Chapter 18

Agriculture for development

TAKE-HOME MESSAGES FOR CHAPTER 18

1. Agriculture is a key sector for development at low levels of GDPpc, with the capacity to make important contributions to aggregate economic growth—through product, factor, and market contributions—poverty and hunger reduction, and the provision of environmental services.
2. The state of world agriculture shows that many countries have achieved success using agriculture for development, ranging from the Western experience to the Asian experience, and more recently China and Vietnam. Yet hunger is still with us, close to the billion-people mark, and many countries have failed to use agriculture for development to its potential, most particularly Sub-Saharan Africa and India in the last 15 years.
3. This neglect of agriculture has been due to a variety of causes, but important among them have been a focus on macro fundamentals with few sectoral concerns, descaling of the role of the state, and the use of transfers for poverty reduction as opposed to higher rural autonomous incomes. The recent food crisis and the continuing dominance of rural poverty in aggregate poverty are outcomes of this neglect.
4. Looking forward, agriculture has to face major challenges. Production will have to increase by 70 percent over the period 2005–50 in a context of competition for land with urban sprawl, falling agricultural productivity gains, demand for biofuels, climate change, and rising water scarcity. This has unleashed a competition for access to land at a world scale with potential high returns to investment in farming.
5. The theory of induced technological innovations explains the land-saving or labor-saving bias of technology in terms of changes in relative factor prices affecting public research priorities.
6. The gains from technological change accrue to consumers if food is non-tradable and to producers if tradable, with a corresponding product or land-market treadmill inducing the demand for new technologies.
7. Food security requires not only the availability of food but also continuous access to food, and proper use of food for nutritional achievements. Like poverty, food insecurity can be chronic or transitory. Governments can attack food insecurity through a vast array of market instruments and direct interventions.

AGRICULTURE FOR DEVELOPMENT

Seen from a long historical perspective, agriculture has been a (if not the initial) major development instrument for humanity. The Neolithic period, some 10,000 years ago, saw the birth of agriculture, which supported the first boom in world population. The dominance of Eurasian civilizations over others originated, according to Diamond (1998), in environmental endowments and technological advances supporting differentially high rates of productivity growth in agriculture. An agricultural revolution freeing labor from agriculture and providing food for a growing urban population was a precondition to almost every single successful industrial revolution (Bairoch, 1973). The recent accelerated-growth successes in India, China, Vietnam, Brazil, and Chile were importantly derived from the rapid growth of agriculture. Current difficulties in industrializing and accelerating growth in many parts of the world, from Sub-Saharan Africa to Yemen and Haiti, are in large part due to failure of these countries to achieve significant gains in productivity in agriculture, what has been called a Green Revolution. Two observations underscore the heavy costs of the failure of agriculture to grow. One is that 75 percent of the 1.2 billion people with incomes of less than a dollar a day are located in rural areas and are dependent for their livelihoods principally on access to land and the performance of agriculture. The other is the periodic return of global food crises that reflect the recurrent failure of agriculture to deliver enough produce to meet rising effective demand and to adjust to new production challenges. Growth failures in agriculture, and what it takes to induce successful agricultural growth, need to be better understood. This is all the more important given that the conditions for successful agricultural growth are both increasingly precarious (with rising land and water scarcity, as well as climate change) and markedly different today than they were in the past, as a consequence of globalization, the emergence of integrated food-value chains, new technological and institutional innovations, and environmental stress. Not only does better use need to be made of agriculture for development, but ways to do this in the current context need to be uncovered, and they will be different from those in the past, and for Africa compared to Asia. This poses a huge and fascinating challenge.

The role of agriculture for development is multidimensional: it can be an important source of growth in low-income countries, it is a source of livelihoods for half of humanity and can be a powerful instrument for poverty reduction, and it can be a source of resource saving for the other sectors of the economy and of environmental services such as carbon capture and biodiversity conservation (World Bank, 2007). We analyze each of these roles in turn. These multiple functions of agriculture for development imply that there will likely be trade-offs among them, as opposed to straight win–wins, and managing trade-offs implies the need to set priorities at the national level for how to best use agriculture for development in each particular country.

Agriculture as a source of growth

Agriculture can be a key source of growth for the rest of the economy at early stages of development, when the agricultural sector still looms large in employment of the labor force and in GDP (Mellor, 1966). The way in which agriculture helps the other sectors of the economy grow can be decomposed into the product, factor (capital, foreign exchange, and labor), and market contributions of agriculture. Agricultural growth can in turn have large multiplier effects in inducing industrial growth. Low-income countries typically have comparative advantage in agriculture more than in other, more institutionally demanding sectors.

Product contributions

The rise of labor productivity in agriculture allows farm producers to deliver a "marketed surplus" (defined as production above their own retention of product for consumption and factor use) to the urban environment where it can feed a labor force engaged in other activities. Hence it is the productivity of labor in agriculture that determines how large the urban population can be. An alternative way of seeing this is that greater productivity in agriculture helps lower the price of food, which in turn lowers the urban nominal wage (the cost of labor for industry) for a given real wage (the standard of living). This is particularly the case when food is largely non-tradable, as in India due to policy restrictions on trade, and in many Sub-Saharan Africa countries due to high transactions costs in reaching international markets. A lower urban nominal wage in turn raises the return to investment in industry and favors economic growth. This is the logic captured in the neoclassical dual-economy growth models seen in Chapter 8. Another product contribution is through forward linkages between agriculture and industry, whereby agriculture makes raw materials available to agro-processing and food value chains, allowing the expansion of these sectors (Hirschman, 1958).

Capital contributions

This is the so-called financial surplus of agriculture: namely, a monetary transfer out of agriculture that can be invested in other sectors of the economy, supporting their growth. The policy instruments through which these monetary transfers have taken place have differed by country and period of history.

Tax on agriculture, including a land tax

Imposing a land tax is how Japan mobilized a financial surplus to invest in industry following the Meiji restoration (1878–1917), fueling its industrial revolution (Ohkawa and Rosovsky, 1960). Rapid productivity gains had occurred in agriculture with the use of irrigation, fertilizers, and improved seeds. This allowed the state to raise a land tax on landlords, who in turn collected higher rents from the tenants working their lands. This land tax was so hefty that it contributed 85 percent of government revenues in the 1880s. These public revenues allowed the state to invest in infrastructure, technology development, and industry, prompting the emergence of a class of private industrial entrepreneurs. Clearly, productivity growth in agriculture was the mother of Japanese industry.

Imposing a tax on the raw value of the land (i.e. without improvements that would be deterred by taxation) has been a favorite of economists for a long time, in particular Henry George (1839–97) in the US. It has been called by Milton Friedman the "least bad tax" because it does not distort resource allocation as land is inelastic in supply, and it induces intensification of underused land to cover the tax. Yet, politically, raising a tax on land has proven difficult because of the power of the landlord class and because costs are immediate, while benefits are spread over a long period of time.

Confiscation of product and forced deliveries at a low price

Under Stalin, Russia in the 1930's collectivized agriculture, fundamentally as a way of gaining control over agricultural output and forcing collective farms to deliver a predetermined quota of production to the state, for subsequent sale as cheap food to urban workers. Forced deliveries, low prices to producers, and cheap food for urban consumers was how agriculture generated a financial surplus to support cheap labor for accelerated heavy industrialization. This model was implemented by Nasser in Egypt and Nehru in India, with cheap food obtained through forced deliveries sold in government-run fair-price shops.

"Invisible transfers" through the terms of trade turned against agriculture

Low food prices allowed the provision of cheap food to the urban sector and hence cheap labor to industry. This is how an agricultural surplus was extracted from agriculture in Latin America. Food prices were kept low through export taxes (e.g. in Argentina), eventual price controls, export bans, and mainly overvalued exchange rates under the import-substitution industrialization (ISI) strategy (see Chapter 10). Low food prices were the equivalent of a tax on agriculture, except that the transfer was "invisible" as it occurred through market transactions.

Foreign-exchange contributions

Foreign-exchange earnings are essential for industrialization as many capital goods, intermediate goods, and raw materials need to be imported. Agriculture has for most countries been the main source of foreign-exchange earnings. This was the case with coffee in Brazil, sugar in Cuba, cereals and beef in Argentina, fruit in Chile, tobacco in Malawi, cocoa in Ghana and Côte d'Ivoire, tea in Kenya, and rubber in Malaysia. Foreign-currency earnings must be channeled through the central bank, which can give low (overvalued) exchange rates to agricultural exporters to favor industrial importers of raw materials and capital goods. Export taxes on agricultural commodities have also been a major source of foreign-currency earnings for governments as they are easy to levy when commodities transit through harbors. Raising income taxes on individuals or value-added taxes on enterprises is much more institutionally demanding.

Labor and welfare contributions

The dual-economy models, both classical and neoclassical, stressed the contribution made by agriculture to industrialization in releasing labor from agriculture for industrial employment. This rural–urban migration of the labor force can originate in surplus agricultural labor (classical model), or in gains in labor productivity in agriculture, with a key role for technological change in achieving this result (neoclassical model). In Russia, the mechanization of agriculture (allowed by economies of scale in large collective farms, or *kolkhoz*) had the explicit purpose of substituting capital for labor in production, allowing especially young male labor to move to factories. Hence much of Russian agriculture was left in the hands of the male machinery operators and middle-aged female workers who remained in the *kolkhoz*.

There are two other less visible, but important, contributions of agricultural labor to industrialization. One is the human capital embodied in rural–urban migrants, with the cost of rearing, feeding, educating, and training the migrants paid by agriculture, while the benefits are captured by the receiving non-agricultural sector, a phenomenon identical to the cost of the brain drain for emitting countries in international migration. The other is "farm-financed social welfare" (Owen, 1966), where agriculture pays the cost of maintaining surplus labor and of providing safety nets to unemployed and aged households. A common phenomenon, for instance, is reverse migration during economic downturns, with rising urban unemployment and lack of safety nets for idle workers. An estimated 20 million unemployed Chinese urban workers returned to their villages during the financial crisis of 2008. With agriculture (and the urban informal sector) providing this safety-net function, urban employers and governments can save on the provision of social protection to the urban labor force, and maintain political stability in spite of the heavy social costs of a downturn.

Market contributions

Industry needs to find a domestic market for its products, either non-tradables or potentially tradables, until economies of scale and learning-by-doing reduce average costs to the level of the border price and enable entry to the international market. For this reason, the size of the domestic market has been key to the success of ISI strategies (as we saw in Chapter 8), and the market for industrial goods can be created by agriculture. This occurs through two types of linkage between agriculture and the other sectors of the economy (Hirschman, 1958). The first is backward linkages, whereby agriculture demands industrial products as intermediate goods for agricultural production. This includes factors of production such as fertilizers, tools, and machinery. The second is final-demand linkages, where incomes earned in agriculture and spent on non-agricultural consumption goods create a market for industry. This is the strategy of ADLI (agriculture demand-led industrialization) advocated by Adelman (1984). Rising expenditures from agricultural incomes drive industrialization by expanding the size of the domestic market for industry. This has been a powerful motive for redistributive land-reform policies and technological change for smallholder farmers. Mellor (1998) largely credited the mid 1960s Green Revolution in India with the subsequent growth of industry. China's current interest in land reform (allocating property rights over land to its current users) can be interpreted as an effort to expand the domestic market for industry among its 800 million rural households at a time when export demand is expected to decline due to slow growth in OECD countries.

Growth multipliers

Because of the numerous relations between agriculture and the other sectors of the economy, growth in agriculture can induce growth elsewhere. This is measured as growth multipliers. For instance, for China during the 1980–2001 period, estimated multipliers show that a US$1 growth originating in agriculture induced a US$1 growth in the rest of the economy, while a US$1 growth in the rest of the economy induced only a US$0.18 growth in agriculture (de Janvry and Sadoulet, 2010). Investing in agriculture thus has growth spillover effects in the rest of the economy. These growth multipliers of agriculture are believed to be larger in low-income countries, Sub-Saharan Africa in particular, because much of the industrial (agro-processing) and services (food-marketing) sectors are linked to the performance of agriculture (Christiaensen and Demery, 2007). Successful agricultural growth is thus seen as a potentially effective trigger of growth for the rest of the economy at the initial stages of industrialization.

Comparative advantage in agriculture

Many low-income countries have their comparative advantage in agriculture, making agriculture the priority sector for growth in an open economy (World Bank, 2007). There are three reasons why this is the case for most Sub-Saharan Africa countries. The first is factor endowments, due to the fact that many of these countries are rich in natural resources, with much growth potential in agriculture still to be captured, in part because of previous underinvestment. Sub-Saharan Africa has some of the lowest yields in the world, indicating both a huge challenge—namely, how to get yields to increase—but also a huge opportunity as there is probably no place in the world where current yields are further away from potential. The second reason is a weak business climate, with infrastructure and institutions that limit competitiveness in more complex manufacturing and high-value services, but are less constraining on agriculture and agro-industry. The third is the existence of large economies of scale in manufacturing that make it difficult for newcomers to enter the international market and which, again, are less binding on agriculture. Agriculture and its associated agro-industries thus offer comparative advantages in the short run, and a path toward industrialization via agro-industry in the longer run. For these countries, investing in agriculture can be the most cost-effective growth strategy toward industrialization and successful structural transformation (Mellor, 1998).

Agriculture as an effective instrument for poverty reduction

There is strong empirical evidence that growth in agriculture is particularly effective for poverty reduction. This is for the simple reason that most of the world's poor are in rural areas, where they are engaged in, or dependent upon, agriculture for their livelihoods. As we saw in Chapter 2, 78 percent of the world's extreme poor are rural and 63 percent of them work in agriculture. Its effectiveness in reducing poverty is an advantage that agriculture has over growth in other sectors; but agriculture has two disadvantages for poverty reduction. One is that it typically has a smaller share of GDP, meaning that growth in agriculture will have a lower weight in aggregate poverty reduction than that of a larger sector. The other is that growth in agriculture is typically lower than growth in non-agriculture. Even in China and India, countries with relatively good agricultural performance over a recent ten-year period (2003–13), average annual growth in agriculture was 4.5 percent and 4.1 percent respectively, compared with 11.1 percent and 7.2 percent in industry, and 10.7 percent and 8.9 percent in services. Whether agricultural growth is better for poverty reduction is thus an empirical issue. To address it, it is necessary to carefully account for the channels through which agricultural growth affects poverty.

Christiaensen *et al.* (2011) distinguish four channels through which agricultural growth may result in poverty reduction. Let P be a poverty index that can be P_0, P_1, or P_2. The rate of change in poverty can be written as an identity as follows:

$$\frac{dP}{P} = \left(\frac{dP}{P}\frac{Y}{dY}\right)\frac{dY}{Y}.$$

In this expression, Y is GDPpc and dY/Y is the rate of growth in GDPpc. The term in brackets is the elasticity of poverty with respect to income: namely,

$$E_P^Y = \frac{dP}{P}\frac{Y}{dY} = \frac{dP/P}{dY/Y},$$

which measures the degree of the pro-poorness of growth, what Christiaensen *et al.* call "participation." Poverty reduction is thus the product of a participation and a growth component as follows:

$$\frac{dP}{P} = E_P^Y \frac{dY}{Y} = \text{Participation component x Growth component.}$$

Decomposing GDP into agriculture (Y_A) and non-agriculture (Y_N) gives

$$\frac{dP}{P} = s_A E_P^{Y_A}\frac{dY_A}{Y_A} + s_N E_P^{Y_N}\frac{dY_N}{Y_N},$$

where s_A and s_N are the shares of agriculture and non-agriculture in GDP respectively.

Agricultural growth also contributes to growth in non-agriculture, and, reciprocally, what we can call indirect growth effects.

The channels through which agriculture and non-agriculture growth affect poverty can then be summarized in Figure 18.1.

There are four channels:

1. The direct growth effect of agriculture.
2. The indirect growth effect of agriculture on non-agriculture growth.

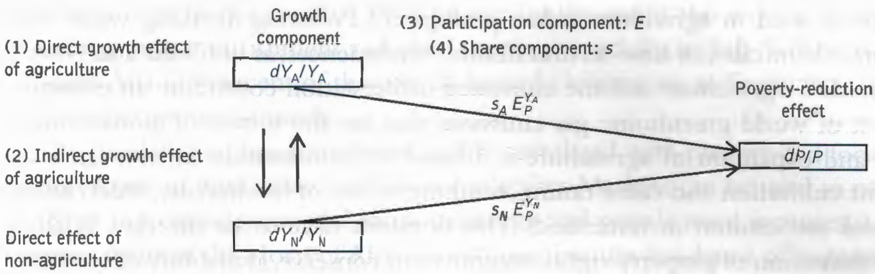


Figure 18.1 *Channels through which agriculture growth affects poverty*

Source: based on Christiaensen *et al.*, 2011.

3. The participation component measured by the elasticity of poverty with respect to growth.
4. The share component measured by the importance of agriculture in GDP.

Results show that agriculture has a larger indirect growth-multiplier effect than non-agriculture, ranging from 1.6 to 1.8 for Asia and 1.3 to 1.5 for Sub-Saharan Africa and Latin America and the Caribbean. This means that every one dollar of growth in agriculture induces another 60 to 80 cents of growth in non-agriculture in Asia and 30 to 50 cents in Sub-Saharan Africa and Latin America and the Caribbean. In low-income countries (mainly Sub-Saharan Africa), 1 percent GDP growth in agriculture induces three times more extreme-poverty reduction than a 1 percent GDP growth in non-agriculture. This result is driven by the much larger participation of poorer households in growth from agriculture. When the poverty line is at US$2 a day instead of US$1 for extreme poverty, it is the growth of non-agriculture that becomes more effective for poverty reduction. In middle-income countries, too, it is non-agriculture growth that is more effective for poverty reduction. In all cases, the degree of pro-poorness of growth increases with the degree of equality in the distribution of income. Thus the conclusion is that the growth of agriculture is very effective for poverty reduction at early stages of development, when income is low and poverty extreme, and this all the more so when inequality is low.

At higher levels of income, away from extreme poverty, other sectors become more instrumental for poverty reduction. Datt and Ravallion (2011) find that, while agriculture was most effective for poverty reduction in India until 1991, the growth of the service sector and urbanization, which pull people out of agriculture, have been the main drivers of poverty reduction since then. In Indonesia, Suryahadi *et al.* (2009) find that the service sector is the most effective, followed by agriculture, with no contribution coming from manufacturing growth.

Agriculture for resource saving and environmental services

Agriculture is a major user and frequent misuser of natural resources. For instance, while water is increasingly scarce for urban users, worldwide 80 percent of captured fresh water is used in agriculture, often profligately. Polluting drinking water with agricultural chemicals can have serious health consequences, as in China and Northern India. LDC agriculture and the associated deforestation contribute an estimated 25 percent of world greenhouse gas emissions that are the source of global climate change—and expansion of agriculture is a cause of deforestation as new lands are opened for cultivation and cattle raising, resulting in loss of biodiversity, local climate change, and soil erosion in watersheds. This does not have to be the case. With an adequate definition of property rights, incentives to conserve, availability of resource-saving technology, and effective collective action in using CPR, agriculture can be a major source of resource saving and of the provision of environmental services (Chapter 15). The farming systems of the rural poor can also be made more resilient to climate change, which is increasingly essential to their food security. Managing the connections among agriculture, natural-resource conservation, and environmental sustainability has become an integral dimension of how agriculture can be used for development. Productivity gains in agriculture for growth and poverty reduction, i.e. future Green Revolutions, particularly in Africa, need to be compatible with the rising constraints of resource saving and environmental sustainability. In other words, future Green Revolutions need to be "doubly green" (Conway, 1999), achieving yield gains in an environmentally sustainable fashion, a major constraint given that world food production will have to increase by another 70 percent over the next 40 years to feed a population projected to reach at least 9 billion in 2050 (FAO, 2008).

THE STATE OF WORLD AGRICULTURE

Hunger is still with us, even if large-scale famines have declined

The world food situation remains both unsatisfactory and precarious, in spite of the extraordinary successes of agriculture in keeping up with a growing population. The world food system is rapidly being transformed by deep structural forces, including globalization of the sources of food, the emergence of integrated food-value chains and supermarkets, rapid urbanization and income growth that lead to changes in diets toward high-value products, major technological and institutional innovations in production, rising energy prices (except in the recent period), and climate change (von Braun, 2007). With food prices rising sharply from 2006, access to food has become increasingly precarious for millions of poor people. Close to 1 billion people remain chronically undernourished, and this number has been rising in the context of the food and financial crises (FAO, 2008). This is one out of every six people in developing countries (17 percent), one out of three in Sub-Saharan Africa, and two out of three in the poorest countries such as Burundi. Undernourishment is particularly high, and devastating, for children (Gross and Webb, 2006): 26 percent of children in the world, 28 percent in Sub-Saharan Africa, 48 percent in South Asia, and 50 percent in Guatemala suffer from wasting. One third of deaths of children under the age of five, totaling some 3–5 million/year, is due to malnutrition, a human cost that could be avoided. Beyond death, malnutrition of children under the age of two has irreversible consequences for growth, health, and mental development. While the MDG 1 of halving poverty by the year 2015 will be met for the world, this is not the case for that of halving undernourishment and child wasting, especially in Sub-Saharan Africa and in South Asia (78 percent of the world's wasted children are in South Asia, in spite of successful economic growth).

The incidence of hunger is more highly correlated with poverty and food entitlements (access to food) than with food availability. Markets can be used to make food available, but countries need foreign exchange and people need income to access it. Famines recur in the Horn of Africa and Niger, but the incidence of large-scale famines has been curtailed, in part thanks to greater political competition and freedom of the press in exposing these events to national and world attention. Sen (1982) observed that large-scale famines could occur in pre-independence India (such as the 1943 Bengal famine, which killed between 1.5 and 3 million people) and in China during the Great Leap Forward (1957–62), which killed between 10 and 30 million people. However, there were no famines in post-independence India once freedom of the press and democracy could expose famines and make politicians accountable. This hypothesis was tested by Besley and Burgess (2002) using a panel of 16 Indian states over the 1958–92 period. They found that states with more active local media and more competitive local politics were more effective at responding to natural disasters (drought and floods) by organizing public food distribution.

While large-scale, geographically concentrated famines are increasingly rare, undernourishment still affects millions of dispersed people who may live next door to people who are not necessarily malnourished. Progress in reducing undernourishment has been uneven across regions. Figure 18.2 characterizes three dimensions of the problem: the percentage change in the prevalence of undernourishment between 1992 and 2012 (horizontal axis), the prevalence of undernourishment in the total

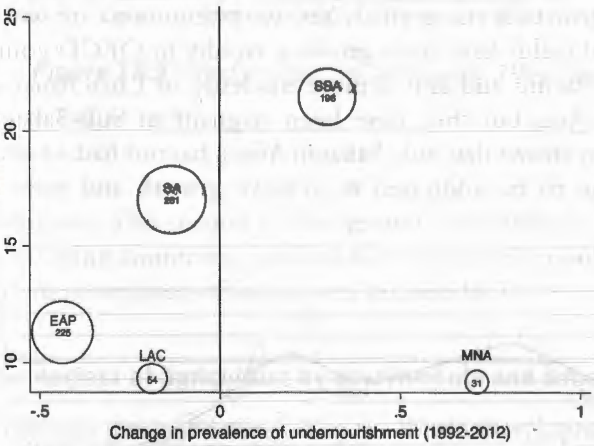


Figure 18.2 *Changing prevalence of undernourishment by region, 1992–2012 (percentage change), prevalence (percentage) and numbers (million) in 2012. Size of bubbles is proportional to millions of undernourished people in 2012*

Source: World Bank, *World Development Indicators.*

population in 2012 (vertical axis), and the number of undernourished in millions in 2012 (size of the bubbles). While the prevalence of undernourishment fell in East Asia and the Pacific, South Asia, and Latin America and the Caribbean, it increased in Sub-Saharan Africa and the Middle East and North Africa. The incidence of malnourishment remains high in Sub-Saharan Africa (22 percent) and South Asia (17 percent). The largest numbers of malnourished people are in South Asia (281 million), East Asia and the Pacific (225 million), and Sub-Saharan Africa (196 million). Malnutrition and hunger thus remain a huge problem, with inadequate progress relative to accepted goals and with high welfare and efficiency costs.

Productivity growth in agriculture, but uneven performances

The best indicator of the ability of agriculture to feed humanity is the real price of food grains. Remarkably, it has declined by 55 percent over the last century, from a smoothed index of 2.2 in 1900 to 1 in 2000 (Figure 18.3). This long decline was interrupted by price spikes during three cataclysmic world events: World War One, World War Two, and the Cold War, when Russia invaded Afghanistan in 1973 and the US imposed a trade embargo to use "food as a weapon." But this long-term decline notably came to an end in 2000, precipitating a food crisis in 2008, and a new era of rising prices and increased price volatility. As can be seen in Figure 18.4, these recent price events are closely associated with rising and highly unstable energy prices.

The performance of agriculture has been quite uneven across regions, with rapid growth in per capita food production in East Asia and stagnation or decline in Sub-Saharan Africa. Sub-Saharan Africa remains the only region in the world where food production barely keeps up with population growth (Figure 18.5).

With the availability of new land becoming rapidly exhausted, even in Africa where past output growth has basically been achieved via area expansion, the main source of agricultural output growth is rising yields. Yet two phenomena are worth noticing. The first is that cereal yields have been growing rapidly in OECD countries and in East Asia and the Pacific, and also, if more modestly, in Latin America and Caribbean and in South Asia; but they have been stagnant in Sub-Saharan Africa (Figure 18.6). This clearly shows that Sub-Saharan Africa has not had a Green Revolution, a major challenge to be addressed to achieve growth and poverty

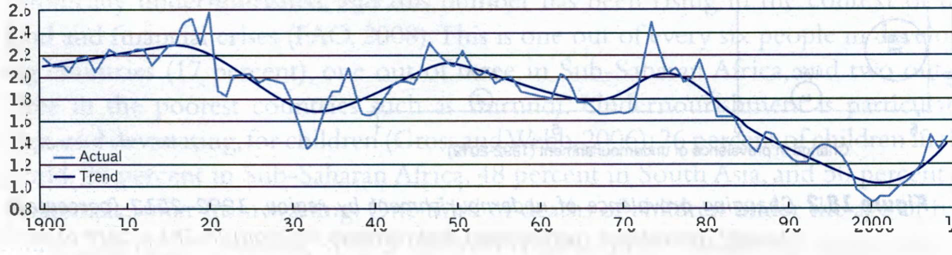


Figure 18.3 *International food real-price index, 1900–2010, 1997=100*

Source: IMF, *Commodity Price System* database.

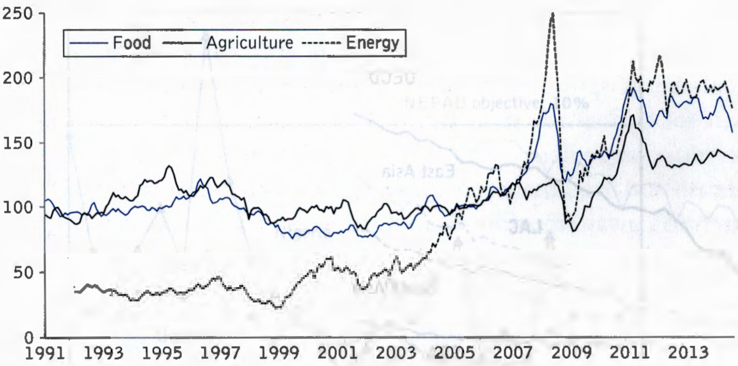


Figure 18.4 *Food-price spikes in 2008 and 2011 and increasing volatility. Monthly prices, 1/1991–9/2014, 6/2005=100*

Source: World Bank, *Global Monitoring Report.*

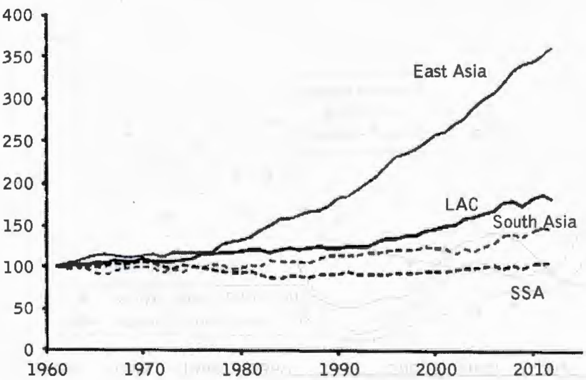


Figure 18.5 *Food production per capita, 1961–2012, 1961=100*
Source: FAO, FAOSTAT.

reduction. The second is that growth in yields has been declining since 1963 in developing countries, signaling the neglect of agriculture and explaining in part the recent recurrence of food crises (Figure 18.7).

The neglect of agriculture by governments and donors

The main message conveyed by the World Development Report 2008, *Agriculture for Development*, was the neglect of agriculture by governments and donors, starting with the stabilization and adjustment policies put in place by the Washington Consensus in response to the debt crisis of 1982. This happened in spite of evidence that agriculture can be a key source of growth for poor countries (see Chapters 3 and 8) (while growth was stagnating in Sub-Saharan Africa); that agriculture can be an effective

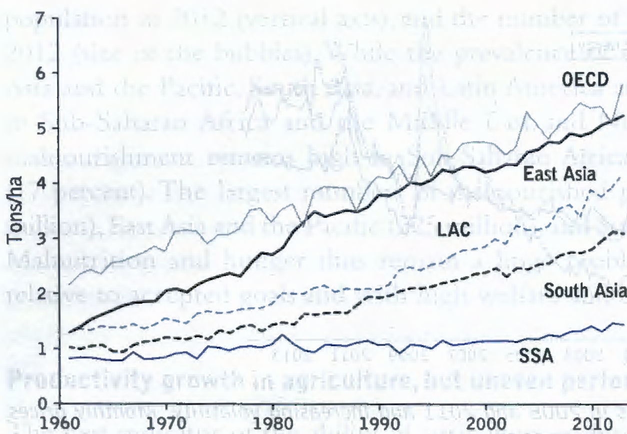


Figure 18.6 *Cereal yields across regions (ton/ha)*
Source: FAO, FAOSTAT.

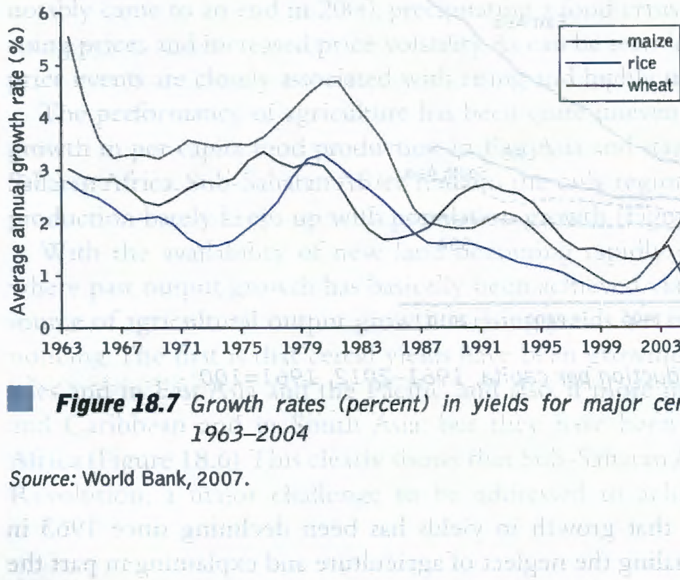


Figure 18.7 *Growth rates (percent) in yields for major cereals in developing countries, 1963–2004*
Source: World Bank, 2007.

instrument to reduce rural poverty (while MDG 1 was failing in Sub-Saharan Africa); and that agriculture can be a source of resource savings and environmental services (while it was absorbing 80 percent of captured water and contributing 20 percent of GHG emissions). The two most evident indicators of neglect are: (1) a declining share of agriculture in public expenditures (illustrated here by Uganda and Nigeria, where it is 4 percent of public expenditures) when African governments have agreed under NEPAD (New Partnership for Africa's Development, an African Union program) that some 10 percent of public expenditures should go to agriculture (Figure 18.8), which corresponds to the general level of expenditure in successful Asian countries when they were at a similar level of development; and (2) a declining share of agriculture in

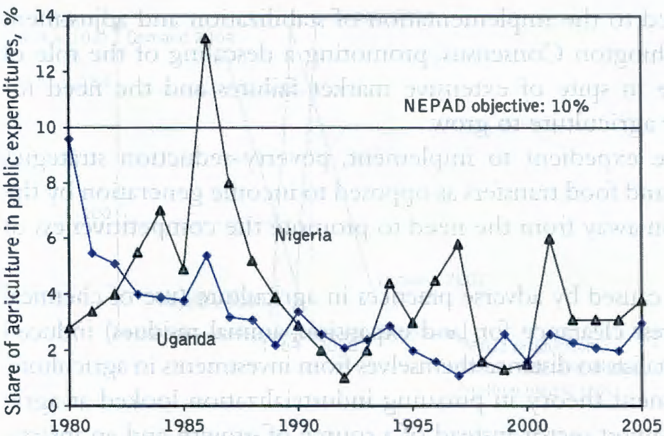


Figure 18.8 *The neglect of agriculture: share of agriculture in public expenditures in Nigeria and Uganda compared to the NEPAD 10-percent objective*

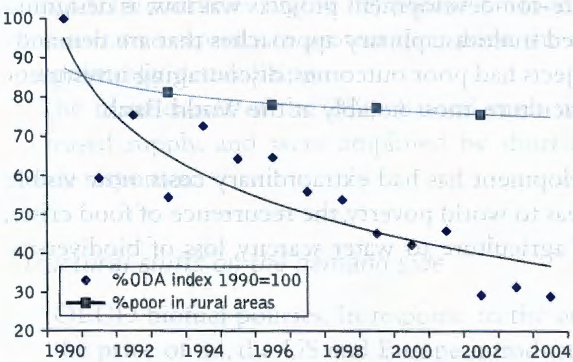


Figure 18.9 *The neglect of agriculture: share of agriculture in overseas development assistance (black line) compared to the share of rural areas in poverty*

Sources: OECD, ODA; World Bank, *PovcalNet*.

overseas development assistance, falling from 12 to 4 percent over the last 15 years, in spite of a steady 75 percent of world poverty being located in rural areas (Figure 18.9).

Why has agriculture been neglected by governments and donors over the last 25 years, with such heavy economic, social, and environmental costs? This is a heatedly debated issue, with much finger pointing. The following seven reasons make a compelling case.

1. Low and falling international commodity prices—due in part to extensive OECD farm subsidies (reaching the extravagant level of US$1 billion/day; see Peterson, 2009) leading to excess production and subsidized exports—discouraged investment in developing-country agriculture.

2. The 1982 debt crisis led to the implementation of stabilization and adjustment policies under the Washington Consensus, promoting a descaling of the role of the state in agriculture in spite of extensive market failures and the need for strong state support for agriculture to grow.
3. Because they are more expedient to implement, poverty-reduction strategies stressed the use of cash and food transfers as opposed to income generation by the poor, diverting attention away from the need to promote the competitiveness of smallholder farmers.
4. Environmental damage caused by adverse practices in agriculture (use of chemical fertilizers, pesticides, forest clearance for land expansion, animal residues) induced donors and environmentalists to distance themselves from investments in agriculture.
5. Misconceived development theory in pursuing industrialization looked at agriculture as a backward, sunset sector instead of a source of growth and an instrument for poverty reduction.
6. Ill defined roles for the state, the market, and civil society in agricultural development led to contradictions and inefficiencies, strongly constraining private sector investment in agriculture that was expected to replace declining public investment.
7. The rate of success of agriculture-for-development projects was low, as designing and implementing them required multidisciplinary approaches that are demanding in skills and time. Many projects had poor outcomes, discouraging investment and foreign-aid support for agriculture, most notably at the World Bank.

The neglect of agriculture for development has had extraordinary costs, now visible in the high contribution of rural areas to world poverty, the recurrence of food crises, and the unabated contributions of agriculture to water scarcity, loss of biodiversity, and climate change.

Why a food crisis in 2008?

It is shocking that there are food crises, with sharply rising and volatile prices, in our world today, in spite of globalization, integrated food-value chains, and remarkable technological and institutional innovations in agriculture. Why do they happen? A feature of food markets is that both supply and demand are quite inelastic in the short run: demand because food is an essential good, supply because it takes another season or two to respond to price incentives. As a consequence, relatively small movements in either supply or demand can have large price effects, especially if world stocks are low, as they were in 2007. This can be seen in Figure 18.10: between 2004 and 2007, world production of maize, rice, and wheat increased by 4.5 percent (from 1969 to 2058 million metric tons), while prices increased by 84 percent. The burden of food-price movements is largely borne by the poor. The food budget shares of poor people tend to be quite high, reaching 60–70 percent for the poorest, and rising prices can have very large welfare costs for them. In addition, the poor have a more price-elastic demand for food (say, –0.5) than the rich (near zero). They absorb a larger proportion of the quantity adjustment necessary for the market to balance supply and demand. The same happens between poor and rich countries, with the burden of imbalance in

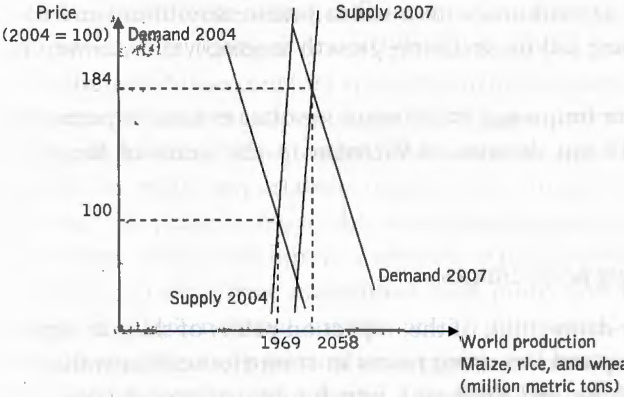


Figure 18.10 *World supply and demand for cereals, 2004 and 2007*

Source: FAO, FAOSTAT.

world supply and demand borne by the poor countries with more-elastic import demand. In countries highly dependent on food imports and with weak fiscal and administrative capacity to protect their poor, the consequences can be socially costly and politically destabilizing.

The main causes of the 2006–8 food crisis were factors that increased demand, decreased supply, and were amplified by short-run speculation and opportunistic policy responses.

Structural shifts on the demand side

1. OECD biofuel policies. In response to the energy crisis, with sharp increases in the price of oil, the US and Europe introduced mandates according to which 10 percent of fuel consumption has to be met by ethanol, while restricting imports of cheap sugarcane-based ethanol from Brazil. As a consequence, ethanol production absorbed 30 percent of US corn production, contributing importantly to the rise in price on the international market.
2. Rapidly rising incomes in large emerging countries such as China and India, inducing changes in diets toward meat and dairy products, and sharply increasing import demand for animal feed, particularly soybeans and corn from Brazil and the US.
3. Continued population growth.

Structural shifts on the supply side

1. High oil and fertilizer prices following the upsurge in petroleum prices pushed production costs upward in agriculture, as we saw in Figure 18.4.
2. A strong US dollar (weak domestic currencies), implying high prices in local currency units for countries that must acquire dollars to import commodities on the world market.

3. The long-term neglect of agriculture, with a fall in public investment and foreign aid going to agriculture, led to declining growth in crop yields, as we saw in Figures 18.8 and 18.9.
4. Climate change and greater frequency of extreme weather events, in particular droughts in Australia and crop diseases in Vietnam in the years of the food crisis.

Short-run responses amplifying price shocks

Low food stocks prevented any dampening of the impact on prices of shifts in supply and demand. Adverse policy responses to rising prices in countries such as India and Egypt, which imposed export bans, and Argentina, which imposed export taxes, also contributed to destabilizing international markets. And low interest rates induced speculative capital to move into commodity markets.

While prices have declined from their mid 2008 peaks, due in part to a global economic slowdown that contracted incomes and demand, prices are expected to remain high and volatile for the next 10–15 years. In October 2010, international rice and maize prices were respectively 80 percent and 100 percent above their 2005 prices. High and volatile food prices signal a continuing food crisis that governments need to address both through short-term policy responses (reduced import tariffs on food, social-safety nets to protect the poor) and medium/long-term investments in agriculture to supply the domestic market and generate incomes for the rural poor. Clearly, more attention needs to be given to the determinants of agricultural growth and to access to food for the poor if future food crises are to be avoided.

DETERMINANTS OF AGRICULTURAL GROWTH

Agricultural production responds to three determinants: price and market incentives, availability of sources of growth (technology, inputs, institutions, and public goods), and sustainability in resource use. We briefly review each, stressing in each case the development dilemmas involved and the corresponding policy implications.

Market and price incentives

Price policies

Empirical studies have shown that farmers are responsive to price incentives. This was a major contribution made by T.W. Schultz (1965), who showed that developing-country smallholder farmers are "poor but efficient." What he meant by this is that they are poor because they have little land, few other assets, and use a low-productivity traditional technology, but that they efficiently allocate the meager resources they control in response to price signals. For this reason, "getting the prices right" has been a concern in inducing agriculture to grow (Timmer, 1986). Yet in the short run, higher producer prices imply higher consumer prices, so there is a fundamental redistributive political-economy dilemma in setting the price of food. The historical outcome of this dilemma has been an "urban bias" in price setting against agriculture (Lipton, 1977). Krueger *et al.* (1991) have shown that, in 1980, agricultural taxation was often 40–50 percent for exportables in low-income countries, lowering the domestic price of food correspondingly. Today, agricultural taxation (on commodities such as sugar, cotton, cocoa, coffee, and tobacco) has declined to 19 percent in these countries, while importables (typically rice, maize) tend to be lightly protected, on average 10 percent above the world market price (Anderson and Martin, 2005). However, while developing countries have liberalized their agricultural markets, OECD countries have maintained high protection for their producers (30 percent above the international market price). This induces surplus production in these countries, depressing international prices, and hurting LDC exporters of commodities such as cotton and oilseeds. The Doha round of trade negotiations, under the leadership of the WTO, was expected to press the OECD countries to liberalize their agricultural markets, but they have to this day failed to progress. To reduce the negative impact of their farm policies on developing countries, OECD countries have "decoupled" support for their farmers from production by replacing commodity-price support by direct income transfers. In theory, income effects, as opposed to commodity-price support, should be neutral on production; but it isn't, as it reduces risk and liquidity constraints on producers when there are insurance- and capital-market failures (which there always are), creating incentives to produce more. Clearly, progress needs to be made in the Doha trade negotiations to open OECD agricultural markets to developing-country farmers if prices are to create undistorted incentives to invest in agriculture.

Agricultural markets

In recent years, food markets have been deeply transformed by the development of integrated value chains and the "supermarket revolution" (Reardon and Berdegué, 2002). As can be seen in Figure 18.11, food value chains integrate input producers, farmers, intermediaries (traders, wholesalers), agro-processors, retailers, and consumers into complex relations that allow exchange of information, support contracts, provide financing, define and enforce sanitary and phytosanitary standards, encourage risk sharing, and finance research among private actors. These relations are facilitated along the value chain by business enablers that provide financial services, telecommunications, transport, and energy sources to actors in the value chain. Supermarkets are rapidly becoming the main channel through which urban consumers access their food, even in poor countries, because there are such large economies of scale in food retailing and because they offer guarantees of food safety through privately enforced quality standards.

Atkin *et al.* (2015) use an event-analysis approach to analyze the impact on prices and employment of the entry into Mexico of foreign supermarkets. They use precise information on the location and date of the opening of the supermarkets, and relate this to high-frequency data on store prices, consumption, and employment in the same locations over the period 2002–14. They find that supermarkets create large welfare gains through a decline in the local cost-of-living index, not only by introducing cheaper commodities, but also by enhancing local competition. There is some adverse

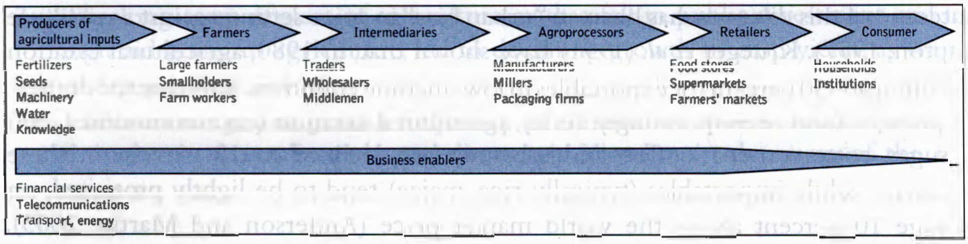


Figure 18.11 *Structure of integrated food value chains*

effect on traditional retail stores, with closures and loss of employment, but overall all income groups gain from the lower prices. The effect is, however, quite regressive, with a welfare gain twice as large for the highest income groups compared to the poorest.

Food export markets are also changing. They are increasingly shifting away from cereals toward non-traditional exports of high-value activities such as fruit (Chile), vegetables (Senegal, Kenya, Guatemala, Peru), fish (Vietnam), and meat (Brazil). These activities can provide sources of income for the rural poor because they tend to be highly labor intensive. They can also be produced by smallholders if they can organize (joining in cooperatives or producer organizations) and link to the value chains. However, there are also risks that smallholder farmers become excluded because it is easier for supermarkets to contract with large farmers, increasingly cutting off smallholders from access to domestic consumers. Family farms can sell directly at local farmers' markets, but their struggle for competitiveness and survival is very much dependent on their success in integrating into modern food value chains through which an increasingly large share of food supply reaches consumers.

Technological change

Because there are strict geographical limits to horizontal expansion (i.e. to the incorporation of new lands in production, also called growth on the extensive margin), future growth in agricultural output will have to come mainly from vertical expansion (gains in TFP, also called growth on the intensive margin). As can be seen in Figure 18.12, most of the growth in cereal production since 1961 has been achieved through yield gains in East Asia, and more recently in South Asia and Latin America as well. This is in sharp contrast with Sub-Saharan Africa, where growth is still being achieved through area expansion. However, even in Africa, area expansion is now severely limited and yield gains will have to become the major source of growth. For this reason, concerns with the growth of agriculture have emphasized technological and institutional innovations that can raise TFP. We focus here on the role of technological innovations in agricultural growth.

To be used and have an impact on output growth, technology needs to meet three requirements:

Generation. It must be generated, be socially profitable, and locally available.
Adoption. It must be adopted by individual farmers for whom it is fit.

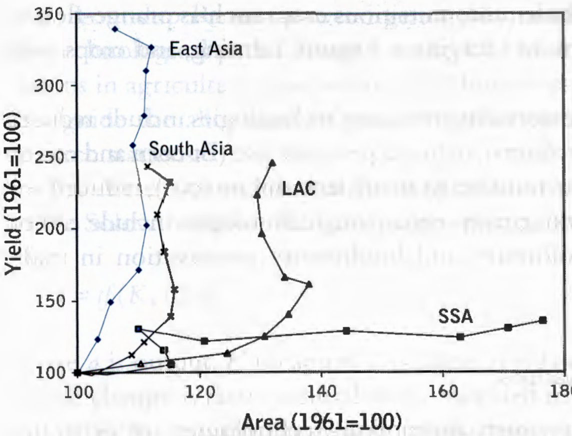


Figure 18.12 *Roles of area and yield in the growth of cereal production over the 1961–2005 period. Each point is a five year average*

Diffusion. It must diffuse across farmers, creating partial- and general-equilibrium effects on prices and on producer and consumer welfare.

We analyze these below.

Generation of technological change: theory of induced technological innovations

Types of technology

Technology can consist in an overall shift in the production function, as in the Solow model, where a TFP gain will help increase output for a given combination of inputs, or equivalently reduce input cost in achieving a given level of output. More specifically, however, technology is aimed at achieving specific gains that will be attractive to the adopter, with a variety of benefits or costs to others as a consequence of adoption. We can distinguish the following five categories of technologies:

- *Land-saving/yield-increasing*: they include high-yielding seed varieties (HYV), fertilizers, insecticides and pesticides, and irrigation. These are the technologies of the Green Revolution.
- *Labor-saving/cost-reducing*: they include animal draft for plowing and hauling, and mechanization such as tractors and harvesters. Labor-saving can be for low-skill labor (desirable in MDCs, where labor costs are high) or for high-skill labor (desirable in LDCs, where they are in short supply).
- *Risk-reducing*: this includes crops tolerant to flood, drought, and heat (abiotic resistance) and to pests and diseases (biotic resistance), and farming systems that provide diversification and resilience to shocks.

- *Quality-improving*: examples include more nutritious crops such as orange-fleshed sweet potatoes, high-lysine corn and sorghum, organic farming, and crops with enhanced storage or shelf life.
- *Externality-reducing or enhancing:* externality-reducing technologies include reduced water pollution (less need for fertilizers), reduced pesticide use (Bt corn and cotton (crops genetically modified to be resistant to many harmful insects)), reduced soil erosion (zero tillage, terracing); externality-enhancing technologies include carbon sequestration, agroecology, agroforestry, and biodiversity preservation in traditional farming systems.

Theory of induced technological innovations

What are the mechanisms through which appropriate technologies are generated that respond to farmers' needs? In the theory of induced technological innovations, Hayami and Ruttan (1985) show that this is driven by relative factor scarcity. Technology can be used to substitute for the most constraining factors, i.e. the factors with the greatest rise in relative prices. Where land is scarce and labor plentiful, the price of land will rise relative to that of labor, and innovations should be land-saving, seeking to raise yields (output per unit of land) through technological changes in seeds, farming systems, chemicals, and water management. Historically, this was the technological path pursued in Asia (especially Japan) and Europe (Figure 18.13). The Green Revolution, based on improved water control, high-yielding seed varieties, fertilizers, and chemicals for pest control, is part of this effort. By contrast, where land is plentiful and labor is scarce, the wage will rise relative to the price of land, and innovations should be labor-saving, seeking to raise the productivity of labor through innovations in mechanization (harvesters, tractors) and labor-saving chemicals

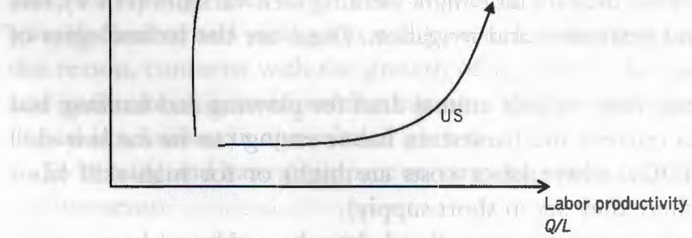


Figure 18.13 *Induced technological innovations to respond to relative factor scarcity. (Q = agricultural output, A = land area, L = labor force in agriculture)*

(e.g. Roundup Ready to weed genetically modified (GMO) crops). This has been the technological path followed in the US, Australia, and Canada. The bias of innovations in agriculture (land-saving or labor-saving) is thus "induced" by price signals that guide the allocation of resources to research priorities in public agricultural-research stations.

The theory of induced technological innovations can be formalized as follows. In the Solow tradition, the generic production function for agriculture would be:

$$q = tf(K, L, A),$$

where q is output, K is capital, L is labor, A is land, and t is TFP. In this case, technological change is factor neutral as it is not tied to any particular factor of production, and it shifts upward the whole production function. In the theory of induced technological innovations, by contrast, technological change is embedded in capital and it can be land-saving or labor-saving. The production function is represented as a two-level function where output is function of a labor index f_L and of a land index f_A as follows:

$$q = q\left[\overbrace{f_L\left(\underbrace{t_L K_L, L}_{\textit{High substitution}}\right), f_A\left(\underbrace{t_A K_A, A}_{\textit{High substitution}}\right)}^{\textit{Low substitution}}\right],$$

where:

f_L = labor index,
f_A = land index,

with low substitution between the two indices,

t_L = labor-saving technological change,
K_L = capital goods that substitute for labor,
t_A = land-saving technological change,
K_A = capital goods that substitute for land (i.e., raise yields),

with high substitution between the labor-saving input $t_L K_L$ and labor, and between the land-saving input $t_A K_A$ and land.

This specification of the production function for agriculture helps contrast two technological paths depending on which factors become relatively more expensive. In the US, as the country was industrializing, labor in agriculture was increasingly scarce relative to land. As a consequence, the wage–price-of-land ratio (w/p_A) was rising. This induced technological change to save on labor, the factor becoming relatively more expensive. As a consequence, labor productivity (q/L) has been rising. In Japan, by contrast, land was increasingly scarce relative to labor due to population growth.

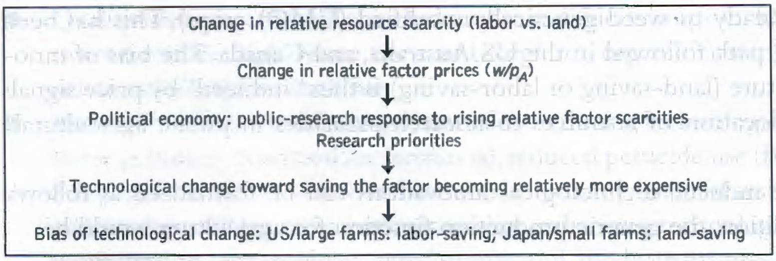


Figure 18.14 *Logical sequence in induced technological innovations*

As a consequence, the wage-price-of-land ratio was declining. This induced technological change to save on land, the factor becoming relatively more expensive. As a consequence, land productivity (q/A) has been rising.

The logical sequence in the Hayami and Ruttan theory of induced technological innovations is shown in Figure 18.14.

This theory of technological bias can also be applied to the contrast between large and small farms when there are labor- and land-market failures. On small farms, effective labor costs are low while effective land costs are high. Small farms are thus identical to Japan: they need land-saving technological change to be more competitive. By contrast, on large farms, effective labor costs are high and effective land costs are low. Large farms are thus identical to the US: they need labor-saving technological change to be more competitive.

Political economy of technological biases

If technological change is a public good (especially land-saving biological innovations that tend to be non-rival, while labor-saving mechanical innovations can more easily be produced by the private sector) with a budget constraint, the technology that prevails depends on the relative power of large vs. small farmers in the political arena. These farmers engage in lobbying and collective action to pressure public research to allocate budgets to land-saving or labor-saving technological change. If large farmers dominate the political process, then the course of technological change may starve small farmers of land-saving technological change. Small farmers will only acquire technology biased in correspondence with their factor price ratios if they can muster political support, which they typically lack. This was used to explain the lack of public research in Green Revolution technology in Argentina, as demanded by small farmers operating under land constraints, while large farmers, who dominated the allocation of public funds to research, were more interested in labor-saving technological change (de Janvry, 1973).

We can also return to the analysis of international transfers of technology and factor biases we analyzed in Figure 8.4 (in Chapter 8). There, using an Innovation Possibility Frontier, we showed that technology generated in MDCs with high labor/capital price ratios may not be optimum for LDCs with the opposite relative factor prices. This can be applied to the contrast between skilled-labor-saving vs.

unskilled-labor-saving technological change. Since most of the international agricultural research is done in MDCs, it is oriented to reducing the use of low-skill labor (for example, Roundup Ready herbicide used on GMO crops) instead of high-skill labor (Acemoglu and Zilibotti, 2001). LDCs would need research that reduces the need for scarce high-skill labor (e.g. with difficult management techniques such as integrated pest management and precision farming). Yet the technology available as an international public good is driven by factor scarcity in MDCs as opposed to that prevailing in LDCs, creating a second-best option for the LDCs. New technology is not as appropriate as it could be. The success of Bt crops in India, Brazil, and Argentina may be precisely due to the fact that it substitutes for high-skill labor in simplifying pest-control decisions (Qaim and Zilberman, 2003).

Adoption of technological change: farmers' decisions

Once available, technology must be adopted to have an impact on output growth. We saw that adoption of yield-increasing technology has been successful in East and South Asia and in Latin America, but that it is lagging in Sub-Saharan Africa. While 90 percent of the maize area harvested in East and South East Asia is planted with high-yielding varieties, and 57 percent in Latin America and the Caribbean, it is only 17 percent in Sub-Saharan Africa (Gollin *et al.*, 2005). Fertilizer consumption in kilograms per hectare of arable land in 2012 was 372 in East Asia and the Pacific, 161 in South Asia, 125 in Latin America and the Caribbean, 89 in the Middle East and North Africa, and only 15 in Sub-Saharan Africa (World Bank, *World Development Indicators*). Even where technology is successfully adopted, there exist categories of farmers that are constrained in adoption, typically smallholder farmers. A fundamental question, then, is to understand the barriers to technology adoption for Sub-Saharan Africa's smallholder farmers (Foster and Rosenzweig, 2010). A broadly held perception is that, while more new technologies need to be developed especially for Africa and for smallholders, there are many already existing, nationally available, and socially profitable technologies that remain unadopted. Why is this the case? Significant research efforts have been devoted to answering this question (see, for example, the Agricultural Technology Adoption Initiative, ATAI, 2015; Jack, 2011). The array of potential barriers is huge, and all barriers must ultimately be removed for adoption to occur. They fall into five categories.

Profitability

Technology may not be sufficiently profitable for many categories of farmer to adopt it. This is expected to be a first-order-of-importance barrier in Africa due to distorted prices (trade policies with high import tariffs), high transaction costs (poor infrastructure, lack of market facilities such as storage), lack of adaptation to heterogeneous local conditions, local unavailability as private-sector agro-dealers may not be in place, and high prices due to economies of scale (for instance, in importing fertilizers by bags instead of full shipping containers).

Foster and Rosenzweig (2010) discuss the fact that profitability is difficult to measure. At what wage should labor be valued when it is largely provided by the family?

With large weather fluctuations affecting yields in rain-fed farming, profitability varies from year to year, yet long series are not available. It is consequently difficult to accurately discount profitability for risk. Production conditions are highly differentiated across space, with prices affected by distance to market, with the result that profitability may decline sharply as soon as one gets to a certain distance from major markets.

Duflo *et al.* (2008) used an RCT with randomly assigned levels of fertilizer applied as "top-dressing" (i.e. two months into the growing season, after the plant has germinated and once the probability that it will grow to fruition is high) to maize in Kenya. The results are for one place in one year, and hence have limited external validity. In addition, the level of use of other inputs may not be adapted to the assigned level of fertilizer, raising questions about the internal validity of experimental conditions. The results they obtained suggest that there is a large heterogeneity in returns across farmers. While potential returns appear high, what matters is getting the amounts of fertilizer applied right. Hence the issue of adoption is not only whether to adopt or not, but, importantly, how to adopt, for which information and learning are essential, as we will see below.

Using historical data on hybrid maize cultivation in Kenya, Suri (2009) shows that there is considerable heterogeneity in profitability and adoption across categories of farmer. Marginal farmers have low net gains from adoption, and do not adopt. Many farmers with high expected returns from adoption do not adopt because of the high cost of adopting, due especially to poor infrastructure. For this reason, she observes that adoption is most intense for a middle group of farmers with both positive expected gains and low costs in adopting. Most important in this study is the emphasis on heterogeneity, explaining both uneven adoption across farmers and the need for customized adaptations to overcome idiosyncratic obstacles to adoption.

Finally, lack of private profitability (while the technology is socially profitable) may be due to positive externalities not captured by the adopter. A mechanism to internalize externalities is missing, transferring to the adopter the full benefit of his decision. Externalities may happen in learning, where farmers benefit from experimentation done by others. In this case, subsidies should be given to early adopters to induce full adoption by the more entrepreneurial farmers (Besley and Case, 1994). Externalities also occur in adopting soil-conservation and biodiversity-preservation techniques. Payments for environmental services (as explored in Chapter 15) have the purpose of implementing transfers when positive externalities limit adoption and induce under-provision of a privately delivered environmental service (Zilberman *et al.*, 2008).

Information and learning

Information about the existence, use, and expected benefits of adoption may be missing, particularly when the technology is new. A key proposition here is that the value of a given agricultural technology depends on local conditions, hence farmers need to learn how to use the technology in their own particular location. This information could be obtained from demonstration plots, through learning-by-doing, or through learning-from-others.

In their pioneering study of farmers' adoption of Green Revolution technology in India, Foster and Rosenzweig (1995) show that learning a new technology is essential for adoption as optimal use of technology depends on local conditions. Farmers can learn from their own experiments with the new technology, or from the experience of their neighbors. Using data for a panel of households, and tracking the roll-out of the Green Revolution across time and space, they find that imperfect knowledge about how to use new varieties is indeed a significant barrier to the adoption of these varieties. Learning-from-others (i.e. learning spillovers) increases adoption. For farmers with experienced neighbors, the new technology is significantly more profitable than for those with inexperienced neighbors. A given increase in average experience of a farmer's neighbors increases profitability by almost twice as much as the same increase in his own experience. However, the opportunity to learn from others slows down adoption as farmers would rather wait to assess their neighbors' experience with the new technology. The existence of positive learning spillovers implies that there is underinvestment in learning. Subsidies to early adopters are then justified to increase the level of adoption.

Conley and Udry (2010) improved on the learning-from-others idea by looking at the role of social networks in adoption. They studied the use of fertilizers on a new crop, pineapples, in Ghana. Again, technology is local and there is a need to learn by oneself or from neighbors in deciding to adopt. They used detailed survey data on who talks to whom about agricultural practices within social networks, and on what each farmer's neighbors do. They found that social learning is important. People adjust their fertilizer use based on their neighbors' experiences, paying particular attention to bad news. The effect is largest for inexperienced farmers. They also found that people pay more attention to farmers with similar wealth and with more experience than them.

These results show that learning how to use a technology, not just whether to use it or not, is important for adoption. There are high returns to experience (learning-by-doing) and to spillovers (learning-from-others). The extent of communication through social networks, and the type of information exchanged, are evidently context specific. Cai *et al.* (2015) show that farmers in traditional Chinese communities communicate to peers what they know about a new technology—weather insurance in this particular case. They are, however, not willing to tell others what decision they have taken regarding adoption for fear of being wrong and losing face with others as a consequence of bad judgment.

Credit and insurance market failures

In agriculture, there typically exists a long lag between planting and harvesting, implying that money is tied up in production for a long period of time. Lags are typically four to six months for cereals, but more than one year for cassava, and four to five years for tree crops such as coffee and cacao. Many technologies have large upfront costs, requiring credit, yet credit for smallholder farmers is largely unavailable. The microfinance revolution has sought collateral substitutes to provide access to credit to the poor, but the cost of microfinance loans remains too high for most agricultural activities. Other forms of access to credit have been explored, including using standing crops as collateral. Savings can also be promoted as an alternative to loans. For capital goods, such as KickStart irrigation pumps, rental-with-option-to-buy is a way of supporting adoption without formal lending arrangements.

Risk is also a major factor preventing the adoption of new technologies. Lack of access to insurance implies the need for risk management, maintaining farmers in the use of traditional crops. But even where insurance products are available, including index-based products that can overcome AS and MH problems in insurance, uptake has been very low. Cole *et al.* (2013) show that this is due to lack of trust in the insurance provider, high cost, and poor quality of the insurance product.

In general, progress in lifting credit and insurance market constraints has been insufficient. Agriculture has not benefited from the microfinance revolution. New credit and insurance products that can meet the cost requirements of agriculture are needed.

If insurance fails, technology itself can be a response to risk and insurance market failures. New rice varieties that are tolerant to extensive periods of flooding or of drought have recently been released. Dar *et al.* (2013) used an RCT approach to distribute 5kg minikits of flood-tolerant seeds to farmers in Odisha, India. They found that adoption of these varieties not only helped farmers cope better with floods, but also allowed them to engage less in risk management, using in particular better planting practices and early fertilizers. Farmers do this because they know that the risk of losing their investment in the crops due to flooding has now been reduced. The remarkable result is that the risk-reducing technology is good not only in bad years (through improved shock coping) but also in good years (through reduced risk management) (Emerick *et al.*, 2014). Specifically, yield losses avoided in a flood year are on average 682 kg/ha. The average gain in normal years due to ex-ante behavioral response is 283 kg/ha. Since there is one flood year for every three to four normal years, the expected gain in normal years for every flood year is between 566 kg/ha and 849 kg/ha—say, 700 kg/ha. Over time, the gain from risk management (achieved through behavioral response) thus approximately doubles the gain from improved shock coping (achieved through agronomic research).

Lack of secure property rights

In Sub-Saharan Africa, property rights over land are typically vested with the state, as opposed to users. Lack of secure property rights prevents farmers from investing in agricultural technologies that have lasting value. There is very little investment in irrigation and soil conservation as even fertilizers tend to have residual value on soil fertility over several years. Goldstein and Udry (2008) show that cocoa farmers in Ghana are unwilling to invest in soil fertility because of insecurity of continued access to land. Lack of formal titles also prevents farmers from using land as collateral in accessing commercial bank loans.

Behavior

Farmers' decisions about new technologies may not be consistent with profit maximization. The field of psychology and economics, pioneered by economists such as Thaler (1980), Kahneman and Tversky (1979), and Rabin (1998) has opened new perspectives on the behavior of poor people in developing countries. This has been applied by Duflo *et al.* (2011) to farmers' behavior toward adoption of new technologies such as fertilizers for maize production in Kenya. The question is: why do farmers not keep part of the cash earned from the harvest sale to buy fertilizers when they know that they are subject to credit constraints and that the use of fertilizers on the following year's crop will be highly profitable? A hypothesis is that it may be due to present-biased preferences (also called hyperbolic discounting), whereby farmers procrastinate in putting money aside for the future purchase of fertilizers.

Hyperbolic discounting is a situation in which people discount the entire future more than they discount any future period relative to the previous one. Normal discounting is written as: $U_t = \sum_{k=t}^{T} \delta^{k-t} v(c_k)$, where δ is the discount factor. By contrast, hyperbolic discounting is written as: $U_t = v(c_t) + \beta \sum_{k=t+1}^{T} \delta^{k-t} v(c_k)$. There is present bias if $\beta < 1$. For someone with present bias, \$100 now may be preferred to \$110 in one month even though \$110 in two months is preferred to \$100 in one month. There is time inconsistency in preferences. Sophisticated procrastinators, knowing that they will fail to set money aside at harvest time for future purchase, will seek commitment devices to place restraint on their future behavior.

Duflo *et al.* (2011) set up an RCT to test this proposition and to identify the types of farmer to whom this applies. Farmers were randomly allocated to two treatment arms and a control: T1 were visited by an agent at harvest time and, as a nudge, offered the opportunity to buy fertilizer then, with free delivery at planting time (called the SAFI: Saving and Fertilizer Initiative); T2 were visited by the agent before harvest, and asked when he should return to sell fertilizer, providing an opportunity for procrastination, although the sale offer was the same as in T1. A third group served as control. A fourth group was offered a large subsidy to measure the effect of price incentives. The results showed that the SAFI was taken by 30–40 percent of the farmers and increased fertilizer use by 10 to 12 percent. The effect of visiting early was comparable to a 50 percent reduction in price as measured in the fourth group. Many farmers in T2, offered the ex-ante choice of deciding when the agent should come back, chose to have the person come back immediately after harvest as opposed to later. This suggests that many farmers are sophisticated procrastinators, i.e. they know they need help in setting aside cash for the purchase of fertilizers. The conclusion is that behavior matters, that procrastination may be important in explaining low adoption, that many farmers know that they have a time-consistency problem and are interested in the availability of commitment devices, and hence that new incentive schemes should be put in place to help people discipline themselves in technology adoption.

Diffusion of technological change: market effects and incidence of benefits

The diffusion of a technological change is the aggregate outcome of adoption decisions. It is driven by both the supply (availability) of technology and by farmers' decisions to adopt, making up the demand side. Griliches (1957) was the first to recognize the existence of a logistic pattern in his classical study of the diffusion of hybrid corn across the US (Figure 18.15). Seed companies made the hybrid seeds available first in states with larger potential effective demand (Iowa, Wisconsin, etc.). Once available, farmers would initially slowly adopt, then adoption would accelerate, and finally converge to a potential 100 percent, the logistic pattern. The new technology came later to states with less potential effective demand (Texas, Alabama), and diffusion was slower and eventually incomplete.

Ultimately, as markets re-equilibrate following a technological change, who benefits among producers and consumers depends on how prices adjust, which in turn depends on the elasticity of demand for the good. If it is a non-tradable good, demand is inelastic. As supply shifts, prices fall, benefiting consumers. The diffusion of innovations is propelled by the "product-market treadmill" of falling average costs and falling prices (Cochrane, 1958). As prices fall, early adopters' profits are erased. Schumpeterian farmers demand more new technology which, when innovated and adopted, will again increase supply and lower prices. There is in this fashion a continuing race between falling costs and falling prices, the so-called technological treadmill on which farmers always run after new technology, to find themselves at a standstill in terms of long-term profits.

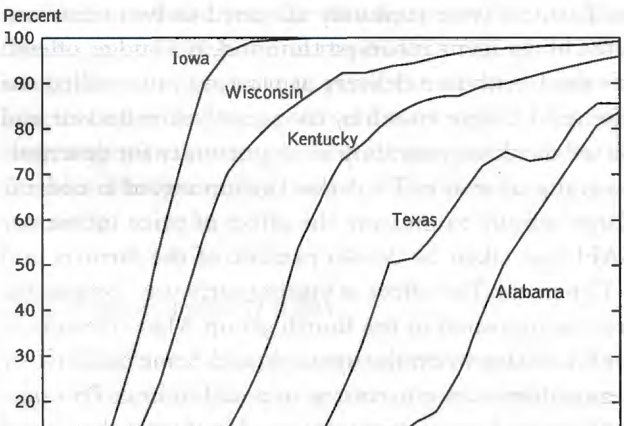


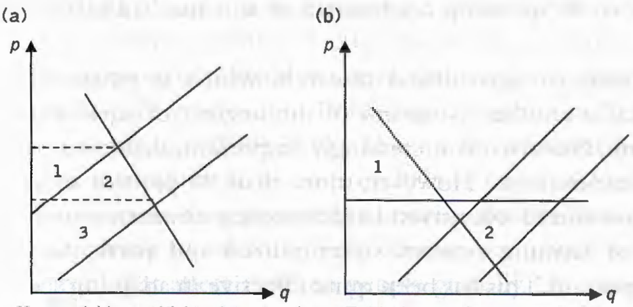
***Figure 18.15** Logistic diffusion pattern for hybrid corn seeds in the US*

Source: Griliches, 1957.

If, by contrast, the good is tradable, then demand is infinitely elastic. Supply shifts without a decline in prices and producers gain. The gain in producer surplus is capitalized into land values. The treadmill thus occurs via the land market, forming a "land-market treadmill." As technology diffuses across farmers, average costs fall and land prices and land rents rise. These rising costs eventually push farmers to seek new technological innovations in a technological treadmill.

These contrasted partial-equilibrium effects are represented in Figure 18.16. With a non-tradable good (a), the net social gain from technological change is absorbed by the rise in consumer surplus, all the more so when demand is more inelastic. With a tradable or price-supported good (b), the net social gain is absorbed by farmers in the form of a rising producer surplus. There are evidently stronger long-term incentives for farmers to adopt a yield-increasing technological change when it is used to produce a tradable or price-supported good.

This result about non-tradable goods has something to say about adoption of technological innovations in shallow markets, where demand is inelastic. In Sub-Saharan Africa, poor infrastructure and high transportation costs imply that markets tend to be isolated and shallow. A new technology, such as fertilizers or improved seeds, will shift local supply and quickly depress prices on local markets, choking further adoption. Unless a technological treadmill is in place to reduce production costs further, adoption will be limited. The key to sustained adoption, then, is to connect local to global markets to make demand more elastic, allowing farmers to capture the gains from the technological innovations they adopt in their operations. Limited



Non-tradable good (closed economy)

$\Delta CS = 1 + 2 >> 0$
$\Delta PS = 3 - 1 \sim 0$
$NSG = 2 + 3 \sim \Delta CS$
Product treadmill
Falling prices
AC↓, p↓
Consumers gain
Demand for new technology by Schumpeterian farmers, consumers, and employers

Tradable good (open economy)
Price-supported good

$\Delta CS = 0$
$\Delta PS = 2$
$NSG = 2 = \Delta PS$
Land-market treadmill
Rising land rents
AC↓, land rents↑
Producers gain
Demand for new technology by farmers

Figure 18.16 *Welfare gains from technological change for a non-tradable good (product-market treadmill) (a) and a tradable good (land-market treadmill) (b)* profitability of technological innovations is not an issue of the technology, but of the market conditions in which the technology diffuses. Linking farmers to deep markets through infrastructure investments is thus essential to a Green Revolution for Africa.

Role of the state in R&D

One of the important public goods for agriculture is investment in agricultural research. The reason why it is a public good is that many innovations have benefits that are non-rival and non-excludable such as better agronomic practices and improved farming systems. This research also has large positive externalities across countries. As such, agricultural research is an international public good. Estimates of the internal rate of return to investment in agricultural research have repeatedly been found to be very large, of the order of 40 percent (Alston *et al.*, 2000). This is higher than the rate of return in alternative public-goods investments, indicating that there is underinvestment in agricultural research. Why is this the case?

The most obvious answer is the positive externalities of research and the tendency for governments to under-provide public goods. There are also large economies of scale, favoring large over small countries. For this reason, the world's strongest public agricultural-research systems are found in Brazil (*Embrapa*), China, India, and the US (USDA and the Land Grant College System). The CGIAR (Consultative Group for International Agricultural Research) is an international non-profit alliance supporting 15 research centers across the globe that aims at remedying national-level underinvestment. It was at the heart of the 1960s Green Revolution, which doubled or tripled yields in the major cereals (wheat, corn, and rice). In spite of high returns to its spending on research, it too has had relatively stagnant budgets.

The tendency to underinvest in agricultural research, which is particularly notable in Sub-Saharan Africa, is another symptom of the neglect of agriculture. Private research (e.g. Monsanto, Novartis) is increasingly important, thanks to patent protection on biological innovations. However, more than 90 percent of this investment is located in industrialized countries. In developing countries, with a great deal of heterogeneity of farming systems, decentralized and participatory approaches to research are important. This has been quite effective in adapting seeds to local conditions, and is part of the institutional innovations needed to complement technological innovations. Introduction of GMO can make important contributions, but this technology has been used mainly for commercial crops in industrialized countries, with the exception of Bt cotton in India and South America. Bio-safety issues and public research for smallholder farming need to be addressed to make this technology effective for development and available in Africa, where it is badly needed, in part to address the rapidly rising threats of climate change with drought-, flood-, and heat-resistant seed varieties. Agroecology is another promising technological path as it addresses constraints on complete farming systems and seeks to find solutions that limit the use of external inputs, making the approach particularly useful in contexts and for farmers failed by markets. These two approaches—GMO and agroecology—should be seen as complementary, as opposed to ideological fortresses, as has been the case.

Sustainability in resource use and environmental services

Agriculture and the environment are closely interrelated. Agriculture intensification is reducing biodiversity and creating agrochemical pollution, overuse of scarce water, and health costs from pesticide poisoning. Animal diseases can affect humans, such as avian flu. Agriculture in fragile environments is contributing to deforestation and climate change. Climate change is probably the greatest challenge to the sustainability of farming systems, particularly in tropical and mountainous environments. Agriculture needs to help mitigate emissions, and it needs to adapt to climate change. Solutions include better technology (drought and flood resistance, precision farming aided by GPS observations), water management (larger reservoirs), payment for environmental services (carbon-trading schemes with payment for zero tillage and avoided deforestation), and devolution of resource management (irrigation schemes, watershed management) to local communities. Approaches to farming systems such as conservation agriculture and agro-ecology seek to achieve sustainability by enhancing the productivity of natural systems, as opposed to using mechanical and chemical technologies. There has been much underinvestment in these lines of research as well.

FOOD SECURITY IN DEVELOPING COUNTRIES

The state of malnutrition and hunger

The MDG 1 aimed at reducing by half the incidence of both extreme poverty and hunger between 1990 and 2015. Yet while substantial progress has been made in reducing poverty, this has not been the case for hunger. The incidence of hunger has fallen from 18.9 percent in 1990–2 to 12 percent in 2011–13, short of the MDG goal (FAO, IFAD, and WFP, 2013). There were 1 billion hungry people in 1990–2, 878 million during the food crisis in 2008–10, and 802 million in 2011–13. Qualitative deficiencies in diets exceed quantitative deficits. Inadequate diets, so-called hidden hunger, result in micronutrient deficiencies (particularly lack of iodine, Vitamin A, and iron) that affect 2 billion people globally. Quantitative and qualitative malnutrition is particularly devastating for children in the 1,000 days after conception. 165 million children in the world are stunted, preventing them from reaching their full physical and cognitive potential.

Inadequate diets also include overweight and obesity. Using the BMI as the indicator (equal to height in cm over weight in kg), 34 percent of world population is overweight, with a BMI in excess of 25, a number equal to 2.4 billion people. The number of overweight people has risen faster in developing than in industrialized countries: it rose from 321 million in 1980 to 557 million in 2008 in industrialized countries (a 174 percent increase), while it rose from 204 million to 904 million in developing countries over the same period (a 443 percent increase). Being overweight, and especially obese (a BMI of 30 and above, affecting 700 million people, or

29 percent of the overweight population), is associated with Type 2 diabetes, cardiovascular diseases, and some types of cancer. The WHO estimates that 2.8 million people die from obesity every year. Shockingly, the number of overweight people is now almost three times the number of people in hunger, and 62 percent of them are in developing countries.

Determinants of food insecurity and national policy approaches

How do we explain food insecurity? The commonly accepted definition of food security is "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2008). As for poverty, it is useful to distinguish between two types of insecurity: chronic and transitory (Staatz *et al.*, 2009). And it is useful to recognize three causes of food insecurity: availability, access, and use (adequacy). Each has particular determinants, and each can be addressed with specific policy options. Policy instruments in turn can consist in interventions through markets, or in direct state interventions (Galtier, 2011). This combination of types, causes, and instruments gives us a typology of policies and programs that can be used to reduce food insecurity (Table 18.1).

The entries in the table show the tremendous complexity of food insecurity, and the multiple policy and program instruments that can be mobilized to address it at the national level. Interventions concern the supply side (availability), the demand side (access), and the use of food (behavior, culture).

- *Supply side: increasing production.* The FAO (2009) estimated that global agricultural production will need to increase by 70 percent between 2005 and 2050 to accommodate population growth, higher incomes, and shifting diets linked to urbanization. We have seen that this increase will have to come from productivity improvements since horizontal expansion has largely reached its limits. This is made all the more challenging by climate change, soil degradation, water scarcity, and rising energy prices. Investment in agricultural research will be important for this, yet we know that there is a tendency for underinvestment in agricultural research, particularly when it is a public good (Alston *et al.*, 2009). There are important debates between an agroecology approach, which minimizes the use of external inputs, and promotion of a "doubly Green Revolution," which balances the use of chemical technology (fertilizers, pesticides) with concerns for sustainability and a reduced agricultural contribution to GHG emissions and environmental degradation (de Schutter, 2010).
- *Supply side: availability to consumers.* Three important areas of debate must be considered here: livestock, biofuels, and waste. The first is whether the shift to meat-based diets that accompanies rising incomes and urbanization can be contained. Livestock production occupies 26 percent of agricultural land in pasture and 33 percent for the production of animal feed, mainly maize and soybeans, or a total of some 60 percent of world agricultural land. The expansion of pasture is a major source of deforestation, and livestock production contributes to 18 percent

Table 18.1 *Food insecurity in developing countries: policy instruments*

Type of food insecurity	*Type of policy instrument*	*Causes of food insecurity*			
		Lack of availability of food (supply-side)	*Lack of access to food (demand-side, entitlements, direct access)*		*Misuse of food (household)*
Chronic insecurity	Interventions through markets	Make markets work better in time and space	Aggregate economic growth		
	Direct state interventions	Invest in agriculture for productivity gains	Income-generation programs		Home economics and nutrition training
		Long-term food aid	Social-assistance programs for the chronic poor		
		Biofortification of staple foods	Enhance productivity in smallholder farming		
			Risk coping (ex-ante relative to shocks)	*Risk management (ex-post relative to shocks)*	
Transitory insecurity	Interventions through markets	Make markets work better in time and space	New financial products	Emergency loan programs	
	Direct state interventions	Intervene in markets to stabilize prices	Enhance production in smallholder farming	Social assistance for vulnerable individuals (quick-response programs)	Emergency feeding practices

of world GHG emissions, a larger share than transport. The second is the demand for biofuels. Biofuel mandates in transport in the US and EU were one of the most important factors explaining the global food-price increase in 2008. Biofuel mandates and food security currently lack coordination. The third is the magnitude of food waste. The FAO (Gustavsson *et al.*, 2011) estimated that one third of total food production is lost or wasted. Waste per capita is estimated at 95 to 115kg/year in Europe and North America, and 6 to 11kg/year in Sub-Saharan Africa and South/Southeast Asia. In developing countries, waste is principally a result of inadequate storage and packaging/processing facilities, as well as to poor connections between farmers to markets.

- *Demand side: poverty*. Even if world supply has been overall adequate, with generally falling real food prices from the 1950s to the 2008 price spike, large groups of world population remain too poor to satisfy their basic nutritional needs. Largest among them is smallholder farmers, who, paradoxically, are a majority of the world's poor and malnourished (World Bank, 2007). Yet, as we will see in Chapter 22, there has been a lack of support for smallholder farmers, both for their own food production and to help them integrate into food markets to achieve competitiveness with larger commercial farmers. An important area of intervention to promote food security is thus the development of efficient local food systems, in which smallholder farmers can play a major role.

National food-security strategies

Implementing a food-security strategy, as described in Table 18.1, requires the ability to formulate comprehensive national strategies, as Brazil did in its Zero Hunger program. Piecemeal approaches will not work. However, formulating comprehensive strategies is demanding. It requires data collection, the analytical capacity to diagnose and establish causalities, broad consultations in defining medium-term strategies, sustained access to financial resources, and coordination across sectors, something that governments are notably bad at doing. No wonder that reducing malnutrition and hunger has been so difficult to achieve.

International coordination for food security

Due to the importance of international trade in food, domestic food prices are strongly affected by international prices. This was a major lesson of the 2008 food crisis, during which exporting countries responded to rising international prices with export bans or higher export taxes to protect their domestic consumers. Avoiding this requires greater international coordination. Yet world governance for food security is seriously lacking. The international community has begun to address this issue by reconstituting a Committee on World Food Security (CFS) with a membership of nation states, international organizations, NGOs and philanthropic foundations, and the private sector. This is a unique, ongoing experiment that may yet succeed or fail. Its achievements to this point have been limited to providing voluntary guidelines on such issues as the management of food-price volatility, access to land, biofuel mandates, climate change, social protection for food security, and investment in smallholder farming (CFS, High Level Panel of Experts on Food Security and Nutrition).

THE POLITICAL ECONOMY OF AGRICULTURE FOR DEVELOPMENT

Why is it so difficult to make good agricultural and food-security policies? There may be political-economy specificities to agriculture and food that explain the persistence of underuse and misuse of agriculture for development. Indeed, there are many dilemmas that stand in the way of good policy.

1. *There is a basic dilemma in "getting the prices right" for food products.* Prices should be set low for consumers to reduce hunger and increase their real incomes, but they should be set high to give incentives to farmers to invest in agriculture (Streeten, 1987). The price of food will always be politically charged, as it is a cost for some and a benefit for others, with both parties always dissatisfied and struggling for price gains. An alternative to the use of low-food prices for food security would be to use targeted social-assistance programs to protect the poorest groups. Yet, today, the International Labor Office (ILO, 2011) estimates that some 75 percent of world population does not have access to social protection against unemployment, illness, disability, crop failures, and spikes in food prices.
2. *There is a key aspect of heterogeneity among poor farmers that creates a price-policy dilemma.* Some are net sellers who benefit from higher prices, while others are net buyers who, like consumers, benefit from lower prices. Since many of the world's poor (possibly a majority) are net buying farmers, it is difficult to use prices to raise the income of net selling smallholders, many of whom are also poor, without creating a serious conflict of poor against poor (World Bank, 2007).
3. *There is a basic short-term–long-term policy dilemma in allocating scarce fiscal resources to respond to a food crisis that originates in rising food price.* Should fiscal resources be used to ease the short-run food problem for consumers (e.g. through food-aid programs) or should they be used to invest in agriculture and address the long-term productivity problem (thus increasing supply and reducing future upward pressures on prices)? The political economy of crisis response tends to favor consumers over producers, eventually reproducing the neglect of agriculture that may have caused (or at least contributed to) the crisis.
4. *There is a basic policy dilemma in seeking to achieve food security between reliance on comparative advantage and trade, and reliance on national food self-sufficiency.* Should food security be sought through greater domestic self-sufficiency or should a country use its comparative advantages and trade for food? This debate runs deep through the development community. The International Assessment of Agricultural Knowledge, Science, and Technology for Development (IAASTD, 2009), an intergovernmental process sponsored by the UN, took the position that food security should be achieved through food self-sufficiency. This position was also endorsed by the UN Special Rapporteur on the Right to Food (de Schutter, 2010). The World Bank (2007) and the International Food Policy Research Institute of the CGIAR take the position that countries should capitalize on

comparative advantage and trade for food security, with due account given to various sources of risk. Domestic prices of non-tradable foods are typically more unstable than international prices due to more variable local climate and smaller market size; but this was briefly reversed during the 2008 global food crisis. The choice of domestic self-sufficiency vs. food dependency to achieve food security depends on the origins of food shocks (international price shocks, domestic weather shocks, or employment and income shocks). It also depends on how well international and domestic food markets work, and whether a country can access international loans (e.g. through the IMF) to purchase food in case of emergency.

5. *There may exist a dilemma in achieving the multiple objectives of development through agriculture.* Agriculture is important not only as a sector producing a particular product (say, a pile of rice) but also as a process that involves households, communities, and the environment. The process of agricultural production is important in achieving a country's development objectives: smallholder farming will likely be more effective for poverty reduction, but large farms may be better for productivity gains and to access sophisticated markets through integrated value chains. This may lead to a trade-off between poverty and productivity (growth) that feeds into the policy debate on the relative merits of small vs. large farms, and to concern with the current "land grab" by large farmers, often through foreign direct investment (Deininger and Byerlee, 2011).
6. *There may, similarly, exist trade-offs*, and hence the need for difficult policy choices, between productivity gains using agro-chemicals (pesticides, antibiotics) and the health of farmers and farmworkers; intensification of farming and environmental degradation; irrigation for higher yields and breeding grounds for mosquitoes; and land expansion for agricultural growth and deforestation (e.g. expansion of soybean and cotton production in the Brazilian Cerrado region).

To conclude, we note that agriculture has, overall, been highly successful in feeding a rapidly rising world population and in inducing industrial growth in agrarian economies and in helping reduce poverty, with India, China, and Vietnam recent examples. Yet it has also been underused and misused, and nowhere is this more obvious than in Sub-Saharan Africa, where it still has a large unrealized potential role to play. The food crisis, failure to meet the MDG on hunger, and climate change make seizing this opportunity all the more urgent. In the end, however, whether agriculture is used for development or not is a political decision. The neglect of agriculture is not a mistake, but a social choice. Remedying this situation will require: (1) greater public awareness of what agriculture can do for development, (2) identification of more effective approaches in using agriculture for development, as opposed to relying on cash transfers and migration to reduce rural poverty, (3) the development of skills to use agriculture effectively for development, from producers' organizations to national governments and international organizations, and (4) commitments by governments and donors that they will give more importance to agriculture in their development plans and budgets. The current failures of agriculture have increased popular support for increased investment in agriculture. But support needs to be translated into sustainable action for the potential developmental role of agriculture to be more fully captured.

CONCEPTS SEEN IN THIS CHAPTER

Marketed surplus
Multiple functions of agriculture
Capital contributions
Forced deliveries
"Invisible transfers"
Market contribution
Green Revolution
Land-saving and labor-saving technology
Induced technological innovations
Logistic diffusion pattern
Barriers to adoption
Underinvestment in agricultural research
Food insecurity: availability, access, and use of food

REVIEW QUESTIONS: AGRICULTURE FOR DEVELOPMENT

1. What is meant by the "contributions of agriculture to development": product, factor (capital, foreign exchange, labor), and market contributions to growth; contributions to poverty reduction; contributions to the provision of environmental services?
2. If agriculture is good for growth and poverty reduction, why has it been neglected by governments and aid donors over the last 25 years?
3. What is the theory of "induced technological innovations," and why are innovations biased to respond to relative factor scarcity? Why was technological change in agriculture labor-saving in the US and land-saving in Japan?
4. How are the benefits from technological change differentially appropriated by producers and consumers depending on whether the commodity is tradable or non-tradable? When demand is inelastic, why are farmers on a technological treadmill?
5. How is a household's food insecurity related to the availability, access, and use of food?

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