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Department of Agricultural & Applied Economics

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Food Insecurity and Its Determinants in Asia and the Pacific

By

Douglas Southgate and Ian Coxhead

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FOOD INSECURITY AND ITS DETERMINANTS IN ASIA AND THE PACIFIC[1]

Douglas Southgate
Ohio State University

Ian Coxhead
University of Wisconsin

Abstract

In Asian-Pacific developing countries, the prevalence of food insecurity has diminished dramatically in the past generation. Despite this, many millions continue to suffer from persistent or periodic food insecurity. The causes of food insecurity are both structural and market-related, including influences of public policy on market operations. The most vulnerable populations are those that simultaneously experience both these forms of insecurity. The places they inhabit tend to have poor-quality land, are exposed to climatic and other environmental risks, or both. These same populations either have relatively weak links with the non-food economy, in which higher wages and better income-earning opportunities make food self-sufficiency less important, or are prevented from accessing opportunities in the non-food economy because of poor or misguided policies.

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1. Introduction

Food insecurity and poverty are intertwined and the alleviation of both is strongly correlated with overall economic progress. Nowhere are these linkages more apparent than in Asia and the Pacific. Other than during the financial crisis of 1997 and 1998, every large economy in the region and practically all the smaller ones have registered positive (and in many cases high) rates of expansion for more than two decades, the most notable exceptions being Myanmar, North Korea, and the Philippines (Southgate, Graham, and Tweeten 2007, pp. 229-231). Thanks to this expansion, tens of millions of people no longer suffer from severe economic deprivation. In East Asia and the Pacific, for example, the incidence of extreme poverty, defined using the World Bank's $1.25/day standard, fell from 79 percent of population in 1981 to 18 percent in 2005 (Chen and Ravallion 2008).

Major strides have been made toward food security as well. The FAO estimates that in 1969-71, 762 million people in Asia were undernourished. Despite population growth, that estimate fell to 722 million in 1979-81, 582 million in 1990-92, and 535 million in 1995-97. Estimates for 2003-05 indicate a slight rise, to 542 million. The countries experiencing increases between 1995-97 and 2003-05 were India (31 million), Indonesia (10 million), Pakistan (9 million), and the Philippines (0.5 million). All other Asian countries show a decline or no change (FAO 2008b).

To put the aggregate achievement into proper perspective, consider that, as recently as four decades ago, no part of the developing world had a higher prevalence of food insecurity than Asia and the Pacific. Indeed, the threat of famine in the region where more than half the human race lives was severe enough to provoke widespread despondency during the 1960s and 1970s. Environmentalist Paul Ehrlich, for one, concluded that many parts of Asia and the Pacific were beyond hope, and argued that continued food aid to countries such as India was futile (1968, pp. 141-149).

But notwithstanding the correlation between economic growth and reductions in *aggregate* poverty and hunger, progress toward food security has been far from uniform. As the above figures reveal, three of Asia's largest and poorest nations – India, Indonesia, and Pakistan – recorded increases in undernourishment between the late 1990s and the early 2000s and these increases exceeded the declines registered elsewhere in the region, such as in Bangladesh, China, and Vietnam. Even in countries that have experienced rapid economic expansion and noticeable declines in the overall prevalence of food insecurity, subpopulations that are chronically or periodically under-nourished still exist – precisely because these subpopulations have conditions or characteristics which prevent them from benefiting as the aggregate economy expands. Circumstances that combine to produce food insecurity include poor land quality, exposure to environmental risks, and isolation from labor and other markets. Gender inequality can also interfere with adequate nourishment, not only for women but also for their children.

This paper's assessment of food insecurity in Asia and the Pacific is predicated on a definition of the problem that is consistent with the FAO's declaration that the goal of ending hunger around the world will have been achieved "when all people at all times have physical, social, and economic *access* [emphasis added] to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002, p. 49). In addition, our diagnosis of the causes of food insecurity draws on a framework offered by Nobel-laureate economist A.K. Sen. In his 1981 book, *Poverty and Famines*, Sen proposes two broad

categories of the causes of food insecurity, one being *structural* and the other *market-related*. The first sort of insecurity has to do with one's incapacity to *produce* enough sustenance on one's own. In contrast, market-related insecurity arises when a household, region, or country that may have structural food insecurity is also unable to *exchange* its own output or assets (including labor) for sufficient food.[2]

As recent trends in Asia and the Pacific demonstrate, various processes – including population growth, the development of new agricultural technologies, environmental degradation, etc. – exacerbate or alleviate structural food insecurity. By the same token, a wide array of policies and institutions influence the terms of market-based exchange between people at risk of going hungry and other economic actors. As these policies and institutions change, market-related food insecurity is affected.

2. Structural food insecurity

Structural food insecurity results because land, labor, and complementary productive resources at the disposal of a household, region, or nation are not adequate to produce all the food it needs. One possible reason might be land scarcity. But structural insecurity can also be a consequence of technological backwardness, the unavailability of non-land inputs, or climatic adversity, such as drought.

By definition, structural food insecurity exists for urban communities and even for entire nations (e.g., Singapore) which are very short of arable land. But whether or not the inhabitants of these settings actually experience hunger hinges on market- and policy-related factors. Indeed, the incidence of food insecurity is trivial if the non-agricultural output of urban areas can be exchanged for adequate amounts of food.

Structural food insecurity can also be a problem for rural populations located at the arable margin, such as drought-prone areas in western China and northeastern Thailand; high-altitude settings in the Himalayas and in the mountains that divide China from its southern neighbors; and coastal regions that are highly susceptible to typhoons, for example in the central Philippines and central Vietnam. For deficit areas such as these, structural food insecurity may be measured in terms of the number of months a population can feed itself from one year's output of rice. This statistic is often reported, from the household level all the way up to the national level, since rice is the staple cereal for most Asians and on average accounts for over 40 percent of daily caloric intake (Pandey 2008).

Structural deficits in the capacity for food production can change, sometimes quite dramatically in just a few years. Demographic expansion, for example, can increase population density in the countryside, thereby increasing the pressure on agricultural land. In contrast, improved human nutrition and health increase a population's capacity for productive work. Also, the introduction of new agricultural technologies, such as high-yielding varieties of grain, alters the productivity of land – as do irrigation, drainage, and other improvements in physical infrastructure, which almost always are paid for by government. Thanks to a steady flow of agricultural innovations from the international agricultural research system, including the

[2] Sen (1981) refers to these as "direct entitlement failure" and "exchange entitlement failure," respectively.

International Rice Research Institute (IRRI), yield growth was sustained for about two decades beginning in the middle 1960s. Just as Ehrlich and others were declaring that Asia's fate was sealed, this Green Revolution was making possible major changes in farming practices throughout the region.

In the rest of this section, we survey the broad processes that have added to or diminished structural food insecurity in Asia and the Pacific. These include population and demand growth, the intensification of agricultural production and introduction of new technologies, and more recent stresses associated with environmental degradation.

A. Population and demand growth

Current problems of food security in Asia must be viewed in the context of population growth and economic expansion, both of which have direct impacts on food demand. Demographic increase in the region is decelerating, though still substantial. By world standards, economic growth has remained high in the best-performing regional economies and, with a few exceptions, has accelerated in those that embarked later on globalization and economic liberalization.

In 1950, Asia's population was 1.34 billion, equal to 54 percent of the global total. During the next quarter century, human numbers in the continent went up by 2.1 percent per annum, reaching 2.26 billion in 1975. During the next 25 years, annual growth was slower, averaging 1.7 percent. But there was less demographic expansion in Europe, North America, and other affluent regions, so Asia's share of the global population was larger at the turn of the twenty-first century than it had been 50 years earlier: 3.46 billion out of 6.06 billion, or 57 percent (UNDP 2002, pp. 162-165).

In Asia as in other parts of the world, dramatic declines in human fertility have been the primary reason for decelerating population growth. In China, for example, the total fertility rate (TFR) fell from 2.5 births per woman in 1980 to 1.8 births in 2006 (World Bank 2008b). If the latter rate, which is lower than the replacement level of 2.1 births per woman, is sustained for a few more decades, China's population will contract.

By no means is China the only Asian and Pacific nation to experience a reduction in human fertility. To the contrary, comparable declines have occurred throughout the region, falling to or below the replacement level in nearly every country where per-capita income equals or exceeds $3,000,[3] with a correction for purchasing power parity (PPP), and registering sizable reductions elsewhere.[4] Human fertility exceeds the replacement level in the world's second most populous nation, though not by much. After being equal to 5.0 births per woman in 1980, India's TFR has now fallen to 2.5 (World Bank 2008b).

Natural increase (defined as the difference between birth and death rates) will continue in Asia for a few more decades, although the specter of unbridled growth in human numbers has

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[3] Examples include Indonesia, Sri Lanka, and Thailand, with TFRs in 2006 of 2.2, 1.9, and 1.8 births per woman, respectively (World Bank, 2008b).

[4] Between 1980 and 2006, the number of births per woman fell from 7.0 to 3.9 in Pakistan and from 6.1 to 2.9 in Bangladesh (World Bank, 2008b).

receded in the world's largest and most populous continent. In various countries, including but not limited to China, growth in food demand is now driven less by demographic expansion than by the dietary diversification and improvement resulting from better standards of living.

Notwithstanding intra-regional variations and the impacts of periodic slow-downs, the general trend in Asia is one of increased household earnings. This affects what people eat in multiple ways. Whereas penurious households use most of their available resources to satisfy caloric requirements – usually by consuming the cheapest available carbohydrates – diets quickly diversify as poverty is left behind. More fruits and vegetables are eaten, for example, and protein intake increases. The most important consequence of improved living standards in Asia and the Pacific, not to mention other developing regions, is increased consumption of meat, dairy goods, and eggs. This in turn causes additional corn and other grains to be fed to cattle, poultry, and other livestock.

Table 1 shows current trends in human numbers and GDP per capita in various countries and, for some countries, income elasticities of food demand (i.e., relative growth in demand resulting from a 1 percent increase in earnings). This information can be combined to obtain simple estimates of annual demand growth, which are provided for some countries in the final column of Table 1.

[Table 1 about here]

Of the 14 nations listed in Table 1, Nepal is the only one where demand growth is mainly the result of demographic expansion. Elsewhere, including a number of countries where annual population growth exceeds 1.5%, growth in per-capita consumption (calculated by multiplying growth in average incomes by income elasticity) exceeds the rate of population increase. Although elasticity estimates are not provided for the two largest nations, improved living standards are undoubtedly the main driver of demand growth in China and India.

B. Agricultural intensification

As reported in Chapter 4, aggregate food insecurity in Asia has abated in recent decades. This has happened even though, as already indicated, human numbers and food consumption have been going up at a rapid clip. Moreover, increases in population and food demand, which have been outstripped by growth in the supply of edible goods, have not unleashed an unmeasured expansion of agricultural land use. The main reason for this outcome is the agricultural development taking place in Asia since the middle 1960s.

Recent changes in farming have been influenced in various ways by demographic and geographic realities. Since agriculture and civilization have such a long history in China, India, Java (Indonesia's most populous island), and other settings, population density is elevated in many parts of the continent. In addition, opportunities to increase crop and livestock production by expanding the geographic domain of agriculture are limited. Even where such opportunities exist (on some Indonesian islands for example) agricultural extensification (i.e., the expansion of cultivated area) has adverse environmental impacts, such as biodiversity losses that occur as farmers colonize tropical forests and other species-rich habitats. Between these environmental

impacts and the direct expenses farmers must incur to clear away trees and other vegetation, no major increase in agricultural land use is anticipated in the region (Fischer and Heilig 1997).

Elevated population densities have induced the kind of agricultural intensification characteristic of settings where land is in short supply. According to the hypothesis of induced innovation, agricultural development is accomplished by raising the productivity of either labor or land, whichever is scarcer. In places, such as Australia, where labor is scarce relative to land, mechanization (i.e., the substitution of implements and machinery for labor) is a basic feature of agricultural development. In contrast, a combination of land scarcity and labor abundance, which has been the fundamental reality in Japan since before the twentieth century and is the norm today in tropical Asia, encourages the adoption of measures to raise land productivity, including fertilization, irrigation, and biological improvement (Hayami and Ruttan 1985).

The Green Revolution, which got under way in many parts of Asia in the middle 1960s, is a classic illustration of an increase in land productivity induced by the relative scarcity of natural resource inputs to agriculture. This advance was made possible by research and testing carried out over many years with support provided initially by the Rockefeller and Ford Foundations and later by donor agencies such as the World Bank and U.S. Agency for International Development. Thanks to this research and testing, new varieties of rice and wheat were developed which produced more grain than traditional strains when fertilizer and irrigation water were applied to farm fields (Dalrymple 1985).

As indicated in Figure 1, improved varieties of rice and wheat were adopted very quickly in South and Southeast Asia. Something else to observe about the Green Revolution is that small farmers in favorable production environments adopted new technology about as readily as other producers (David and Otsuka 1993). In addition, the new technologies greatly increased labor requirements per hectare and per year (due to multiple cropping). As a result, more employment was created for the poorest of the rural poor, who generally lack land and earn their primary incomes through employment on others' farms. The greatest impact of the Green Revolution was to raise cereal yields – not just in Asia but, as is shown in Figure 2, throughout the world. With yields and output going up, food prices fell, including for people who otherwise would have starved (Dalrymple 1985; Southgate, Graham, and Tweeten 2007, pp. 110-111).

As reported in Table 2, fertilizer use and irrigation have continued to increase since the Green Revolution.[5] So have agricultural yields. There are just a few nations where crop production per hectare did not rise by at least 50 percent between 1980 and 2000. Among these exceptions are Malaysia and Sri Lanka, where yields already had reached high levels three decades ago. Another is Thailand, which is the world's leading exporter of rice and where fertilizer applications and irrigation are not high relative to regional norms. During the last two decades of the twentieth century, China, India, and Vietnam registered yield gains of 60 percent, 81 percent, and 114 percent, respectively.

[5] Application rates in China had climbed already to 149 kg/ha in 1980 and since then have risen above 250 kg/ha, which exceeds the rate in most affluent nations. Fertilizer use in India, Indonesia, Pakistan, Thailand, and a number of other countries also rose from 65 kg/ha or less to 100 kg/ha or more. Meanwhile, the irrigated share of cropland was increasing in many places. This share declined in China and Indonesia, not because fewer hectares were being irrigated but instead due to the geographic expansion of rain-fed agriculture. Almost everywhere else, a larger percentage of arable land is irrigated today than was the case in 1980 – even in Pakistan, where little more than one in every four hectares planted to crops was rain-fed three decades ago.

[Table 2 about here]

Thanks mainly to yield growth, agricultural output increased faster than human numbers during the last three decades of the twentieth century (Table 3). Exceptions to this trend include roots and tubers in China and neighboring nations and corn, millet, and pulses in India and the surrounding region. In addition, fruit and vegetable production went up at a very fast rate, in response to the dietary diversification resulting from improved living standards, although more because additional land was planted to these commodities than because of yield growth. However, output of rice, which is the staple crop throughout Asia, went up faster than population mainly because of yield increases, during as well as since the Green Revolution.

[Table 3 about here]

Land productivity gains during the Green Revolution were instrumental in reducing structural food insecurity in Asia. Will these gains continue into the future? Though no prediction can be made with certainty, future yield growth faces two easily identifiable threats. One of these is environmental damage, including land degradation. The other is the diminishing rate of technological innovation, resulting in part from reduced budgets for agricultural research and development.

Each of these threats is examined in the sub-sections that follow.

C. Environmental degradation

Addressing the structural causes of food insecurity through supply-side interventions – such as infrastructure improvements, irrigation development, and technological innovation – is necessary for eliminating food insecurity, but not sufficient. This is so partly because the productivity of agriculture's underlying resource, which is land, does not remain constant under conditions of intensive production. Furthermore, as emphasized in the next section of this paper, economic conditions must also be right for production and productivity to grow, in response to additions to productive capacity.

Land degradation is analogous to technical deterioration. In other words, it is the converse of land-saving innovations associated with the Green Revolution. Continuous and intensive cultivation, especially of a single crop, without compensating investments in the maintenance of soil fertility and health can reduce cereal yields, even in well-managed settings such as experimental plots at the International Rice Research Institute (Cassman and Pingali 1995). Salination, soil compaction, lower water tables, and other broad environmental changes are other important agriculturally-related sources of productivity loss in some areas. Thus land degradation, and specifically the loss of soil productivity due to agricultural intensification, has offset some of the structural food security gains of the Green Revolution.

This form of environmental degradation is mainly local in nature. The most influential assessment of global land degradation suggests that 5 to 6 million hectares of farmland

(equivalent to 0.3 to 0.5 percent of the world's arable area) are lost permanently each year due to human-induced land degradation (Oldeman *et al*. 1991). Soil quality on three quarters of the world's agricultural land has been fairly stable during the last 50 years, but on the remaining share degradation is widespread and has accelerated. Productivity has declined substantially on about 16 percent of agricultural land in developing countries – primarily at the margins of cultivation, especially desert fringes and in steeply-sloped and high-altitude settings (Scherr 1999). Tropical Asia has been less affected than other low-latitude settings, however (Coxhead and Øygard 2008).

How does environmental degradation interact with food insecurity? At the household level, poverty and environmental degradation go hand in hand. The food-insecure discount the future very heavily, and lack the resources necessary to design and apply sustainable practices. In Asia, extreme poverty (and thus food insecurity) is most prevalent among remote rural populations, frequently ethnic minorities that lack resources as well as opportunities to participate in the wider economy. These populations are thus more dependent on their own production, but at the same time must depend on mountainous soils that are low in nutrients and that are easily leached and eroded. To summarize, land degradation, vulnerability to crop losses, and food insecurity are all part of a web of chronic marginalization and poverty.

Agricultural intensification itself has had mixed environmental impacts during and since the Green Revolution. Thanks to higher yields in established lowland settings, encroachment on forests and other natural ecosystems by food cultivators has been largely arrested. Indeed, it is no exaggeration that tropical forests in most of Asia (not to mention many other parts of the world) would now be spoken of in the past tense had the Green Revolution not made possible the cultivation of more crops per year of higher-yielding cereal varieties on existing land. [Of course, this has not forestalled continued deforestation due to unsustainable timber extraction and the production of oil palm and other industrial crops (see, e.g., Curran *et al*., 2004).] But balanced against the undeniable benefit of slower deforestation are some of the negative consequences of raising crop yields by relying more on chemical inputs and irrigation. The limits of that strategy for agricultural intensification are indicated by a study from the Philippines, which found that the value of additional rice harvested due to the application of pesticides may be exceeded by the costs of poor health suffered by farmers and others exposed to that input (Pingali *et al*. 1995).

Agricultural intensification also has had far-reaching consequences for hydrologic resources. Throughout the developing world, crop and livestock production accounts for all but a small portion of overall water use. In East and Southeast Asia and the Pacific, agriculture's share is 81 percent, compared to 14 percent for industry and just 5 percent for households. The corresponding shares in South Asia are 94, 3, and 4 percent, respectively (World Bank 2008b).

There is no doubt that agricultural pressure on hydrologic resources is excessive. One reason for this is market failure, which occurs if growers do not fully internalize the environmental costs of crop and livestock production. For example, chemical inputs that are not absorbed by crops or fixed in soil are apt to find their way into rivers, lakes, and the sea. The economic consequences of pollution caused by this run-off, which might include fish kills and increased expenditures on water treatment, are not taken into account by farmers. As a result, they tend to apply too many chemicals and use too much water. These problems have reached extreme proportions in Central Asia, in part because water mismanagement in one country imposes costs on its downstream neighbors.

Market failure is not the only reason for the waste and mismanagement of hydrologic resources in the agricultural sector. In many places, it is not even the leading explanation. To promote agricultural intensification, a number of governments subsidize irrigation – and not by a little, but by a lot. All too often, the payments made by farmers fall short of the recurring costs of operating and maintaining canals, pumping stations, and other infrastructure needed to channel water to their fields. When this occurs, irrigators make no contribution whatsoever to the amortization of capital expenses, which are considerable. With prices thus distorted, farmers have little reason to adopt conservation measures. Indeed, water use by farmers has become so excessive that additional irrigation development is now constrained by the resulting conflicts over resources between agriculture, on the one hand, and industry and households, on the other (Rosegrant, Cai, and Cline 2002). Irrigation runoff has its own environmental effects as well, contributing in some areas to increased salination.

While abundant water (where available) has helped to achieve and maintain gains from the Green Revolution, the subsidies implicit in providing water to farmers at prices that are far below costs are classic examples of policy failure.[6] But these are not the only examples in Asian agriculture. As in a number of countries, the Indian government provides fertilizer to farmers at below-market prices. Furthermore, nitrogen (from urea and other sources) is particularly cheap relative to phosphorus and potassium. In response, Indian farmers apply too much of the first nutrient and too little of the second and third. Accordingly, crop growth is held back by the limited availability of phosphorus and potassium and the returns to nitrogen applications are diminished. It is estimated that a switch to more balanced fertilization, as agronomists recommend and as would occur if price distortions were eliminated, would cause annual production of rice and wheat to increase by 160 million tons and 25 million tons, respectively (Roy 2003, cited by Southgate, Graham, and Tweeten 2007, p. 111).

Not all environmental risk is related to the actions of farmers. In addition to on-site and localized degradation of land and water resources, tropical Asia could face increasingly severe environmental risks as the result of global climate change. Agriculture could be threatened in various ways. In Asia and the Pacific, one important manifestation of climate change may be the increased frequency of storms, which affect low-lying coastal and deltaic areas. The resulting impacts were exemplified in May 2008, when Cyclone Nargis and the storm surge it created caused salt water to inundate a large part of the Irrawaddy Delta, which is Myanmar's main rice-growing region. There were substantial losses of both production capacity during the 2008 growing season and stored rice from previous harvests, which increased vulnerability to hunger nationwide. Furthermore production capacity may be diminished in the future because of damage to infrastructure and the loss of farm machinery, draught animals, and resources for the purchase of seeds and fertilizer (FAO 2008a).

A second trend related to climate is rising sea levels, which are predicted to threaten some of the most productive (or potentially productive) food-growing areas in Asia and the Pacific. A rise of 50 cm, which according to some projections could occur by 2070, would inundate more than half a million square kilometers of coastal land in the region, mainly in the

[6] Efforts to address this policy failure, mainly through water-pricing structures, have had remarkably little success. One reason is that farmers' demand for water appears to be singularly unresponsive to price. Also, transaction costs are high and the barriers to water "smuggling" are relatively low (Molle and Berkoff, 2007).

Gangetic delta system spanning India and Bangladesh, the Irrawaddy Delta in Myanmar, Vietnam's Mekong Delta, and the Pearl River Delta in southern China. Other possible consequences of global warming include increased rainfall variability and yield reductions caused by heat stress.

D. Lagging research and development

There is no doubt that a key cause of improved food security over the past generation in Asia and the Pacific was the provision of a steady flow of productivity-enhancing agricultural innovations, starting, but by no means ending, with the Green Revolution. At a global summit convened in Rome in June 2008, UN Secretary General Ban Ki-Moon paid special attention to the need for continued support for agricultural research and development, and his assessment that current funding is deficient is consistent with all available evidence.

Public-sector budgets appear to have peaked during the 1980s (Pardey and Beintema 2001). During the last decade of the twentieth century, government funding held steady in affluent nations. Meanwhile, budgets fell in the developing world, presumably because government authorities regarded technological progress in agriculture as a low priority so long as food was cheap. Support for the activities of the international agricultural research centers also diminished. For example, the International Rice Research Institute, which was the source of most of the breakthrough gains of the Green Revolution in tropical Asia during the 1960s and 1970s, saw its budget fall in inflation-adjusted terms from $US55m per year in 1992 to under $US30m in 2004 (Otsuka 2005).

In the United States and a few other affluent nations where intellectual property rights are generally respected, private agribusiness firms spend large sums on agricultural biotechnology. This private investment substitutes to an extent for expenditures by the public sector benefiting crop and livestock production. The governments of three developing nations – Brazil, China, and India – also provide substantial support for research and development, including biotechnology. But elsewhere in the developing world, this support has dwindled to very low levels, as Pardey and Beintema (2001) emphasize.

Reflecting the consensus among specialists in agricultural development, Secretary General Ban has called for a renewed commitment to research and development. The "overall price tag for national governments and international donors," he states, "could exceed $15 to 20 billion annually, over a number of years" (Ban 2008).[7]

3. Market-related food insecurity

No matter what the aggregate rate of technical innovation is, and despite intensive use and conservation of land and other scarce resources, there will always be countries – and certainly subpopulations within countries – that are incapable of feeding themselves from their own

[7] Future improvements in agricultural technology depend on factors other than financial support. For example, conservation of biodiversity, which is particularly threatened in insular environments (e.g., remote islands in the Pacific Ocean), is also needed.

production. More than that, many of these countries and subpopulations should not be expected to do so. Having made this observation, we turn to the second set of causes of food insecurity, broadly defined as being market-related.

The concept of market-related food insecurity captures factors governing the terms of trade (i.e., the relative prices at which exchange takes place) between food-deficit households, areas, or economies, on the one hand, and the outside world, on the other. The term "market" is used here in the broadest possible sense. Aside from the operation of markets as conventionally understood, it includes the *failures* of markets, such as when insurance cannot be used to cover the risks resulting from lost crops or associated with price variability. Also included are explicit governmental actions that influence or even supplant market operations through the deployment of instruments such as trade and pricing policies and the involvement of state instrumentalities in food production, storage, and distribution. Market-related food insecurity is complementary to structural insecurity in the sense that the former is a challenge for households, regions, or countries that cannot achieve structural food security, and are thus bound to be net food buyers.

The concept of market-related food insecurity is best understood, and the main issues outlined, by considering a hypothetical poor household that suffers from chronic structural food insecurity. To simplify, suppose that labor is the only resource that the household, which is a net buyer of food, can supply to the market in exchange for food and other goods. The terms of trade between this household and the market can be described by the ratio wL/CPI, where w is the wage earned per hour of effective labor (L) supplied by the household and CPI is the relevant consumer price index.[8] CPI serves as a deflator for converting nominal (e.g., dollar) earnings into a measure of purchasing power. Thus, the same ratio, wL/CPI, defines real income (Y) for most households, although Y for households receiving transfers (T) equals $(wL+ T)/CPI$.

Key influences on purchasing power having been identified, we now consider dynamics of the market-related food insecurity. An arithmetic conversion of the expression for Y provides its equivalent in percentage growth form, in which the symbol, Δ, refers to the year-on-year growth rate of a variable (so, for example, ΔY represents the growth rate of Y) and S is the initial portion of total nominal income derived from labor earnings:

$$\Delta Y = S(\Delta w + \Delta L) + (1 - S)\Delta T - \Delta CPI.$$

For the individual household, purchasing power (and by extension food security) is increased by higher wages offered in labor markets, by an increase in its effective labor endowment, and by higher transfers. Conversely, purchasing power is diminished by increases in the prices of food and other purchased goods. Labor and wage changes have a larger effect on purchasing power when the initial share of labor earnings is large (i.e., the value of S is close to 1). Conversely, when labor force participation is not a sizable contributor to household income (i.e., S is close to zero), changes in transfer income gain in relative importance.

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[8] The weights attached to individual goods in this index are shares of the household's budget allocation. Thus, for example, if the 60 percent of the household's expenditure is on food and the remainder on non-food, then a 10 percent rise in the price of food, with other prices unchanged, would increase *CPI* (and thus reduce the household's real income) by 0.6*10% = 6%.

As indicated in the four sub-sections that follow, government policies may affect ΔCPI directly, for example through food subsidies or barriers to agricultural trade policies. Also, policies may affect Δw directly, perhaps through labor-market interventions. However, in developing countries the effects on w tend to be indirect, such as when foreign direct investment inflows raise labor productivity and bid up wages. Other interventions may augment the effective labor endowment, such as through provision of health and education services. Of course, ΔT is subject both to government policy influence and the actions of others (e.g., foreign aid programs) that target the welfare of the poor. Thus, in the context of a more real-world version of our simple framework, it is clear that economic growth and development policies exert multifarious influences on the capacity of households, communities, and nations that do not supply themselves with adequate food.

A. Markets and food insecurity

Even in Asia's food-exporting countries, households that are net sellers of food comprise a surprisingly small fraction of the population. Vietnam, for example, is the world's second largest exporter of rice. Yet even in the country's "rice basket" areas, less than half the population sells more rice than it buys: 47 percent in the Mekong Delta and 45 percent in the Red River Delta (Glewwe and Linh 2008).

For those who do not produce enough food to supply their own needs, escape from food insecurity depends on the terms of trade at which they exchange their production (e.g., non-food agricultural output) or their assets (e.g., labor) for food and other basic wants. If these terms of trade are unfavorable, or move in an unfavorable direction, individuals or communities can exist in, or fall into, a state of food insecurity. Conversely, an improvement in the terms of trade, for example due to falling food prices or rising wages, can be a source of improved food security among the poor.

The physical conditions of agriculture, including infrastructure and technology, typically change quite slowly. Moreover, many food-insecure populations confront production conditions so adverse that technological and infrastructural improvements may still leave them unable to reach self-sufficiency. Under these circumstances, markets (and the institutions and policies that influence their operation) play a major role in determining who is food-insecure and for how long. Importantly, markets transmit the effects of macroeconomic growth (or of failure to grow) to food deficit areas and communities. The problem of food insecurity, like that of poverty, is frequently traceable to macroeconomic conditions and market failures rather than to chronic structural deficits. Sen noted that the Bengal famine of the early 1940s was one of flawed distribution, not underproduction. So did Ravallion (1987) in his seminal study of the 1974 famine in Bangladesh. During China's last famine, during the Great Leap Forward of 1958 to 1961, 20 million people or more died because of starvation or hunger-related causes while the country continued to sell grain on the international market (Short 1999, pp. 486-505).

B. Wages, labor, and migration

In the long run, the security of food supplies at every level of the economy can only be assured by guaranteeing that the purchasing power of the poor is adequate to cover food costs, and that markets and market-related infrastructure are in place to meet their demands in a timely fashion.

As labor is typically the most important economic asset of the poor, it is not surprising that labor markets are of singular importance as factors determining the escape from poverty.

In some ways, economic development can raise the productivity of rural labor *in situ*. The Green Revolution was an example of technological innovations with complementary investment (irrigation, etc.) that raised the productivity of on-farm labor. But more and more, growth occurring *outside* of agriculture is of the greatest importance for the welfare of the poor. Modern economic growth in many parts of Asia is increasingly characterized by urban and industrial job expansion. This induces internal migration, especially the movement of labor out of regions that tend to be structurally deficient or are routinely vulnerable to supply shocks. Myanmar, northeastern Thailand, central and western China, northern and north-central Vietnam, the central Philippines, and rural Java and large parts of Sumatra in Indonesia are all experiencing out-migration, primarily by workers who are rural, poor, landless, or land-deprived.

Migrants' principal motives may be negative (distress; displacement) or positive (opportunity). But since each of these motives results in the same action, it is very difficult to distinguish between the two. Often the best an analyst can do is to make inferences by examining outcomes after the fact – in particular, by assessing whether migrants are better off after the move than before. One proximate indicator is the existence and growth of employment opportunities in the destination. High or rising underemployment and unemployment, falling earnings, widespread labor exploitation, and other obvious signs of hardship among migrants are clear evidence of distress-related motives, and poverty and food insecurity in urban slums are no less severe for being in an urban setting.

For example, the slums and squatter communities that pervaded Manila in the 1980s and 1990s reflected both persistent anti-agriculture policies and sluggish growth for the economy as a whole, resulting in widespread economic and social dislocation and insecurity. In Asia's most deprived populations, especially in Myanmar and North Korea, cross-border migration is a gamble of utter desperation by those for whom staying home almost certainly means severe under-nutrition. About 1.5 million Burmese workers in Thailand have crossed the border to work in jobs that are "dirty, difficult, and dangerous" (not to mention degrading) and that pay only two-thirds of the wages offered to Thai workers (Kulkolkarn *et al*. 2007). In Vietnam, some of the migration in recent years has been distress-driven. This is especially true of women from rural areas whose circumstances have changed due to death of a spouse or divorce and who must relocate to find work to support dependent children, aged parents, or invalids (Kabeer and Tran 2000; GSO 2005). Similar experiences can be observed in many other Asia-Pacific economies. Thus, the aggregate growth success of most of the region's economies conceals pockets of poverty within which little progress has been achieved.

The departure of out-migrants has mixed effects at home. Certainly, there is a loss of labor, often the most productive labor. But offset against this is both a reduction in mouths to fed at home, which raises structural food security, and the flow of remittances (when it occurs), which provides an additional source of purchasing power and frequently helps insulate against unanticipated rural income shocks due to crop failures or agricultural price fluctuations. Migration also creates dynamic positive effects, as knowledge about other labor market opportunities flows back to the source population and enters the decision-making of future potential migrants (Phan and Coxhead 2007).

Opportunity-driven migration is clearly a more positive experience. Booms in the growth of export-oriented, labor-intensive manufacturing jobs in China, Thailand, Vietnam, and Bangladesh have created direct benefits for relatively poor populations located far away in those same countries – either by raising the wage offered for their labor or by increasing effective employment rates, measured in terms of hours worked per month (Manning and Bhatnegar 2004; Phan and Coxhead 2007). Under these circumstances, migration and economic growth are complementary, and both work to raise purchasing power and reduce income volatility for many poor people. Migrants in foreign-invested factories in the Pearl River delta, in Ho Chi Minh City, in Dhaka, and in many other locations throughout Asia accumulate savings and send home remittances that help to spread the gains from globalization through a much wider community.

However, even these relatively optimistic stories about the distribution of gains from globalization contain cautionary tales in which the very poorest households and communities are prevented from taking part in the general improvement of levels of living, frequently because their level of deprivation is such that they cannot afford to take the risky and costly step of sending family members out to participate in other labor markets. This is very often because they lack access to capital markets, as borrowed capital is often needed for the 'investment' of migrating (Jalan and Ravallion 2002; Coxhead and Phan 2008). In addition, government policies sometimes restrict internal migration, especially rural-to-urban migration. This is famously the case in China, where the *hukou* residence certificate, which has the effect of discouraging internal labor movement, has been at its most effective in limiting the mobility of the poorest households. By segmenting the labor market and preventing some would-be migrants from taking advantage of opportunities for urban-based employment, restrictions such as these act like a tax on rural earnings (Zhai and Hertel 2004).

Clearly, there is no single, generally applicable conclusion about the links between labor incomes and food insecurity. Distress-driven migration is *symptomatic* of poverty and deprivation, whereas opportunity-driven migration almost certainly contributes to its alleviation. Data on migration and remittances in Asia are incomplete, which impedes analysis.

C. Food prices

The other side of the purchasing power ratio defined at the beginning of this section is the price of food sought by poor households. Whereas higher wages and better labor productivity improve real income for food-deficit households, increases in food prices reduce it. From the Green Revolution until the early years of this century, the real price of rice (as measured by the deflated Bangkok export price) declined substantially. Between 1975 and 2002, it fell from about $US800/ton (in 2002 prices) to about $200/ton. This represents, on average, a very substantial improvement in purchasing power for populations that spend between one-third and two-thirds of total earnings on basic food items. During the same period, undernourishment (as a percentage of the population) fell in East Asia from 45 percent to 12 percent; in Southeast Asia from 39 percent to 12 percent; and in South Asia from 37 percent to 21 percent (see Chapter 2, Table 2.1).[9]

[9] Data for earlier years are available at http://www.fao.org/faostat/foodsecurity/index_en.htm.

Soon after the turn of the twenty-first century, however, the long decline in real food prices reversed. Having fallen to $200/ton in 2002, the price of rice in world markets began to climb, nearly reaching $700/ton during the first half of 2008. This and related food price trends, which have been dramatic enough to grab newspaper headlines and spur talk of a global "food crisis," also exceed the gradual increases that many economists forecast could happen, depending on future changes in demand and supply.

Some political figures have blamed recent price increases on speculators, even though no evidence has been provided that some person, group, or firm has been trying to "corner the market" (Young 2008). Accusations of speculation would be worth considering if there were no other explanation for recent price increases. But this is not the case – certainly not in the world's largest economy. The U.S. dollar has lost nearly half its value relative to the euro in recent years, falling from a peak of €1.15 in 2001 and early 2002 to €0.65 in early 2008. In light of this devaluation, is it any wonder that more dollars must now be offered in exchange for any given amount of food?

Another trigger for higher food prices has been the increase in oil prices. For a very straightforward reason, the latter increase is a direct consequence of monetary devaluation in the United States. International petroleum prices are always expressed in dollars and, as the U.S. currency has lost value, exporting countries have demanded more dollars for every barrel they supply. Expensive energy has affected the food economy in various ways, generally driving up prices of edible products. Certainly, production costs are sensitive to energy prices where agriculture is mechanized. But these prices matter even in settings where tractors and other machinery are rarely used. Chemical synthesis of nitrogen fertilizer, which has been a critical ingredient for yield growth, requires a lot of energy. So does the transportation of inputs and output. Even where crop production is un-mechanized, therefore, the cost of food rises and falls as the scarcity of energy varies.

Another linkage between energy and agriculture has to do with the search for alternative energy sources, which gains strength when conventional fuels are costly. Some of these alternative sources are agricultural, including the conversion of commodities such as sugar and corn into alcohol (or ethanol) as well as the production of biodiesel from palm oil. The European Union has set a goal that biofuels comprise at least 5.75 percent of all transport fuel by 2010 (Commission of the European Communities 2006). In the United States, the conversion of corn into ethanol is encouraged with import restrictions and subsidies, which cost the U.S. Treasury $7 billion per annum (Doornbosch and Steenblik 2007, p. 6). The effects of rising food and vegetable oil prices and the consequent conversion of agricultural lands on the world's poor have attracted substantial attention, with a leading UN official describing the diversion of land to oil palm as a "crime against humanity" (http://news.bbc.co.uk/2/hi/americas/7065061.stm).

Observing that "a moratorium on grain-based biofuels would quickly unlock these commodities for use as food," Joachim von Braun (2008) contends that "this measure might bring corn prices down globally by about 20 percent." also says that wheat prices would fall by 10 percent if biofuel development ceased (von Braun 2008). However, biofuel development is by no means the only cause of higher food prices. Export restrictions also have had an impact. According to the World Bank (2008a), more than thirty nations, including several with the potential to be major suppliers in international commodity markets, adopted export restrictions in late 2007 and early 2008. As a result of these restrictions, prices climbed even higher, to the detriment of food consumers everywhere.

The recent global rise in food prices is the joint outcome of yield slowdowns, diversion of land and cereals to non-staple food uses, export restrictions, and other interventions. Although hard data are not yet available, there is a wealth of informal evidence that rising food prices have pushed large numbers of Asia's poor and near-poor into higher risk of food insecurity, offsetting the positive effects of rising employment and labor incomes even in the fastest-expanding economies. For Asia's food-insecure populations, a "perfect storm" of purchasing-power failure looms, if the current global slowdown destroys jobs just as other factors retarding food supply growth keeps food prices at or near their current high levels.

D. Development policy interventions

Economic growth has indirect yet powerful influences on consumer welfare. At the aggregate level, purchasing power never improves, and often deteriorates, in the absence of sustained economic growth. Despite several decades of economic growth in most of Asia, some nations have not put in place the macroeconomic and other policies required for sustained economic expansion. Others, such as the Philippines, have achieved nothing better than anemic per capita improvements, accompanied by persistent high levels of poverty.

This is not the place to explore the reasons for aggregate growth failures in detail, although it is important to note a strong correlation between the degree of international economic integration and the potential for economic growth. Countries that have pursued strongly inward-oriented policies have experienced the least growth rates in per capita income, and now have the greatest levels of food insecurity and vulnerability to shocks. North Korea and Myanmar are Asia's most extreme examples of inward orientation, but low growth rates also have been recorded in other countries, such as the Philippines and India, during periods in which distortionary and persistent inward-orientation strategies have been pursued. During these periods, these countries experienced not only lower growth overall, but also in most cases diminished resilience to global macroeconomic shocks such as those occurring after the 1970s oil price rises and during the global recession of 1979 to 1981.

The Philippine economic collapse in 1984 to 1985 illustrates the dangers (Balisacan 2003). During a contraction of about 14 percent over the two years, poverty is estimated to have risen by at least 10 percent – a trend surely associated with a higher incidence of food insecurity through a loss of purchasing power on the part of the poor. Similarly, Thailand's adjustment during the same period (1981 to 1986) saw an increase in the number of poor people from 9.5 million (20 percent of the population) to 13.6 million (26 percent of population), and an increase in the average income shortfall of the poor (the poverty gap) from 27 percent of the poverty line to 35 percent (World Bank 1990, Table 3.3).

Explicit agricultural policy measures have also been highly influential in creating or lessening food insecurity. In contemporary Asia, the two countries with the greatest risk of starvation, North Korea and Myanmar, are both characterized not only by brutal and highly corrupt dictatorships, but also in the economic sphere by pervasive and extreme levels of intervention in the operation of markets, and of state actions that undermine the institutional basis for domestic production and trade in goods, services, and labor. As with the food policies prevalent throughout Asia in an earlier era, some of these interventions are intended, paradoxically, to ensure food security for part of the population – the urban part – by holding down food prices or otherwise suppressing markets for edible goods. Ironically, these sectoral

policies, if maintained for a long period, can very easily create hardship and even starvation in food-producing areas by depriving farmers of inputs, incentives, and even the discretion to choose appropriate agricultural techniques and methods. Myanmar is a tragic example of gross policy failure of this sort. Formerly one of the world's largest rice exporters, it is now one of the poorest countries in Asia and indeed the world, with high rankings on virtually all correlates of food insecurity. North Korea, which professes a state ideology of "self-reliance" (*juche*), has paradoxically gained the distinction of becoming the world's largest recipient of rice donations.

Elsewhere among nations where food security has been addressed in part through trade policy, less extreme interventions have delivered less in terms of long-term food security than might have been hoped for. The Philippines and Indonesia, which are the world's two largest rice importing countries, have both tried (and failed) to meet food security goals with policy packages that strive both to restrict cereal imports and to stimulate increased domestic supply (Coxhead 2000). More recently, China, which has its own history of failed interventions in domestic food production and trade, has taken actions that suggest a similar motivation. In 2006, national authorities, who obviously were equating food security and self-sufficiency, decreed the preservation of 120m ha of farmland in an effort to preserve food security (The Economist 16 October 2008). However, the two concepts are not only fundamentally different, but may be unrelated. Efforts to achieve the former are typically very costly, especially when the opportunity cost (of importing) is taken into consideration. Interventions in support of food self-sufficiency can undermine the operation of local markets, distort producer incentives, and increase susceptibility to domestic supply shocks when import responses are slow. While food crises such as the price surge of 2007 and 2008 may occasionally justify unusual measures, the record of large food importers in Asia indicates that striving for self-sufficiency may actually undermine efforts to achieve food security in the long run.

At the national level, transfers also matter. Food aid, a transfer is specifically relevant to our subject, is important for some large food-deficit economies. FAO data show that from 2000 to 2004 Indonesia received an average of 131,000 tons of rice food aid per year,[10] the Philippines 67,000 tons, Cambodia 26,000 tons, and North Korea a staggering 496,000 tons; the latter was equivalent to 71 percent and 47 percent of the Asian and world totals, respectively (International Rice Research Institute 2008).[11] Food aid is, of course, an after-the-fact attempt to alleviate existing food shortages and insecurity. However, long-term development assistance and development policy include many other forms of transfer that are intended to raise the purchasing power of the poor. Moreover, many transfers to food-insecure households do not take the form of food and do not necessarily emanate from government or international aid agencies. During the 1980s Philippine economic crisis, the proportion of households whose primary income source was transfers or other unearned income rose from 6 percent (1971, the closest comparable figure) to 18.3 percent in 1985, which was "the year of shared poverty in post-war Philippine history" (Rao 1988).

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[10] This figure does not include aid flows after the Indian Ocean tsunami of 26 December 2004.

[11] Authors' calculations from FAO data compiled by the International Rice Research Institute (http:irri.org/science/ricestat/data/may2008/WRS2008-Table15.pdf, accessed 4 November 2008).

4. Incidence of food insecurity by gender and within households

Great strides toward food security have been made in the world's most populous continent, although progress has been far from uniform. In East Asia and the Pacific, where two-fifths of the population were chronically or often hungry as recently as the early 1970s, the prevalence of food insecurity has fallen to approximately 10 percent. In contrast, this prevalence is much higher in India and neighboring countries.

Many studies suggest that the South Asian difference has to do in part with the direct and indirect impacts of gender-related discrimination. As Smith *et al*. (2003) report, "the extremely low status of women relative to men in South Asia compared with that in Sub-Saharan Africa is thought to compromise women's own health, the subsequent birth weight of their children, and the quality of care their children receive." This inequality, which is said to be commonly observable in practices such as allowing a household's males to eat before females, often causes women to go hungry. The prevalence of such practices may help explain why five out of every six Indian women are anemic – as opposed to two our of every five women south of the Sahara, where average earnings, educational attainment, access to clean water, and other indicators of well-being are all inferior.

IFPRI investigators Smith *et al*. (2003) find that the feminization of food insecurity has direct consequences for women's offspring. The birth weight of one-third of India's newborns is abnormally low; in contrast, the corresponding figure in Africa is one-in-six. Low birth-weight babies tend to have persistent health problems and their development is often impaired. This is why the percentage of children who are malnourished in South Asia (50 percent of 5-year-olds) is higher than in any other part of the world, including Sub-Saharan Africa (33 percent of 5-year-olds). The capacity of malnourished children for physical labor later in life can be reduced, and even their intellectual development can be impaired. Hence, childhood deprivation, which traces in part to gender inequality, ends up reducing the productivity of adult labor and therefore creates long-term structural food insecurity.

The same investigators concede that cultural factors have much to do with the problem they have studied. However, Smith *et al*. (2003) also argue for taking into account the gender dimension of food insecurity in programs for childhood nutrition, which attract considerable support. For example, reducing iron deficiency among women would help to lower the incidence of severely underweight newborns. This could be accomplished even if little were done (or, in the short run, little could be done) to change intra-household power imbalances between men and women, which Smith *et al*. (2003) document. Studies from India, Bangladesh, and Pakistan, which have been summarized by Quisumbing *et al*. (1995), all demonstrate that the nutritional status of women and men can be improved by rebalancing the gender allocation of resources, opportunities, and decision-making power within the household. A more recent study suggests that preference for sons in patrilineal systems systematically reduces nutritional status for girls because parents of girls will continue bearing children until the desired number of sons has been reached; therefore, girls will have larger numbers of siblings with whom they must share resources, other things equal (Jain 2008). There is a need for more research to disentangle "cultural" from other causes of gender-based inequality in nutritional and food security status, in South Asia and possibly elsewhere.

5. Summary and conclusions

We have examined the food situation in Asia and the Pacific by distinguishing between structural insecurity, defined simply as local or domestic production being exceeded by local or domestic consumption, and market-related insecurity, which arises when a household, region, or country is unable because of market or policy failure to exchange its own output or resources for sufficient food.

Structural food insecurity changes over time because of various processes, some in the agricultural sector and others having to do with the entire economy or population or with the natural environment. As we have documented, growth in food demand in Asia and the Pacific is no longer driven primarily by demographic expansion. Instead, this growth is mainly a consequence of improved living standards, which have caused per-capita consumption of livestock products and other edible goods to increase.

Since the 1960s, food supplies in Asia and the Pacific have grown faster than demand. Moreover, increases in crop and livestock output have resulted mainly from agricultural intensification, during and since the Green Revolution, and not because of agriculture's geographic expansion. However, the pace of yield growth has been slackening, partly because of environmental constraints on agricultural intensification and partly because of lagging support for agricultural research and development.

Food insecurity is influenced by the operation or failure of markets. Market-related food insecurity is complementary to structural insecurity in the sense that the former is a challenge for households, regions, or countries that cannot achieve structural food security – that is, are net buyers of food. Markets, moreover, are influenced by explicit governmental actions, instruments such as trade and pricing policies, and the involvement of state instrumentalities in food production, storage, and distribution. Used judiciously and in response to unexpected shocks, such as those that occurred in 2007 and 2008, these interventions may be effective at stabilizing food supplies and prices. But experience in Asia, as in other parts of the world, suggests that the effectiveness of intervention declines as it becomes more pervasive and longer-lasting.

In this paper, we have examined various ways in which market-related food insecurity is alleviated or exacerbated. An increase in the effective purchasing power of impoverished populations, whether resulting from an increase in earnings or transfers or from a decline in food prices, diminishes the incidence of food insecurity. Similar results are obtained by augmenting the effective labor endowments of those same populations, for example through the provision of health and education services. When economic opportunities in other settings draw migrants from impoverished areas, overall food insecurity improves. However, no such result obtains if hunger and desperation cause people to relocate to places where their economic prospects stand little chance of improvement.

Food insecurity was once endemic in Asia and the Pacific, but is now confined largely to specific subpopulations whose characteristics and conditions combine both to make them structurally food insecure and to depress their terms of trade relative to the rest of the economy. In some cases, identification of vulnerable populations requires intra-household analysis, focusing for instance on the status of women. In large measure, further progress toward food

security in Asia and the Pacific requires initiatives that target the needs of these populations. Development of agricultural technology well-suited to remote places where land quality is poor and where environmental risks are severe is a case in point. Alleviating nutritional deficiencies for women, both for their sakes as well as for those of their offspring, is another.

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Table 1 Growth in Population, Average Income, and Food Demand in Selected Asian and Pacific Nations in 2007

Country (ranked by average income)	Population Growth (%)	Growth in Per-Capita Income (%)	Income Elasticity of Food Demand	Demand Growth (%) *
Malaysia	1.66	3.97	-	-
Thailand	0.61	4.12	0.65	3.29
Philippines	1.87	5.34	0.66	5.39
China	0.62	11.20	-	-
Sri Lanka	0.30	6.47	0.70	4.83
Indonesia	1.15	5.10	0.69	4.67
India	1.21	7.72	-	-
Vietnam	1.22	7.17	0.73	6.45
Pakistan	2.11	4.16	0.72	5.11
Mongolia	1.06	8.70	0.77	7.76
Bangladesh	1.64	4.78	0.73	5.13
Laos	1.73	5.25	-	-
Cambodia	1.74	8.43	-	-
Nepal	1.67	0.80	0.75	2.27

* The formula for this calculation is: Δ demand = Δ population + [elasticity x Δ income per capita], where Δ denotes percentage growth. Missing from this definition is an interaction term, Δ population x [elasticity x Δ income per capita], which is of very small magnitude.

Sources: World Bank (2008) for population and income growth;
ERS-USDA (2003) for income elasticities.

Table 2 Rural Population Density, Fertilizer Use, Irrigation, and Cereal Yields in Selected Asian Nations, 1980 and 2000

Country (ranked by average income)	Rural Population Density in 2001 (persons/km^2 of arable land)	Fertilizer Use (kg/ha)		Irrigation (% of arable land)		Cereal Yield (kg/ha)	
		1980	2000	1980	2000	1980	2000
Malaysia	554	427	670	6.7	4.8	2,828	3,132
Thailand	326	18	112	16.4	27.1	1,911	2,654
Philippines	564	64	134	12.8	14.6	1,611	2,692
China	561	149	256	45.1	36.3	3,027	4,845
Sri Lanka	1,607	180	277	28.3	33.6	2,462	3,520
Indonesia	591	65	124	16.2	14.4	2,837	4,141
India	460	35	107	22.8	32.2	1,324	2,390
Vietnam	923	30	341	25.6	37.6	2,049	4,375
Pakistan	438	53	136	72.7	81.6	1,608	2,266
Mongolia	87	8	3	6.7	4.8	573	751
Bangladesh	1,228	46	166	17.1	49.6	1,938	3,312
Laos	495	4	11	13.1	18.2	1,402	3,140
Cambodia	274	5	0	5.8	7.1	1.615	2,178
Nepal	668	10	26	22.5	36.2	2,521	3,453

Source: World Bank (2008).

Table 3 Trends in Arable Land, Crop Yields, and Output, 1970 to 2000

East and Southeast Asia

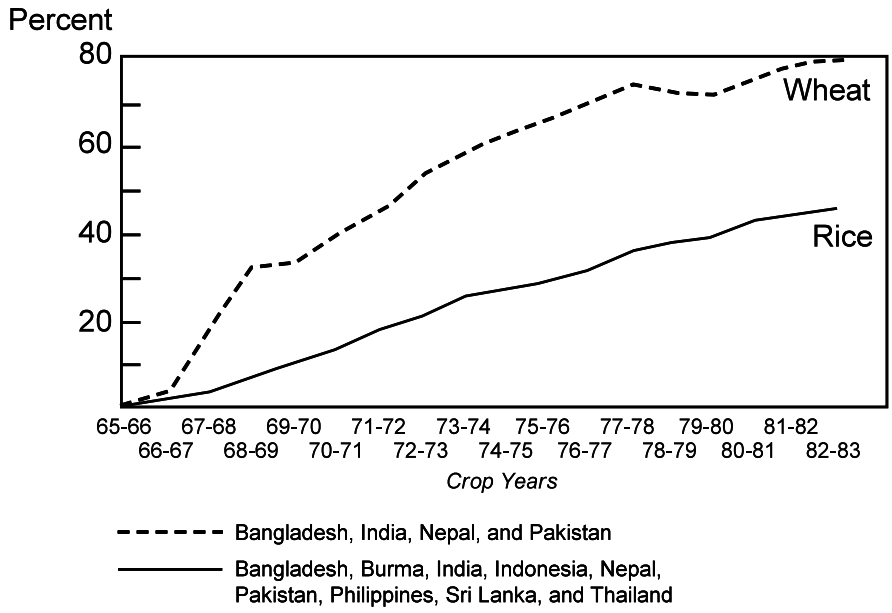
Crop	Production in 2000 (million tons)	Average Annual Growth of Arable Land (%)	Average Annual Yield Growth (%)	Average Annual Output Growth (%)
Rice	344	0.4	1.8	2.2
Vegetables	313	4.4	1.5	6.0
Roots and Tubers	239	0.1	1.2	1.3
Corn	127	1.0	2.7	3.8
Fruits	105	4.7	1.2	5.9
Wheat	100	0.1	4.0	4.1
Oil Crops	41	2.2	3.7	5.8
Other Cereals	15	-3.5	1.4	-2.2

South Asia

Rice	184	0.5	2.0	2.5
Wheat	98	1.4	2.8	4.3
Vegetables	71	1.7	1.2	3.0
Fruits	40	3.0	1.2	4.3
Pulses	15	0.3	0.2	0.5
Corn	14	0.4	1.0	1.6
Millet	10	-1.7	0.7	-1.0
Oil Crops	10	1.3	1.4	2.6
Sorghum	10	-1.6	0.7	0.5

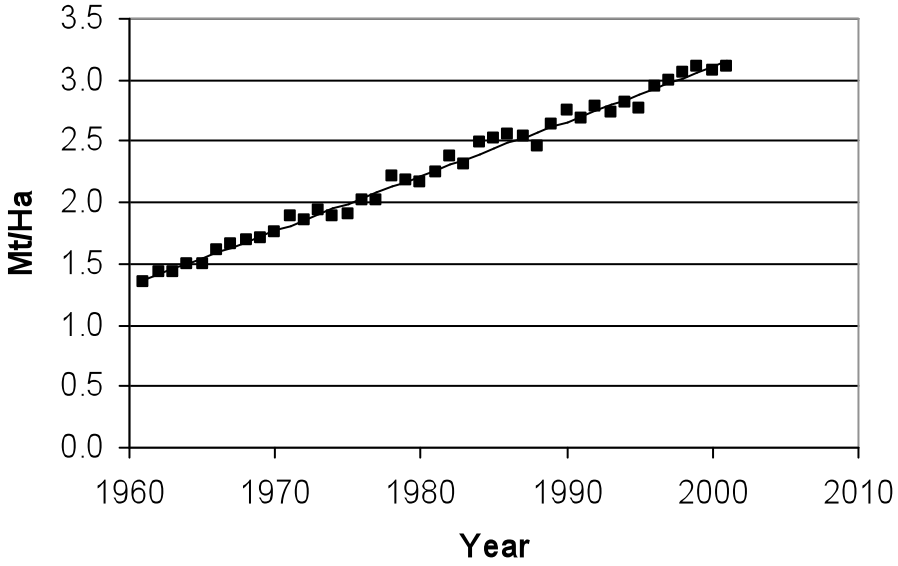
Source: Dixon and Gulliver with Gibbon (2001), pp. 182 and 228.

Figure 1 Area Planted to High-Yielding Varieties of Rice and Wheat in South and Southeast Asia, 1965-66 to 1982-83



Source: Dalrymple (1985), p. 1071.

Figure 2 Average Global Cereal Yield from 1961 through 2001



Source: Southgate, Graham, and Tweeten (2007), p. 58.