nevertheless, the population of some food-deficient countries will continue to grow while others decline.
- Improving agricultural productivity globally, and particularly in food-deficient countries, will be important to meet this challenge, as will continued improvements in international trading rules that allow the flow of food to where it is needed.
- Food security also requires economic development and higher incomes in the least developed countries, which will reduce poverty and increase the access of the poor to food.
- There are many future challenges to increasing food production globally, including slowing agricultural productivity growth, the impacts of climate change, and increased competition for scarce resources such as water, fertiliser and land.
- Australia produces far more food than it consumes and has the income to meet all its food security needs. However, its surplus food production meets only a small part of world food consumption needs. Australia's greatest contribution to global food security will be through provision of technical cooperation assistance to food-deficient countries.

Global food requirements will continue to increase in coming years, as populations rise and as growing incomes promote both an increasing volume and a changing pattern of food consumption. This paper examines issues around global food security from an Australian perspective.

Food security has two dimensions: the physical availability of food, and the capacity of people to pay for the food they need. Food security does not imply self-sufficiency. The Food and Agriculture Organization (FAO) has estimated that 925 million people do not have sufficient food to eat. The continuing existence of this large population of undernourished people is a problem of poverty demanding long-term solutions that are targeted to the needs of individual countries.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 2003).

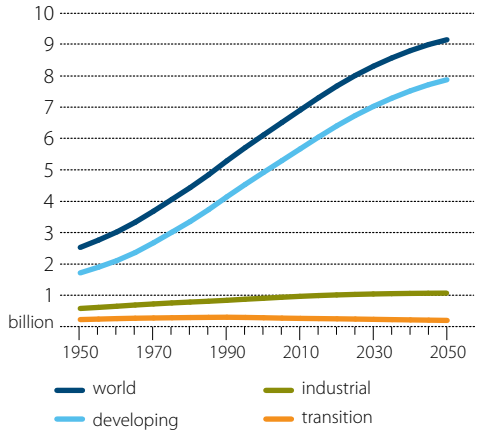
There is no foreseeable risk to Australia's food security. Australia produces twice as much food as it consumes, produces almost all its fresh food, and can easily afford the food it imports. Australia is also a competitive supplier of bulk commodities, fresh foods and processed foods (such as meat and dairy products) to world markets. However, Australia's strength in providing food to other countries faces a number of challenges over coming decades. The rate of growth in agricultural productivity is declining in Australia, and perhaps globally, as growth in investment in research and development (R&D) has declined. Additional challenges include climate change, increasing pressure on limited resources such as land, water and fertiliser, and, if Australia follows the path of a number of other countries, demand from non-food uses of crops, particularly for biofuel.

Global population growth

United Nations population data and projections (UN 2009) show the global population reaching 9.1 billion by 2050, an increase of 32 per cent from 2010. Most of the additional population will be in developing countries. Between countries and regions, population trends show considerable diversity. The Americas, Africa and Oceania are projected to show continuing population growth through this period. However, the population of the Russian Federation has been declining for the past 15 years, Europe's population is expected to peak in the course of the current decade, and China's in the 2030s. By 2050, global population growth is projected to slow to 0.34 per cent annually (compared with an annual average of over 2 per cent in the late 1960s, and a little over 1 per cent currently) and is likely to begin contracting later in the century. However, significant population growth is likely to continue beyond this time in some of the world's most food insecure regions (Lutz, Sanderson and Scherboy 2001).

The word's population growth is slowing, but the populations of some food-deficient countries will continue to grow while others decline. Food security is an issue that needs to be considered in a regional context.

1 Growth of world population



Note: For a list of countries in each of these categories, see FAO (2006). In short, industrial countries are those of Western Europe and North America plus Australia, New Zealand, Japan, South Africa and Israel. Developing countries include the bulk of those in Asia, including the Middle East, Africa, Latin America and Oceania. Transition countries include the Russian Federation and others of the former USSR and Eastern Europe, including those that have joined the European Union
Source: UN 2009

In absolute terms, the world's population is expected to grow by 2.2 billion in the next 40 years to 2050, and a significant part of the additional population will be in countries that have difficulties feeding themselves.

Almost one billion (or 43 per cent) of the additional population will be in Africa. Countries such as Niger, Ethiopia and Uganda are among those likely to face high population growth and ongoing food security problems (FAO 2006). Asia's population will increase by more than one billion, including 400 million additional people in India. China's small and subsequently negative rate of growth will nevertheless represent an additional 63 million people by 2050.

Global income growth

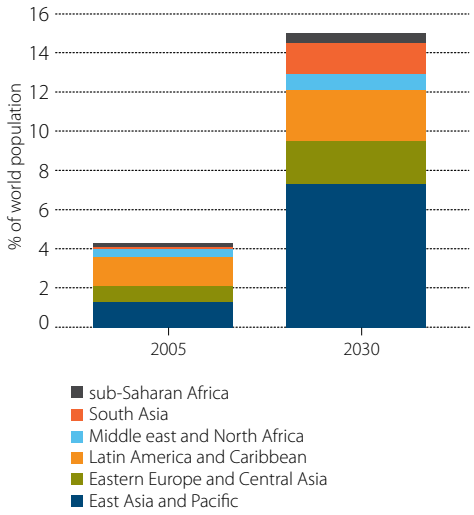
The World Bank (2007) has forecast that the developing countries will increasingly power the global economy, with their per capita incomes growing by 3.1 per cent a year, on average, between 2010 and 2030. The share of the developing countries in global output is expected to increase from about one-fifth to nearly one-third, and they may represent half of the world's purchasing power by 2030. China and India will be major drivers of this economic growth and of an associated expansion in global trade. But this growth is not likely to be uniform across developing countries, with sub-Saharan Africa experiencing much slower growth than other regions. Per capita incomes in the developing countries of East Asia and the Pacific are forecast to grow by between 4.5 and 6.5 per cent annually, and in South Asia by between 2.5 and 5 per cent annually. The benefits would also not be spread evenly within countries. Technological progress demands skilled workers, and the unskilled may fall further behind.

Continuing economic growth and an expansion in the middle classes, particularly in Asian countries, will also drive increased food consumption.

Growth in demand for food and changing patterns of demand

The effect of growing incomes will be more visible where base levels of consumption are lower; that is, as a population moves from poverty towards middle class. As shown in figure 2, the proportion of the world population accounted for by middle classes in developing countries is expected to expand from around 4.9 per cent in 2005 to almost 15 per cent in 2030. At higher income levels, people already have a more adequate diet and there is less potential for food consumption to increase further. FAO projections show global food consumption per person (expressed as kcal/person/day) increasing by an average 0.29 per cent a year in the period to 2030, but growing more slowly at 0.15 per cent a year in the period 2030 to 2050 (FAO 2006). However, growth rates will be around double this in food deficient regions of the world such as sub-Saharan Africa and South Asia.

2 Middle class, incomes of $4000 to $17 000 (PPP)



PPP Purchasing Power Parity facilitates comparison between countries with different price levels
Source: World Bank Global Economic Prospects 2007

Combining expected population growth with income growth means food consumption will increase by 68 per cent between 2000 and 2050. This implies an annual growth rate of 1.04 per cent, compared with growth of 2.2 per cent annually between 1970 and 2000.

1 Projected growth in population and food consumption

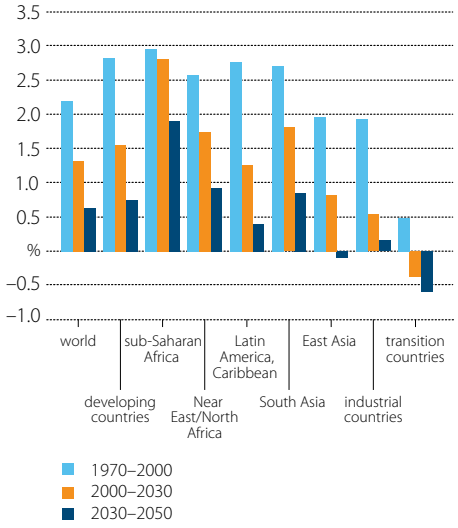
	average annual growth rates, %, 1970–2000			average annual growth rates, %, 2000–2030			average annual growth rates, %, 2030–2050		
	kcal/ person **a**	population **b**	food consumption	kcal/ person **a**	population **b**	food consumption	kcal/ person **a**	population **b**	food consumption
World	0.49	1.70	2.20	0.29	1.03	1.32	0.15	0.48	0.63
Developing countries	0.77	2.05	2.83	0.36	1.20	1.56	0.18	0.57	0.75
Sub–Saharan Africa **c**	0.15	2.80	2.95	0.57	2.23	2.81	0.42	1.48	1.91
Near East / North Africa **c**	0.00	2.57	2.57	0.17	1.56	1.74	0.09	0.82	0.92
Latin America and Caribbean	0.74	2.02	2.77	0.32	0.94	1.26	0.13	0.28	0.40
South Asia	0.47	2.23	2.71	0.51	1.29	1.81	0.33	0.53	0.86
East Asia **c**	0.49	1.48	1.97	0.35	0.47	0.82	0.06	–0.17	–0.10
Industrial countries	1.19	0.74	1.94	0.07	0.47	0.54	0.03	0.13	0.16
Transition countries	0.41	0.08	0.49	0.28	–0.64	–0.37	0.19	–0.78	–0.59

a Calculated from FAO (2006) table 2.1, p. 8. **b** From UN population data, v. **c** FAO Developing regions. Japan, Israel and South Africa not included.
Kcal=1000 calories, a measure of the energy contained in food.

The average calorie intake for developing countries is expected to rise from 2650 kcal a person a day in the mid-2000s to 3000 kcal a person a day by 2050, thus significantly improving nutrition. However, it is likely that considerable population groups will remain deficient in food.

With global food consumption growing at decreasing rates to 2050, agricultural production can also expand at a slower rate than in the past without prices rising.

3 Annual rate of growth in food requirements



Source: Extrapolated from FAO (2006) and UN population data, http://esa.un.org/unpp/index.asp

A different pattern of food consumption is emerging, as higher demand for livestock products is stimulated by increasing disposable incomes in developing countries, especially in the emerging markets of Asia, Latin America and the transition countries of Eastern Europe and the former USSR. Consumption of livestock products (meat, milk and eggs), vegetable oils and, to a lesser extent, sugar, forms an increasing proportion of intake as incomes and food consumption grow. In Asia, demand growth for meat and edible oils outstripped population growth by a wide margin over the past 15 years (World Bank 2009). Demand for meat and dairy products (and feed grains) is expected to continue to expand more rapidly than demand for grain.

Food consumption patterns vary markedly between the developing regions. Sub-Saharan Africa and South Asia have particularly low levels of meat consumption. There are a number of developing countries where meat consumption is less than 10 kg a person a year, and in some of these the trend is downward. (By comparison, Australian meat consumption in recent years has varied between 100 and 110 kg a person). In the case of South Asia, annual meat consumption is estimated at 5.5 kg a person in 2000, projected by the FAO to increase to 18 kg a person through the first half of the 21st century. East Asia, in contrast, consumes much more meat—39.8 kg a person in 2000—and this is expected to increase to 73 kg a person by 2050. Consumption per person of vegetable oils is expected to increase by 60 per cent in developing countries through the first half of the century; in South Asia, this consumption will almost double (FAO 2006). Consumption of fresh fruit and vegetables is

projected to expand in some countries, including China and some in the Middle East and North Africa, but less in others (Msangi and Rosegrant 2011).

Global food production

Global food production has historically grown faster than global population, reflecting increased availability of food per person. Between 1961 and 2008, world population grew by 117 per cent while food production grew by 179 per cent (Keating and Carberry 2010). Declining real prices over a long period indicate that, with growth in productivity, supply has strengthened more rapidly than demand. Food production would be higher if there was stronger demand for food. However, this under-utilised production capacity coexists with almost one billion undernourished people unable to afford sufficient food at their income levels and current food prices.

With populations and incomes growing, agricultural production will need to continue to increase, albeit at a slower rate, if future demand for food is to continue to be met at current price levels. Strong productivity growth and the utilisation of hitherto unused cropping should ensure the continuing adequacy of food supplies (World Bank 2009).

Improvements in agricultural productivity over time have enabled agricultural production to meet consumption growth while lowering the real price of food. The challenges to continuing these productivity increases remain high in the future.

The increased emphasis on consumption of livestock products will influence production patterns in the future. According to the FAO, global production of meat has expanded by around 2.2 per cent annually for the past decade and is expected to continue growing, but at a slower rate, to 2050. The FAO projects that growth in wheat production, which has been around 1.4 per cent a year in the past decade, will slow to 0.5 per cent a year by the middle of the century. Coarse grains output, fuelled by growing demand for livestock feed and for industrial uses such as ethanol production, has grown by 2.3 per cent annually in the past decade, and is expected to grow significantly faster than wheat over the next 40 years.

While past growth in agricultural production, sustained in large part by technologically driven gains in yields, may be taken as a guide to future potential, there are challenges to future productivity growth. Per capita availability of resources such as water and land will become more limited, while climate change may require adjustments to production techniques and locations. Potential increases in the cost of mineral fertilisers and in the use of resources to produce crops for non-food uses, particularly for biofuel, may both drive up the cost of producing food.

The supply of food could be further enhanced if waste were to be reduced. Keating and Carberry (2010) note that estimates of post-harvest losses range from 10 to 40 per cent. Even at the bottom of this range the food supply could be increased markedly by reducing losses.

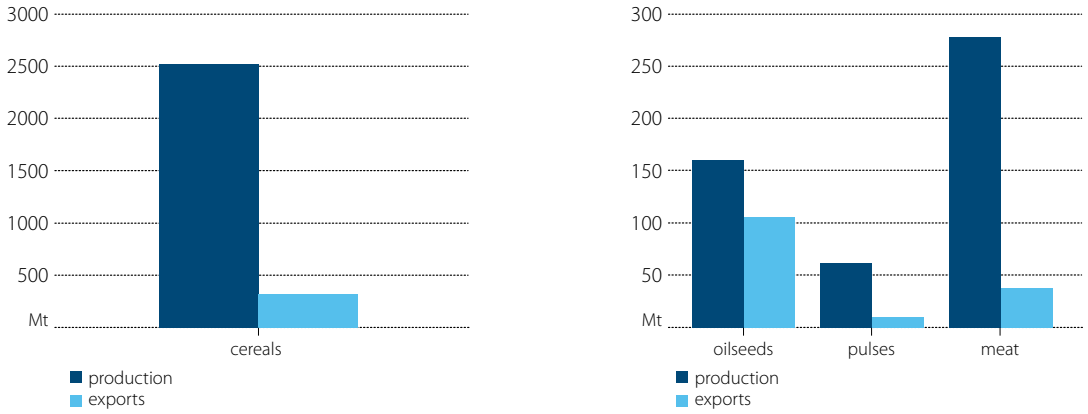
Research and development on food supply chains could be as important to food security as research to improve yields.

Global trade in food

While global trade in foodstuffs is of considerable importance—to some countries more than others—it constitutes a relatively small proportion of total world production and consumption. Exports of meat, cereals and pulses over the period 2000 to 2007 averaged 11, 13 and 16 per cent of global production, respectively; however, trade in oilseeds was much more significant, at 62 per cent of production. Exports of meat and pulses, relative to their levels of production, have increased over the past 20 years (FAO 2010a).

The removal of import and export barriers will be an important part of meeting the global challenge of moving food to where it is most needed and, through improved incomes, enhancing people's capacity to buy food.

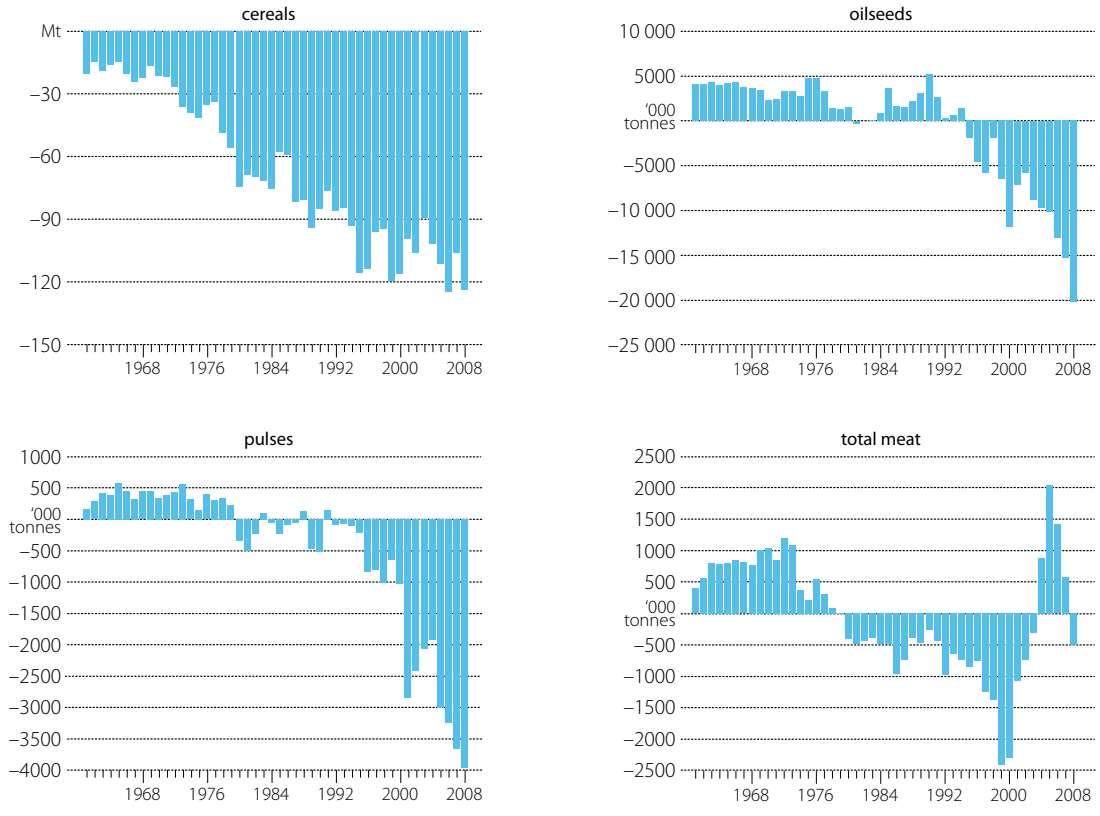
4 Global production and exports of selected commodities



Source: FAO 2010a

Overall, developed countries have tended to dominate food exports in recent decades, in many cases with the assistance of their agricultural support programs, while developing countries in the aggregate have been net importers. World trade in foodstuffs is dominated by cereals, particularly wheat. The United States, Canada, the Russian Federation, the European Union and Australia are the major net exporters of wheat, shipping to countries in Africa, Asia, Latin America and the Middle East (the trade flowing predominantly from developed and transition countries to developing countries). Trade in other commodities shows a less consistent pattern between developing and developed countries over time. Since the mid-1990s the developed countries have come to dominate exports of oilseeds and pulses. However, developing countries dominated meat exports from 2004 to 2007, as Brazil's shipments of beef expanded markedly and those of the United States were variable.

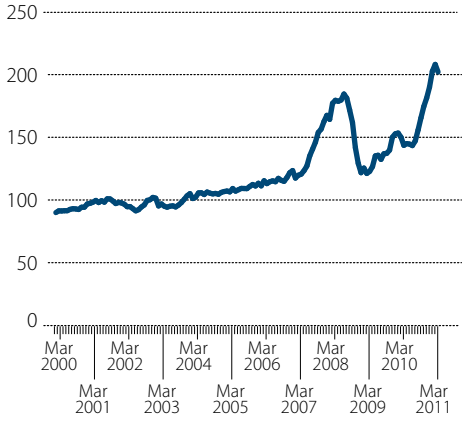
5 Net exports from developing countries



Source: FAO 2010a

The policy framework in which global trade takes place will be important for future food security. Import restrictions clearly limit trade, and while tariffs on food commodities are typically fairly low, other barriers are often applied.

6 FAO food price index, 2002–2004 = 100 deflated by World Bank MUV deflator



Source: www.fao.org
MUV Manufactures Unit Value deflator

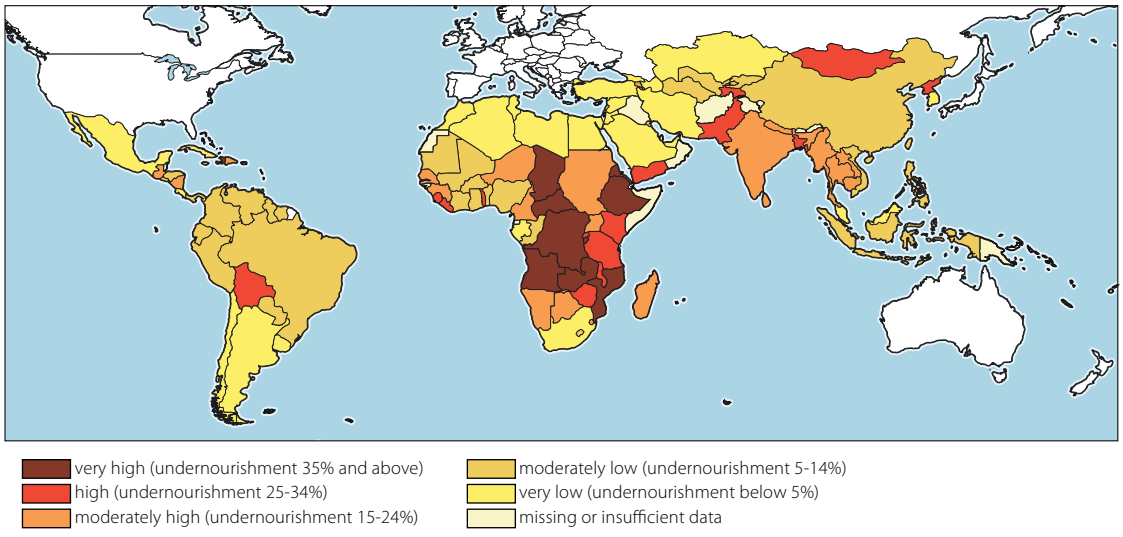
In situations of high global food prices in recent years, some countries have imposed restrictions on exports. This immediately increases the availability of food and reduces its price to consumers in the country concerned, while having the opposite effect on the global food market. Importantly, it also disguises incentives to farmers in that country to increase production at a time when more food is most needed globally.

Similarly, export subsidies and food aid provided in non-emergency situations can have the effect of lowering incentives to produce food for farmers in recipient countries. Such arrangements are conducive to continued poverty over the long run rather than creating an environment for poverty alleviation.

Trade liberalisation, including reform of agricultural support regimes, improves the allocation of resources to different activities in the economy and thus increases incomes. Higher incomes reduce poverty and improve food security by increasing the access of the poor to food.

For some countries, food imports are, and will remain, crucially important to their food security. The low-income food-deficit countries rely on imports, for which many struggle to pay, and are the focus of attention on the world's hungry. For these people it is not the physical availability of food but their ability to pay for it that is critical to survival. The United Nations Millennium Declaration of 2000 set out eight major Millennium Development Goals, the first of which is to eradicate extreme poverty and hunger (United Nations 2010). Two of the targets specified under this goal are to halve, between 1990 and 2015, the proportion of people whose income is less than US$1 a day, and to halve, between 1990 and 2015, the proportion of

map **1** Prevalence of undernourishment in total population (%), 2005–07



Source: FAOSTAT 2010 (www.fao.org/hunger)

people who suffer from hunger. Through the period of high food prices in 2007–08 and the subsequent global financial crisis the number of hungry people grew from 847 million to more than one billion. In 2010 the FAO estimated that the number had fallen to 925 million (FAO 2010c), due largely to a more favourable economic environment in 2010 and the fall in food prices in 2009. Subsequently, however, food prices rose in 2010 and into 2011 to exceed the high levels of 2008, and the number of undernourished people may be expected to have risen again. Map 1 shows the global distribution of undernourished people.

Assisting developing countries achieve food security

Developing countries require assistance to improve both the ability of their people to buy food—through economic development—and their ability to produce food. As a middle-sized developed economy, Australia seeks to maximise the effectiveness of the aid it provides to these countries and needs to ensure this is targeted towards encouraging economic development.

Poor, food-deficit countries face many problems. Undernourishment itself deepens other aspects of poverty by reducing capacity to work, reducing resistance to disease and inhibiting children's mental development and educational achievements (FAO 2002). Such countries typically suffer from poor infrastructure, low levels of education and skills, limited investment, and low levels of inputs used in agriculture. The labour forces of many African countries in particular have been devastated by HIV/AIDS. In many countries, poor governance at all levels is a barrier to stable agricultural production and growth.

Increased agricultural production generates income, leads to reduced poverty and improved food security in rural areas, and can become an engine for broader economic development and hence for improved national food security. As a country with advanced expertise in agricultural technology, economics and policy, supported by strong educational and research institutions, Australia is well placed to help global food security by providing technical assistance to developing countries to improve their own agricultural capacity.

The Australian Agency for International Development (AusAID) manages most of Australia's aid program. It provides development assistance and disaster relief to overcome poverty and facilitate food security on a bilateral basis in many developing countries, as well as working with multilateral agencies. It is currently implementing a four-year global food security initiative aimed at countries in Asia, the Pacific and Africa, which focuses on 1) lifting agricultural productivity; 2) improving access to and returns from markets; and 3) providing social safety nets to protect the vulnerable against economic and natural shocks.

The Australian Centre for International Agricultural Research (ACIAR) channels Australia's assistance directly to the development of agriculture in thirty countries in five regions: Papua New Guinea and the Pacific; Southeast Asia; North Asia; South Asia; and Africa. It is a statutory authority that encourages Australia's agricultural scientists to use their skills for the benefit of developing countries. It commissions research into improving sustainable agricultural production in developing countries, funds related training and communicates the results of funded research. Australia contributes to a wide range of agricultural research in developing countries through its support of the Consultative Group on International Agricultural Research and its network of International Agricultural Research Centres.

In addition, Australia contributes to alleviation of poverty and hunger by supporting the United Nations and its specialised agencies such as the FAO and the World Food Programme, as well as the World Bank. The G20 group of countries is also becoming increasingly significant in anti-poverty and food security activities.

Australia is a member of the World Trade Organization and participates actively in discussions and negotiations to help encourage a more open global trading system, which is an important contributor to global food security.

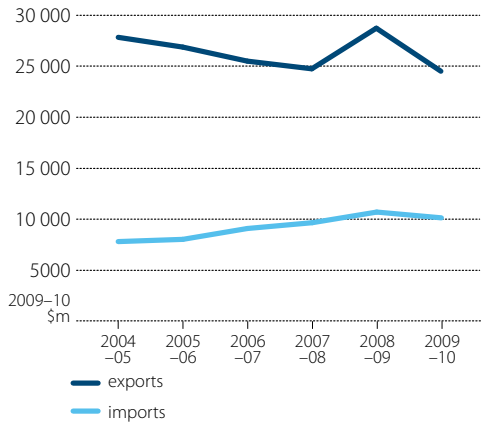
Australia's food security

As a trading nation with an open economy, growth in Australia's food production is likely to focus primarily on those products for which it has comparative advantage; that is, on those products in which Australia can compete internationally. For example, Australia has traditionally had a comparative advantage in broadacre agricultural products that are produced with the extensive use of land and limited inputs of labour. These commodities include cereals, oilseeds, beef and sheep meat, as well as sugar and dairy. These products are likely to continue to form a major part of Australia's food exports.

While food imports by Australia have been increasing in the past decade, Australia remains in a strong surplus position. Australia's integration in the global food economy with an increasingly sophisticated pattern of exports, imports, processing and distribution provides the Australian consumer with choice among a greater diversity of products, with more price competition. Economic prosperity, derived in part from participation in the global economy, guarantees Australia's food security.

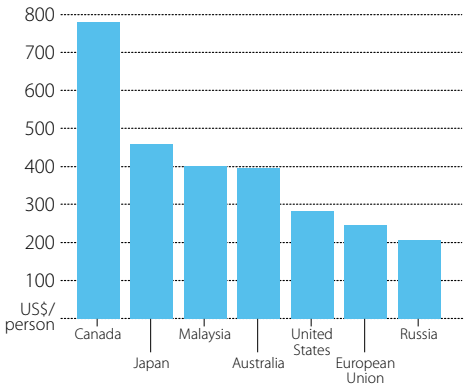
Most of Australia's tariff and quota measures against agricultural imports have been removed during the past two decades. In addition, quarantine measures have been established that allow the import of a greater number of products while managing the risk of entry of pests and diseases. This has resulted in notable increases in imports of, for example, pig meat and some horticultural products. Because of the perishability of fruits and vegetables and the availability of low-cost domestic produce, imports of horticultural products are dominated by processed product, which accounts for around 90 per cent of fruit and vegetable imports. Where fresh fruit and vegetables are imported, these are often counter-seasonal to Australia's production.

8 Food exports and imports



Sources: ABARES 2011 *Australian commodities* March quarter

7 Food imports per person in selected countries, 2009–2010



Sources: Comtrade, United Nations Commodity Trade Statistics Database, http://comtrade.un.org/db/dqBasicQuery.aspx; United Nations 2009, World population prospects, the 2008 revision, population database, Population: http://esa.un.org/unpp/

Although imports are playing a larger role in Australia's food supply, Australia's agricultural production is, overall, well in excess of consumption requirements, and a considerable surplus is available for export. Over the past decade, wheat production has averaged around 3.5 times the volume needed for domestic consumption, while beef and veal production has been around 2.8 times the quantity consumed (derived from ABARES 2010). Total food exports averaged over the three years 2006–07 to 2008–09 amounted to 54 per cent of food production (Penm, Rees and Moir 2010). Expenditure on imports in 2009–10 amounted to more than 40 per cent of the receipts for food exports, but most of Australia's imported food is relatively highly valued, with a high level of processing, and the quantity of food involved is much less than suggested by its cost.

The high income levels of most Australians ensures their capacity to purchase the food they need, whether imported or domestically produced. As a consequence, Australia's food security would not be threatened by any diminution of food self sufficiency that might occur with increased imports in the future.

Australia's role in meeting global food needs

On average, between 2007–08 and 2009–10, Australia's exports of wheat and flour amounted to around 11 per cent of total world exports, but only 2 per cent of global consumption. Over the same period, Australia's sugar exports were equivalent to almost 6 per cent of global trade but only 2 per cent of consumption (ABARES 2010). Beef exports between 2004 and 2007 accounted for 15 per cent of global trade but only 1.5 per cent of global consumption (FAO 2010a).

Australia's exports contribute to the supply of food available to food-deficit counties. However, Australia is a relatively small producer in global terms, and exports are likely to be directed to markets of the highest value rather than to countries with the greatest food need.

The value of Australia's food exports in 2009–10 was $24.5 billion (ABARES 2011). Asian markets have become increasingly important destinations for Australian exports in the past two decades. Japan remains the most important destination, taking around 20 per cent of Australia's food exports by value. Indonesia, the Republic of Korea, Malaysia and China all now take a higher proportion of food exports than in 1990–91. New Zealand, the United Kingdom and some countries in the Middle East, including Saudi Arabia and the United Arab Emirates, have also become more important export destinations. Some of the countries to which Australia exports food have serious food security problems. In recent years, between 28 and 42 per cent of wheat shipments have been to countries where more than 10 per cent of the population is undernourished.

However, Australian exporters are focused on markets of highest value such as those of the developed economies and the rising middle classes in the growing developing countries, including China and the ASEAN countries, which are expected to shift in demand away from staples toward a wider variety of food products (Kim, Thompson and Penm 2010). To a large extent, Australia's food exports are not oriented towards countries with serious food security problems but rather the incentive is for farmers and exporters to supply the markets where they receive the highest returns for their products.

Australia has the capacity to feed far more people internationally through technical assistance in the agricultural sectors of the world's food-deficit countries than through the export of food produced in Australia.

Potential challenges to agricultural production

Productivity in agriculture

Productivity refers to production per unit of input. In agriculture, productivity is often expressed as yield, or production per unit of land used. This is a partial productivity measure in that production is related to a single input. Productivity with respect to other inputs, including labour, capital or water can also be considered. Total factor productivity is a measure that captures the change in production from a given set of all inputs.

Australian agricultural industries face a number of challenges to increased production in the future. These include the need for technological development that allows the continuation of advances in productivity; the influence of climate change; and competition for resources.

Around two-thirds of the gross value of agricultural production in Australia in recent years can be attributed to gains in productivity (Gray et al. 2011). Total factor productivity in Australian broadacre agriculture grew at an average of 1.4 per cent annually

2 Volume of Australian exports of wheat and flour to selected countries with food-deficit population [a]

	Wheat exports [b]					Food security characteristics of country [c]		
						Number undernourished (million)	Prevalence of undernourished in population	Depth of hunger – food deficit of undernourished population [d]
	2004–05	2005–06	2006–07	2007–08	2008–09	2005–2007	2005–07	2004–06
	kt	kt	kt	kt	kt	Million	%	kcal/ person/day
Ethiopia	0	8	0	0	5	32	41	310
Bangladesh	162	179	3	65	337	42	27	290
India	0	93	1 593	9	1	238	21	260
Indonesia	2 720	3 016	2 574	1 608	2 728	30	13	230
Pakistan	653	146	0	0	0	43	26	280
Sri Lanka	66	46	0	5	50	4	19	250
Thailand	478	545	192	255	336	11	16	210
Yemen	314	499	385	408	714	7	31	270
Sum of above	4 394	4 532	4 747	2 350	4 172	406		
Total to all destinations	15 780	15 168	11 196	7 408	13 410			
% to food insecure countries	27.8	29.9	42.4	31.7	31.1			

a Countries where more than 10 per cent of the population are undernourished. **b** July–June year. Exports are of wheat (including spelt, groats, meal and pellets) and meslin (mixed grain, especially rye mixed with wheat), plus plain white flour, wholemeal flour and self-raising white flour in wheat equivalent (conversion 1:1.29). Source: ABS, *International Trade, Australia*, cat. no. 5465.0, Canberra. **c** Source FAO 2010, Food security statistics, http://www.fao.org/economic/ess/food-security-statistics/en/. **d** The intensity of food deficit is considered low when it is less than 200 kilocalories a person a day and high when it is higher than 300 kilocalories a person a day.

between 1977–78 and 2007–08. In the period 1977–78 to 2000–01, productivity grew at 2 per cent a year in trend terms, but has since reversed to contract at 1 per cent a year in trend terms. Productivity growth in the dairy industry has similarly proceeded more slowly after 2000–01 (Nossal and Sheng 2010). While the reductions in productivity growth in recent years are due, at least in part, to adverse seasonal conditions and reduced irrigation water availability, they also indicate a fundamental slowdown in technological progress (Gray et al. 2011).

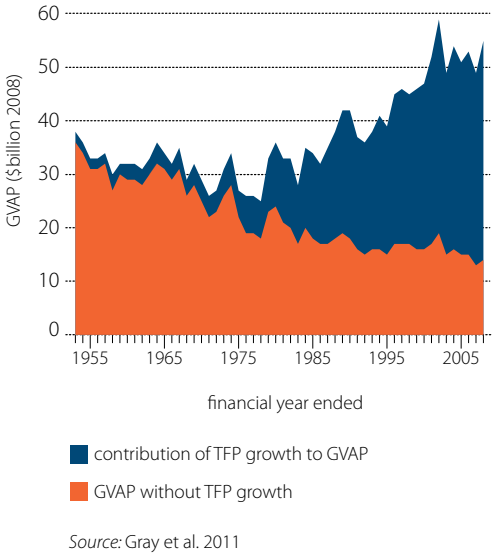
Globally, yields of major crops have increased more slowly in recent years than 30 and 40 years ago (Sheales and Gunning-Trant 2009).

A key driver of productivity growth is investment in R&D, and it is notable that Australian public expenditure on R&D in agriculture, which grew at an average of 6.5 per cent a year between 1953 and 1980, has since grown at only 0.6 per cent a year (Nossal and Sheng 2010). The effect of this slowdown in R&D may now be evident in the slower productivity growth. The negative effects of any reduced R&D effort may continue for a long time, as it may take up to 35 years for the full effects to be felt (Nossal and Sheng 2010). Private investment in agricultural research is also important, although data are less readily available. In the United States, private R&D expenditure in agriculture was reported to be growing faster than public expenditure, which it had exceeded by 1996 (Tokgöz 2002). In Australia, private R&D expenditure is much less than public spending. However, Australia does derive significant benefits from R&D undertaken by other countries, with this estimated to account for around half of the productivity gains in Australian agriculture between 1953 and 2007 (Sheng, Gray and Mullen 2011).

One notable outcome of research in recent decades is the development of genetically modified organisms (GMOs), including crop plants that are resistant to pests and that are able to withstand the herbicides used to control weeds. These plants have contributed to productivity gains in agriculture in recent years, particularly in the case of feed grains, maize and soybeans (Alston, Beddow and Pardey 2010).

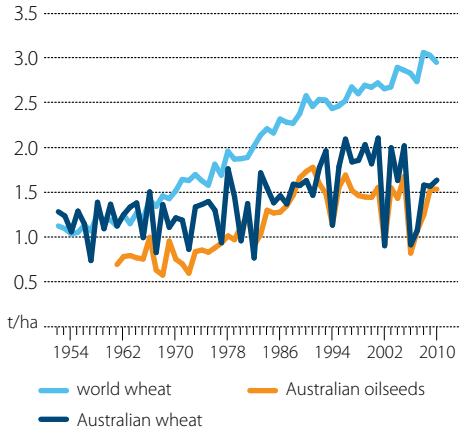
Advances in agricultural productivity have been the main factor behind increased food production in the past, and will be critically important to the ability of humankind to feed itself in the future. But productivity growth has slowed in recent years, reflecting, in part, lower investment in R&D both globally and in Australia.

9 Contribution of total factor productivity growth to the gross value of agricultural production (GVAP), 1952–53 to 2007–08



Source: Gray et al. 2011

10 Crop yields



Source: ABARE–BRS

Despite their contribution to productivity, public caution toward GMOs currently restricts their potential. In particular, their lack of acceptance in Europe reduces productivity gains there, as well as constraining their use in other countries that export large proportions of their products to Europe. This also limits the incentive to invest in R&D. The lack of acceptance in Europe is of particular concern in African countries that, as suppliers to the European Union, are unable to adopt the technologies that benefit agricultural production in many other parts of the world. Nevertheless, as discussed earlier, there is significant prospect for yield and production improvement in Africa from the adoption of known non-GM seed varieties and more modern production techniques.

For productivity gains to be fully realised, technologies need to be acceptable to consumers and others in the supply chain. Australia's commercial experience with GM crops was limited largely to cotton and carnations (Acworth, Yainshet, and Curtotti 2008), but canola has more recently gained approval for production in all producing states except South Australia.

Climate change

The potential effects of climate change on agriculture in Australia and globally were assessed by Gunasekera et al. (2007). Increasing temperature, changing rainfall patterns and an increasing frequency of extreme events are expected to reduce agricultural production below the levels it would otherwise reach (the baseline) in many, but not all, countries through the 21st century. If mitigating and adaptation actions are not taken, global wheat production in 2050 could be 5.1 per cent lower than the baseline, and beef and dairy production could each be 11 per cent lower. Agricultural production is likely to be more adversely affected in lower latitudes, where developing countries are predominantly situated; in mid to high latitudes, the impact will be less severe, and in some cases will be positive.

Although agricultural production in Australia is expected to rise substantially in the future, the extent of this rise may be lessened by the impact of climate change. Climate change mitigation policies can also have an adverse effect on agricultural production.

In Australia, rainfall levels in northern areas may change little, but Australia's major cropping and livestock production areas in the south-west could be as much as 40 per cent drier by 2070 than in 1990 (Gunasekera et al. 2007). By 2050, climate change has the potential to constrain Australian wheat production to 13 per cent below the baseline, to constrain beef production by 19 per cent, and to constrain dairy production by 18 per cent.

Agricultural trade is likely to be lower than it would be without climate change because of two factors: lower agricultural output; and lower demand influenced by the slower economic growth of trading partners. At the same time, trade will play a part in balancing the impact of global warming, allowing regions of the world with positive (or less negative) effects to supply those with more negative effects (Nelson et al 2010).

While climate change is expected to affect agriculture, agricultural activities also affect climate change. In Australia, as in many countries, there has been discussion about mechanisms to impose a price on carbon emissions. Even if agriculture were excluded from the direct imposition of a carbon tax, it would be indirectly affected through both increased prices of inputs such as fuel, fertiliser and chemicals and any pass-back of the tax on outputs such as transport and processing.

Resources for food production

While by far the greatest gains in food production have come from improvements in yields, past increases in Australian production were due, in part, to expansion of cropping areas. However, Australia's total farm area reached a peak of 500 million ha in the mid-1970s and has since declined to a little more than 400 million ha. There may be some scope for additional land to be brought into agricultural production—in northern Australia, for example—but development is likely to be limited without the stimulus of higher prices for food and significant investment in infrastructure.

At the same time, some land is being lost to urban, mining and industrial uses, and there is a risk that land could become degraded by further salinity, acidity and encroachment of pests and weeds, thus limiting the potential for increased food production.

In Africa and South America, there remains unused land that can be farmed. In some of the Newly Independent States of the former Soviet Union, land which has been taken out of cropping in the past 20 years could be reinstated (OECD–FAO 2009). However, infrastructure support remains an issue for agricultural development in those regions, and expansion would depend on price incentives. Water availability could impose more severe constraints on food production than could land availability. Competition from other users, including industry and urban households, is already intense in many countries where the expansion of irrigation has been an important driver behind increased crop yields. In the future, a substantial slowdown in the global expansion of irrigated land is expected (OECD–FAO 2009), with future gains coming from improved performance of existing irrigation.

Agricultural production requires resources such as land, labour, capital equipment, water and other inputs, including energy, fertilisers and pesticides. Agriculture competes with other sectors of the economy for some of these resources; for others, competition exists primarily among agricultural products.

Where additional resources such as unused land or water do exist, environmental considerations are likely to constrain their use.

The availability and cost of farm labour depends on the performance of agriculture relative to other sectors in the economy. Many developing countries have, in the process of economic development, seen an exodus of labour from agriculture to other industries. Currently, in Australia, competition between agriculture and other sectors, particularly the buoyant mining sector, may have implications for farm labour. Australian agriculture has paid lower wages and had difficulty recruiting the labour it needs (Sheales and Gunning Trant 2009). Technological developments, particularly in the cropping sector, have increasingly allowed the substitution of mechanical equipment for labour, and employment on Australian farms has declined from more than 400 000 in the 1960s to a little more than 300 000 in recent years (ABARES 2010).

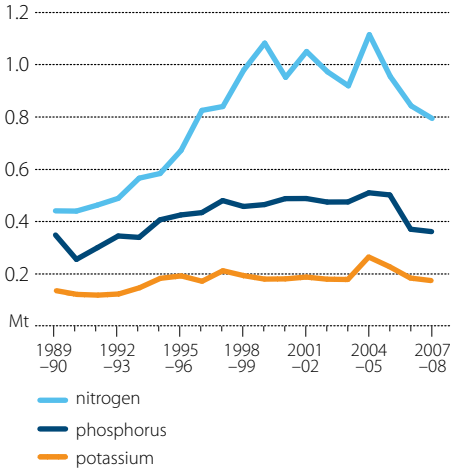
With farms predominantly owned by individual families, the capital required for mechanisation and other on-farm investment has been largely derived from within the farm business and from bank credit. A small number of larger company-owned farms have had access to equity capital, with a small proportion of these farms using overseas capital. The increasing capital requirements of agriculture might have been expected to favour increased investment by domestic and foreign companies, but this does not appear to have happened to any significant extent despite the productivity gains that might have accrued from it.

Fertilisers are essential inputs to Australian agriculture, and have been used intensively. Nitrogen in particular has been used in increasing quantities. Most of Australia's fertiliser is imported. From 2001 to 2009, imports amounted to around 56 per cent of the phosphatic fertiliser used, 77 per cent of the nitrogen used and 100 per cent of the potassium used (ABARES 2010). Phosphate rock, from which phosphatic fertilisers are manufactured, is partly imported and partly mined from domestic deposits (See box on phosphate rock reserves).

Current economic reserves of potassium amount to more than 200 years, but there are also considerable potential reserves. Nitrogen is available from the atmosphere in virtually unlimited quantities, though the cost of converting atmospheric nitrogen to fertiliser—mainly by using natural gas—is considerable. There are also limited deposits of mineral nitrates. Sulphur is considered to be available in quantities sufficient for the foreseeable future (USGS 2010).

Energy is an essential input to agricultural production. With considerable reserves of oil remaining, and with prospects for the further development of alternative sources of energy, it seems unlikely that food production will be constrained by any physical limits to energy availability. However, the price of energy can be expected to increase in real terms, and the costs of using it to be further increased by carbon trading or tax arrangements. There have been linkages made between price rises in energy and also for food. These linkages could also be important for future price movements.

11 Fertiliser use, Australia



Source: ABARES *Australian commodity statistics*

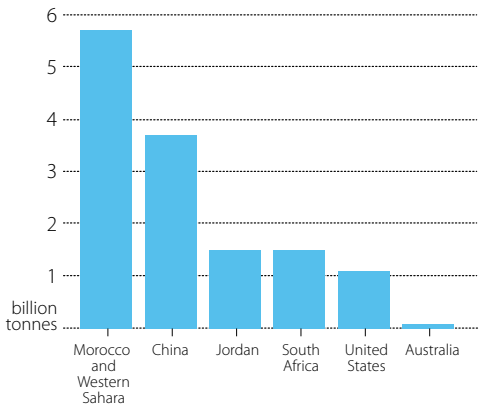
Fishery resources are also important determinants of future food production. With fish stocks under threat, there may be little capacity for increased production of capture fish over the longer term. Consumption of fish is particularly important in some countries, such as Japan and Norway, and it is a significant although smaller part of global food consumption, constituting around 6 per cent of protein intake and 1 per cent of calorie intake at the world level (FAO 2010a). Aquaculture now constitutes 36 per cent of total fish production (OECD–FAO 2009) and is expected to continue to grow.

Box 1 Phosphate rock reserves

At the present rate of extraction, current global reserves of phosphates that can be economically extracted would be sufficient for around 100 years with current usage patterns. Additional reserves, which cannot be economically extracted at present, amount to several times that quantity, and large undersea reserves are also known to exist (USGS 2010). Australia has relatively small deposits of phosphate rock. Of the major plant nutrients, phosphorus appears to be the one with some potential for shortfalls in supplies to generate significant price increases, particularly as reserves occur in a relatively small number of countries, notably China and Morocco.

However, there are new technologies for the more efficient application of fertiliser, where the application rate is varied in accordance with soil requirements. In the longer term, development of new plant varieties should reduce the need for fertilisers, while possibilities exist for recycling minerals from human waste. As higher prices give an incentive for exploration, discoveries of additional reserves are also possible.

12 Phosphate rock reserves



Source: US Geological Survey 2010

Competition for resources – non-food agricultural production

Agriculture has traditionally been the source of non-food commodities such as cotton, wool and other vegetable and animal fibres; rubber; beverages; industrial oils; tobacco; and forestry products. Traditionally, these commodities have competed with food production for agricultural land, but more recent developments now see intensified competition between food and non-food applications of the same crops. The recent expansion in production of biofuel, particularly ethanol, has been of considerable importance, and other products of the so-called 'biobased economy', including bioplastics, pharmaceuticals and lubricants, could become more significant in the future (Langeveld, Dixon and Jaworski 2010). All these commodities contribute to the income, and hence the food security, of the farmers who produce them. However, they employ resources that could otherwise be used for food production.

Biofuels are of particular interest because they have been promoted by government subsidies and mandates, particularly in the United States and Europe as well as in Australia, and have recently had a considerable impact on markets. Rosegrant (2008) estimated that 30 per cent of the increase in cereal prices between 2000 and 2007 was attributable to demand for ethanol production.

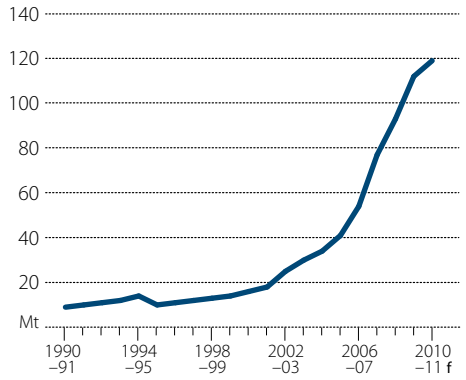
Increasing production of biofuel, together with traditional production of other non-food commodities, compete with food for resources and can contribute to reduced supplies and higher prices of food.

While the higher food prices stimulated by biofuel production have obvious negative implications for poor food-importing countries and households, the medium to longer term implications may be different. Where a positive supply response is possible, the higher prices will stimulate production, in importing as well as exporting countries, with 'potentially positive implications for economic growth, poverty reduction and food security' (FAO 2008).

Biofuel production in Australia is small but has the potential to become more significant. In the United States, almost one-third of corn produced or one-quarter of all cereal produced is used to produce ethanol. Globally, ethanol production is forecast to

grow at 6.6 per cent annually in the period to 2018, and biodiesel at a faster rate of nearly 9 per cent annually (OECD–FAO 2009). This growth will be driven largely by government mandates and subsidies rather than commercial incentives, and will continue to place upward pressure on food prices. Mandates in particular override the normal working of the market and can be expected to increase prices and to contribute significantly to food price instability.

13 US corn used in ethanol



f ABARES forecast
Sources: USDA , Economic Research Service

The longer-term future of biofuel production is difficult to predict, as the policies that drive it may prove to be more transient than the underlying economic and commercial reality. It is likely that the introduction of second-generation technology, using cellulosic rather than starchy material as feedstock, would have different implications for food security, possibly offering greater opportunities to developing countries while posing a smaller threat to food supplies.

Concluding comments

The global food security challenge is not about the capability of world agricultural producers to produce enough food to feed the world, but rather is about ensuring that the poorest people in the world have the economic and physical access to the food they require to meet their nutritional needs.

Australia is able to produce sufficient food to meet its needs and has the income to achieve national food security. Australia's prosperity, coupled with its participation in the global economy, will ensure this food security for the foreseeable future.

Australia has a role in global food security but this is not principally in producing food for the world's food deficit countries. Australia will feed far more of the world's poor by providing technical assistance that helps them in feeding themselves, thereby enhancing their economic development and thus their ability to afford food.

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