UNCTAD (United Nations Conference on Trade and Development) (2004), *The Least Developed Countries Report: Linking International Trade with Poverty Reduction*. Geneva: UNCTAD.
UNDP (United Nations Development Program) (2003), *Making Global Trade Work for People*. Earthscan: London.
Winters, L.A. (2002), Trade liberalization and poverty: what are the links?. *World Economy*, **25**(9), 1339–1367.
Winters, L.A., N. McCulloch and A. McKay (2004), Trade liberalization and poverty: the evidence so far. *Journal of Economic Literature*, **XLII**(1), 72–115.

14. Enhancing food security: agricultural productivity, international trade and poverty reduction

Peter Warr

14.1 INTRODUCTION

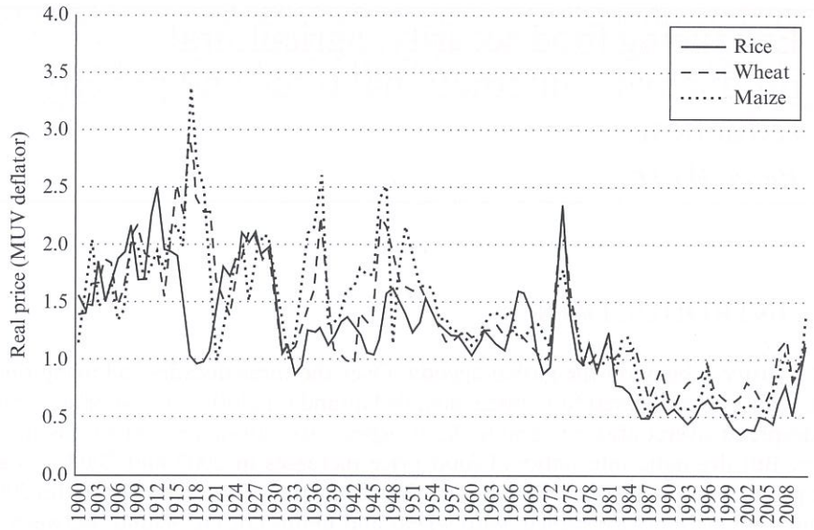
Food security is back on the global agenda. Over the three decades following the mid-1970s, falling international food prices signaled abundant global food supplies, resulting in widespread overconfidence about the prospects for continued reductions in global hunger. But dramatic international food price increases in 2007 and 2008 and subsequent price surges in 2010 and 2011 ended this complacency. Between 2006 and 2008 the international price of rice tripled, with wheat and maize not far behind. Between them, these three cereals are the staple foods of the majority of the world's poorest people and expenditure on them accounts for a large proportion of household budgets. Among the poor, net purchasers of these commodities typically outnumber net sellers, such as small farmers. Poor people are consequently those most vulnerable to an increase in food prices. For those poor people who are net purchasers of food and for the governments and other institutions concerned with their welfare, highly volatile food prices are deeply worrying.

Figure 14.1 shows long-term data on the international prices of rice, wheat and maize, relative to manufactured commodities, covering more than a century. Three features of the behaviour of these prices are revealed by the data:

1. all three real prices have declined markedly over the long term;
2. all three have been highly volatile; and
3. all three increased significantly in recent years.

At the end of the twentieth century the real price of food was well below half of its level a century before. Even at the very height of the price increases of 2007–08, the relative price of food was still well below its level throughout the first two decades of the twentieth century. Advances in agricultural productivity were the central source of this achievement, confounding the eighteenth century prediction of Thomas Malthus that mass starvation was (and remains) inevitable. This long-term trend of cheaper food explains the recent complacency regarding agriculture and food discussed above. But the price surges of the last decade have shown the folly of ignoring food security (Timmer, 2010).

Although food and agriculture are now receiving greater attention, decades of neglect have not helped (Headey and Fan, 2008; Timmer, 2008). Between 1980 and 2005 total annual foreign assistance to less-developed countries that was designated for agricultural development declined from US$8 billion to US$3.4 billion, a reduction from 17



Source: Author's calculations, using data from World Bank.

Figure 14.1 International real prices of rice, wheat and maize, 1900 to 2012

to 3 percent of total foreign assistance to these countries. In the 1980s, 25 percent of US foreign aid went to agriculture. In the 1990s, it was 6 percent and, in 2011, it was 1 percent. The share of World Bank lending going to agriculture was 30 percent in 1978, 16 percent in 1988 and 8 percent in 2006. In many developing countries themselves, public commitment to investment in agriculture has also waned, as other development priorities have seemed more promising.

Human well-being requires a continuous and reliable supply of nutritious and safe food, in adequate quantities. Obviously, the concern for food security derives from the reality of food *in*security, the social and political consequences of which are potentially dire. But what does food security or its opposite mean, and what determines it? Are there degrees of food insecurity? The definition of food security is discussed in Section 14.2, including the possibility of developing quantitative measures for it.

The theme of the chapter is that enhancing food security has three major components:

1. reducing the relative price of food;
2. reducing poverty; and
3. providing special food-related assistance to disadvantaged groups and to the wider population in emergency circumstances.

Point (1) is about reducing the cost of producing and delivering food domestically or purchasing it on international markets, and hence the price at which food is available to households. Point (2) relates to households' capacity to purchase food, along with other essential commodities. Point (3) recognises the necessity to care for individuals and groups who are missed by the drivers of poverty reduction and for whom even reduced

real prices of food do not ensure dietary adequacy. It also relates to the broader public provision of emergency food supplies during natural and anthropogenic disasters.

Subsumed in the definition of 'food' in this discussion is a nutritional and safety issue, meaning food which meets human nutritional requirements and which is hygienic. These three themes of poverty reduction, reducing the relative price of food, and the provision of social food safety nets, are pursued in the remainder of this chapter.

Reducing the relative price of food (point (1)) means lowering the price at which households can obtain food with the nutritional and safety characteristics they require. Two distinct sets of policy-related issues are involved in the determination of food prices: the productivity and competitiveness of the domestic food production and marketing system; and the role of international trade. These two sets of issues are discussed in Sections 14.3 and 14.4 of this chapter, respectively. Globally, the levels of productivity in agriculture and in off-farm food processing and distribution systems are the principal long-term determinants of food prices, though trade can also play a cost-reducing role by making the global food system more efficient. But for individual countries trade policy with respect to food can be a critical determinant of domestic food prices (Warr, 2005, 2008). Following the food price shocks of 2007–08 the issue is how the long-term cost-reducing benefits of international trade can be achieved without exposure to huge short-term price spikes in food prices, induced by volatile international markets.

Poverty reduction (point (2)) is central because for most people, for most of the time, food security is a matter of purchasing power. The rich are never food insecure, except in the most extreme circumstances of wars or natural disasters, and even then the poor are more severely affected. Sustainable poverty reduction is central to enhancing food security, long-term, because by definition poverty reduction entails increasing the capacity of poor households to purchase essential commodities, including food. Fortunately, quite a lot is known about what it takes to achieve a sustainable reduction in poverty. But food is different in some important respects, especially in the short-term. Section 14.5 of this chapter examines the relationship between poverty reduction and food security.

Special food-related assistance (point (3)) relates to the role of social food safety nets, including whether special assistance is best provided in-kind, in the form of food itself, or in cash. It can generally be expected that poverty reduction will coincide with improved food security, but exceptions can occur. Recent research on India illustrates the possibility that although poverty incidence declines, food security may not improve. This is especially likely when food prices rise significantly relative to other prices. Although poverty reduction can be expected to reduce the proportion of the population that is food insecure, there will always be groups requiring special assistance, or periods when food prices rise unexpectedly, causing more widespread food insecurity.

Competing demands for agricultural output, coming from feed and fuel demands, in addition to food for a rising population, mean increased pressure on Asian food markets. In most of Asia, there is very limited scope for increasing the supply of agricultural land, but agricultural yields have barely kept up with population growth. As the demand for agricultural output rises, land will become even more scarce. Overuse of fertilizers, pesticides and herbicides will become an increasing danger, with serious environmental consequences. The development of pesticide resistance within major insect pest populations is a particular danger, given the widespread overuse of a limited number of major pesticides in monocrop rice agriculture.

International food markets can play a constructive role at the margin, but in almost all Asian countries the challenge of rising demands for food must be met overwhelmingly by expansion of domestic output. Moreover, this must be achieved with no more, and possibly less, land allocated to agriculture than at present and with a diminishing proportion of the total workforce. If this is to occur without substantial increases in food prices there is only one mechanism available – increased productivity. This must occur especially within agriculture itself but also throughout the food supply and input supply chains. Improved agricultural technology makes it possible to achieve expanded food production without raising domestic prices, thereby injuring the poor, and without necessarily drawing large areas of additional land into agricultural production, promoting the destruction of remaining forests and other ecologically important habitats.

Raising productivity requires investing in rural infrastructure and promoting research and development activities that facilitate food production. The agricultural sectors of the developing countries of Asia and the Pacific have great potential for increased productivity. But adaptive research at the individual country level is required to achieve that potential. Greatly enhanced long-term public investment in agricultural research and development is required. But agricultural research has been neglected in many countries of the Asia-Pacific region.

Against this lies the specter of climate change, which promises to make the maintenance of food security even more challenging. Rising temperatures are likely to have a greater effect on wheat production than on rice or maize, but changes in the location of production, in response to climatic change, would be enormously costly for rice-producing Asia. Research is required to find means to cope most effectively with the consequences for agricultural production of significant increases in temperature, which now seem unavoidable.

14.2 THE MEANING OF FOOD SECURITY

14.2.1 Why Food is Different

Food is not a 'normal' commodity. It has no substitutes. If we are unable to obtain adequate food we suffer, and soon die, regardless of how much we possess of other things. Moreover, because our bodies lack the capacity to store large amounts of energy and other essential nutrients, we must have adequate food intake almost continuously. This applies most especially to children, whose development may be impaired irreversibly by prolonged dietary inadequacy. But for large numbers of poor people, the reliability of food supplies cannot be assumed. The prospect of food insufficiency, even if the probability is small and even if the expected duration of inadequate intake is short, is frightening for anyone. For these reasons, it makes sense to speak of 'food security' in a way that we do not speak of, say, 'clothing security' or 'entertainment security'. We can survive for a long time without a reliable supply of these things.

Food is different, but not *uniquely* so. Other things are also essential for well-being, including clean drinking water, shelter, access to basic medical care and basic education for children. None have substitutes. If any one of them is lacking, no amount of the others can make up for it. The cruel nature of poverty is that it compels households

to make choices among these items, *all* of which are essential for a minimally adequate standard of living. It is therefore important to recognize that a focus on food security and nutritional adequacy does not mean that other requirements for a decent life can be ignored or that they can necessarily be sacrificed in the interest of greater food security.

14.2.2 Defining Food Security

At the 1996 World Food Summit food security was defined as existing 'when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life.' The World Health Organization (WHO) adds to this definition a description that is widely cited and drawn upon in subsequent studies. It says that food security rests on three pillars:

- food availability (sufficient quantities existing);
- food access (households are able to obtain the quantities required); and
- food use (appropriate nutrition and hygiene).

Both definitions are useful. Because the WHO decomposition is so widely adopted, it is helpful to consider its relationship to the three principal themes of this chapter – that improved food security rests on poverty reduction, reductions in the price of food and the existence of social safety nets.

The first two components of the WHO definition, food availability and food access, are generally understood to relate to the national level (aggregate supplies) and the household level (capacity to purchase). But there is another way of interpreting these two categories. Food availability may be thought of in terms, not of aggregate quantities of food, but of the prices at which food is available. This in turn depends on productivity in the production and distribution of food within the domestic economy, the capacity of international trade to augment domestic food supplies and supplementary measures to provide food to households otherwise unable to purchase it. *Improving food availability is about reducing the supply price of food.*

Food access, the capacity of households to obtain the food they require, depends on the level of household incomes relative to the price of food. In the case of economically disadvantaged households and in emergencies, it also depends on the existence of food social safety nets. But as noted above, food is not the only requirement for a decent life. The poverty line is a measure of the amount of income required to purchase the goods and services needed for a minimally adequate standard of living, and because food accounts for such a large share of the household budgets of the poorest households it necessarily forms a large component of the poverty line. Poverty incidence measures the proportion of households whose incomes fall below this poverty line. Food access is therefore inversely related to poverty incidence. A lower level of poverty incidence means a higher proportion of households with adequate access to food. But reducing poverty incidence is not enough. Some households will continue to be food-deficient even though poverty incidence falls, and unexpected disasters can also lead to temporary but widespread hunger. *Improving food access is about reducing poverty and creating food social safety nets.*

Viewed in this way, the WHO decomposition of food security maps directly into the

three-part framework: price of food/poverty reduction/food social safety nets. But a remaining problem with both the WHO and World Food Summit definitions is that they are non-quantitative. Our interest in the subject of food security derives from the fact that the stated conditions for food security do *not* always exist, as defined. But the degree of departure from these conditions varies. The focus on food security is motivated by the possibility of food insecurity, but there are clearly degrees of food insecurity, some more severe than others (United States Department of Agriculture, 2000). It is not obvious how varying degrees of departure from full food security could be quantified, based on the World Food Summit or WHO definitions. An operational definition would make quantification meaningful.

It is not enough to know merely whether food security does or does not exist. We need to be able to quantify the degree of departure from full food security. In contrast, for example, the concept of poverty incidence has been precisely defined quantitatively, making it possible to study scientifically the causes of changes in poverty incidence over time and across environments.

It is helpful to distinguish between three levels of food security.

1. *Household level* food security refers to having access to adequate food at all times, roughly along the lines of the above definition. At the household level, food 'security' relates to more than just the adequacy of food intake today. It implies something forward-looking, involving *expectations* of future circumstances and not simply present conditions. In particular, it relates to the expected availability of sufficient food in the future, which inherently involves uncertainty.

Oversimplifying, suppose there are just two time periods, 'today' and 'tomorrow'. Food security relates to the household's expectations about the availability of food tomorrow, relative to the amount required. The household may have adequate food today, and may always have done so in the past, but there is nevertheless some possibility of not having adequate food available in the future, and this is the basis for a measure of the degree of the household's food insecurity.

2. *National level* food security must surely be founded on food security at the household level. If households are not food secure, it is hard to see how the nation could be. But national food security is often taken to mean something quite different – *food self-sufficiency* – meaning that sufficient food is present within the country to make imports unnecessary. The basis for the focus on eliminating imports is mistrust of international markets as sources for a nation's food requirements. But this concept does not coincide with food security at the household level and can be in conflict with it.

For example, consider a country that normally imports food. One way to eliminate imports is to prohibit them (disregarding the possibility of smuggling). This will raise the price of food within the country, stimulating additional supplies and reducing demand. The domestic price will rise sufficiently to eliminate the difference between total domestic demand and supply. But the increase in the price means that household food consumption will be lower than the level in the presence of imports and may be below that required by the World Food Summit definition. That is, food self-sufficiency may be in conflict with food security (Warr, 2005, 2011).

3. *Global level* food security means whether global supplies are sufficient to meet aggregate global requirements. Reportedly, there are around 1 billion hungry people in the world and also 1 billion obese people. The amount of food currently produced is

seemingly enough for everyone, leaving only a problem of distribution among individuals. But while arithmetically correct, this simplistic description of the problem does not necessarily provide a practical means of reducing hunger in poor countries. Increasing food production in the poorest parts of the world may often be the most effective means of reducing global hunger.

14.2.3 More Than Calories

Nutritionists emphasize that food security is about more than just caloric intake. Protein intake is important as well, along with essential fats and micronutrients. Moreover, data relating to average, population-wide nutrient intakes miss the special importance of adequate nutrition for the development of children. Malnutrition in childhood contributes to mortality, mental and physical impairment and chronic disease risk across the life cycle in a way that cannot always be remedied by improved diets later in life. In economic terms, malnutrition in childhood impedes the formation of human capital through investment in education, with subsequent implications for economic growth. Survey-based data summarized by Neufeld et al. (2012) show high levels of stunting in children under 5 years of age in South and Central Asia and parts of Southeast Asia. In South Asia childhood stunting has been reported in 40 percent of children and severe wasting in over 5 percent. But in addition the data show high levels of both anemia (low levels of blood hemoglobin, arising from dietary iron deficiency) and vitamin A deficiency in India, Pakistan, Nepal, Cambodia and Myanmar. Not far behind are Bangladesh, Vietnam, Indonesia and the Philippines.

Data assembled by WHO confirm that as real GDP per capita rises, the incidence of childhood stunting declines, on average, but the incidence of adult and childhood obesity rises. A reflection of the latter is the rising incidence of diabetes in Asia. In India and China the incidence of diabetes is already far higher than in Japan and even exceeds that in Western countries like the United States and Italy. Caloric adequacy is a necessary but not sufficient condition for food security. *Nutritional security* is about meeting (but not overly exceeding) dietary requirements across a range of essential nutrients. Clearly, nutritional insecurity can exist for some groups even in the presence of food abundance.

14.2.4 Quantifying Food Security

The expectations-based concept of household-level food security is illustrated in Figures 14.2 and 14.3. Consider a household that is uncertain about future food availability. Figure 14.2 depicts a probability density function (PDF) describing that household's expectations about future food availability, relative to the amount required, R. The probability, p, that food consumption will be inadequate is given by the shaded area under the PDF, as indicated. Figure 14.3 now converts this same information to a cumulative distribution function (CDF) showing, on the vertical axis, the cumulative probability that available consumption will be less than or equal to the amount indicated by the horizontal axis. The probability that consumption will be less than or equal to R is now the intersection between R and the CDF, shown as p. This probability provides one possible measure of food insecurity and $1 - p$ is a measure of food security.

Figure 14.3 makes it possible to add something not readily inferred from Figure 14.2.

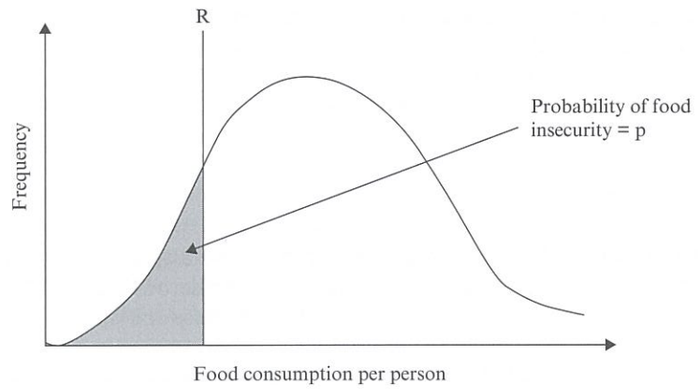


Figure 14.2 Expected food intake for a household: probability density function (PDF)

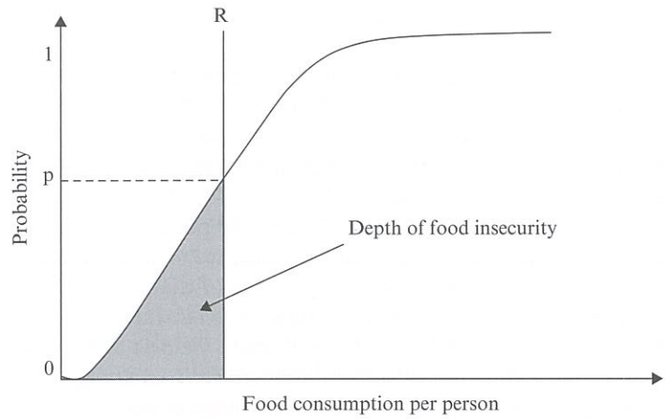


Figure 14.3 Expected food intake for a household: cumulative distribution function (CDF)

We can measure not just the probability that consumption will be inadequate, but also the expected magnitude of the inadequacy. The area under the curve, shown by the shaded area, represents the expected (probability-weighted) gap between the amount of food required, *R*, and the amount that will actually be available. For the better off, this expected gap may negligible, but this is far from the case for poor households. Conceptually, this gap measure provides a better indicator of the magnitude of food insecurity than just *p*, the probability of food insecurity. Measuring it empirically is another matter.

At the national level, Figure 14.4 now draws upon the above concepts to show a cumulative distribution function of expected food consumption per person. The population of size *N* is ordered from lowest food consumption per person (left hand side of the horizontal axis) to the highest (right hand side). If food requirement per person is again

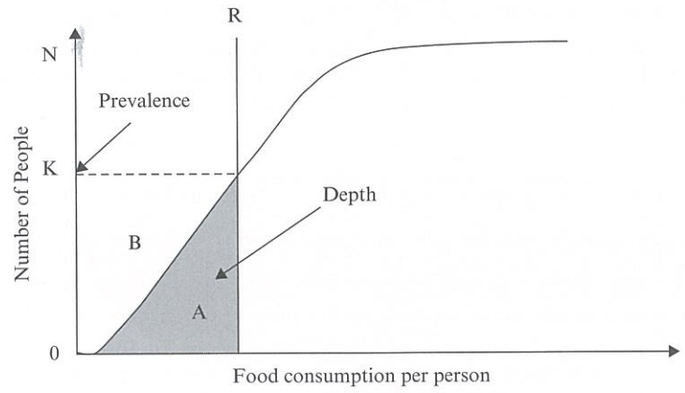


Figure 14.4 Expected food insecurity for the nation: cumulative distribution function (CDF)

R, the number of persons with intake less than or equal to *R*, the *prevalence of food insecurity*, is given by *K*. The proportion of the population whose intake is expected to be inadequate is therefore *K*/*N*. The total amount of food that would need to be consumed by these *K* persons for their intake to be adequate is given by the rectangle *KR*. Their actual consumption is the area *B*. Area *A* is therefore a measure of the degree to which actual consumption falls below the requirement. It indicates the *depth of food insecurity*, or alternatively the magnitude of the food security gap. A measure of the depth of food insecurity that might be compared across countries is its magnitude relative to either total consumption or the total consumption that would occur if all persons consumed exactly *R*, given by *RN*.

The concept of food security that makes most sense relates to forward-looking expectations of what food intake may be in the future, both at the individual and national levels. But these expectations are not readily observed empirically. Data about current levels of food intake are useful as indicators of what these expectations may be.

14.2.5 Empirical Estimates of Food Security

Several measures of food security are available, all based at the national level. The International Food Policy Research Institute (IFPRI) publishes a Global Hunger Index (GHI) and various Food Security Vulnerability Indices (FCVI). The Economist Intelligence Unit in association with Dupont publishes a Food Security Index (FSI). In addition the Food and Agriculture Organization (FAO) of the United Nations, in association with the World Bank publishes a widely used Food Price Index (FPI).

It is important that the calculation of the FPI uses as commodity weights the values of *international trade* in the commodities concerned, rather than *global consumption*. This means that commodities such as sugar, that are highly traded, receive high weights relative to commodities such as rice, where international trade is small, even though rice is a much more important commodity in terms of global consumption. This has been important in interpreting recent price surges because sugar prices have been increasing

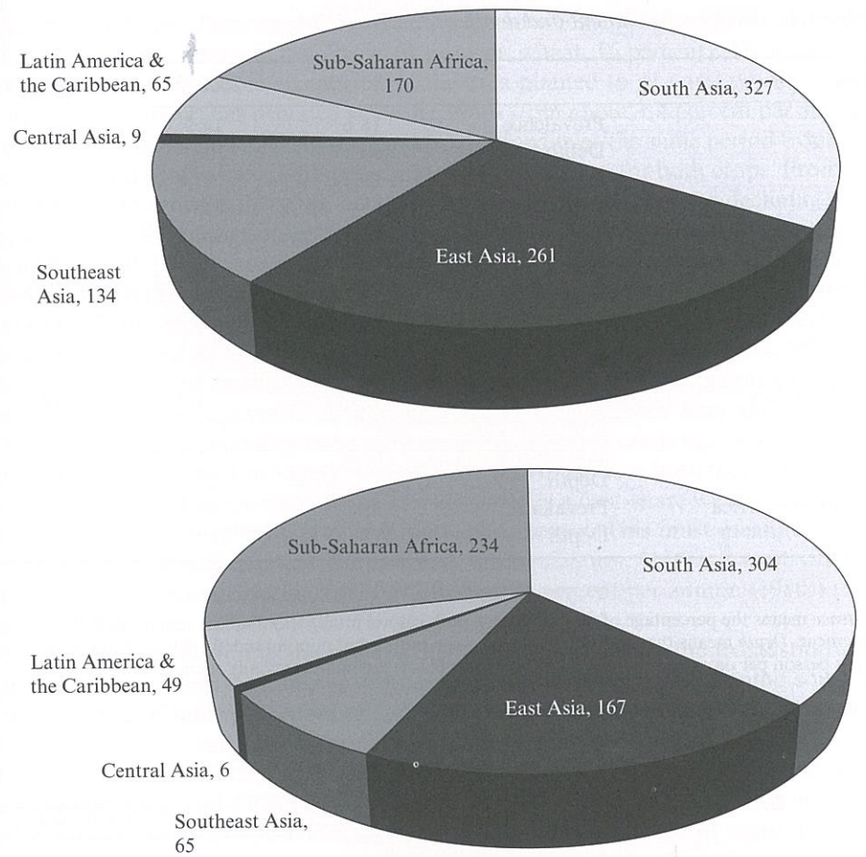
dramatically, but not those of staples such as rice. The FPI has increased as a result of the sugar price increases, reflecting their large weight in the index, but staple food prices were much more stable, a fact not reflected in the behavior of the index. While the spikes in the level of the FPI in 2007–08 did indeed reflect increased prices of staples, more recent price surges did not.

Considerable progress in the quantification of food security was made in a recent joint report of the FAO, the International Fund for Agricultural Development (IFAD) and the World Food Program (WFP), *The State of Food Insecurity in the World, 2012* (FAO/IFAD/WFP, 2012). The report presents improved estimates, for most countries of the world, of average availability of dietary energy supplies and average protein supplies. It also provides data on access to food, measured as physical access in the form of paved roads relative to total roads, road density and the density of rail lines, and economic access in the form of food prices, though these prices are not related in the report to incomes, as is done in measures of poverty incidence. The report contains important information on nutritional outcomes, including the prevalence of undernourishment and the 'depth of the food deficit', corresponding closely to the concepts discussed in relation to Figure 14.4, above.

Over the two decades from 1990–02 to 2010–02 the total number of undernourished people in the world declined from 1 billion to 868 million and the number in the Asia-Pacific region declined from 739 to 563 million. Figure 14.5 and Table 14.1 summarize these newly available data. While in 2010–12 the proportion of the population that was undernourished was lower in the Asia-Pacific region than in sub-Saharan Africa (at 26.8 percent), the population of Asia and the Pacific was so much larger that the absolute number of undernourished people in Asia and the Pacific was still more than double (at 563 million) the number in sub-Saharan Africa (at 234 million). In South Asia alone the number of undernourished people (327 million) exceeds the total number in sub-Saharan Africa.

The most striking feature of the data is the variation in the rates at which undernourishment has declined in different parts of the world. In Asia as a whole the rate of decline far exceeds the global rate. In sub-Saharan Africa the absolute number of undernourished people increased over these two decades by 38 percent, but within Asia the total declined by 24 percent. The rate of improvement also varied widely within Asia. In Southeast Asia the absolute number of undernourished people declined by more than 50 percent and East Asia was not far behind, at 36 percent. But the rate of decline was much lower in South Asia, at 7 percent. There may be many reasons for the variation but the differences seemingly correlate with differences in rates of poverty reduction, themselves correlating with differences in rates of economic growth.

The relationship between undernourishment and poverty incidence is explored further in Figure 14.6. For the developing countries as a whole, progress towards achieving the Millennium Development Goal target of halving by 2015 the 1990 rate of undernourishment is slightly behind schedule (shown by the dashed line), whereas for Asia and the Pacific as a whole the target has already been reached. The chart suggests that movements in undernourishment and poverty incidence are correlated, but that the relationship is far from a perfect one-to-one connection.



Source: FAO/IFAD/WFP (2012).

Figure 14.5 Numbers of undernourished people, 1990–92 and 2010–12

14.3 ENHANCING FOOD SECURITY THROUGH PRODUCTIVITY IMPROVEMENT

What caused the long-term decline in real food prices shown in Figure 14.1? The main answer is clear: improvements in farm-level productivity, combined with post-harvest productivity gains (Alston et al., 2010). Both agricultural productivity and post-harvest productivity are discussed in this section.

14.3.1 Raising Agricultural Productivity

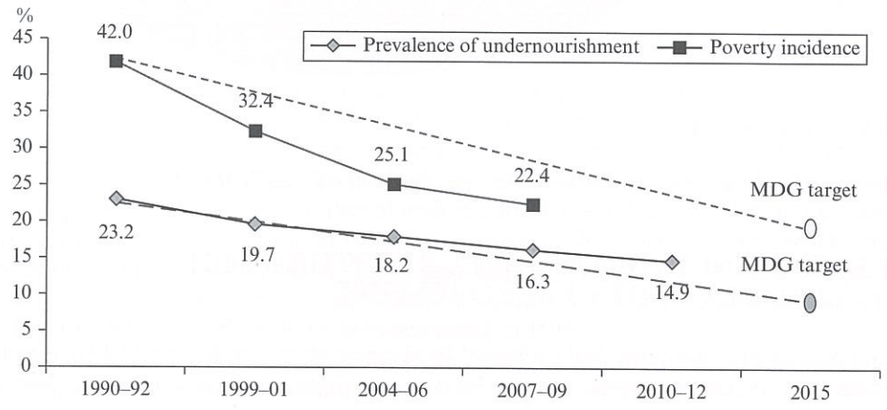
Agricultural productivity determines the cost of producing food at the farm level. Sombilla et al. (2012) study the long-term rates and determinants of productivity growth

Table 14.1 Undernourishment and depth of food deficit

Region		1990–92	2000–02	2010–12
World	Prevalence	18.6	14.9	12.5
	Depth	130	106	94
Asia	Prevalence	23.7	17.6	13.9
	Depth	165	125	104
Central Asia	Prevalence	12.8	14.5	7.4
	Depth	NA	98	51
East Asia	Prevalence	20.8	14.3	11.5
	Depth	151	98	77
South Asia	Prevalence	26.8	21.3	17.6
	Depth	175	150	127
South East Asia	Prevalence	29.6	19.2	10.9
	Depth	214	132	77
Oceania	Prevalence	13.6	15.9	12.1
	Depth	82	98	74
Sub-Saharan Africa	Prevalence	32.8	29.7	26.8
	Depth	235	219	205

Notes:
Prevalence means the percentage of the population with caloric intake less than the minimum daily requirement. *Depth* means the mean difference between intake and minimum daily caloric requirement, in kcal per person per day, among those whose intake is below the minimum daily requirement.

Source: Data from FAO *Food Security Indicators*, 2012.



Note: Poverty incidence data are not yet available for 2010–12.

Source: Data from FAO *Food Security Indicators*, 2012 and World Bank, PovcalNet database (http://iresearch.worldbank.org/PovcalNet/index.htm).

Figure 14.6 Undernourishment and poverty in the developing countries

in Asian agriculture. Their study focuses on rice and wheat, which together account for half of total caloric intake in Asia (rice, 34 percent; wheat, 16 percent). Their data show that within Asia as a whole, expansion of the area planted to rice and wheat (allowing for multiple cropping) has declined since the 1960s from about 1.4 percent per annum to zero in the decade 2000–10. Yield growth also declined over the same period from about 5 percent per annum (wheat) and 3 percent (rice) to 1 percent for both crops. Production growth for both crops is therefore currently 1 percent per annum, and declining, barely keeping pace with population growth.

Sombilla et al. (2012) present preliminary evidence on rates of total factor productivity growth (TFPG) that are more encouraging. Their data run from the decade of the 1980s to the decade of the 2000s. In the case of rice, these data show that TFPG increased in the Asia-Pacific region as a whole from 1.27 percent per annum (1980s) to 2.7 percent (2000s). According to these results, TFPG in rice production in the decade of the 2000s was 2.22 percent per annum in East Asia, 3.52 percent in south Asia and 3.1 percent in Southeast Asia. Combining this with the information on declining yield growth, the productivity of factors of production other than land must have been increasing rapidly, more rapidly than the reported rate of TFPG, which is a cost-share weighted average of the growth rates of productivity of the individual factors. This must mean, in particular, that labor productivity was increased by mechanization. In the case of wheat the data indicate a moderate decline in TFPG from 4.94 percent per annum (1980s) to 3.15 percent (2000s).

Constraints on sustaining the growth of productivity include the exhaustion of the potential of the Green Revolution technology, the problem of maintaining soil health in the presence of multiple cropping and the threats posed by new strains of pests and diseases, some with resistance to existing chemical methods of control. Soil erosion and salinization, water pollution and excessive water withdrawal from underground sources also threaten continued TFPG at the rates measured. Small farm sizes are a constraint to raising productivity through mechanization, despite the emergence of machinery rental markets in some areas.

Tenure arrangements affect rights to land and this in turn affects incentives of farmers to invest in productivity-enhancing improvements. Improvements in legal rights to land have not been rapid enough in many Asian countries. Credit markets remain insufficiently developed, partly as a result of ill-defined rights to land, limiting its capacity to serve as collateral. Public investment in infrastructure, especially roads, reduces transport costs and thus simultaneously raises prices received from sale of output and reduces prices paid for purchased inputs, again raising incentives for farmers to invest in productivity enhancement (Menon and Warr, 2008).

By far the most important constraint on productivity improvement is the supply of knowledge, determined by investment in research and extension. This is taken up the following section, drawing upon evidence for Indonesia.

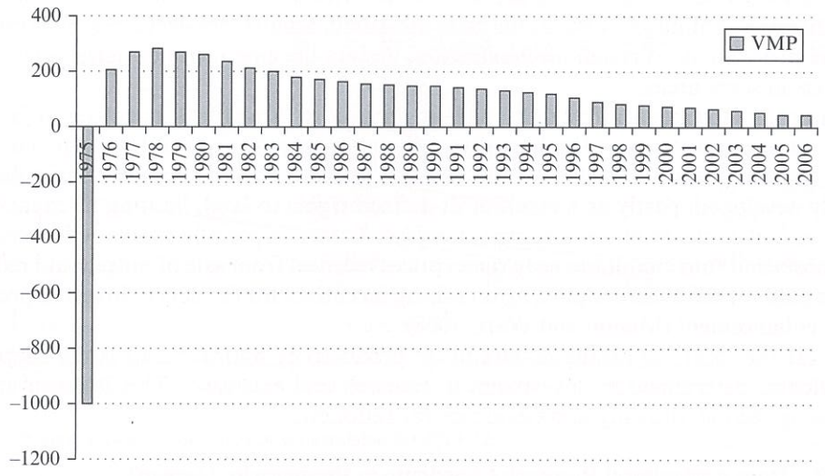
14.3.2 Does Agricultural Research Contribute to Productivity Growth?

Growth of total factor productivity (TFPG) has contributed significantly to output growth in Asian agriculture. There has apparently been a TFPG slowdown in recent years, especially for Asian countries other than China. Refocusing attention on what determines

TFPG in agriculture is thus important for understanding and sustaining long-term agricultural growth and thereby maintaining its contribution to reduction of real food prices.

This section looks at these issues within the context of Indonesia. It examines the extent to which agricultural research within Indonesia contributes to the enhancement of productivity growth, while controlling for other possible determinants of agricultural productivity growth, including international agricultural research, infrastructure investments, extension, weather changes and epidemics. The data used relate to the years 1974–2006. The results show that the expenditure on agricultural research had a significant effect on total factor productivity in Indonesian agriculture. The impact elasticity (percent change in total factor productivity from a 1 percent increase in research expenditure) is estimated at 0.0774.

Based on these econometric results a projection is made of the impact on total factor productivity within Indonesian agriculture of a 1 billion Rupiah increase in agricultural research occurring in the year 1975. The impact that this expenditure change has on the value of Indonesian agricultural output is estimated from the analysis, extending over the three decades following the initial investment. The results are depicted in Figure 14.7 below. The figure shows the initial investment cost of 1 billion Rupiah and the value of the subsequent stream of additional output that this investment makes possible, all measured at constant prices. From this it is possible to estimate the real rate of return (at constant prices) from a marginal increase in investment in Indonesian agricultural research. The estimated annual real rate of return is 27 percent, well above rates normally required for public investments. It is concluded that Indonesia has vastly under-invested in this form of public expenditure and an increase is warranted. If means could be found to raise the efficiency of publicly funded agricultural research this would further enhance the case for increased public investment.



Source: Author's calculations.

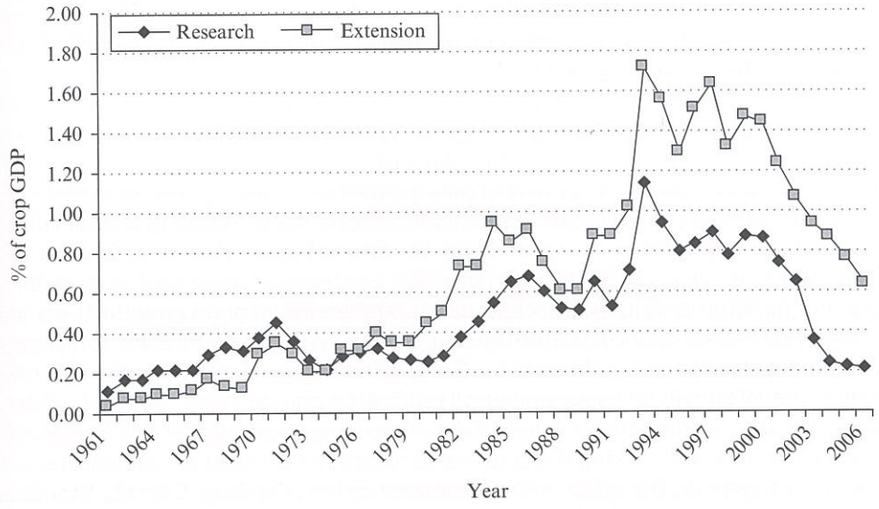
Figure 14.7 Estimated stream of effects, 1 billion Rupiah investment in agricultural research in 1975 (millions of Indonesian Rupiah, constant 1975 prices)

14.3.3 Declining Research and Extension Expenditures

In several countries, public investment in agricultural productivity has declined markedly. This is shown in the case of Thailand, in Figure 14.8 below. The figure shows research and extension intensities, which means expenditure on research and extension, respectively, expressed as a ratio of the level of crops' contribution to GDP, or the level of value-added generated in crop agriculture.

The decline since 2001 is especially notable. A significant policy story lies behind these data. Since 2001, successive Thai governments have not neglected rural people but have instead sought to benefit them, and win their electoral support, through transfers of public revenue that benefit rural people in the short-term rather than through investments in agricultural productivity that benefit rural people in the long-term.

The flow of new agricultural technologies emerging from the CGIAR agricultural research system has slowed. Renewed international commitment is urgently required. Investment is also needed in agricultural research within the developing countries themselves and in training the next generation of agricultural researchers, needed to maintain the momentum of productivity growth in agriculture over the coming decades. The kind of research that is most needed is adaptive, taking the outputs of the international research establishments and modifying them to suit local circumstances. While fundamental agricultural research involves long lags before it produces benefits in the form of enhanced productivity, the adaptive research needed in developing countries pays off much more quickly. But commitment to it has declined alarmingly in many countries.



Source: Public research and extension budget from the Bureau of the Budget and agricultural GDP from the National Economic and Social Development Board, Bangkok.

Figure 14.8 Research and extension intensities in crops in Thailand, 1961 to 2006

14.3.4 Raising Post-harvest Productivity

Although international trade has an important role to play in the enhancement of food security, domestic trade is far more important. For example, in the extreme case of rice, only 2 percent of Asia's total consumption is traded internationally. The economic shape of the other 98 percent is changing rapidly, especially in the way food is marketed. Reardon et al. (2012) point out that a transformation is occurring in all three segments of the overall food value chain: upstream (farming and input supply), midstream (processing and wholesale) and downstream (retail). As a rough average, about half of the final price of food to the Asian consumer is estimated to arise at the farm level and the other half is accounted for by post-farm costs. Of course, these proportions vary considerably across localities and across commodities. The important point is that productivity is relevant at both farm and off-farm levels. Both affect food security by driving access to food because they determine the cost of food to the final consumer. Off-farm productivity is approximately as important for food security as farm level productivity, but receives far less attention.

Overall, the food supply chain revolution is capable of delivering benefits to both farmers and consumers, by lowering off-farm costs. The process is driven primarily by the private sector, but public policy has an important role to play. First, monopolistic practices must be prevented, through the maintenance of competition. Reduction of barriers to entry of new firms is an effective means of preventing the development of exploitative monopolies. Second, much of the private sector activity is dependent on the provision of public infrastructure. Reliable electricity supplies are necessary for cold storage. Road construction and maintenance opens new farming areas to possible participation in the supply chain revolution by reducing transport costs. Liberalization of foreign direct investment (FDI) restrictions facilitates the development of cost-efficient supermarkets and processing facilities.

14.3.5 Adapting to Climate Change

The 2007 report of the IPCC projects rising temperatures throughout the twenty-first century. The range of projected temperature increases is wide, reflecting scientific uncertainty and the dependence of the outcome on future human decisions. Nelson et al. (2009), Rosegrant et al. (2010), Knox et al. (2011) and several other studies, present evidence that Asian crop yields will decline, despite the beneficial plant growth effects of an increase in carbon dioxide concentration in the atmosphere. In South Asia, for example, the effect is projected as a substantial reduction in crop production by the end of the century. The effect will be larger on wheat yields than on rice yields, but rice yields are also projected to decline. Water run-off from upstream glacial sources will increase, but this will occur primarily during the monsoonal season, rather than the dry season, when the water is required. The effect will be increased risk of flooding. Overall, the climate is likely to become more volatile and less readily predictable. These worrying effects are superimposed on increasing demand for land from non-agricultural sources and the effects of land degradation.

Rosegrant (2012) reports the results of biophysical crop modeling studies that provide quantitative estimates of yield effects of expected climate change by 2050, compared with a no-change scenario. For irrigated rice the effect is a reduction of 14 to 20 percent, for irrigated wheat 32 to 44 percent, irrigated maize 2 to 4 percent, irrigated soybean 9 to 18 percent. The spread in expected yield effects is wider for rainfed crops, with the possibility of some positive effects, especially in more temperate regions. In Pacific island countries, significant yield reductions are expected in traditional staple crops, including sweet potato, taro and cassava.

Combining these results with economic modeling, Rosegrant projects an increase in food prices of about 20–70 percent by 2050. Compared with the no-change scenario, these price increases imply an average reduction in caloric intake in Asia of 13–15 percent. Childhood malnutrition levels, which are directly linked to caloric intake, are projected to increase from the 65 million in 2050, projected under the no-change scenario, to around 75 million with projected rates of climate change. Rosegrant concludes that aggressive investments in agricultural research, rural roads and irrigation facilities could eliminate about three fourths of the increase in childhood malnutrition that climate change will otherwise produce.

Timmer (2012) emphasizes that the effects of climate change will be highly variable, but may be largest in tropical and equatorial regions, with some increases in productivity in temperate regions. The effects are likely to include a net global loss of agricultural land, changing crop suitability, increased frequency of natural disasters, and greater temporal and geographic variance in production. Given the geographical heterogeneity of expected effects and the scientific uncertainty surrounding them, Timmer emphasizes the importance of flexibility in the policy adaptation to climate change.

14.4 ENHANCING FOOD SECURITY THROUGH INTERNATIONAL TRADE

International trade plays an important role in promoting the food security of importing countries and, through earnings of foreign exchange, in promoting the economic development of exporting countries. But international markets can also be sources of instability in access to food, provoking policy responses that can accentuate the very volatility of international prices that motivated these interventions. How can the volatility of international food prices be reduced?

In the absence of international trade, the costs of producing food would differ between countries. In those countries where food production costs are lower, international trade encourages expanded food production. In countries where food production costs are higher, production shifts away from food and towards other commodities. The former countries become exporters of food and the latter importers. The result is a global lowering of the costs of delivering food. But as the events of 2007–08 illustrate, these gains carry with them a vulnerability to short-term international price increases.

The international food price increases of 2007–08 had significant effects on the way food security is perceived. In Asia, the overwhelmingly important staple is rice, although wheat is also important in some areas, especially in parts of South Asia. The thinness of the international rice market exacerbates its volatility and limits the capacity of the international market to buffer the effects of periodic disruptions to supply in individual countries (Gilbert, 2011).