have different needs for public support such as infrastructure, legal systems, market-related rules and norms. They also have different impacts on the natural environment. Economic development can introduce rapid changes in underlying factors, thus placing pressure on a system.

Technical Determinants of Farming Systems

Technical elements, including both physical and biological factors, help determine the potential types of crop and livestock systems. Physical factors — including climate, land, water access, capital items, and distance to markets — are unique to each location; although water access and other capital items can be altered through investments and new technologies. Similarly, investments in roads alter the relationship between physical distance and travel time. For example, the nomadism, discussed below, that prevails in many arid regions of the world, represents an adaptation to harsh climates. However, the introduction of wells has encouraged more settled farming or ranching in parts of nomadic areas. Global climate change is likely to have a profound effect on farming systems, and we are already seeing adjustments to agricultural practices as weather patterns and temperatures change.

Biological factors including pests and crop and livestock varieties are even more susceptible to modification. In the short-run, however, these factors play a major role in defining the prevailing agricultural system. The existence of the tsetse fly in areas of the African humid tropics has created farming systems that are dramatically different from those in similar climates where the fly does not exist. Animal traction is not an option in areas where the tsetse fly is common. Technologies to control the fly can help spread animal traction and alter traditional farming relations.

Institutional and Human Determinants of Farming Systems

Institutional and human elements influencing farming systems are characterized by both exogenous (externally controlled) and endogenous (internally controlled) factors. Factors largely outside the control of individual farmers include social and cultural norms and beliefs, historical factors, population density, market opportunities and marketing systems, and off-farm employment opportunities. For example, high population densities in many South Asian countries are partly responsible for the very different farming systems there as compared to the systems found in the relatively low-density areas of sub-Saharan Africa and Southeast Asia.

Politically determined institutions such as pricing policies, credit policies, macroeconomic policies, trade policies, and land-tenure systems affect the farming system. Land ownership is highly skewed in many countries. In areas of Central America, for example, large commercial farms and plantations exist alongside small peasant subsistence and semi-subsistence farms. The farming practices used in these areas are significantly influenced by the distribution of land; plantations rely on landless and small holding workers as suppliers of labor and the laborers mix off-farm incomes with food crops grown on their own holdings. These small holders adopt diversified livelihood strategies within the overall context of their farming system. The prevailing patterns of land uses, crops produced, and technologies on different-size farms is clearly affected by the distribution of land holdings. In many areas of the world, people have only use-rights over the land they farm. In much of Africa, for example, families are given land to farm but they cannot rent or sell it to others, and cannot use it as collateral for credit. Such land-use institutions influence incentives for investments in land improvements, which, in turn, influence the prevailing farming system. The political system itself may dictate collectives, communes, or private property as the primary means of organizing land use in agriculture.

Endogenous or farmer-controlled determinants of agricultural systems include family labor, management ability, education, knowledge, as well as the goals for which farmers are striving. Investments in education affect the value of time used on and off the farm, and as educational levels change, farming systems change in response. The risk associated with agricultural production, particularly in arid, rain-fed regions, has forced farmers to adapt their practices to ensure survival. These adaptations are determined, in part, by the farmers' degree of risk aversion, which is affected by income, education, etc. Any of these exogenous or endogenous factors can change over time. New technologies and population growth are two particularly important determinants of how and in what direction agricultural systems change over time.

MAJOR TYPES of FARMING SYSTEMS

While the specific type of farming system in use depends on a large number of factors (see Figure 8-1), many years ago Duckham and Masefield grouped farming systems into three basic types: shifting

cultivation, pastoral nomadism, and settled agriculture (Fig. 8-2).[2] Settled agriculture includes many subtypes. Let's briefly examine each of these systems.

Shifting Cultivation

Shifting cultivation is an old form of agriculture still practiced in many parts of the world. As the name implies, it involves shifting to a new piece of land when the fertility of the original patch runs out or when weeds and other pests take over. The movement may be fast or slow, and animal manure may extend the use of one location. Migration from one piece of land to another may be random, linear, or cyclic. When cyclic, the rotation frequency can last as long as 30 to 45 years.

Shifting cultivation also has been called *slash and burn* because usually new areas are cleared by slashing the brush with a machete and burning it to clear the fields and release nutrients into the soil. Capital investment in the farm is low, with machetes, digging sticks, and hoes being the primary tools. Typical crops include corn, millet and sorghum, rice, and roots. Usually the crops are mixed. Shifting cultivation is still practiced on about 15 percent of the world's exploitable soils, particularly in Africa and Latin America. It is popular where population pressures are not too severe.

Shifting cultivation is frequently associated with insecure control over the land, either because of absentee, government, or unclear ownership status. It has been linked to soil erosion and other environmental problems in several developing countries, partly because there are few incentives to invest in practices that maintain soil fertility.

Pastoral Nomadism

Pastoral nomadism involves people who travel, more or less continuously, with herds of livestock. Pastoral nomads have no established farms, but often follow well-established routes from one grazing area to another. Although probably only about 15 million pastoral nomads are found in the whole world, they move through an area almost as large as the entire cultivated area in the world. They are especially prevalent in the arid and semi-arid tropics. Some examples include the Masai of Kenya and Tanzania, the Hima of Uganda, the Fulani of West Africa, the Bedouin of the Eastern Mediterranean, and the nomads of Mongolia.

[2] See Alec N. Duckham and G. B. Masefield, *Farming systems of the World* (London: Chatto and Windus, 1970). Substantial variation is observed within these highly stylized farming system typologies.

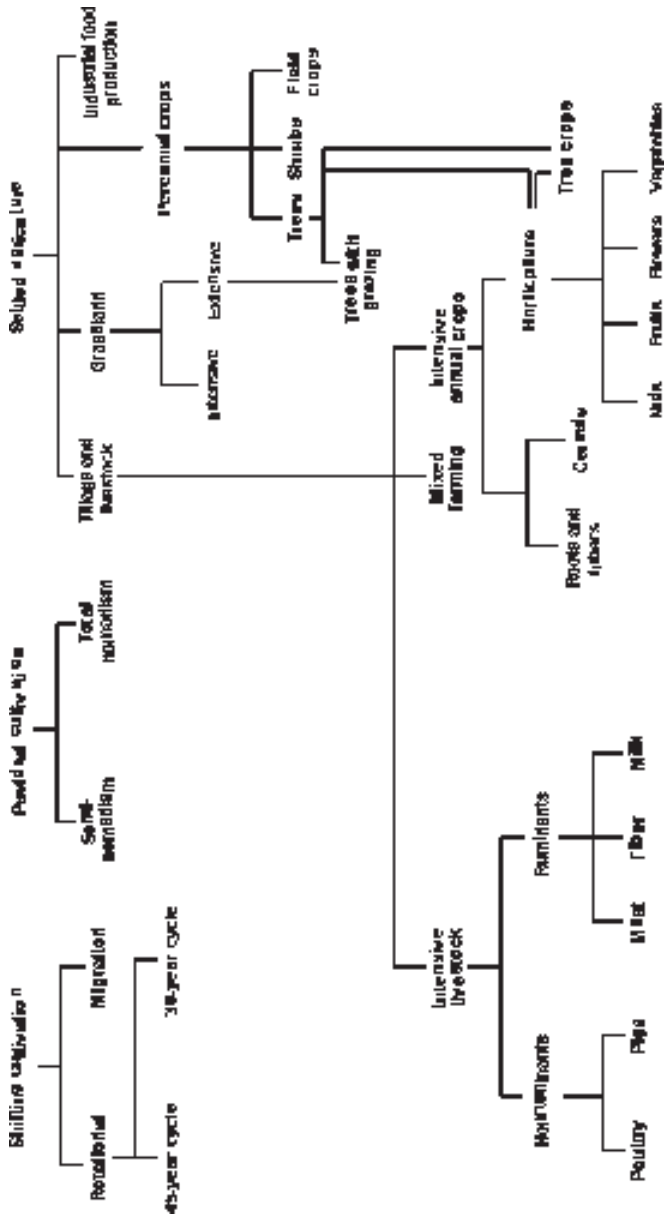
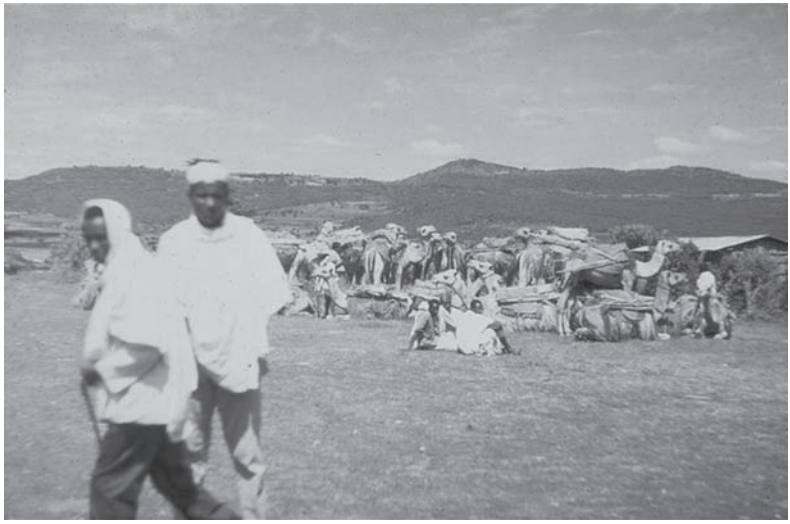


Figure 8-2: Example of a classification of world farming systems.



Nomads are common in the northern half of Africa
(photo: Mesfin Bezuneh).

Pastoral nomadism can be total or partial. In the latter case, the nomads have homes and some cultivation for part of the year. Typically five or six families travel together with 25 to 60 goats and sheep or 10 to 25 camels. Sometimes they own cattle as well. The livestock eat natural pasture and their productivity is low.

Pastoral nomadism is associated with a variety of problems. Because grazing takes place on common land, there is a tendency for overgrazing because every individual farmer wishes to maximize his or her number of animals. As the animal population increases, grazing areas deteriorate and incomes shrink. This problem is known as the "Tragedy of the Commons," and ample evidence shows that traditional management systems have evolved in response to it. Little scope for technical improvement exists in pastoral nomadic systems, and serious problems arise in years of drought. As the human population grows, additional pressures are placed on the resource base supporting the nomadic system. Global climate change presents an especially acute problem for pastoral nomad systems. Increases in temperatures will reduce pasture productivity and increase demand for water, and both factors will lower productivity. Accelerating desertification will result and will further lower productivity.

Settled Agriculture

Settled agriculture includes a variety of agricultural systems such as mixed farming systems, intensive annual crops, intensive and extensive

livestock systems, and perennial crops. The dominant farming systems result from an enormous amount of human experimentation. The systems we see most often produce a relatively high and certain return in storable products per unit of effort. They have spread from farmer to farmer, replacing other settled systems that are far less productive.

Mixed farming usually involves a mixture of crops and livestock. Few farming systems in developing countries consist of just one commodity. However, what is meant by mixed farming is the integration of crops and livestock production. As mentioned in Chapter 7, mixed farming is common in traditional agriculture because it produces relatively high returns while helping to manage risk, makes efficient use of labor and land, and helps maintain soil fertility.

Intensive annual crops are extremely important in the world. About 70 percent of the cultivated area of the world is planted to the major grain crops, which include wheat, rice, and corn. Other important annual crops are barley, millet, sorghum, roots, tubers, vegetables, and pulses (such as beans, peas, and peanuts).

Perennial crops are grown and harvested over several years and include crops such as cocoa, coffee, bananas, and sugarcane. Some are grown in large plantations but often on very small farms as well, even in the same country. On small-scale farms, perennial crops are often *interplanted* with annual crops such as corn and beans. Perennial crops tend to be high-valued and are frequently exported. They also can help prevent soil erosion and preserve biodiversity in ecologically fragile areas.

Intensive livestock systems include both *ruminants* (for example, cattle, buffalo, sheep, and goats) that produce milk, meat, fiber, dung, and other products, and *non-ruminants* (for example, pigs and poultry) that are particularly important for their meat and eggs. These animals are often fed grains in addition to pasture and forage. In a few countries, intensive livestock systems involve carefully managed grasslands or pasture.

Extensive livestock systems include a variety of grazing systems on semi-arid range, high and cool mountain pastures, wet lowlands, and more. Livestock may graze on leaves as well as grass.

In summary, a large number of crop and livestock systems exist, many of which have been relatively productive or at least well suited to their environment. As population expands and other conditions change, a particular system may no longer be adequate and is forced to change (see Box 8-1). Few systems are static for very long today, and several offer potential for improved productivity.

BOX 8-1.
POPULATION DENSITY AND AGRICULTURAL SYSTEMS

The intensity of land utilization varies worldwide, and there is a close relationship between this intensity and the density of population in a particular region. Boserup hypothesized that pressure from increasing population has caused a shift in recent decades from more extensive to more intensive systems. This classification scheme traces a continuum from shifting cultivation to settled agriculture:

1 Forest fallow cultivation: one- to two-year planting of plots followed by a 20- to 25-year fallow period.
2 Bush fallow cultivation: 6- to 10-year fallow period. Periods of uninterrupted cultivation may be as short as 1 to 2 years, or as long as 5 to 6 years.
3 Short fallow cultivation: fallow lasts one or a couple of years.
4 Annual cropping: land is left uncultivated only between the harvest of one crop and the sowing of the next.
5 Multi-cropping: the most intensive system of land use; the land bears two or more successive crops every year.

Boserup hypothesized that increased population densities put pressure on food production systems to increase outputs. Successively more intensive systems require increased labor inputs for weeding and cultivation, and more varied farming implements. In forest fallow cultivation, only an axe is needed, and as the fallow period is shortened, implements such as hoes, plows, and even irrigation systems are used.

Different patterns of land use exist within similar agro-climatic zones. For example, the land used for intensive cultivation in parts of Nigeria is remarkably similar to the land used for long fallow cultivation in the same country. Thus, Boserup concluded that humans not only adapt to the climatic conditions they face, but actually change the relationship between the conditions and agricultural output by using methods that enhance soil fertility. These adaptations are mostly influenced by rates of population growth.

Source: Ester Boserup, *The Conditions of Agricultural Growth* (London: Allen and Unwin, 1965), especially Chapter 1, pp. 15-22.

The Influence of the Political System

In Fig. 8-1, political factors were listed as significant determinants of farming systems, including land tenure systems. The political system can dictate how property rights are allocated, including collective, commune, and other types of land tenure arrangements. When systems such as collectives and communes restrict individual farmers' responsibilities

and rights to manage farm resources in response to market signals, the result has usually been inefficiency and waste of those resources. Political systems that allow independent family farms to operate in competitive markets have generally yielded higher productivity levels and faster growth rates over time. A particularly important example of this is the reform of communist China's collective land tenure system.

Beginning in 1979, China allowed individual farmers to respond more freely to market incentives and since then has experienced significant increases in agricultural production (see Box 8-2). Adoption of new technologies and use of purchased inputs such as fertilizer have increased substantially. These changes have occurred rapidly in China, causing important changes in world markets. Remember that China has more than 13 billion people. Agricultural growth in China has, over time, stimulated broad-based increases in income, and this income growth will have profound implications for food markets, such as increased demands for animal proteins. A challenge for the world food system is to make adjustments to meet these emerging demands.

Government policies other than rules governing land tenure also affect farming systems. Price policies that favor certain products over others or promote the use of different inputs can have a strong impact on the types of crops planted, on how long they are grown, and even on the degree to which traditional farmers interact with markets. Policies affecting the value of the land create incentives for more or less investments in land. For instance, policies that discriminate against agriculture, such as export taxes, are quickly reflected in lower values of agricultural land. Population and family planning programs can affect population densities, which influence the nature of the agricultural system.

In summary, the major types of farming systems in the world include shifting cultivation, pastoral nomadism, and several types of settled agriculture. These systems, particularly settled agriculture, can be affected in a major way by the political system in the country, which dictates private or public control over land use. Other government policies influence agricultural systems both directly and indirectly.

ECONOMIC DETERMINANTS of INPUT USE and CROP and LIVESTOCK MIX

As noted above, policies can influence the evolution of farming systems by changing relative prices of inputs and outputs. Let's examine more carefully how economic factors affect the choice of inputs and, more broadly, the type of farming system. In Chapter 5 we introduced the concept of an *isoquant* to illustrate that the same level of output can

BOX 8-2.
CHINESE AGRICULTURAL SYSTEMS

In rural areas of China prior to 1979, the agricultural production system was organized according to guidelines established in the national agricultural plan. Farming operations were organized into collective teams of 20 to 30 households; these teams were required to sell fixed quantities of output to the government at set prices. Quantities produced in excess of the quotas were also surrendered to the government. The collectives had some freedom to adjust inputs, but the acreage planted to each crop was determined by government planners.

This rigid system led to stagnation in agricultural output. Between 1957 and 1978, per-capita grain production grew at a 0.3 percent annual rate, while soybean and cotton production per capita *declined*, respectively, by 3.0 and 0.6 percent annually. In 1978, rural incomes were virtually identical to levels of 20 years earlier. This poor performance of the agricultural sector had important implications in a country where 80 percent of the population resides in rural areas.

In 1978, the government decided to introduce the *Household Responsibility System*, which restored individual households as the basic unit of farm operation. Under this system, a household leases a plot of land from the collective, and, after fulfilling a state-set grain procurement quota, can retain additional output. This output can be consumed or sold to the government. The households have flexibility to determine acreage for individual crops. At the same time, the government prices of agricultural commodities were increased, and the prices paid for above-quota grain production were increased substantially above quota prices. Agricultural output began to grow rapidly following these reforms, and agricultural growth averaged 6% per year from 1978–2003. These reforms led to a wholesale change in the Chinese agricultural system; by 1983 over 97 percent of the collective teams in China had been converted to the new system.

Sources: Justin Y. Lin, "The Household Responsibility System Reform and the Adoption of Hybrid Rice in China," *Journal of Development Economics,* vol. 36 (2), 1991, pp. 353–73; Ehou Junhua, "Economic Reform: Price Readjustment (1978–87)," *Chinese Economic Studies*, vol. 24 (3), Spring 1991, pp. 6–26.

be produced with more than one combination of two inputs. The concept of *allocative efficiency* relates to how well farmers choose the correct amounts of inputs to apply and outputs to produce given the available technology, assuming they are trying to maximize profits. While farm and family decisions are inter-mingled, their success and even survival depends in part on how efficiently they allocate their productive assets.

Efficient farmers are able to combine inputs in a way that reflects their relative prices. Efficient farmers also choose the most profitable output levels. The farming systems described in this chapter vary in terms of intensity of input use and productivity, but they all represent long-term adjustments to prevailing conditions. As a result, we can conclude that they are efficient. As relative scarcity (and hence prices) of inputs and outputs change, these efficient producers will make adjustments to input mixes and amounts of output.

In Figure 8-3, the curved isoquant represents the combinations of labor and animal power that can be used to produce a specific amount of output, with a given level of all other inputs; for example, two tons of corn on one acre of land. We expect all farmers to produce somewhere along this curve. Production to the right or above the curve would use more inputs than needed, and would be technically inefficient. Production to the left or below the curve is technically impossible, given the other resources and technology available to the farmer. The slope of the isoquant is known as the *Marginal Rate of Technical Substitution* (MRTS) between the two inputs. In this case, the isoquant's slope is the additional animal time needed to save one hour of labor time. We expect farmers to adjust their use of animals and labor until the value of that labor time just equals the cost of adding animal time. In terms of the graph, we expect farmers to adjust until the slope of the isoquant

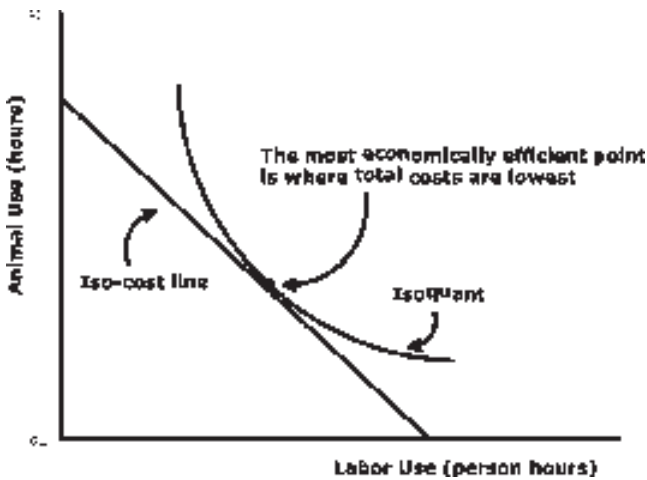


Figure 8-3: Input efficiency given relative input scarcity.

just equals the price of labor relative to the price of animal power. That ratio is the slope of the relative price line, also called an iso-cost line because it traces a line of constant total cost. The economically efficient input combination is the point where the isoquant and the isocost curves are tangent or where the MRTS equals the input price ratio. If the price of labor goes down relative to the price of animal power, the isocost line would become flatter, tangency would occur at a point farther down the isoquant, and more labor and less animal power would be used. Thus, the drive to be efficient leads to changes in input mixes and, over time, this drive can alter the farming system. As an example, compare differences in farming systems between Africa, where labor is relatively scarce and land is relatively abundant, and South Asia, where labor is relatively abundant and land relatively scarce.

Similar trade-offs occur between different kinds of output. In Figure 8-4, the curved line represents the *production possibilities frontier (PPF)* or the combinations of corn and beans that can be produced with available resources. As with Figure 8-3, we expect farmers to produce somewhere along this curve. Production inside the curve would generate less output than is possible, and so be technically inefficient. Production outside the curve would be technically impossible, given these resources and the technology. The slope of the PPF is known as the *Marginal Rate of Transformation* (MRT). In this case, that slope is the amount of additional corn that can be produced with one less unit of beans. Again, the allocatively efficient combination of outputs depends on the relative prices of these two outputs. For example, if the price of beans rises relative to the price of corn, the iso-revenue line becomes steeper and it pays to shift more resources into producing beans and away from corn.

Input and output combinations observed in farming systems around the world are heavily influenced by technologies, resource bases, and relative prices. Farmers allocate resources to maximize their families' well-being, taking into account expected costs and revenues. Economic profitability is just one factor they consider in their decision-making, but usually an important one.

SUMMARY

Farming systems in the world exhibit considerable variability. Both technical and human factors determine the types of farming systems. Technical factors include both physical and biological factors. Institutional and human factors are characterized by both externally and internally controlled forces. The major farming systems of the world can be grouped into three classes; shifting cultivation, pastoral nomadism, and

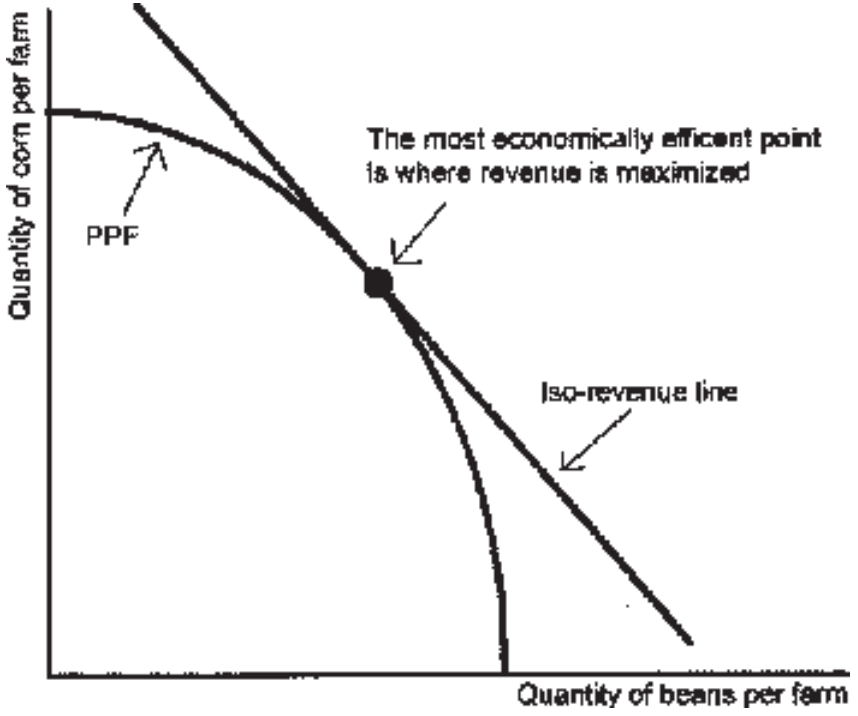


Figure 8-4: Output efficiency, given the technology and resource base.

settled agriculture. Settled agriculture represents a variety of agricultural systems including mixed farming systems, intensive annual crops, intensive and extensive livestock systems, and perennial crops.

IMPORTANT TERMS and CONCEPTS

Farming systems
Human determinants of farming systems
Intensive annual crops
Iso-costs and iso-revenues
Mixed farming system
Pastoral nomadism
Perennial crops
Political determinants of farming systems
Production possibility frontier
Settled agriculture
Technical determinants of farming systems

Looking Ahead

In this chapter, we briefly examined the nature and diversity of existing agricultural systems in developing countries and determinants of farming systems. In the next chapter, we focus on environmental or natural resource problems that can influence the ability of a farming system to improve and achieve sustainable development.

QUESTIONS for DISCUSSION

1 What are the major technical determinants of farming systems?
2 Describe the major human determinants of farming systems. Be sure to distinguish exogenous from endogenous factors.
3 How might the political system affect the nature of the farming system?
4 What is shifting cultivation and why is it more commonly found in Africa and Latin America than in Asia?
5 What is pastoral nomadism and what problems might be present in this type of system?
6 Distinguish among the major types of settled agriculture.
7 How do the optimal quantities of inputs and outputs change as iso-cost and iso-revenue lines become flatter, and why?
8 In what sense is the Boserup argument, presented in Box 8-1, consistent with the discussion of economic determinants of input use and output choice?

RECOMMENDED READINGS

Duckham, Alec N., and G. B. Masefield, *Farming Systems of the World* (London: Chatto and Windus, 1970).

Lin, Justin, "Agricultural Development in China", Chapter 31 in Carl K. Eicher and John M. Staatz, eds. *International Agricultural Development* (Baltimore: Johns Hopkins, 1998).

Ruthernberg, Hans, *Farming Systems in the Tropics* (Oxford: Oxford University Press, 1980).

CHAPTER 9

Resource Use and Sustainability

> …poverty compels people to extract from the ever shrinking remaining natural resource base, destroying it in the process. In fact, the major characteristic of the environmental problem in developing countries is that land degradation in its many forms presents a clear and immediate threat to the productivity of agricultural and forest resources and therefore to the economic growth of countries that largely depend on them. — Schramm and Warford[1]

THIS CHAPTER

1 Examines the nature of environmental or natural resource problems that influence the sustainability of agricultural development in developing countries
2 Identifies the principal causes of environmental problems in developing countries
3 Discusses some potential solutions to environmental problems in developing countries

NATURE of ENVIRONMENTAL PROBLEMS

Sound management of natural resources is widely recognized as essential for sustainable agricultural and economic development. Yet the effects of environmental degradation and poor natural resource management are increasingly evident throughout the world. The wide-ranging yet often interrelated problems of soil erosion, silting of rivers and reservoirs, flooding, overgrazing, poor cropping practices, desertification, salinity, water-logging, deforestation, energy depletion, climate change,

[1] Gunter Schramm and Jeremy J. Warford, eds., *Environmental Management and Economic Development* (Baltimore: Johns Hopkins University Press, 1989), p. 1.

loss of bio-diversity, and chemical pollution of land, water, and air, are increasing problems in many developing countries. The poorest countries tend to be most dependent on their natural resource base and thus have the potential of being the most vulnerable to environmental degradation. These countries find environmental problems particularly difficult to solve because rapid population growth, outmoded institutional relationships, poverty, and a lack of financial resources conspire against solutions. The poorest people within these countries usually suffer the most from environmental degradation.

As agricultural and economic development occur, forces are set in motion, some reducing and others increasing the pressures on the environment. Changes in the rate of population growth, new technologies, social and institutional relationships, the increased value of human time, and shifts in the weight placed on future as opposed to current income all influence the relationship between human activity and the environment. Economic and environmental policies together with other institutional changes can either alleviate or aggravate natural resource problems. The nature of particular types of environmental problems is discussed below, followed by a description of causes and potential solutions.

Global Versus Local Problems

Many environmental problems are local in cause, effect, and potential solution. Others are regional or even global. Problems such as erosion may be local, but also have more widespread implications if soil is deposited in rivers and transported to neighboring regions and countries where the silt raises river levels causing flooding. Others such as deforestation may appear local but can affect the global climate as carbon is released into the atmosphere. Environmental problems affect every nation in the world, can hinder the long run-sustainability of farming systems, and appear to be a growing concern. The following is a brief description of the more serious environmental problems facing developing countries.

Soil Degradation, Erosion, Silting, and Flooding

Topsoil is one of the world's most important natural assets. Farmers frequently invest in trying to improve it through soil fertility amendments and by using soil conservation techniques. But these investments are costly, and the poorest farmers are often unable to borrow money to undertake them and less willing or able to wait for the future benefits they provide. As a result, we observe that the lowest-income farmers often draw down their "soil capital", applying insufficient soil amendments

Farming an erodible hillside in Ecuador.

to fully replenish the nutrients removed at harvest or generated through natural processes. In effect, they are "mining" soil nutrients. The resulting soil degradation is usually reversible, if and when farmers find it profitable to apply more nutrients than plants withdraw.

An irreversible kind of degradation is excessive soil erosion, due to the exposure of soil to wind and water runoff. The extent of the world erosion problem is difficult to assess because few nations have systematically surveyed their soil resources. Nevertheless, the amount of agricultural land being lost due to soil erosion is estimated to be at least 20 million hectares per year.[2] An erosion rate of 50 tons per hectare is common in upland watersheds in many developing countries, whereas soil can regenerate somewhere between 0 and 25 tons per hectare.[3]

A loss of 50 tons per hectare represents only about 3 millimeters from the top of the soil, yet often the gullies and exposed bedrock from uneven erosion scar the landscape. The effects on productivity are potentially serious. Eroded soils typically are at least twice as rich in nutrients and organic matter as the soil left behind. Soil nutrient losses can be partially replaced by use of chemical fertilizers, but only up to a point, and fertilizer can be expensive. At any rate, the yields with

[2] See Norman Meyers, "The Environmental Basis of Sustainable Development, " in Schramm and Warford, eds., *Environmental Management and Economic Development*, p.59.

[3] See Alfredo Sfeirounis, "Soil Conservation in Developing Countries," Western Africa Projects Department, World Bank, Washington, D.C., 1986.

fertilizers are lower than they would be in the absence of erosion, so that erosion reduces productivity below its potential. It is estimated that erosion of good soils in the tropics may be resulting in maize-yield reductions of 10 to 30 percent.[4]

Soils are seriously deteriorating in the hills of the Himalayas, on the steep slopes of the Andes Mountains, in the Yellow River basin in China, in the Central American highlands, in the Central Highlands of Ethiopia, and on densely populated Java. The worst erosion in terms of average soil loss per hectare is found in the crescent from Korea to Turkey, in Eastern Europe and the former Soviet Union, followed by the Central American highlands, and in the Sahel in Africa. Differences are due to the intensity of cultivation on highly erodible soils and availability of soil conservation alternatives.

The indirect or off-site effects of erosion through silting of rivers and reservoirs are perhaps more serious than the on-site effects. When reservoirs fill with sediment, hydroelectric and irrigation storage capacity is lost, cutting short the useful lives of these expensive investments. When rivers silt up, flooding occurs during rainy seasons. For example, soil erosion in the hills of Nepal causes flooding in the plains of Nepal, India, and Bangladesh.[5] Flooding in the Yellow River basin in China is another example.

Desertification

Excluding real deserts, potentially productive drylands cover about one-third of the world's land surface. About one-sixth of the world's population lives in dryland areas that produce cereals, fibers, and animal products. In arid regions with under 300 mm of annual rainfall, vegetation is sparse and nomadic herding of such animals as goats and cattle predominates. In semi-arid regions, with 300 to 600 mm of rain, dryland farmers grow cereals such as wheat, sorghum, and millet in more

[4] See Meyers, The Environmental Basis of Sustainable Development, " in Schramm and Warford, eds., *Environmental Management and Economic Development.*

[5] While flooding is a serious periodic problem in many countries, not all or even most flooding is due to silt. Low-lying countries such as Bangladesh and parts of Egypt, Indonesia, Thailand, Senegal, The Gambia, and Pakistan are particularly vulnerable to flooding due to high river levels during the rainy season and sea surges during storms. About 80 percent of Bangladesh, for example, is a coastal plain or river delta. In l998, approximately two-thirds of this country of 130 million people was flooded. While a certain amount of normal flooding can have a positive effect on agricultural production, excessive flooding results in substantial loss of life from disease as well as drowning

Houses flooded in Dhaka, Bangladesh.

settled agriculture. The semi-arid regions are smaller in area but more densely populated than are arid regions.

The term *desertification* applies to a process occurring in arid and semi-arid regions. Desertification involves the depletion of vegetative cover, exposure of the soil surface to wind and water erosion, and reduction of the soil's organic matter and water-holding capacity. Intensive grazing, particularly during drought years, reduces vegetative cover; the loss of vegetation reduces organic matter in the soil and thus changes soil structure. After a rain, the earth dries out and becomes crusted, reducing the infiltration of future rains. Then, even more vegetation is lost for lack of water, the surface crust is washed or crumbles and blows away, leaving soil that is less fertile and unable to support much plant life.

Cropping, particularly when very intensive and when combined with drought, is another major cause of desertification. If soil organic matter is depleted by intensive farming practices and not replaced, a process similar to that described above occurs. As supplies of firewood dwindle, people use dried manure for fuel rather than fertilizer. As the soil loses its fertility, crop yields fall and wind and water erosion accelerates. Eventually the land may be abandoned.

Moderate desertification may cause a 25 percent loss of productivity while severe desertification can reduce productivity by 50

percent or more. It is estimated that 65 million hectares of productive land in Africa have been abandoned to desert over the last 50 years. Desertification is particularly a problem in the Sahel region of Africa and in parts of the Near East, South Asia, and South America. In terms of people directly affected, approximately 50 to 100 million people are currently dependent on land threatened by desertification. Areas where desertification is a problem also tend to be areas with rainfall that is both low and unpredictable. The ensuing periodic droughts create short-term severe food crises in those areas.

Salinity and Waterlogging

Irrigation, one of the oldest technological advances in agriculture, has played a major role in increasing global food production. However, bringing land under irrigation is costly, and degradation of irrigated land through questionable water management practices is causing some land to lose productivity or be retired from production completely. The major culprits are waterlogging and salinity.

Seepage from unlined canals and heavy watering of fields in areas with inadequate drainage can raise the underlying water table. Almost all water contains some salts. High water tables concentrate salts in the root zones and also starve plants for oxygen, inhibiting growth. Inadequate drainage also contributes to salinization when evaporation of water leaves a layer of salts that accumulate and reduce crop yields. A typical irrigation rate leaves behind about 2 to 5 tons of salt per hectare annually, even if the water supply has a relatively low salt concentration. If not flushed out, salt can accumulate to enormous quantities in a couple of decades.

Estimates are that between one-quarter and one-half of the world's irrigated land is affected by moderate to severe salinization. Some 20 to 25 million hectares are affected in India, 7 to 10 million hectares in China, and 3 to 6 million hectares in Pakistan. Other developing areas severely affected include Afghanistan, the Tigris and Euphrates river basins in Syria and Iraq, Turkey, Egypt, and parts of Mexico.

Deforestation and Energy Depletion

Forests play a vital role in providing food, fuel, medicines, fodder for livestock, and building materials. Tropical forests provide a home for innumerable and diverse plant and animal species. They protect the soil, recycle moisture, represent a sink for atmospheric carbon dioxide, and provide livelihoods for millions of human beings. But forests are being cleared at a rapid rate. During the 1980s, about 15 million hectares of tropical forest were being cleared each year; the rate has fallen

Deforestation has led to soil erosion in Nepal.

somewhat since then, but today somewhere between 5 and 8 million hectares per year are being lost.[6] The earth's forested areas have declined by about one-half in the last century. Deforestation continues at a rapid pace in countries such as Brazil, Indonesia, Mayanmar, Zambia, Tanzania, and Nigeria. These countries account for approximately 60 percent of the World's annual loss of tropical forests.[7]

Deforestation creates environmental problems on land and in the air. Forest clearing degrades soils and increases erosion in tropical watersheds. Soils in tropical forests tend to be fragile and unsuited for cultivation; their fertility is quickly depleted as erosion follows the tree clearing. In semi-arid areas, deforestation contributes to loss of organic matter, increases wind and water erosion, and speeds the rate of desertification. As forests are burned to clear land, carbon dioxide and carbon monoxide are emittedinto the atmosphere, contributing to climate change. It is estimated that more than 20 percent of the net increases to atmospheric carbon comes from deforestation.

[6] Frédéric Achard, Hugh D. Eva, Hans-Jürgen Stibig, Philippe Mayaux, Javier Gallego, Timothy Richards, Jean-Paul Malingreau, "Determination of Deforestation Rates of the World's Humid Tropical Forests," *Science,* 9 August 2002:, vol. 297, no. 5583, pp. 999–1002.

[7] Food and Agricultural Organization of the United Nations. 2006. Global Forest Resources Assessment; Progress toward sustainable forest management. FAO Forestry Paper 147, Rome., 350 pp.

In developing countries, seven out of ten people depend on fuel wood for meeting their major energy (cooking and heating) needs. The FAO estimates that three out of four people who rely on fuel wood are cutting wood faster than it is growing back. When people cannot find fuel wood, they turn to other sources of organic matter such as dung for fuel, thereby depleting soil fertility and aggravating soil erosion and desertification.

Deforestation also threatens the world's biological diversity. Tropical forests cover only 7 percent of the world's landmass, yet they contain more than 50 percent of the plant and animal species.[8] In Madagascar, for example, there were, until recently, 9500 documented plant species and 190,000 animal species, most of them in the island's eastern forest. More than 90 percent of the forest has now been eliminated, along with an estimated 60,000 species.[9]

Climate Change

The Earth's climate is undergoing change. Surface temperatures increased by 1°F during the 20th century, and the 1990s were the hottest decade of the century. Projections of future increases range from 2.5°F to 10.4°F by 2100.[10] Strong consensus now exists among the world's scientists that climate change is evident in shifts in ranges of flora and fauna, earlier onset and lengthening of growing seasons, and major changes in rainfall patterns. Observed changes in abundance of plant and animal and changes in ecosystem compositions have been attributed to climate change. As world temperatures rise, average sea levels also rise, thus threatening coastal lands. Violent storms, monsoons, droughts, floods, and generally increased weather variability are likely. And global climate change could alter disease prevalence and be very hard on certain animal species because their ecosystem may shift while the property-line boundaries of their preserves do not.

While there is some disagreement about the degree to which human activities affect the rate of climate change, it is clear that agricultural systems throughout the globe will feel its effects. Impacts are likely to vary substantially between regions. In higher latitude areas, agricultural productivity is predicted to rise with moderate temperature

[8] See E. O. Wilson, "The Current State of Biological Biodiversity," chapter 1 in E. O. Wilson, ed., *Biodiversity* (Washington, D.C.: National Academy Press, 1988), p. 8.

[9] See Robert Repetto, "Managing Natural Resources for Sustainability," in *Sustainability Issues in Agricultural Development*, ed. Ted J. Davie and Isabelle A. Shirmer (Washington, D.C.: World Bank, 1987), p. 174.

[10] See Tom M. L. Wigley, "The Science of Climate Change," Pew Center on Climate Change Report, 2005.

increases, while sub-Saharan Africa and coastal areas in Asia are likely to feel the strongest adverse effects. Semi-arid and arid areas are particularly vulnerable and will suffer a decrease in water availability, increased likelihood of drought and growing heat stress. In these same areas, groundwater resources are likely to decline so that moisture-related plant stress will lower productivity. Other areas will feel more mixed effects, but overall the most likely outcomes are more variability in weather patterns, including deeper and more prolonged drought, increased temperatures and reduced productivity in rain-fed tropical and sub-tropical agriculture, reductions in access to fresh water, and expanding populations of pests and diseases.

Climate change will affect agricultural productivity, and people will likely respond to it by adjusting their farming techniques and their livelihood strategies. We are only now beginning to understand the degree of adaptation, but evidence shows that people in the most affected areas have already started to change the way they farm and generate their livelihoods. In the short-run, farmers adapt by changing crop mixes, using water conservation measures, and adopting risk-management techniques to lessen the consequences of more frequent droughts. They adjust their livelihood strategies to include more non-climate-affected sources of income. For example, they work off the farm and change their migration strategies.

Over the longer run and as the change in climate increases, more options are needed to create opportunities to adapt. Governments may invest in, and farmers may adopt, technologies and production techniques that reduce the impact of climate change. Agricultural research systems can respond by producing shorter-season seed varieties that are more tolerant of drought, rice varieties that are more tolerant of salinity, and other germplasm that is resistant to environmental stress. Enhanced means of managing soil moisture can be identified through research. Farmers may adopt conservation farming techniques that minimize disruption of the soils and lower exposure to rainfall shortages. Conserving water is a particular concern because it is estimated that 70 percent of freshwater use is currently devoted to agriculture.

It is important to recognize that if the projections of the scientific community are correct, the world is in a race against time. Adaptation will mitigate some of the ill effects of climate change, and some areas will likely prosper following adaptation. But adaptation will not ameliorate the ill effects of climate change in the most adversely affected regions. In low-lying coastal regions and some of the more arid areas, the imperative is to attain improvements in well being over the short- to medium-term. Over the long haul, climate change is likely to alter

the environment to such a degree that no adjustments in livelihood strategies will suffice.

Chemical Pollution

Misuse of chemical pesticides and fertilizers has contaminated the land and water in many developing countries, damaging the health of producers and consumers, stimulating the emergence of pests resistant to pesticides, destroying the natural enemies of pests, and reducing fish populations or rendering them unsafe for human consumption. Acute pesticide poisonings are common, and little is known about potential long-term health effects. Few developing countries have established effective pesticide regulatory and enforcement systems.

Hundreds of pests have become resistant to one or more chemicals, and the number is growing. Fertilizer runoff increases nitrate levels in ponds and canals, reducing oxygen levels and killing fish. Excessive pesticide levels often destroy fish in irrigated rice paddies.

Heavy use of pesticides and fertilizers tends not to hurt agricultural production in the short-run. However, as resistance to pesticides builds up and predators are reduced, future production potentials are jeopardized. And society bears the cost of off-farm pollution.

CAUSES of ENVIRONMENTAL PROBLEMS

Environmental degradation can result from physical, economic, and institutional factors. Many environmental problems are interrelated; for example, deforestation, erosion, and silting of rivers and reservoirs are all linked. Natural resource degradation usually has direct and indirect causes. For example, desertification can directly result from overgrazing and poor cropping practices, but indirectly result from poverty and population growth. Physical or technical causes of natural resource degradation are often the most visible. Land clearing for timber, fuel wood, cattle ranching, or farming causes deforestation. Deforestation results in loss of biodiversity, loss of soil, and diminished soil fertility since soil uncovered in tropical forests loses its fertility quickly. If the forest is burned, carbon dioxide enters the atmosphere. If the area is semi-arid, loss of forests can contribute to desertification. Desertification can also result from overgrazing, which itself is caused by too many cattle eating grass in an area subject to dry spells or droughts. Intensive cropping in semi-arid areas contributes to desertification. Many other examples of physical causes of natural resource degradation can be cited. Salinity and waterlogging result from poorly managed irrigation systems. Chemical pollution results from excessive fertilizer and pesticide use. Silting of rivers and tidal surges during storms cause flooding.

The challenge in solving such problems, however, is in understanding what factors affect individual and group decisions about natural resource use. These factors are both economic and determined by institutions. Institutions include the legal system, cultural norms, market structures, and other rules of behavior affecting decision-making incentives. Once we understand how economic and institutional factors affect decisions about resource use, we can begin to formulate strategies to address the most serious environmental problems.

Economic Causes of Natural Resource Degradation

An important economic cause of natural resource degradation occurs when markets fail to reflect the true value of resources or the true costs of actions. Market failures emerge due to the presence of externalities, high costs of information, and in the provision of public goods. An externality is created when decision-makers impose costs on others without considering these costs when making the decision. Farmers, for example, may create off-farm costs associated with soil erosion or pesticide pollution without considering these external costs (see Box 9-1). Furthermore, a lack of information about or concern for environmental damage creates costs that lead to environmentally destructive behavior. For example, the farmer may be unaware that his farming practices are damaging long-term productivity or that cost-effective practices are readily available to improve the situation. In such cases, the market is failing to adequately transmit information to the farmer. Environmental quality is a public good, which means it is very costly to prohibit someone from benefiting from it and one person's benefiting from it does not preclude another from benefiting from it. It is well known that the free market is associated with an undersupply of public goods. All these forms of market failure contribute to natural resource problems.

Poverty is another economic condition associated with environmental degradation. Poverty drives people to farm marginal lands intensively, to seek fuel wood, and to follow other agricultural practices that produce food at the potential sacrifice of future production. As discussed in Chapter 4, poverty reinforces population growth, which is a major contributor to deforestation, overgrazing, and farming on steep slopes, drylands, and flood plains.

The concern of the poor for the present, implying heavy discounting of future costs and benefits, is matched by the needs of governments in developing countries to deal with internal and external debt problems. Indeed, the existence of debt problems in many countries reflects previous decisions to spend on current consumption rather than save for the future. Governments follow policies that encourage natural

resource-based exports to pay off debts and import capital goods. They lack the financial resources to address environmental problems.

Countries implementing economic development programs usually find high rates of return to many types of capital investment. The high interest rates often characteristic of these cases encourage current consumption and may place demands on natural resources. Interest rates in developing countries are also influenced by interest rates in major developed countries, due to linkages through international financial markets.

Institutional Causes of Natural Resource Degradation

A major cause of environmental degradation is institutional failure, both private and public. Existing social structures and local customs may not be adequate to preserve the environment as economic development proceeds. Or, environmentally constructive social structures and customs may be destroyed by national policies or by increases in the costs of transactions and of acting collectively. In some cases, inadequate institutions are the legacy of colonial interference or the result of more recent international influence.

Market institutions determine how well markets work and, as noted above, market failures are a chief cause of environmental degradation. These market failures mean that the market is not transmitting the true value of the resource to the decision maker. Market failures can be due to inadequately defined property rights, costs associated with monitoring and enforcing property rights, and weak enforcement institutions. It may be unclear, for example, whether the farmer has the right to pollute the water or whether downstream users have the right to clean water. Even if these rights are legally clear, they may be difficult or impossible to enforce. Thus, weak property rights contribute to the market failure.

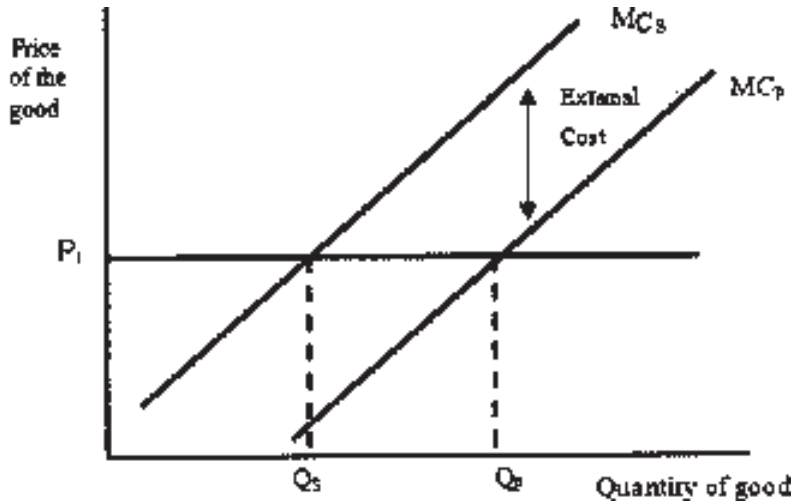
Inadequate property rights in forest, pastures, and ground and surface waters can undermine private or local collective incentives to manage resources on a sustainable basis. In some areas the land or water resource was traditionally held in common. Under a common-property regime, people in the village or community had access to use the resources but did not own or rent them privately. When the local society could maintain authority over the resource, or when population pressures were such that the resource was in abundant supply, then this common property could be managed in a socially optimal manner. However, as population increases and as national policies usurp local authority, breaking down traditions and customs, incentives for resource preservation and traditional means of controlling access often

are destroyed. If one person does not cut down the tree for fuel wood, another will. Or, if one person's goat does not eat the blade of grass, another person's goat will. Or, if one person does not use the water or catch the fish, another will. The result is that incentives exist for each individual to overexploit resources because otherwise someone else will.

Common-property regimes do not necessarily cause resource mismanagement if local institutions create incentives to efficiently manage the resource. In many areas of Africa, common-property institutions were said to cause overgrazing on rangelands. However, attempts by the government to replace these institutions with private ownership

BOX 9-1.
EXTERNALITIES and PRIVATE DECISIONS

One market failure associated with environmental degradation is the divergence between private and social costs of actions. This divergence is caused by the presence of external costs. An external cost exists when an activity by one agent causes loss of welfare to another agent *and* the loss is not considered by the author. The effect of externalities on private decision-making is illustrated in the figure below.



A farmer who cannot influence market prices will produce a good up until the point where the private marginal cost of its production (MC_p) equals the market price. In the figure, this point is shown where $MC_p = P_t$ and Q_p units are produced. An external cost is represented by the social marginal cost curve (MC_s), which exceeds the private cost curve. From society's point of view, the desirable production level is Q_s (where $MC_s = P_t$). Thus, the externality leads to more production of the good than is socially desirable.

schemes were largely counterproductive, contributing to more rapid degradation of resources and leading to increased economic inequality. Efficient indigenous resource management institutions were replaced by less effective but more modern institutions. Common-property institutions can certainly be a viable means of managing resources.[11]

In areas of frontier colonization, poorly defined and inadequately enforced property rights can create incentives for over-exploitation of natural resources. For example, the Peten Region of northern Guatemala is currently undergoing high rates of deforestation, particularly in its western extremities. In the western Peten, the Guatemalan government established the Laguna de Tigre national park in 1990. It was hoped that a national park would slow settlement and lead to conservation of the forest in its original state. However, the government does not have the resources to monitor and discourage settlement on these isolated public lands, and a weak legal system prevents enforcement of laws prohibiting illegal settlement. As a result, illegal settlers are deforesting the lands, while population pressures are growing, water is increasingly scarce, and ecological integrity has been destroyed.

Public policies are another major institutional cause of natural resource degradation. Agricultural pricing policies, input subsidies, and land use policies often discourage sustainable resource use. Governments in developing countries intervene in agricultural markets to keep food prices artificially low. These interventions cause land to be undervalued, reducing incentives for conservation. And, low incomes make the investment required for sustainable output difficult. On the other hand, higher agricultural prices raise the value of land, and, as a result, can contribute to increased deforestation.[12] These competing impacts of agricultural prices on the environment make it important that policy impacts be explored as a part of government decision-making.

Governments frequently subsidize fertilizer and pesticides, in part to compensate for keeping farm product prices low. If fertilizer or pesticide use causes an externality, then subsidies, because they increase input use, will increase the level of the externality. Subsidies may be indirect, in the form of roads or export subsidies that encourage deforestation. Road access is strongly associated with deforestation in all

[11] See Daniel W. Bromley, ed., *Making the Commons Work* (San Francisco: Institute for Contemporary Studies Press, 1992).

[12] See Arild Angelsen and David Kaimowitz, "Rethinking the Causes of Deforestation: Lessons from Economic Models," *The Woirld Bank Research Observer*, vol. 14, no. 1 (February 1999), pp. 73–98.

regions of the world. Subsidized irrigation water can encourage its wasteful use.

Land tenure and land use policies may cause exploitation of agricultural and forest lands with little regard for future productivity effects. Short leases, for example, create incentives to mine the resource base for all it is worth in the short-run. And, as just noted, it is an error to think that local incentive problems can be entirely corrected by national policies. Bromley and Chapagain point out that, in Nepal, national policies on forests have destroyed local conservation practices and incentives.[13] A common policy in Latin America has been to require that in colonized areas land needs to be developed, which usually means cleared of trees, prior to receiving title to the land. A large part of the deforestation in the Brazilian Amazon is associated with these types of titling rules.

Land use patterns are sometimes affected by colonial heritage or other international influences. In parts of Latin America and the Caribbean, large sugarcane, coffee, and banana plantations, or even cattle ranches, are found in the fertile valleys and plains, while small peasant farms intensively producing food crops dot the eroding hillsides. The low labor intensity of production in the valleys depresses job opportunities and forces the poor to rely on fragile lands to earn incomes. These patterns are the legacy of colonialism. Colonial powers in Africa changed cropping system to cash cropping in areas where cash cropping could not be supported by the natural resource base. Peasants have been forced onto marginal lands, reducing lands for nomads. Traditional nomadic trading patterns were also disrupted.

These and other institutional policies have contributed to natural resource problems, as they exist today. Institutional change is therefore one of the potential solutions to these problems, as described below.

POTENTIAL SOLUTIONS to NATURAL RESOURCE PROBLEMS

Solutions to environmental problems contain technical, economic, and institutional dimensions. Technical solutions are needed to provide the physical means of remedying natural resource degradation, while economic and institutional solutions provide the incentives for behavioral change.

[13] See Daniel W. Bromley and Devendra P. Chapagain, "The Village Against the Center: Resource Depletion in South Asia," *American Journal of Agricultural Economics*, vol. 68 (December 1984), pp. 868–73.

Technical Solutions to Natural Resource Problems

A variety of technical solutions are available to solve deforestation, erosion, desertification, flooding, salinity, chemical pollution, and other environmental problems. Where technical solutions are lacking, government-sponsored research and education can develop new natural resource-conserving practices and facilitate their adoption.

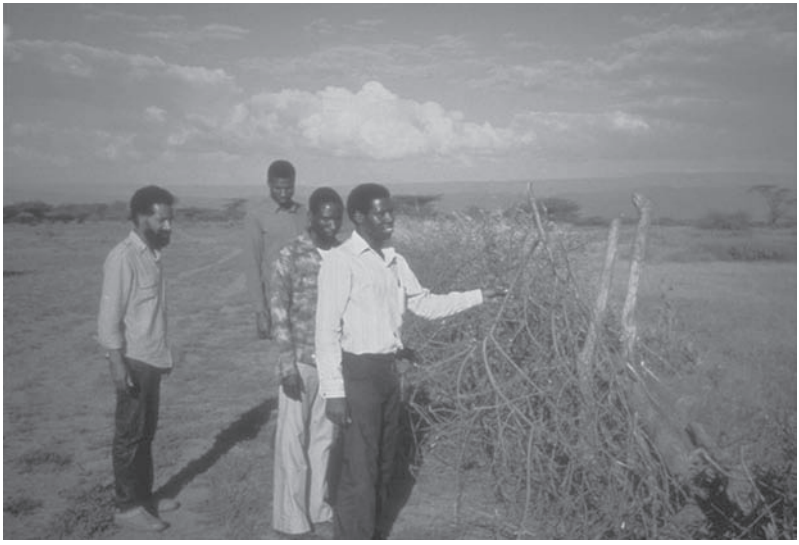
Windbreaks, contour plowing, mulching, legume fallow crops, alley cropping, deferred grazing, rotational grazing, well-distributed watering places, and re-vegetation or reforestation are all examples of physical practices that could help reduce soil erosion, silting, and desertification. Solar pumps, biogas generators, and more efficient cooking stoves can provide or save energy, thereby reducing fuel-wood consumption, deforestation, and desertification. Embankments can provide protection from flooding for limited areas, and dams can be built on rivers to control water flows.

Irrigation canals can be better lined to reduce waterlogging and salinity and conserve water resources. Integrated pest management techniques can be developed that involve increased biological and cultural control of pests to reduce pesticide pollution. Germplasm banks can be used and conservation reserves established to preserve endangered plant species.

These are just a few of the potential technical or physical solutions to environmental problems. In many cases these technical solutions are already known, but in others additional research is essential for success. In the pest management area, for example, much work still needs to be completed on biological controls for major pests in developing countries. Integrated pest management (IPM) is a family of pest management techniques that lowers dependence on toxic pesticides; in many countries, these techniques are technically feasible, but have not been widely spread to farmers due to limited extension and agricultural outreach services in many developing countries.[14]

The availability of technical solutions to natural resource problems is essential for reducing environmental degradation. In almost all cases, however, these solutions must he combined with economic and institutional changes that create incentives for behavioral change. Without these incentives, it is unlikely that the technologies will be widely adopted, since they usually imply increased costs to their users.

[14] See George W. Norton, E. A. Heinrichs, Gregory C. Luther, and Michael E. Irwin, eds., *Globalizing Integrated Pest Management: A Participatory Research Process* (Ames, Iowa: Blackwell Publishing, 2004).



A brush fence in Kenya being used to facilitate rotational grazing.

Economic and Institutional Solutions to Natural Resource Degradation

International and natural agricultural research systems can generate new technologies that increase food production and incomes. As incomes grow, population pressures are reduced, and the demand for environmental protection increases. New institutions may be formed (or existing institutions may evolve) in response to this demand, and incentives for resource conservation are created.

As countries develop, the major source of growth is not the natural resource base, but new knowledge (see Chapter 5). This knowledge can, to some extent, substitute for natural resources and is less subject to the diminishing returns associated with more intensive use of natural resources. Increases in agricultural productivity resulting from the new knowledge or technologies not only raise incomes, but also the value of human time. As the value of human time increases, population growth rates decline, with favorable implications for natural resource problems.

The best immediate way to solve natural resource problems is, however, through reforms of economic policy or institutional changes that reduce market failures. Reducing the discrimination against agriculture in pricing policies should help. Low returns to agriculture depress farmland prices and the returns to investments in land conservancy practices, as noted earlier. Low returns reduce the demand for

Spraying pesticides in the Philippines.

labor and therefore labor income. If returns to agriculture were raised, subsidies on inputs such as agro-chemicals could be eliminated. However, increased returns to agriculture also put additional pressure on forest resources, so institutional mechanisms to reduce deforestation must accompany changes in agricultural pricing policies.

Several means are available for addressing the underlying market failures associated with environmental degradations. Subsidies and taxes can be used as ''carrots'' or ''sticks'' to reduce externalities or off-site effects associated with agricultural and forestry use. An example of a conservation subsidy (i.e., a "carrot'') might be a program in which the government shares the cost of building terraces, wind-breaks, and fences, or of planting trees. In some cases, local workers can be paid in-kind with food from internationally supplied food aid. An example of a "stick'' is a sales tax on chemical pesticides. Such subsidies are designed to "internalize" the externality, so that the economic actor considers the social costs associated with his or her decisions.

Institutional change that creates secure property rights will help address some problems of environmental degradation. Ownership of land titles increases the returns to long-term investments in land. On

BOX 9-2.
INSTITUTIONS and DEFORESTATION in the BRAZILIAN AMAZON

Brazil contains 3.5 million square kilometers of tropical forests, some 30 percent of the world's total. Most of the forests are found in the Brazilian Amazon Basin. Deforestation of this rich reserve of plant and animal species has increased in recent years, raising concerns for its effects on atmospheric carbon levels and on the maintenance of global biodiversity.

The Brazilian government made a conscious decision in the 1960s to develop the Amazon as a means of relieving population pressures, providing territorial security, and exploiting the region's wealth. Ambitious road-building programs, other infrastructure development, agricultural colonization projects, and policies providing tax and other incentives for agricultural and industrial development were begun. These projects had the effect of opening access to the Amazon, and promoting environmentally unsound development.

Tax exemptions and cheap credit spurred the creation of large-scale livestock projects, whose economic and environmental suitability to the region was questionable. The National Integration Program established a network of villages, towns, and cities and cleared lots for in-migrating settlers. The plans for these settlements were made without regard for soil fertility or agricultural potential, and the cleared forest lands were quickly eroded and otherwise degraded.

Environmentally destructive settlement practices are promoted throughout the Amazon by the Brazilian government's practice of awarding land titles only for deforested lands. A migrant in either an official settlement project or an invaded area can obtain title to the land simply by clearing the forest. Once the title is granted, the migrant can sell or transfer it to someone else, and proceed to clear additional lands. Calculations show that it is more profitable to clear land, plant subsistence crops for two years, and then sell and move than it is to remain as a permanent settler.

Clearly, the rate of deforestation in Amazonia is directly influenced by government policies and other institutional arrangements. It is just as clear that policy reform and institutional adjustments can slow, or even reverse, this process.

Source: Dennis J. Mahar, "Deforestation in Brazil's Amazon Region: Magnitude, Rate, and Causes," chapter 7 in Gunter Schramm and Jeremy J. Warford, eds., *Environmental Management and Economic Development* (Baltimore: Johns Hopkins University Press, 1989).

the other hand, the removal of institutions that guarantee land titles only if forests are cleared will help stop deforestation (see Box 9-2). The provision of property rights does not necessarily imply privatization. There are numerous examples of common-property regimes managed in environmentally sound fashions, and it is only when population growth or other changes put pressure on group management that the effectiveness of the management is diminished. Institutional changes that reinforce these common-property management schemes may be more effective than privatization.

Many successful examples can be found of assigning property rights and creating markets for environmental quality. In eastern Peten, Guatemala, community organizations were granted contracts for sustainable use of forest resources. These organizations, because they have the rights to the natural resources, control access to the forest and "police" extractive activities, such as timber harvest by outsiders. As a result, the eastern Peten is still heavily forested, especially in comparison to the west, where inadequate property rights and high enforcement costs have contributed to heavy deforestation (see above). In Zimbabwe, local villagers were given rights to harvest elephants, and sell these rights to foreign hunters. The money from these sales is kept and used for development purposes in the villages. The villagers now see the elephants as a valuable resource and protect them from poachers. As a result, elephant populations are growing rapidly in areas where 15 years ago the elephant was practically extinct.

Certification is a process whereby international markets recognize and reward products that are sustainably produced. For example, wood in the eastern Peten is harvested in an environmentally sustainable manner and is certified as "green" by Smartwood, an international organization. The wood is favorably received in international markets and receives a price premium. Other products, such as coffee, cocoa, and bananas can also be certified as being produced in an environmentally and socially sustainable manner.

Certification is just one element of an emerging family of mechanisms to create markets for environmental goods. Payments for environmental services (PES) are schemes whereby demanders of environmental goods are brought together with suppliers so that both benefit. A global example is the Clean Development Mechanism (CDM) established by an international environmental agreement called the Kyoto Protocol, which allows countries that are committed to greenhouse gas emission reductions to pay for carbon emmission-reducing projects such as reforestation in developing countries as an alternative to more expensive emission reductions in their own country. Local examples of

PES schemes are found throughout Central America, where water-using towns and cities pay upstream farmers to adopt practices that create less damage to water quality. These schemes create a market for the environmental good and induce producers to consider the value of the resource when making decisions.

Regulation is an alternative institutional mechanism for influencing environmental behavior. Although difficult to enforce, regulation can play a role when combined with other economic incentives. For example, burning of crop stubble, farming of particularly erosive lands, or logging in certain areas can be prohibited in conjunction with a program that also provides other government economic benefits to farmers or forest owners. Families can be restricted from settling in flood-prone areas, perhaps with the provision of funds for resettlement. Experience shows that without incentives for changing behavior, regulations tend to be ineffective, since enforcement is costly and there are private incentives to cheat.

Physical restrictions on grazing, land reform programs that distribute land to small farmers, revised leasing arrangements, and many other government-sponsored institutional changes can improve natural resource sustainability if certain principles are followed. First, there is a need for careful assessment of the economic benefits and costs, including externalities, resulting from the policies. Second, local input is needed in the decision-making process. Third, compensation often is required for any losers. That society as a whole will be better off following these institutional changes is not enough. Losers may need to be compensated or they may oppose any change. PES schemes can be exploited in such instances, and those who benefit from the change can "bribe" producers to adopt it.

These three principles hold for institutional changes at various levels — local, regional, national, and international — and they are not always easy to apply. If developed countries want developing countries to reduce carbon-dioxide emissions associated with forest burning, developed countries must be willing to foot part of the bill. The Kyoto Protocol for climate change, adopted in 1997, reflected this need for mutual sacrifice to limit greenhouse gas emissions. It was the product of several years of intense negotiations and reflected developing-country energy needs for economic development. The agreement, although not ratified by the U.S. government, entered into force in early 2005 and sparked creation of markets for trading emission allowances under the CDM. New markets for formerly unvalued environmental goods (such as carbon sequestration) represent opportunities for producers in developing countries. The challenge is to overcome institutional

barriers and information and administrative costs at the local level. PES schemes require careful monitoring to ensure that the land users are adhering to the agreements and a well-functioning legal system to adjudicate claims.

Similarly, governments need to consider what factors affect individual decisions. Solutions to environmental problems do not just emerge from changes in the legal environment. If governments want deforestation reduced, they cannot just pass a national decree. They must involve local decision makers in designing an institutional solution that provides individual incentives for appropriate behavior. Someone may need to estimate the costs and benefits associated with alternative institutional mechanisms. Enforcement mechanisms need to be fair and have teeth.

In many cases, the presence of transactions costs and collective action has created institutional environments that are destructive to the natural resource base. Imperfect information, corrupt government officials, and the absence of new institutional arrangements to replace previous social and cultural norms that constrained behavior harmful to the groups are serious problems. Improvements in information flows and creation of markets to reflect environmental values are essential if such corrupt behavior and reductions in other transactions costs are to be reduced. Education also becomes vitally important. Thus, focusing on communications infrastructure and human-capital development are two keys to environmental improvement.

SUMMARY

Sound environmental management is essential for sustained agricultural and economic development. Yet environmental degradation is evident throughout the developing world. Soil erosion, silting of rivers and reservoirs, flooding, overgrazing, poor cropping practices, desertification, salinity and waterlogging, deforestation, energy depletion, loss of biodiversity, and chemical pollution have become major problems. Poverty, high rates of return to capital, debt problems, rapid population growth, and misguided public policies conspire against solutions. Environmental problems are interrelated, and understanding their causes requires sorting out complex physical, economic, and institutional linkages. Technical solutions are needed for each of these problems, but economic and institutional changes must provide the incentives for behavioral change. As incomes grow, population pressures are reduced, and the demand for environmental protection increases. Economic development means more resources in the long run for addressing environmental problems. Changes in taxes, subsidies, regulations,

and other policies can influence local incentives for conservation. Balancing benefits with costs, obtaining local input in the decision-making process, and compensating losers are needed for effective solutions to local and global environmental problems. Because transactions costs must be reduced for natural resource conservation to occur, information flows must be improved and human capital must be developed.

IMPORTANT TERMS and CONCEPTS

Biodiversity
Chemical pollution
Climate change
Common property
Deforestation
Desertification
Discounting of costs and benefits
Global warming
Environmental degradation
Externalities
Flooding
Greenhouse effect
Institutional change
Market Failure
Natural resource management
Overgrazing
Payments for Environmental Services
Regulations
Salinity and waterlogging
Soil erosion
Subsidies and taxes
Sustainable resource use

Looking Ahead

In this chapter, we examined the nature and causes of environmental problems in developing countries. Potential technical, economic, and institutional solutions were considered so that agricultural development can be sustainable. In the next major section of the book we consider what it takes to improve agriculture more generally from both a technical and an institutional perspective to contribute to sustainable development. However, first, in Chapter 10, we consider the how human resources, including family structure and gender issues, influence standards of living in developing countries.

QUESTIONS for DISCUSSION

1. What are the major natural resource problems facing developing countries?
2. Are the poorest countries the most vulnerable to environmental degradation? Why, or why not?
3. How are flooding and soil erosion related?
4. What is desertification?
5. How are waterlogging and salinity problems interrelated?
6. How are deforestation and energy problems interrelated?
7. What are the major technical or physical causes of natural resource degradation?

8 What common market failures lead to environmental degradation in developing countries?
9 What is a public good? Why might the free market undersupply a public good?
10 How is climate change related to market failure? What efforts to address the market failure might have major impacts on carbon emissions?
11 What are some of the technological solutions to natural resource problems?
12 What are some of the economic and institutional solutions to natural resource problems?
13 How does a PES scheme help correct for market failure?
14 What are three key principles that must hold if institutional changes are to successfully solve environmental problems?
15 Why are reductions in transactions costs important for sustainable natural resource use?

RECOMMENDED READINGS

Markandaya, Anil, Patrice Harou, Lorenzo Giovanni Bellu, and Vito Cistulli, *Environmental Economics for Sustainable Growth* (Northhampton, Mass.: Edward Elgar, 2002).

Pearce, David W., and R. Kerry Turner, *Economics of Natural Resources and the Environment* (Baltimore: Johns Hopkins University Press 1990), pp. 61–9, 342–60.

Schramm, Gunter and Jeremy J. Warford, eds., *Environmental Management and Economic Development* (Baltimore: Johns Hopkins University Press, 1989).

Tietenberg, T. H., "The Poverty Connection to Environmental Policy," *Challenge,* September-October 1990, pp. 26–32.

Tietenberg, T. H., and H. Folmer, eds., *The International Yearbook of Environmental and Resource Economics: 2004/2005* (Cheltenham, UK: Edward Elgar, 2004)

World Commission on Environment and Development, *Our Common Future* (New York: Oxford University Press, 1987).

CHAPTER 10

Human Resources, Family Structure, and Gender Roles

> "Women account for 70 to 80 percent of household food production in Sub-Saharan Africa, 65 percent in Asia, and 45 percent in Latin America and the Caribbean. They achieve this (production) despite unequal access to land, to inputs such as improved seeds and fertilizer, and to information." Lynn R. Brown et al. 2001[1]

THIS CHAPTER

1 Discusses the role of human resources in agricultural and economic development
2 Examines differences in family structure and gender roles in farm households in developing countries
3 Considers determinants of gender roles in farm households

Poor agricultural households in developing countries generally have few assets. Some own small parcels of land, but all households have human assets. The productivity of human assets helps determine prospects for accumulation of other assets and increased income over time. Productivity of labor can be improved through investments in education, health care, nutrition, and acquisition of skills. Decisions about investments in education, how household labor is deployed, and about the size and structure of families are made by families. These decisions depend on policy-based and other incentive structures, cultural norms, and gender roles; such decisions have major impacts on

[1] Lynn R. Brown, Hilary Feldstein, Lawrence Haddad, Christina Peña, and Agnes Quisumbing, Chapter 32, p. 205 in Per Pinstrup-Andersen and Rajul Pandya-Lorch, eds., *The Unfinished Agenda: Perspectives on Overcoming Hunger, Poverty, and Environmental Degradation* (International Food Policy Research Institute, Washington, D.C., 2001).

productivity, asset accumulation, and household well-being. In some societies, for example, girls are less likely to attend school than are boys; in others, women are less likely to receive health care and have shorter life expectancies than do men. We examine the role and determinants of investments in education, how human resources affect household well-being, and the roles of men, women, and children in making decisions and participating in household activities.

ROLE of EDUCATION

The overall productivity of the economy depends on the quantity and quality of inputs into production. Better education, health care, and acquisition of skills are clear means of improving labor productivity. Evidence continually shows that better-educated individuals earn higher incomes and that these higher incomes reflect greater productivity.[2] Education can be an important contributor to improved agricultural productivity; underutilization and low productivity of human resources in agriculture is a serious problem in many developing countries. Better-educated farmers are more able to adopt new technologies, are better able to understand price and market information, and have more access to credit and other forms of capital. Better-educated care givers can prepare more nutritional meals, reduce diseases through improvements in basic sanitary practices, and assist their children in learning at a younger age. Countries that fail to improve the skills and knowledge of farmers and their families find it difficult to develop anything else.

Objectives and Benefits of Education

Rural education is an investment in people that has as its objectives: (1) improving agricultural productivity and efficiency, (2) preparing children for non-farm occupations if they have to leave farming, and (3) enhancing the general quality of life by enabling better decision making. Education may help motivate farmers toward change, teach improved decision-making and farm-management methods, provide farmers with technical and practical information, and lead to better marketing of higher-valued farm outputs. Agricultural extension is complementary to other sources of information because it speeds the transfer of knowledge about new technologies and other research results (see Chapter 12 for more details on extension systems).

[2] Paul Glewwe, "Schools and Skills in Developing Countries: Education Policies and Socioeconomic Outcomes," *Journal of Economic Literature*, vol. 40 (2), June 2002, pp. 436–82.

A country with a literate people in rural areas will have better information flows than one without, due simply to better communications. Communications help reduce the transactions costs that hold back development; they provide information to improve the timing of productive activities and lower risk. Education helps farmers acquire, understand, and sort out technical, institutional, and market information.

The result is that investments in education yield returns not just for the farmer, but for society as a whole — educational attainment is a public good. As education levels increase in a village, all villagers tend to gain from more productive neighbors, better information flows, and more experimentation and innovation. Because it results in a more productive and efficient agriculture and in a more productive labor force for non-farm employment, and because of its public good characteristics, most countries finance education, particularly at the primary and secondary levels. T.W. Schultz has argued that education helps people to deal with economic disequilibria. Thus, as agriculture in a country shifts from a traditional to a more dynamic, science-based mode, the value of education increases.

Education is important not just for farmers and for children who will continue farming, but for those who leave agriculture. Education for non-farm jobs is particularly important for agricultural development if the youth acquire jobs as agricultural extension agents, managers of cooperatives and other business firms supplying inputs to farmers or marketing their products, agricultural scientists, or government officials who administer agricultural programs. Educated children who do not choose agricultural occupations often send remittances back home; these remittances are an important source of investment capital for farmers. It is important to understand that education represents an investment in human beings and that these investments reap returns both inside and outside agriculture. If a child of a farmer becomes educated and decides to leave agriculture and migrate to a city for a job, the individual and society as a whole both gain from the investment.

Education of girls can be particularly important for development. As women become more educated, they live longer and healthier lives, the value of their time increases, the health and nutrition of family members improves, and total fertility declines.[3] They have fewer, healthier, and better-educated children. They also earn more in farming and off

[3] See T. Paul Schultz, "Women's Role in the Agricultural Household," Chapter 8 in Bruce L. Gardner and Gordon C. Rausser, eds., *Handbook of Agricultural Economics* (New York: Elsevier, 2001).

the farm.[4] Payoffs to women's education are found in the short-run through improved productivity, and long-run payoffs include reductions in intergenerational poverty. Although progress has been made in improving girls' access to schooling, gaps remain, particularly in the poorest countries, where girls are only 80 percent as likely as boys to attend school.

Major Types of Education

Three basic types of education exist: (1) primary and secondary education, (2) higher education, and (3) adult education. Most countries have a goal of almost universal primary education and eventually secondary education as well. Primary education provides basic literary and computational skills. Secondary education provides training for students going on to higher education, and technical education for those who seek immediate employment.

The need for higher education related to agriculture depends in part on the growth of employment opportunities in agricultural research, extension, agribusiness, and government. Undergraduate agricultural programs have expanded in many African, Asian, and Latin American countries in recent years. Some of these colleges, such as the Pan-American Agricultural School in Zamorano, Honduras, require a mix of academic and practical training and draw students from several countries.

Postgraduate programs also have expanded in several larger developing countries such as India, the Philippines, Brazil, and Mexico. The quality of these programs is variable, but the programs have a better track record of their students returning home after completing their degrees than do graduate programs in developed countries. Foreign academic training in developed countries also has the disadvantage that the training and research may be less relevant to the home country of the student.

In adult education, often called *extension* education in agriculture, farmers are the primary clientele and the programs are mostly oriented toward production problems facing farmers. Extension accelerates the dissemination of research results to farmers and, in some cases, helps transmit farmers' problems back to researchers. Extension workers provide training for farmers on a variety of subjects and must have technical competence, economic competence, farming competence, and communication skills. Thus extension workers require extensive training

[4] See World Bank, *Engendering Development* (New York: Oxford University Press, 2001).

and retraining to maintain their credibility with farmers. As information requirements for farming increase, adult literacy is gaining importance for understanding agricultural innovations. Technology and extension information are increasingly being transmitted through electronic means, so basic computer literacy is also important. Basic adult literacy and the ability to absorb new messages about productivity-improving technologies are highly complementary, so that over time adult education in rural areas needs to be broadened to include basic skills.

Issues in Education in Developing Countries

Because education is critical for a country's development prospects, several inter-related issues must be addressed by education policy makers. These issues include finance questions, such as measures to recover costs in K-12 education; use of resources to retain students through higher grade levels versus expanding basic coverage to all; decisions about educational curricula, such as providing technical versus more general education; and gender and economic barriers to participation in basic education. Cost recovery measures such as school fees were introduced in many developing countries as part of structural adjustment programs in the 1980s. They are based on the idea that since some of the benefits of education are private and are captured by the individual, the beneficiary (the student or his or her family) should bear some of the costs. They also broaden the financial base of support for the educational system and provide resources to cash-poor local educational districts. However, increasing evidence shows that such fees represent major barriers to participation in education, especially to the poorest, and countries that have abolished fees have seen remarkable growth in school participation. The World Bank, which was a strong proponent of cost-recovery in basic education, now has a blanket policy opposing such fees. Elimination of fees will help reduce gender and economic barriers to participation in education.

Developing countries face choices about the design of their educational curricula in rural areas. While most schools provide basic literacy and mathematics, choices need to be made about technical content. The experience has been mixed relative to agricultural education at the K-12 level in developing countries. While some argue that such schools need to provide useful skills and thus should focus on training in agriculture, evidence shows that design of an agricultural curriculum is difficult and costly. Often training methods do not correspond to conditions faced by poor farmers and time spent in such training reduces time available for other subjects. When rural schools focus too

Female education is as important as male education, yet it is often neglected.

closely on rural-specific skills, graduates face disadvantages when seeking higher education or finding work in urban areas.

FAMILY STRUCTURE and GENDER ROLES

Family structures vary around the world, and that variation implies differences in specific roles played by individual family members in household affairs, in agricultural production and marketing, and in income generation in and out of agriculture. For example, in many West African countries, families live in compound households that include more than one generation, and individual family members are assigned specific parcels of land to farm. In much of Latin America, the basic household is a nuclear family with parents and children, and family members have specific responsibilities within the household and in farming. In many parts of Asia, nuclear families predominate, and in some cases family members work side by side in fields, but in others males and females undertake different tasks. Regardless of the region, women have key roles to play in farming systems. Women are involved not only in household chores and child rearing but are a major source of labor for food production and account for a large proportion of economic activity.

Women threshing wheat in Nepal.

Gender Roles

The term "gender" refers to non-biological differences between women and men, and roles in farming and household decisions in developing countries differ by gender. With the notable exception of strongly Islamic societies, women play two major roles in the rural areas of most developing countries. First, they have household responsibilities for child rearing, food preparation, collecting water and firewood, and other chores. Second, they are paid or unpaid workers in agriculture or off the farm. They produce, process, preserve, and prepare food. They work in the fields, they tend livestock, they thresh grain, and they carry produce to market. In many areas, women manage the affairs of the household and the farm. They sell their labor to other farms and sometimes migrate to plantations. Involvement in farm production may be seasonal, particularly in Asia where, in many countries, women assume major responsibilities for weeding and harvesting, both on their own farms and as paid labor on other farms. Women also work in small industries and in the informal sector, producing goods and services for sales locally or beyond.

Women are important to agriculture in most areas of the world, but they play the largest role in farming in Africa. In many countries nearly all the tasks connected with food production are left to women. Men may tend livestock or produce cash crops, but food crops are generally the purview of women. In Malawi, for example, over two-thirds

of those working full time in farming are women.[5] In some areas of Africa where men migrate to work elsewhere, the entire administration of the household is left to women (Box 10-1). Similar cases exist in the Central American highlands where men migrate seasonally to participate in coffee harvests and to coastal plantations. Households headed by women make up 20 to 25 percent of rural households in developing countries, excluding China and Islamic societies.[6] In Latin America, women care for animals, particularly chickens and pigs, while tending garden vegetables and other food crops. In sugar- and fruit-producing areas, especially in the Caribbean, women work as cash laborers on plantations, and provide a substantial proportion of household income. In Asia, many examples of female farming systems are found. In Nepal, it is estimated that women on subsistence farms produce 50 percent of household income; men and children produce 44 and 6 percent, respectively.[7]

Even though they tend to work much longer days than men, the true extent of involvement of women in agriculturally related activities is often underestimated and misunderstood by policy makers. When surveys are taken, men frequently respond as heads of households, and both men and women usually describe the woman's principal occupation as housewife. In many areas women do not view themselves as "farmers" even when they work long hours on the farm and have large influences over farming-related decisions[8] (see Box 10-2). They are then counted in the survey as economically inactive. This "invisibility" of female employment has led to policies and programs that ignore women and sometimes adversely affect them.

One impact of the "invisibility" of women has been to lower their status. Within the household, this lower status may mean less power to make decisions, less food, fewer heath-related investments in women, and a heavier work and disease burden. In times of household crisis, women and female children may bear a heavier burden; in southern

[5] Janice Juggins, "Gender-Related Impacts and the Work of the International Agricultural Research centers," Consultative Group for International Agricultural Research (CGIAR) Study Paper Number 17, World Bank, Washington, D.C., 1986.

[6] Juggins, "Gender-Related Impacts …."

[7] Meena Acharya and Lynn Bennett, "Women and the Subsistence Sector, Economic Participation and Household Decision Making in Nepal," World Bank Staff Working Paper Number 526, Washington, D.C., World Bank, 1982.

[8] Sarah Hamilton, Keith Moore, Colette Harris, Mark Erbaugh, Irene Tanzo, Carolyn Sachs, and Linda Asturias de Barros, "Gender and IPM," Chapter 14 in *Globalizing Integrated Pest Management: A Participatory Research Process*, edited by George W. Norton, E.A. Heinrichs, Gregory C. Luther and Michael E. Irwin (Ames Iowa: Blackwell Publishing Co., 2005).

BOX 10-1.
GENDER DIVISION of LABOR in BOTSWANA

A study of traditional farms in Central Botswana uncovered illuminating differences in the division of labor by gender. Because men have opportunities to work in mines, a large proportion of rural households are headed by females (40 percent in this study). In agricultural areas, land is held communally by the village, and both men and women can obtain rights to cultivate the land. Mostly sorghum, but also maize, cowpeas, and melon varieties are grown on 4 to 5 hectare plots. Livestock, particularly cattle, are very important.

In all aspects of economic activity there is a stark differentiation between male and female roles. In crop production, men traditionally plow and maintain the fields, women sow the seeds, weed, harvest, and thresh. Men and boys almost exclusively tend and milk livestock (mostly cattle and goats), while women manage the chickens, used mostly for home consumption. Women brew and sell sorghum beer, and beer sales can produce substantial amounts of household income.

Women provide virtually all the labor for household maintenance. Time spent gathering firewood, fetching water, cooking, and in other household chores accounts for 68 percent of the women's total time. Men allocate only 10 percent of their total time to household chores. Even so, women provide 38 percent more time for agricultural fieldwork than do men. Women provide 48 percent of the total hours worked by members of the household, men account for 22 percent, and the children the rest.

Source: Doyle C. Baker with Hilary Sims Feldstein, "Botswana: Farming Systems Research in a Drought Prone Environment, Central Region Farming Systems Research Project," chapter 3 in Hilary Simms Feldstein and Susan V. Poats, eds., *Working Together Gender Analysis in Agriculture*, *Vol. I: Case Studies* (Westford, Conn.: Kumarian Press, 1989), pp. 43–7.

Ethiopia, for example, research shows that women suffer more from shocks to income and health.[9] Lower status of females has been associated with weaker control over household resources, less access to information and public services such as education and health, discrimination in employment, and unequal rights to land and other important assets.[10] Women are less likely to be members of producer and marketing

[9] Stephan Dercon and Pramila Krishnan, "In Sickness and in Health: Risk Sharing within Households in Rural Ethiopia," *Journal of Political Economy*, vol. 108, no. 4 (August 2000), pp. 688–727.

[10] Lisa C. Smith, Usha Ramakrishnan, Aida Ndiaye, Lawrence Haddad, and Reynaldo Martorell, *The Importance of Women's Status for Child Nutrition in Developing Countries,* International Food Policy Research Report number 131, Washington, D.C: IFPRI, 2003.

BOX 10-2.
GENDER and INTEGRATED PEST MANAGEMENT

A recent study by Hamilton and others examines how gender roles in different regions of the world affect the use of pest management practices in agriculture. Studies show that improper use of pesticides can lower household incomes and have negative health consequences for household members. Women have a special interest in pesticide use, as they frequently shoulder responsibility for the health of the family, particularly children. Evidence shows that women have to overcome unique barriers if they or their families are to adopt integrated pest management (IPM) practices, which are usually associated with less use of pesticides. Lack of recognition means that women are often excluded from information about IPM practices; they have less access to extension services, are less likely to participate in training, and are less frequently members of producer organizations, which transmit information to their members. Women also have less access to labor, either due to excessive time demands on their own or limited access to hired labor markets. IPM practices tend to be labor intensive. Women have less access to land and, because of uncertainty associated with IPM, most adopters of IPM have larger holdings; they adopt IPM on part of their lands and use conventional techniques on others.

Despite these constraints, the experience from West Africa, Philippines, and Central and South America found involvement of women to be a key determinant of whether households use IPM or not. Women's participation in field-level trials, in identifying constraints so that research could address them, and in training programs helped spread IPM adoption in all the countries studied. Women are especially receptive to IPM messages because they play a major role in managing household finances and easily recognize the health consequences of mishandled pesticides.

Source: Sarah Hamilton, Keith Moore, Colette Harris, Mark Erbaugh, Irene Tanzo, Carolyn Sachs, and Linda Asturias de Barros, "Gender and IPM," Chapter 14 in *Globalizing Integrated Pest Management: A Participatory Research Process*, edited by George W. Norton, E.A. Heinrichs, Gregory C. Luther and Michael E. Irwin (Ames Iowa: Blackwell Publishing Co., 2005).

organizations and are less likely to have title to land (and thus, access to many forms of credit). These factors affect women's own nutritional and health status and that of their children.

DETERMINANTS of GENDER ROLES in AGRICULTURE

Social, cultural, and religious factors; population pressures; farming techniques; off-farm job opportunities; colonial history; income levels; disease and health conditions; and many other factors determine the role of women in farming systems. Sometimes in areas with apparently similar physical conditions, women assume very different roles. As off-farm job opportunities, population pressures, income levels, and farming techniques change, so too does the role of women (see Box 10-3).

Shifting cultivation with hand labor lends itself more to female labor than does settled cultivation with a plow. For countries with low population densities, adequate food could be raised without using male labor in farming. Men used to spend their time felling trees, hunting, and in warfare. In most areas, agriculture has changed from shifting cultivation to settled agriculture and cash crops. This change has resulted in a greater role for men, but often the role of women in farm work still dominates.

The shift to the plow and draft animals has made a difference in the amount of male labor used in some areas, and long-standing differences in farming techniques undoubtedly account for many of the regional gender differences in farming activities. In regions of intensive cultivation on small, irrigated farms, for example in several Asian countries, men, women, and children must work hard to generate enough production on a small piece of land. Work is mostly done by hand. In contrast, on larger farms, more tasks may be mechanized and women may devote a higher percentage of their time to housework. In some cases, mechanization has displaced female labor and lowered their status as a result, since housework is often under-appreciated. In other cases, especially sub-Saharan Africa, mechanization has increased the amount of land that can be cultivated by men, and put additional strain on women who are responsible for planting and weeding.

Integration of small-scale farmers into the labor market has increased the importance of women's role in agriculture, because it is often the males who find outside wage work. In some countries, males may work away from the household for several weeks or months at a time. In Lesotho, for example, the result has been that 70 percent of the households are headed by women.[11] Diseases such as HIV-AIDS have

[11] Juggins, "Gender-Related Impacts …"

BOX 10-3.
TANZANIA: CONSERVATION AGRICULTURE for SUSTAINABLE DEVELOPMENT

The Conservation Agriculture for Sustainable Agriculture and Rural Development project, which began in 2004, promotes conservation agriculture (CA) for small-scale and resource-poor, especially women, farmers. In the project, energy-efficient agricultural production technologies, combined with participatory methodologies, enable farmers to adopt practices that reduce labor and raise yields and incomes. Women are the main providers of agricultural labor in Tanzania and will benefit most from the reduced labor requirements of CA.

The project was centered in Arumeru District in the Arusha region of Tanzania, a highly agricultural, rain-fed area. The primary conservation techniques are ripper tillers, which reduce tillage by cutting furrows into the soil rather than inverting it completely, and the jab planter allows for planting operations to be done through the soil cover with no tillage. Farmer Field Schools, discussed later in this book, were the main means of training. Participants in the schools were taught in a hands-on manner about CA techniques. Because CA was expected to have a strong impact on women, women represented the majority of field school participants, and women participants were followed carefully to see how CA affected them.

Adoption of CA has three main impacts: reduced demand for household labor, increased food security through higher yields, and increased household income. The labor effects are especially important: in addition to saving labor for planting — predominantly a women's activity — CA requires better coordination of the land preparation and planting, so women and men work together more frequently. Lower labor requirements associated with CA practices affect women and other family members differently. Poor women-headed households benefit from lower labor demands, because a decrease in labor pressures frees family members from the requirement of working in the field. Children can pursue their education uninterrupted by sudden labor shortages. Women in landless households have fewer opportunities to sell their labor, but higher crop yields — and thus higher labor requirements for harvesting — could cushion the reduction in hired-labor opportunities. Additional employment opportunities for rural women laborers as a result of higher yields would have an immediate effect on household livelihoods.

Source: The World Bank and the International Fund for Agricultural Development, Gender in Agriculture Sourcebook (Washington DC: The World Bank, 2009).

further complicated men's and women's roles; as sick people can no longer work in agriculture, women are increasingly assuming productive roles while still being the primary care-giver to the ill.

Policy Implications

Why is it important to address gender inequities in society? First, as a normative concept, gender equality is important in its own right. Women ought to have equal legal and social status because social justice is an important indication of development. Second, many recent studies have shown that gender inequities slow the process of economic development. Lower status of women is associated with less schooling, lost earnings, inefficient allocation of labor, and poor health of women and their children.[12] Over time, gender inequities lead to lower nutritional and health status of children, less educational attainment and slower growth. In agriculture, gender is important as one of the several socio-economic characteristics that influence the adoption of new technologies.

Since women are important in agriculture, their opinions must be sought when designing new technologies. The impact of these technologies on the relationship between men and women should be considered during this design. If women are making production decisions, they must receive education and guidance from extension services. Most international aid agencies, such as the World Bank and the United States Agency for International Development, now recognize that without considering the roles and responsibilities of women and receiving inputs during project development, these projects are much less likely to succeed.

Third, an increasing body of evidence shows that as women's participation in the economy grows, family well-being improves. Income earned by women is more frequently used for purchases that broadly benefit the family, such as for health care, school fees, and food for children.[13]

One means of improving income-earning opportunities for women is to take steps to provide them with inputs such as credit and new seeds. Women often have inadequate access to credit for a number of reasons. First, in many societies, women lack the legal status necessary to enter into contracts. Second, only very infrequently do women hold

[12] World Bank, Engendering Development …

[13] See Norbert Schady and José Rosero, "Are cash transfers made to women spent like other sources of income?" *Economics Letters*, vol. 101 (2008), pp. 246–8; and Cheryl Doss, "The effects of intrahousehold property ownership on expenditure patterns in Ghana." *Journal of African Economies*, vol. 15 (1) (2005), pp. 149–80.

title to land, often necessary as collateral for loans. Third, there seems to be a bias against women in the administration of credit programs.

It is likely that most new agricultural technologies are relatively gender neutral, and we see some efforts on the part of certain public extension systems to reach women farmers.[14] However, lack of female access to credit and purchased inputs in many countries makes many new technologies gender-biased. Furthermore, women often grow food crops that are minor in terms of value of production but are important in the diets of families on small farms. Agricultural research often neglects these crops, and this neglect may have adverse effects on nutrition. In addition, because extension services are still highly male in most countries, communication with female farmers can be inhibited. Even in Africa where women are the majority of farmers, males have greater contact with extension services.

The impacts of credit, technology, and other agricultural policies on women have been exacerbated by discriminatory land reform and settlement policies. In Latin America, where land reform and settlement schemes often have been designed to benefit "heads of households," women have been, by convention, largely excluded. In Ethiopia and Tanzania, rights to lands have been bestowed on men. In Asia — specifically the settlement schemes in Indonesia, Papua New Guinea, and Sri Lanka — land was given only to male heads of households. Inadequate access to land, worsened by government policies, when combined with problems of access to credit, can hinder women's ability to participate in agricultural development. Given the large role that women play in developing-country farming systems, efforts that ignore or discriminate against women have distorting effects and diminish chances of success. Studies have found that farm fields controlled by women often have lower yields due to lack of access to fertilizer and other resources.

Economic development itself can have positive impacts on gender equality. The process of development expands job opportunities, and the presence of more capital raises productivity. These changes raise the value of time — women's time as well as men's. Development also

[14] In The Gambia, research on rice was expected to increase women's income, since women were the primary producers. Instead, following the introduction of new technologies, men took over this production. See Joachim von Braun, Detlev Puetz, and Patrick Webb, "Irrigation Technology and Commercialization of Rice in The Gambia: Effects on Income and Nutrition," International Food Policy Research Institute, Research Report No. 75, Washington, D.C., 1989.

Colombian women receiving instructions on how to vaccinate a chicken.

is typically accompanied by more investments in infrastructure such as water, roads, and electricity. These changes can lower work burdens of women, leaving more time for other duties. Higher incomes leave more resources for investments in assets such as human capital. As incomes grow, gender disparities in education and health status tend to shrink. Public investments in schools and health facilities lower the cost of investing in human capital and help shrink gender inequalities. In fact, gender disparities in education are most acute in the lowest-income countries and almost non-existent in high-income countries.[15]

Despite strong empirical links between economic growth and gender equality, equality is not an automatic bi-product of growth, and the path of development can have important implications for gender relations. Governments that encourage equal participation and foster rights of women often find that growth and greater gender equality march hand in hand. Gender equality has beneficial growth effects, and growth enhances women's rights. Governments can be proactive by reforming institutions to establish equal rights and opportunities for women and men, they can strengthen policy and institutional incentives for more equal access to resources and participation, and they can take active measures to confront disparities.[16] At a minimum, they should take steps to monitor these disparities by measuring women's conditions.

[15] World Bank, *Engendering Development* …
[16] See World Bank, *Engendering Development* …, particularly chapter 6.

Role of Children

Children represent the future human resource base of a country. Economic growth and development over time depend on how resources are invested in children. As noted in Chapter 4, children represent current sources of pleasure for parents, and they are a source of investment for future income gains and security in old age. Children are a major source of farm labor in every region of the world, and their tasks expand with each year of their age. They typically begin by following a parent or sibling into the field and rapidly become involved in hoeing, weeding, harvesting, and other tasks. They feed and otherwise care for animals. They, particularly boys, may work as low-paid farm laborers on other farms. Young girls often care for younger brothers and sisters to free their mother for other work. Farm children throughout the world take on major farm responsibilities at a very young age.

At times, conflicts occur between the use of children in farm duties and providing income to the family and longer-term investments in their education. For example, in times of household crisis, such as drought or crop failures, children may be pulled out of school to lower expenses (such as school fees) or increase incomes. Such informal risk management techniques can have long-term adverse consequences because the child's lifetime productivity is being compromised by reduced access to education. Gender inequalities in investments in children have long-term consequences, but depend on social norms and other factors. For example, in many societies, in time of crisis, decreased spending on girl's education and even health care and food is a common means of coping with household financial stress. Such actions lower the status of girls and their quality of life, but are the product of long-standing cultural norms.

As adults become ill from diseases such as HIV-AIDS and malaria, children are called upon to assume a greater share of farm work and other household responsibilities. Increased disease burdens, especially in sub-Saharan Africa, are rapidly changing the roles of children and altering social structures in rural areas. In fact, some argue that AIDS has increased the vulnerability of entire villages and regions to crop failure and famine by lowering food production and increasing the work burden on children. These factors subvert livelihood-coping strategies and mean that in time of need fewer assets are available to households to help them manage risks.[17] The epidemic is putting immense burden on children.

[17] A. de Waal and A. Whiteside, "New variant famine: AIDS and food crisis in southern Africa," *The Lancet*, vol. 362, October 11, 2003.

Teenage child and her mother sorting the potato harvest on a farm in Ecuador.

Governments recognize the long-term adverse consequences of using children to manage household risks, and recent experiments with conditional cash transfers are showing these programs to be very effective. An example is the PROGRESA program (now called Oportunidades) in Mexico, whereby families are given regular, but modest, cash allotments on the condition that their children remain in school and receive regular nutrition and health interventions. The program has proven to be so successful in increasing children's education participation, reducing drop outs, reducing child labor burdens, and improving child welfare that the Mexican government expanded its coverage so that more than 40 percent of the rural population is now covered.[18] Other similar programs now exist in more than 30 developing countries, including virtually every country in Latin America, and major programs in Bangladesh, India, Indonesia, Turkey and Pakistan.

SUMMARY

The overall productivity of the economy depends on the quantity and quality of labor. Better-educated individuals earn higher incomes and these higher incomes reflect greater productivity. The underutilization and low productivity of human resources in agriculture is a serious

[18] See International Food Policy Research Institute, *PROGRESA — Breaking the Cycle of Poverty*, Washington, D.C: IFPRI, 2002.

problem in many developing countries. Better-educated farmers are more able to adopt new technologies, are better able to understand price and market information, and have more access to credit and other forms of capital. Education also prepares children for non-farm occupations.

Women and children play important roles in agriculture, and these roles vary by region, by stage of development and other factors. Social, cultural, religious, technological, off-farm employment, historical and other factors determine the role of women in farming systems. Women's roles in agriculture have implications for credit and input policies, for the generation and extension of new technologies, and for land reform policies. Gender inequities can have adverse implications for long-term development inside and outside of agriculture. Compelling evidence shows that governments should take proactive steps to lower gender inequalities.

IMPORTANT TERMS and CONCEPTS

Constraints faced by women farmers
Determinants of the role of women in agriculture
Human capital
Impacts of education on development
Impacts of HIV/AIDS
Implications of the role of women in agriculture
Multiple roles of women
PROGRESA
Regional differences in the roles of women
Role of children

Looking Ahead

In this chapter, we briefly examined the role of human resources, family structure, and women and children in the process of agricultural and economic development. In the next section we consider means for improving those systems to increase agriculture's contribution to human welfare. We begin in Chapter 11 by providing an overview of agricultural development theories and strategies before exploring in detail the individual components of those theories and strategies.

QUESTIONS for DISCUSSION

1. How do investments in human capital affect productivity inside and outside agriculture?
2. What is the purpose of education for the farmer and his or her family?

3 Why should farmers support education if it just means their children will move out of farming and do something else?
4 Why might education be considered a public good?
5 What are the major types of education?
6 What roles do women and children play in agriculture?
7 In which region of the world is the role of women in agriculture the greatest?
8 What factors determine the roles of women in agriculture?
9 What are some important implications of the roles of women in agriculture?
10 Why might census statistics and other data undercount female participation in farming?
11 Why do women from near-landless and small-holder households participate more in agriculture relative to those from larger farms with more land ownership?
12 How might gender inequality slow the process of development?
13 What steps might governments take to address problems of gender inequality?
14 How does disease pressure affect the roles of children in farming?

RECOMMENDED READINGS

Baker, Doyle C. with Hilary Simms Feldstein, "Botswana Farming Systems Research in a Drought Prone Environment, Central Regional Farming Systems Research Project," in Hilary Simms Feldstein and Susan V. Poats, eds., *Working Together: Gender Analysis in Agriculture Volume I: Case Studies* (West Hartford, Conn.: Kumarian Press, 1989), chapter 3.

Boserup, Ester, *Women's Role in Economic Development* (London: Allen and Unwin, 1970).

Deere, Carmen D. "The Division of Labor by Sex in Agriculture: A Peruvian Case Study," *Economic Development and Cultural Change,* vol. 30, 1982, pp. 795–811.

Folbre, Nancy, "Engendering Economics: New perspectives on Women, Work, and Demographic Change," *Annual World Bank Conference on Development* (The World Bank, Washington, D.C., 1995).

Food and Agriculture Organization, "Women in African Food Production and Food Security," in J. Price Gittinger, Joanne Leslie, and Caroline Hoisington, eds., *Food Policy: Integrating Supply, Distribution, and Consumption* (Baltimore: Johns Hopkins University Press, 1987), chapter 7.

Gladwin, Christine H., and Della McMillan, "Is a Turnaround in Africa Possible Without Helping African Women to Farm?" *Economic Development and Cultural Change,* vol. 387, 1989, pp. 305–44.

Glewwe, Paul, "Schools and Skills in Developing Countries: Education Policies and Socioeconomic Outcomes," *Journal of Economic Literature*, vol. 40 (2), June 2002, pp. 436–82.

Quisumbing, Agnes R., Lynn R. Brown, Hillary Simms Feldstein, Lawrence Haddad, and Christina Peña, "Women the Key to Food Security," International Food Policy Research Institute, Washington, D.C., August 1995.

United Nations, Centre for Social Development and Humanitarian Affairs, "Women, Food Systems and Agriculture," *1989 World Survey on the Role of Women in Development* (New York: United Nations, 1989), chapter 3.

World Bank, *Engendering Development* (New York: Oxford University Press, 2001).

World Bank and the International Fund for Agricultural Development. *Gender in Agriculture Sourcebook* (Washington, D.C.: The World Bank, 2009).

PART 4

Getting Agriculture Moving

International Rice Research Institute in the Philippines.

CHAPTER 11

Theories and Strategies for Agricultural Development

> The process of agricultural growth itself has remained outside the concern of most development economists.
>
> — Yujiro Hayami and Vernon W. Ruttan[1]

THIS CHAPTER

1 Describes how the sources of agricultural growth tend to change as development occurs, and considers how theories of agricultural development have changed over time
2 Presents the theory of induced innovation as applied to agriculture and its implications for the types of technologies generated and for institutional change
3 Discusses how transactions costs and collective action may alter the direction of technical change, with implications for asset distribution

THEORIES of AGRICULTURAL DEVELOPMENT

We have discussed the importance of agricultural development for solving the world food-income-population problem. We have considered the nature and diversity of existing agricultural systems in developing nations. We now need to consider means for improving these systems to increase agriculture's contribution to human welfare. In this chapter, we provide an overview of agricultural development theories and strategies. In subsequent chapters we examine in more detail the individual components of the basic strategies outlined here. Our overriding concern is to identify strategies that facilitate growth with equity. We

[1] Yujiro Hayami and Vernon W. Ruttan, *Agricultural Development: An International Perspective* (Baltimore: Johns Hopkins University Press, 1985), p. 41.

explore why agricultural development has occurred in some countries and why it has not (or has proceeded very slowly) in others.

Many theories have been suggested to explain how the basic sources of growth (labor, natural resources, capital, increases in scale or specialization, improved efficiency, education, and technological progress) can be stimulated and combined to generate broad-based agricultural growth.[2] It is clear from historical experience that the relative importance of alternative sources of growth changes during the development process and has changed over time for the world as a whole. It is also clear that institutional arrangements such as marketing systems, price and credit policies, a well-functioning legal system, and transparently enforced property rights play an important role in stimulating or hindering development. Let's examine agricultural development theories and evidence to see what lessons they provide for operational strategies.

Expand the extensive and intensive margins

One means of generating increased agricultural production is to expand the use of land and labor resources. The development of agriculture in North America, South America, Australia, and other areas of the world during colonization was based on using new lands. In some cases indigenous labor was also exploited. The opening up of forests and jungles by local populations in parts of Africa, Latin America, and Asia provide additional examples of expanded resource use. Economists call this increased use of land and labor: *expanding the extensive margin*.

In many of these historical cases, surplus lands and labor were used to produce commodities for both local consumption and export. Reductions in transportation costs facilitated exports. In Thailand, for example, rice production increased sharply in the latter half of the nineteenth century, and much of the increased production went to export markets. In many colonies, exports of primary production were extracted for use in more developed countries, and often a large share of the benefits of these exports was not realized by the local countries but was transferred to the developed countries.

[2] Hayami and Ruttan (*Agricultural Development*) have characterized previous agricultural development theories into six basic approaches: (1) resource exploitation, (2) resource conservation, (3) location, (4) diffusion, (5) high-payoff input, and (6) induced innovation. The first part of the chapter draws heavily on their ideas.

Agriculture in Asia is intensive, even in hilly regions.

Agriculture in Asia is intensive even in hilly regions.

Expansion of unutilized land resources provides few opportunities for substantial growth in developing countries today. In areas of Latin America and Africa where additional land does exist, disease, insect, and soil problems prevent its use in agriculture. Abundant labor is available in many countries, and continued growth of the labor force will generate increases in total agricultural output. However, most growth in per-capita agricultural output will have to come from more *intensive* use of existing resources.

Many methods can be used to achieve more intensive resource use. Early efforts in England, Germany, and other European countries included more intensive crop rotations, green manuring, forage-livestock systems, drainage, and irrigation. In many developing countries, these same factors increased land productivity. Terracing is an effective means of conserving soil productivity in hilly areas of Asia. In the mountainous regions of Central America, grass strips have been used to create terrace-like structures that conserve soil and enhance productivity. Crop rotations are frequently used to enhance soil productivity and control pests. Hayami and Ruttan estimate that agricultural development based on similar types of "conservation" has been responsible for sustaining growth rates in agricultural production in the range of 1 percent per year in many countries, including developing countries, for long periods of time.[3]

[3] Hayami and Ruttan, *Agricultural Development*, p. 52.

While scientists are gaining additional knowledge of the technical and institutional considerations that can lower the cost of conservation efforts, population pressures are creating a need for better ways of sustaining the natural resource base. Hence, conservation is likely to play an increasingly important role in maintaining if not expanding agricultural production in the future.

Another means of intensifying agricultural production is to produce more crops per unit of time through altering cropping patterns or using shorter season varieties so that two and three crops can be produced per acres per year where one or two was produced before. Such production changes usually require scientific input to develop the required seeds, tools, or other inputs to make the double or triple cropping possible. Access to irrigation or surface water sources can facilitate this intensification.

Yet another means of intensification is through a process of diversification and production of higher-valued commodities. This means of intensification is likely to become more important as development proceeds and incomes grow, creating increased demand for higher-valued vegetables and meats. Intensity of production can be changed as well by improving transportation systems to bring higher-valued commodities to urban centers. It has long been recognized that the pattern and intensity of agricultural production vary in relation to the proximity of urban-industrial centers and to the quantity and quality of transportation.[4] Closeness to cities and transport matters because of differences in transportation and marketing costs, in effects on labor and capital markets, in the ease of obtaining new and more productive inputs, and in ease of information flows.

One implication of this ''location'' theory of agricultural development is that countries should encourage decentralized industrial development, particularly in the middle and late stages of development. During these stages, strong linkages between agriculture and markets for inputs (fertilizers and pesticides) and outputs can help stimulate the local economy. Developing nations should improve transportation infrastructure in rural areas.

Diffuse Existing Knowledge

Agricultural development can be stimulated by diffusing knowledge among farmers more rapidly within or across national borders. Existing

[4] Today, economists still draw on theories proposed by Heinrick Von Thunen (1783–1850), who studied the optimal intensity of farm enterprises in relation to their distance to urban areas.

technologies and economic knowledge can be transferred from the more progressive to the lagging farmers, thereby increasing productivity. This idea has provided part of the rationale for agricultural extension systems, particularly in farm management. Unfortunately, in some cases diffusion theory has led to unrealistic expectations of the size of potential productivity gains under the existing level of technology.

Diffusion theory also has led to attempts to directly transfer knowledge and technologies from more-developed to less-developed countries. More success has been achieved with transferring knowledge than with transferring agricultural technologies. Adoption of transferred technologies has been limited except where efforts have been made to adapt the technologies to the new setting.

Develop High-Payoff Inputs

More recent agricultural development theory builds on these earlier approaches but adds the important dimension that the process can be accelerated through provision of new and improved inputs and technologies (particularly improved seeds. fertilizers, pesticides, and irrigation systems). This approach, articulated by Schultz in *Transforming Traditional Agriculture,* is based on the idea discussed in Chapter 7 that farmers in traditional agriculture are rational and efficient given their current resources and technologies.[5] What these farmers need are new high-payoff inputs and technologies to increase their productivity.[6]

The need for high-payoff inputs has been widely accepted because of the success achieved by modern wheat, corn, and rice varieties beginning in the 1950s and 1960s. These varieties are highly responsive to fertilizer, pesticides, and water management and have resulted in substantial growth in agricultural output in many developing countries. Some have argued that the relative absence of these inputs has been one factor holding back agricultural development in Africa compared to other developing regions. The distributional or equity effects and environmental impacts of these inputs, however, have been the subject of much debate and are discussed in more detail in Chapter 12.

Hayami and Ruttan argue that the high-payoff input theory is incomplete because it fails to incorporate the mechanism that induces these new inputs and technologies to be produced in a country. The theory also fails to explain how economic conditions stimulate the development of public agricultural experiment stations and educational

[5] Theodore W. Schultz, *Transforming Traditional Agriculture* (New Haven: Yale University Press, 1964).

[6] Hayami and Ruttan have labeled Schultz's approach the "high-payoff input" model.

systems. It does not attempt to identify the process by which farmers organize collectively to develop public infrastructure such as irrigation and drainage systems. In the next section we explore the induced innovation theory proposed by Hayami and Ruttan to address these issues.

THEORY of INDUCED INNOVATION

Induced innovation theory helps explain the mechanism by which a society chooses an optimal path of technical and institutional change in agriculture.[7] The theory says that technical change in agriculture represents a response to changes in resource endowments and to growth in product demand. Changes in institutions are induced by changes in relative resource endowments and by technical change.[8]

Induced Technical Innovation

Technical change in agriculture can follow different paths. Technologies can be developed that facilitate the substitution of relatively abundant and low-cost factors of production for relatively scarce and high-cost factors. A rise in the price of one factor relative to others will induce technical change that reduces the use of that factor relative to others. For example, if the price of land goes up relative to labor and fertilizer, indicating that land is becoming relatively scarce, technologies such as improved seeds will be developed that can be combined with labor and fertilizer to increase production per unit of land.

This process of induced technical change is illustrated graphically in Figure 11-1. The range of possible technologies in time period 0 can be represented by what Hayami and Ruttan call the *innovation possibilities curve*, I_0*. The specific technology employed in that time period is represented by the isoquant I_0. Production occurs at point A with N_0 units of land and L_0 units of labor, the least-cost combination of those resources given the price ratio P_0. Now, if over time labor becomes more

[7] Induced innovation theory was developed originally by John R. Hicks, *Theory of Wages* (London: MacMillan and Co., 1932). Hayami and Ruttan during the 1960s were the first to apply the theory to agricultural development. Their underlying assumption is that technological and institutional changes are vital to agricultural development.

[8] Hayami and Ruttan (*Agricultural Development*, p. 94) define institutions as "the rules of society or of an organization that facilitate coordination among people by helping them form expectations which can reasonably hold in dealing with others. They reflect the conventions that have evolved in different societies regarding the behavior of individuals and groups relative to their own behavior and the behavior of others."

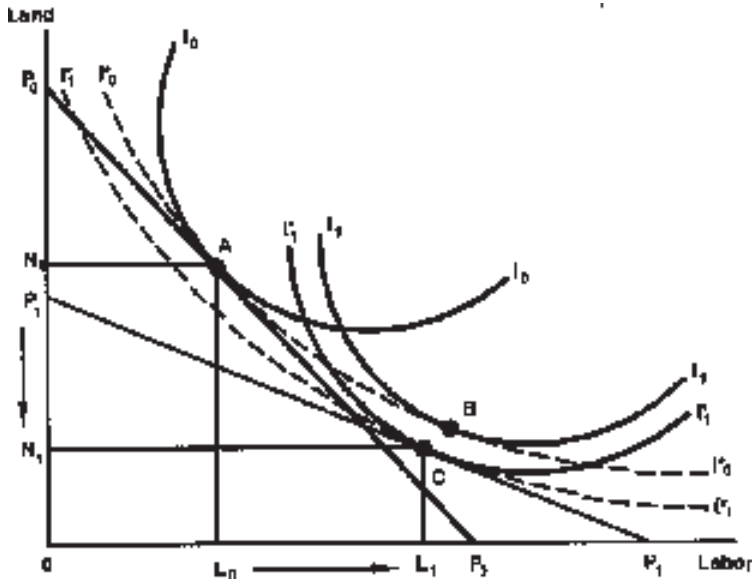


Figure 11-1. A model of induced technical change. If the ratio of the price of land to labor changes from P_o to P_1, incentives are created not only to substitute labor for land and to move from technology I_o at point A to technology I_1 at point B, but also to develop a new technology I'_o at point C. Innovation possibility curves I^*_o and I^*_1 represent the range of potential technologies that can be applied in period 0 and period 1. (*Source*: Hayami and Ruttan, *Agricultural Development.)*

abundant relative to land so that the price of labor is reduced relative to the price of land (the new price ratio is represented by P_1), incentives are created to adopt a more labor-intensive technology. If there were no technical change, production might occur at point B on isoquant I_1. However, the theory of induced innovation says that incentives are created not only to select a new technology from the current technology set (that is, move to point B on I_1), but also to develop new technologies to save scarce resources and use abundant resources more intensively. The new technology set is represented by the new innovation possibility curve I_1*. As the innovation possibility curve moves toward the origin, the same quantity can be produced at lower cost. Following the generation of this new technology set, farmers can adopt the new least-cost technology 1 and employ N_1 of land and L_1 of labor at point C.

Hayami and Ruttan compare the agricultural development histories of Japan and the United States to illustrate the validity of the theory. Japan experienced increasingly higher priced land compared to labor and stressed the development of biological technologies such as improved seeds and fertilizers. These technologies tend to save land and use labor more intensively. The United States, on the other hand, has approximately two times as much land per worker as does Japan. As the U.S. frontier was moved west, land became relatively abundant compared to labor, and the development of mechanical technologies that saved labor was stressed. The result was successful agricultural development in both countries, but agricultural output per worker is 10 times greater in the United States than in Japan while output per hectare is 10 times greater in Japan than in the United States.[9]

Changes in output price relative to an input price also can induce technical change, as illustrated in Figure 11-2. The curve u represents the range of current and possible production technologies in a given time period. Hayami and Ruttan call this the *meta production function*. Specific production technologies are represented by v_0 and v_1. At the initial fertilizer-output price ratio (P_0), producers use technology v_0 and produce at point A. If the price of fertilizer falls relative to the price of output (P_1), then incentives are created to move to point B on the existing technology. If the price ratio P_1 is expected to continue, farmers press scientists to develop a more fertilizer responsive variety, v_1, if it does not already exist. Farmers adopt the new variety and move to point C. In the long run, the meta production function itself may shift as more basic scientific advances are made.

Induced Institutional Change

Incentives are created for technical change, but where do these new technologies come from? How do farmers acquire them? What determines whether technologies are developed that are suitable for all farmers or only for *some* of the farmers? All of these questions are addressed by the theory of induced *institutional* change.

Farmers demand new technologies not only from private input suppliers but from the public sector as well. Hayami and Ruttan argue that public research scientists and administrators are guided by price

[9] Hayami and Ruttan, *Agricultural Development*. Many developing countries, particularly in Asia, are finding the Japanese path of technical change more appropriate than the U.S. path, given their relative resource endowments and the nature of changes in those endowments.

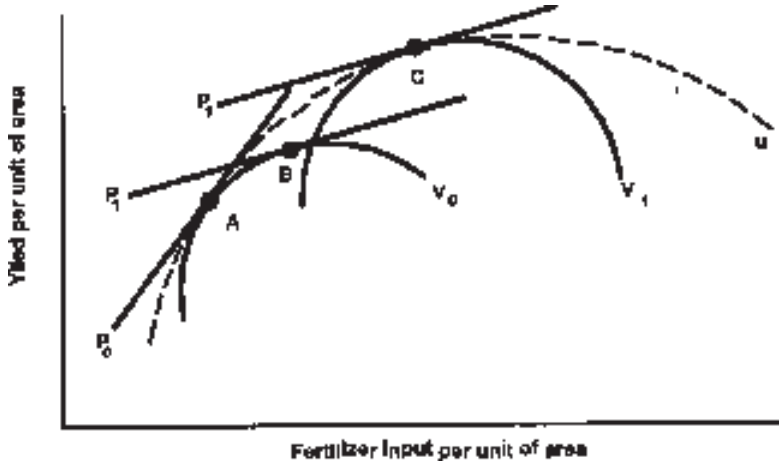


Figure 11-2. Shift in fertilizer response curve as price ratio changes. If the output/fertilizer price ratio changes from P_o to P_1, incentives are created not only to apply more fertilizer and increase output from A to B using the traditional variety v_o, but to develop and adopt a new variety v_1 and to move to point C. Curve u represents the "envelope" of a series of available and potential crop varieties. (*Source*: Hayami and Ruttan, *Agricultural Development.*)

signals and by pressures from farmers. The more highly decentralized the research system, the more effectively these pressures work. Research systems that welcome and facilitate inputs from farmer groups and that engage in participatory planning and research are also more responsive. The development of the research systems themselves can be the result of pressures from farmers who are responding to market forces.

Induced innovation occurs not only in agriculture but in the economy as a whole. For example, as energy and gas prices rise, producers and consumers not only switch to existing, more energy-efficient vehicles, but press for new types of vehicles that are even more fuel saving. The public sector may also respond with laws that require more fuel-efficient cars.

Many other types of institutions (rules of society or organizations) affect technical change and agricultural development. The rights to land, marketing systems, government pricing and credit policies, and laws governing contracts are just a few. The theory of induced institutional

innovation recognizes that institutions can become obsolete and in need of adjustment over time. It says that new technologies and changes in relative resource endowments or price changes provide incentives for a society to demand new institutional arrangements (see Box 11-1 for an example).

Examples of institutional changes induced by technological change can be found in the shift from share tenure to more fixed-payment leases, which has occurred in several countries as new varieties and irrigation systems have increased yields while reducing risks.[10] An example of an institutional change due to a change in relative resource endowments is the switch from communally owned land to more private forms of property rights as population pressures increase land scarcity.

In some countries we observe what appear to be socially desirable institutional changes, technical changes, and relatively rapid and broad-based agricultural development. However, in others we observe what seems to be perverse institutional change, agricultural stagnation, or agricultural growth with the benefits received by only a small segment of the population. Of course many countries fall between these extremes or may move from one group to the other over time. Why do we see these differences in institutional changes that influence agricultural performance, and how do they relate to the theory of induced innovation? The answer lies partly with transactions costs and with the incentives for and effects of collective action by groups of people with common interests.

IMPLICATIONS of TRANSACTIONS COSTS and COLLECTIVE ACTION

The induced innovation theory presented above implicitly assumes well-functioning markets for all products and factors. Prices are assumed to convey all the relevant information to decision-makers, and resources are allocated efficiently and independently of the distribution of assets (such as land) in society. Price-responsive producers are assumed to possess knowledge about alternative technologies, and be able to lobby agricultural scientists to develop improved technologies to save scarce resources. Assuming no economies-of-scale in production, there is one optimal path for technological change.

[10] Share tenure is an arrangement whereby a farmer who is renting land pays the rent with a fixed percentage of the farmer's output.

BOX 11-1.
INDUCED INSTITUTIONAL INNOVATION in JAVA

In Java, customary rules have governed both land rights and labor exchange for many centuries. With traditional technologies, these rules have helped allocate resources so that subsistence levels of foods have been available to all village members. These communal institutions have been put under stress by modern technologies that increase the productivity of labor and the returns to landowners. These changes induce changes in the institutions governing resource allocation.

An example of an institutional innovation is the disappearance of the *bawon* rice harvesting system. This traditional system allowed everyone, whether they were from a particular village or not, to participate in the harvest and share the output. As population grew with traditional technologies, this purely open *bawon* system gradually evolved into various forms, some of which limited harvest rights to village residents, while others limited harvest rights to a set number of participants, or to people who were invited by the farmers.

The widespread diffusion of fertilizer-responsive rice varieties created sharply higher returns to harvest labor, and induced a remarkable change in harvest-contract institutions. One such innovation was the introduction of the *tebasan* system, in which standing crops are sold to middlemen who hire contract labor for harvesting and thus reduce the harvester's share while increasing returns to the landowners. Another institution is the *ceblokan* system, which limits harvesting rights to those workers who perform extra services such as transplanting and weeding without pay. A study shows that in a village where *ceblokan* was first adopted in 1964 by seven farmers, by 1978, 96 out of 100 farmers had adopted the system.

These innovations in harvest-labor institutional arrangements were largely spurred by increased incomes and higher wages accompanying technological innovation. Increased incomes and wages created incentives for farmers to change their labor-contracting system. These changes are now widespread in Java.

Source: Masao Kikuchi and Yujiro Hayami, "Changes in Rice Harvesting Contracts and Wages in Java," Chapter 6 in Hans P. Binswanger and Mark R. Rosenzweig, eds., *Contractual Arrangements, Employment and Wages in Rural Labor Markets in Asia* (New Haven, Conn.: Yale University Press, 1984).

Transactions Costs

Unfortunately, transactions costs affect both factor and product markets, creating the possibility of differing optimal paths of technical change and of institutional change, depending on farm size or other factors. Transactions costs refer to the costs of adjustment, of information, and of negotiating, monitoring, and enforcing contracts.[11] These costs arise because assets are fixed in certain uses in the short-run, because there is a lack of perfect information, because there are differences in the ability to use information, and because people are willing to benefit at the expense of others.[12]

The presence of transactions costs may mean, for example, that the cost of credit decreases as farm size increases, that labor costs per hectare increase as farm size increases (because of supervision costs), and the cost of land transactions declines as farm size increases. Therefore, as farm size grows, labor use per hectare may decline while machinery use per hectare and the demand for capital-intensive technologies may increase. Owners of large farms also maybe quicker to adopt new technologies, because they have fewer credit constraints affecting input purchases.

The presence of transactions costs means that the distribution of assets matters for the direction of technical and institutional change.[13] Because the demand for particular types of technical and institutional changes will vary by farm size, the potential is created for conflicting demands on the public sector. Politicians and other public servants respond to the demands of competing groups by considering their own personal gains and losses. Consequently, a change that would benefit society as a whole may not occur if a politician receives greater private gain from an interest group that does not want the change than from a group that does.

[11] A succinct discussion of transactions costs is found in Douglas C. North, "Institutions, Transactions Costs, and Economic Growth," *Economic Inquiry*, vol. 25, 1987.

[12] William J. Baumol — in "Williamson's The Economic Institutions of Capitalism" *(Rand Journal of Econometrics*, vol. 17, 1986, p. 280) — points out that if there were no fixed or sunk costs in land, capital, or people, resources could easily be transferred to optimal uses. If information were perfect or if people could always figure out how to design contracts to cover any contingency, fixed costs would not matter. If people did not try to profit at others' expense, contracts could be drawn loosely and adjustments made as conditions change.

[13] See Alain deJanvry, Marcel Fafchamps and Elisabeth Sadoulet, "Transaction Costs, Public Choice, and Induced Technological Innovations," in Bruce M. Koppel, ed., *Induced Innovation Theory and International Agricultural Development: A Reassessment* (Baltimore and London: Johns Hopkins University Press, 1995).

Collective Action

When producers of a commodity are few, economically powerful, and regionally concentrated, they may find it easier to act collectively to influence public decisions in their favor than if these conditions do not hold. Even if the conditions do not hold, if a commodity is very important in the diets of people in urban areas or if it earns substantial foreign exchange, the public sector still may act to help its producers. However, if producers are neither organized into a powerful collective lobby nor producing an important commodity for urban consumption or export, they will seldom receive public help such as new technologies. This fact may explain why peasant farmers with small land holdings are often neglected when agricultural research priorities are set.

Implications for Induced Innovation

The implications of transactions costs and collective action for the induced-innovation model presented earlier are illustrated in Figure 11-3. Changes in the underlying resource base for the country as a whole might imply that the least-cost path of technical change would occur in the direction of arrow Z (i.e., a path that would use relatively abundant labor and save relatively scarce land). Following path Z might be facilitated by the development of new labor-intensive, biologically-based technologies. However, if a few large-scale producers, due to the presence of transactions costs and collective action, were able to influence public officials so that technology I'_0 were to be developed rather than I'_1, then technical change might occur in the direction of arrow Y (perhaps through the development and adoption of capital-intensive, mechanically-based technologies) rather than arrow Z. Benefits to the large farmers would be maximized but overall economic efficiency gains might be reduced.

The concern over the existence of transactions costs and collective action is not just a concern over the distribution of the benefits of agricultural development. Rather, it is a concern that the rate of economic growth itself will be diminished as well. If, in the previous example, the farmers demanding path Y were few in numbers, and their total value of production compared to the farmers demanding path Z also was small, then the decision to develop technology along path Y would mean a growth rate below the country's potential.

Policy Implications

The above discussion illustrates that technological progress is important for agricultural development, but so too are institutional arrangements and information. Although the theory of induced innovation

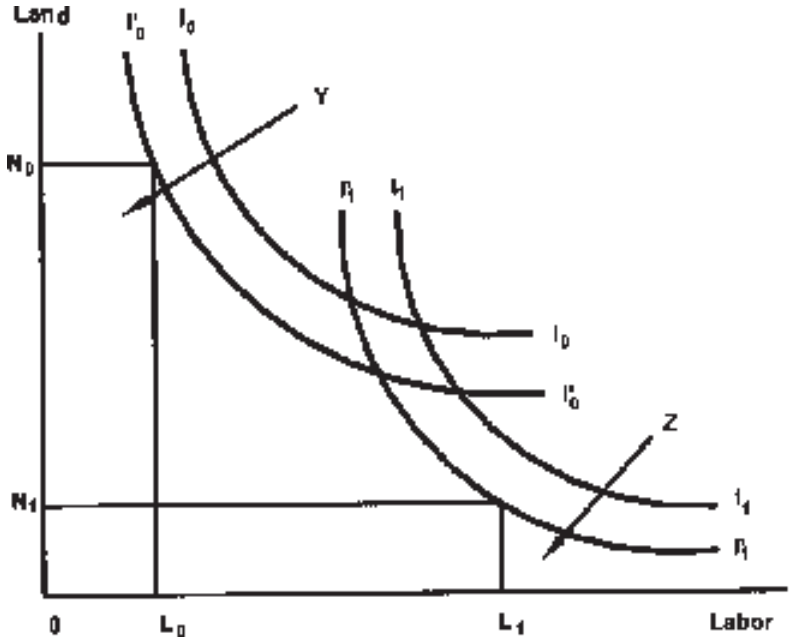


Figure 11-3. Induced technical innovation in the presence of transactions costs. The direction of technical change as dictated by changes in relative factor prices might call for cost-reducing path Z. However, transactions costs and collective action may create pressures to follow path Y, reducing the rate of overall economic growth.

provides an optimistic look at how market forces can work, almost like an invisible hand to stimulate technological and institutional change, the presence of transactions costs and collective action sound a cautionary note that there is an invisible foot out there eager to stomp on that hand. The reality that agricultural and overall economic development has progressed steadily in some countries while stagnating in others, demonstrates that development is neither automatic nor hopeless. An operational agricultural development strategy is needed that recognizes (a) the role that relative prices can play in guiding technical and institutional change, (b) that imperfect information and other transactions costs can sidetrack development unless domestic and international institutions are proactively developed to constrain inappropriate collective action. Inappropriate here is defined as actions that impose gross inefficiencies on the sector or that fail to meet the equity

Improved transportation to reduce transactions costs becomes critical as development proceeds.

goals of a society. In the sections below, several of these institutions are briefly mentioned; they are discussed more thoroughly in subsequent chapters.

Domestic institutions

Land, credit, pricing, marketing, and research policies are all critical to development and adoption of appropriate technologies and for agricultural development in general. Sources of agricultural growth change over time, and few countries today are able to achieve substantial production increases by expanding their land bases. In addition, land currently in production is being degraded in many countries due to population and other pressures on a fragile natural resource base. Ownership of land and other assets is highly unequal in many countries and fragmented in others. Hence one institutional component of an operational agricultural development strategy is to reexamine the arrangements governing land ownership and use and to make any needed adjustments.

Improved transportation, marketing, and communications systems also become critical as development proceeds. Lower transportation, marketing, and communications costs can reduce transactions costs and improve information flows, and thereby facilitate broad-based agricultural growth. Isolated regions tend to be poor regions.

Provision of high-payoff inputs and credit to finance their purchase are additional components of a successful agricultural development strategy. Farmers are rational and relatively efficient given their current resources. Consequently new inputs embodying improved technologies are needed to improve the productivity of farmers in developing countries. Research and technology-transfer policies can facilitate the development and adoption of these technologies. In addition, pricing policies should be designed so as not to discourage the use nor encourage the abuse of improved inputs.

Educational levels of farmers also must be increased to improve their ability to recognize the benefits of and to use the technologies. Education improves the capacity of people to assimilate and use information and thus can help reduce transactions costs.

Macroeconomic and International Institutions

Agricultural development is affected by macroeconomic and trade policies that arise outside the agricultural sector. The levels and types of taxes, spending, and government borrowing can dramatically influence farm prices and input costs. Exchange rates, or the value of the country's currency relative to currencies in other countries, can have major effects on domestic agricultural prices and trade.

In some countries, foreign debt repayments significantly constrain growth and reduce domestic consumption. Internationally influenced interest rates and prices vary substantially over short periods of time, adding an additional measure of unpredictability to debt levels and national incomes. International labor markets for agricultural scientists mean that high salaries draw some of the brightest and most educated scientists to more developed countries and international agencies. Foreign aid is a source of capital and technical assistance for some countries, but is often unreliable and usually comes with strings attached. Developing countries must carefully design macroeconomic and trade policies that do not discriminate against their agricultural sector if they expect it to grow.

Enlightened Self Interest

Any operational agricultural or economic development strategy must (1) recognize individual incentives; (2) consider the lack of perfect information; and (3) include institutional arrangements to offset externalities and other market imperfections. Individuals must feel it is in their self-interest before necessary institutional changes will occur.

Information is valuable, imperfect, and costly to acquire, and can exhibit economies of scale in acquisition. These attributes of information

provide the incentives and the means for some people to use the advantage they have from asset ownership, military power, or their willingness to engage in unscrupulous behavior to acquire information before others.

In fact, even if all assets were initially distributed equally, unless information were available equally to all or unless enforceable rules were instituted to constrain dishonest behavior, the willingness of some to gain "unfair" advantage would eventually lead to unequal distributions of assets. In primitive societies, information is basically available to all, and inappropriate activities are constrained by social and cultural norms. However, as societies become more complex concurrently with economic development, information becomes more imperfect and new institutions are needed to replace the rules that no longer constrain behavior.[14]

People must feel it is in their interest to design and enforce particular institutional changes, and they need to know the implications of those changes. Institutional change involves costs because some people benefit from current arrangements and will fight any change.

The following six suggestions might help lower the cost of institutional change through enlightened self-interest:

- First, in those countries where asset ownership has become so unequal that inefficiencies in property rights are retarding agricultural development, asset redistributions (particularly land) are needed, usually with compensation arrangements (so that the changes will in fact occur).
- Second, improvements in education, communications, and transportation can improve information flows and the ability of a large number of people in the country to act on information.
- Third, decentralized industrial growth should lower labor adjustment costs (and facilitate employment), reduce externalities associated with urban crowding, improve market performances in rural areas, and help stimulate agricultural growth.
- Fourth, social science research can help lower the cost of designing and examining the implications of alternative institutional changes affecting agriculture.
- Fifth, a government structure is needed that includes enforceable laws to protect citizens from each other and from the government itself. Government policies and regulations can also be used to reduce

[14] These ideas are similar to those expressed by North ("Institutions, Transactions Costs, and Economic Growth"), pp. 420–5. North notes that impersonal exchange with third-party enforcement is essential for economic growth. Third-party enforcement implies that legal institutions exist.

market failure. Well-functioning and transparent legal systems with independent judiciaries can help facilitate transition toward enhanced institutions.

- Sixth, improved and enforceable international laws and other institutions are needed to reduce incentives for international abuses of power

SUMMARY

Several theories of agricultural development have been proposed over time. Expansion or conservation of resources, diffusion, use of high-payoff inputs, and induced innovation are some of the major ones. Technical and institutional changes are key components of any operational agricultural development strategy. These changes can be induced by relative price changes resulting from change in resource endowments and product demand. Because of transactions costs, collective action, and the realities of human behavior, agricultural sectors may not follow an economically efficient development path. The distribution of assets has important implications in the presence of transactions costs and collective action. If land is unequally distributed, then, because of transactions costs, the demands (for technologies, inputs, policies, etc.) of one group of producers are likely to be very different from those of others. Collective action can then pull the development process from its optimal path. Institutional changes to improve information flows and constrain exploitive behavior can become critical to agricultural development.

IMPORTANT TERMS and CONCEPTS

Agricultural research and extension
Asset distribution
Asset fixity and adjustment costs
Communications
Compensation schemes
Diffusion theory
Enlightened self-interest
Externalities
High-payoff inputs
Induced institutional innovation
Induced technical innovation
Innovation possibilities curve
International factors
Invisible hand
Location theory
Macroeconomic factors
Market failure
Meta production functions
Perfect information
Resource conservation
Resource exploitation
Transactions costs

Looking Ahead

In this chapter we considered theories of agricultural development and suggested a broad framework for operational agricultural development strategies. In the following five chapters we consider sector-specific

means of generating particular technical and institutional changes to stimulate agricultural growth. In later chapters we consider macroeconomic and international factors. We begin in Chapter 12 by focusing on agricultural research and extension.

QUESTIONS for DISCUSSION

1 Contrast the resource exploitation, resource conservation, and diffusion theories of agricultural development.
2 Why is the resource exploitation theory of agricultural development less useful today than it was historically?
3 Why has the importance of resource conservation increased is recent years?
4 What are the limitations of the diffusion theory of agricultural development?
5 Why has the high-payoff input theory become widely accepted?
6 What criticisms do Hayami and Ruttan make of the high-payoff input theory?
7 Describe the theory of induced technological innovation. Be sure to identify both the importance of relative input price changes and changes in the relative prices of inputs to outputs.
8 Describe the induced institutional innovation theory.
9 Contrast transactions costs and collective actions.
10 What are the implications of transactions costs and collective action for institutional innovation?
11 What do we mean by the term *enlightened self-interest*?
12 How might information be made more accessible to farmers?
13 What are the implications of a grossly unequal asset ownership pattern for economic growth?
14 Why are improved international institutions needed for agricultural development?
15 Why does Japanese agriculture have much higher output per hectare than U.S. agriculture, but much lower output per worker?

RECOMMENDED READINGS

Hayami, Yujiro, and Vernon W. Ruttan, *Agricultural Development: An International Perspective* (Baltimore: Johns Hopkins University Press, 1985), Chapters 3 and 4.

Koppel, Bruce M., ed., *Induced Innovation Theory and International Agricultural Development: A Reassessment* (Baltimore and London: Johns Hopkins University Press, 1995).

North, Douglas, "Institutions, Transactions Costs, and Economic Growth," *Economic Inquiry,* vol. 25, 1987, pp. 415–228.

Ruttan, Vernon W., T*echnology, Growth and Development: An Induced Innovation Perspective* (Oxford: Oxford University Press, 2001).

Williamson, Oliver, *The Economic Institutions of Capitalism* (New York: Free Press, 1985).

CHAPTER 12

Research, Extension, and Education

> The man who farms as his forefathers did cannot produce much food no matter how rich the land or how hard he works.
>
> — Theodore W. Shultz[1]

THIS CHAPTER

1 Discusses the role of public and private agricultural research in generating improved technologies and institutions and the effects of those technologies on income growth and distribution and on food security

2 Describes the major types of agricultural research, and factors influencing the transfer of research results from one country to another

3 Examines the role of technology and information transfer mechanisms such as public agricultural extension and non-governmental organizations

THE ROLE of AGRICULTURAL RESEARCH

A major determinant of growth in agricultural production is the effectiveness of agricultural research. Through research, the productivity of existing resources is increased, new higher-productivity inputs and ways of producing food are developed, and new or improved institutional arrangements are designed. Examples of research outputs include higher-yielding plant varieties, better methods for controlling insects and diseases, increased knowledge about methods for manipulating plant or animal genes, and designs for improved agricultural policies. Research creates the potential for increased agricultural production, moderated food prices, increased foreign exchange, reduced pressure

[1] Theodore W. Schultz, *Transforming Traditional Agriculture* (Chicago: University of Chicago Press, 1964), chapter 1, p.3.

on the natural resource base, and many other positive results. Let's consider in more detail the nature of these effects and the possibilities for negative as well as positive outcomes.

Over time, agricultural research has been associated with improvements in incomes and reductions in poverty. It is estimated that without the productivity improvements generated through agricultural research, an additional 350 million hectares of land, about the size of India, would have been needed to feed the world's population growth since 1960. Productivity gains have thus saved highly erosive fragile soils, reduced deforestation, and helped preserve biodiversity.[2] Specific research successes include a new African rice variety that is more productive and better suited to harsh environmental conditions, cassava varieties that are resistant to cassava mosaic virus and raise yields by 10 tons per hectare, and enhanced strains of tilapia fish that grow 60 percent faster than traditional strains.[3] Despite consistent evidence of high rates of return to agricultural research, pressures to reduce funding for it are frequent.

Impacts on Agricultural Productivity

Productivity increases generated through agricultural research imply a shifting upward of agricultural production functions. The simple example of increasing the output per unit of an input, say fertilizer, is illustrated in Figure 12-1. If a more responsive seed variety is made available through research, output produced per kilo of fertilizer may increase. The research that produced that higher quality seed may be either public or private or both. Public research is conducted in national research institutions, public universities, or government-sponsored research in private entities. Private research is financed by private companies.

Research and subsequent technical change in agriculture raises returns to producers. The value of agricultural production added per worker is shown in Table 12-1 for India, China, Indonesia, Nigeria, and Brazil (five of the more populous countries of the world) for the time periods 1979–81 and 1998–2000. Despite rapid population growth, which might be expected to push production onto more marginal agricultural lands, agricultural productivity per worker rose substantially in each of these countries, about doubling in China and almost tripling in Brazil. This same pattern is found in most other developing countries,

[2] See CGIAR Science Council, *Science for Agricultural Development; Changing Contexts and New Opportunities* (Rome, Italy: Science Council Secretariat, 2005).

[3] See CGIAR Science Council, *Science for Agricultural Development,* for details.

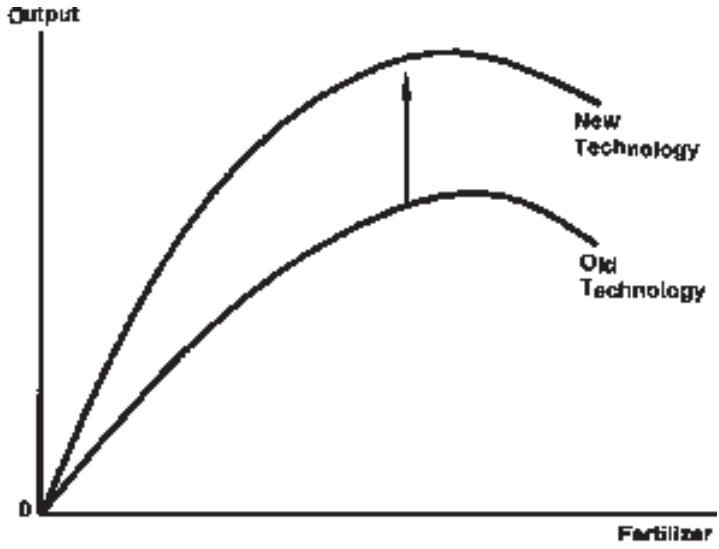


Figure 12-1. The effect of research on input productivity. New technologies generated through research can shift the production response function upward.

Table 12-1. Agricultural Value-added Per Worker (2000 dollars)

Country	1980	1990	2000	2003
India	$273	$348	$389	$406
China	$163	$245	$346	$349
Indonesia	$425	$480	$522	$574
Nigeria	$491	$578	$774	$871
Brazil	$1,113	$1,628	$2,585	$3,227

Source: World Bank, *World Development Indicators* On-line Database.

although output per capita for the total population has declined in several sub-Saharan Africa countries where rapid population growth has outpaced slow productivity improvements.

The examples shown in Figure 12-1 and Table 12-1 are oversimplified in the sense that most new technologies require different mixes of inputs; not all other inputs are held constant. Measurement of total productivity gains due to research requires netting out the cost of any additional inputs employed with the improved technologies. The resulting total net cost reduction per unit of output produced can then be

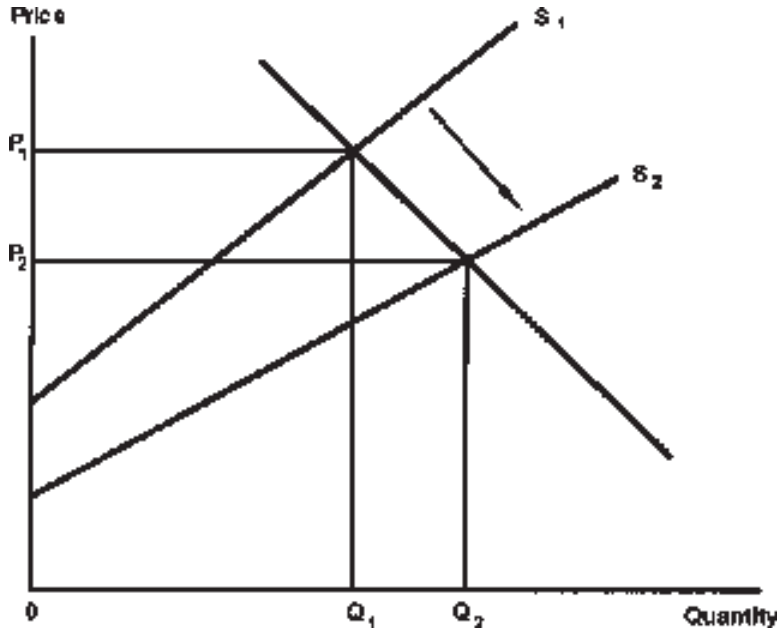


Figure 12-2. Effect of research on supply. Agricultural research reduces the cost per unit of output, thereby causing the supply curve to shift down to the right.

used to summarize the total productivity effect. This total productivity effect is illustrated in Figure 12-2. New or improved technology shifts the original commodity supply curve (S_1) downward to S_2 because the supply curve is a marginal cost curve and the new technology has reduced the cost of production. The new lower cost of production per unit of output means that more output is produced at a lower price. This lower price is good for consumers of the product, but producers might be hurt.

Many studies have been conducted to estimate the economic returns to society from public research investments aimed at achieving these productivity increases. A recent study found more than 1,700 distinct estimates of the returns to various research programs around the world.[4] A summary of the results is presented in Table 12-2. Individual

[4] See Julian M. Alston, Connie Chan-Kang, Michele C. Marra, Philip G. Pardey, and T. J. Wyatt, "A Meta-Analysis of Rates of Return to Agricultural R&D," *IFPRI Research Report 113* (Washington, D.C.: International Food Policy Research Institute, 2000).

programs and projects vary widely in their estimated returns, but on the whole agricultural research has been a highly profitable investment for the societies that undertake it. Both mean and median annual rates of return are well above government cost of capital, or earnings on alternative investments. National leaders have a responsibility to invest scarce public resources in activities that yield high returns.

Increased agricultural productivity not only creates the potential for higher real incomes to producers through lower costs and to consumers through lower food prices, but can also help a country's agriculture become more competitive in world markets. Efficiency gained through higher agricultural productivity can be turned into foreign exchange earnings or savings as a result of additional exports or reduced imports.

The fact that agricultural research has yielded high returns in many countries in the past does not imply that these returns are guaranteed for all research systems or types of research. Each country must carefully consider the appropriate type of research organization and portfolio of activities, given its resource base and special needs (see Box 12-1 for an example of a research portfolio). This issue is discussed in more detail below.

Distributional and Nutritional Effects

Agricultural producers at different income levels, with different farm sizes, in different locations, and with different land tenure arrangements can gain or lose as a result of new technologies and institutional changes generated through research. These gains and losses depend on market conditions, among other factors. Consumers are major beneficiaries of agricultural research due to falling product prices, but the benefits they receive vary as well by income level and are influenced by the nature of the research portfolio. Returns to land versus labor are also influenced by research. Nutritional implications follow from these differential producer, consumer, and factor-income effects.

Farm Size and Tenure: The issue of whether improved agricultural technologies benefit large farms more than they do small farms has been the subject of substantial debate. Farm size is not a major impediment to adoption of new biological technologies such as improved seeds, which are the major focus of developing country agricultural research. However, larger farms do tend to be among the first adopters of many new technologies, probably because it pays large farms more to invest in obtaining information about the technologies. Owners of large farms may have more formal education that helps them process

TABLE 12-2. Rates of Return to Agricultural Research by Commodity Orientation

Commodity orientation	Number of estimates (count)	Mean rate of return (percent)	Median rate of return (percent)
Multicommodity[a]	436	80	47
All agriculture	342	76	44
Crops and livestock	80	106	59
Unspecified[b]	14	42	36
Field crops[c]	916	74	44
Maize	170	134	47
Wheat	155	50	40
Rice	81	75	51
Livestock[d]	233	121	53
Tree crops[e]	108	88	33
Resources[f]	78	38	17
Forestry	60	42	14
All studies	1,772	81	44

a Includes research identified as "all agriculture" or "crops and livestock", as well as "unspecified."

b Includes estimates that did not explicitly identify the commodity focus of the research.

c Includes all crops, barley, beans, cassava, sugarcane, groundnuts, maize, millet, other crops, pigeon pea, chickpea, potato, rice, sesame, sorghum, and wheat.

d Includes beef, swine, poultry, sheep, goats, all livestock, dairy, other livestock, and pasture.

e Includes "other tree" and "fruit and nuts."

f Includes fishery and forestry.

Source: Julian M. Alston, Connie Chan-Kang, Michele C. Marra, Philip G. Pardey and T. J. Wyatt, "A Meta-Analysis of Rates of Return to Agricultural R&D," *IFPRI Research Report 113* (Washington, D.C.: International Food Policy Research Institute, 2000), Table 15, p. 58.

the information, and a greater ability to absorb risk. Large farms often have better access to the credit needed to purchase modern inputs. Most small farms in the same region as large farms do eventually adopt the technologies, but the first adopters typically receive greater income gains from them. Late adopters may be faced with lower producer prices because supplies shift outward as early adopters increase output. Of course even if all producers in a given region adopted a scale-neutral technology at the same time, absolute income differences would widen

BOX 12-1.
MAJOR TYPES of RESEARCH in the NATIONAL AGRICULTURAL RESEARCH INSTITUTION in ECUADOR

The listing below of the major types of agricultural research activities in Ecuador provides an example of a typical applied research portfolio for a small developing country. Given its limited research budget, the country must decide which commodities to concentrate on and how much to emphasize each type of research.

1. **Plant breeding:** development of new lines and varieties that yield more and are resistant to insects and diseases; maintenance of a germplasm collection
2. **Cultural practices:** determination of optimal planting densities, improved harvesting methods
3. **Crop protection:** improved methods for control of insects, diseases, weeds, nematodes, including biological, cultural, and chemical methods
4. **Soils and fertilizers:** development of improved soil conservation methods, chemical analysis of soils including macro- and micro-element analysis, toxicity studies, economic analysis soil conservation, and fertilization practices
5. **Water management:** studies of water needs, improved irrigation methods, salinity control
6. **Mechanization:** design of improved agricultural implements
7. **Socioeconomics:** diagnosis of constraints to technology adoption, monitoring and evaluation of research, analysis of farm management practices and opportunities
8. **Technology validation**: on-farm transferring, testing, and validation of new technologies
9. **Seed production**: basic and registered seed production, technologies for seed production, improved vegetative propagation
10. **Post-harvest technologies:** improved methods for storage, drying, cleaning, packaging, and transporting agricultural products
11. **Agro-forestry:** improved systems of agro-forestry and of pasturing forests
12. **Animal improvement:** animal breeding, introduction and selection of animals from outside the country, adaptation of animals to different climates
13. **Animal health:** prevention and cure of diseases and external and internal parasites
14. **Animal nutrition**: improved forages, analysis of concentrates and other supplementary feeding programs, evaluation of nutritional deficiencies, nutritive value of feeds

Source: Julio Palomino, Planning Director, National Agricultural Research Institution, Ecuador.

because the increased returns per hectare are spread over more hectares on larger farms.

As noted in Chapter 11, not all technologies and institutional changes are scale-neutral. For example, certain types of mechanical technologies can be used profitably on large but not on small farms. With differences in transactions costs, large farmers may press research systems for research results suitable for them even if the country's resource base on average would dictate a different type of technology. Also, while many technologies are scale-neutral and some are biased toward large farms, it may be difficult to generate technologies biased toward small farms. All this implies that reducing transactions costs through improved information is important, but it also implies that research may not be the best policy tool for achieving distributional objectives.

Tenant farmers represent an important producer group in many countries. It is difficult to generalize about the effects of research on the incomes of tenants versus landlords. One might expect that improved biological technologies would make labor more productive and thus help tenants, but the distribution of income gains is influenced by other factors as well. If each landlord has several tenants, so that the average size of landlord holdings is greater than the average size of tenants' farms, then the average landlord would gain relative to the average tenant if each received equal shares of income gains per hectare.

Contractual arrangements influence the distribution of research benefits, and the arrangements may change as well as a result of new technologies.[5] If the tenant pays the landlord a fixed *share* of the output, the division of any income gains after adopting the new technology depends on the relative sharing of both output and production costs. But if the tenant pays a fixed *amount* to the landlord, the tenant can keep the income gains until the landlord raises the rent. Often, increases in land productivity are bid into land rents, and land-owners are able to capture these rents by changing tenancy agreements.

Regional Disparities: Regional differences in resource endowments and basic infrastructure can influence the distribution of research gains among producers. In fact, interregional disparities in the net benefits from research tend to be larger than intraregional disparities. Data from India indicate that the new rice and wheat varieties that increased production so dramatically in that country in the late 1960s benefited primarily the more productive wheat and rice states. Productivity

[5] See George W. Norton, Philip G. Pardey, and Julian Alston, *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting* (Ithaca, N.Y.: Cornell University Press, 1995), Chapter 3.

increased dramatically in the country's northern region. At the same time, during 1967 to 1976, the central and eastern regions actually had decreasing rice yields. These interregional yield differentials diminished over time, but the technologies clearly benefited certain regions more than others.[6] The introduction of modern crop varieties has exacerbated interregional disparities in many countries because those technologies have often required irrigation and greater use of farm chemicals. Producers in dryland areas and regions with poor infrastructure for transporting fertilizer have been disadvantaged. Broadening the scope of agricultural research and decentralizing the research structure should help reduce regional disparities, although rates of return on research aimed at more productive regions are consistently higher than those for marginal areas.

Producers and Consumers: The impacts of technological change on the distribution of income between producers and consumers depend to a large extent on the degree to which quantity demanded responds to price changes. If producers face an elastic demand for their output, increased supplies will place little downward pressure on prices so producers rather than consumers capture most of the benefits of the innovation. Export crops, for example, tend to have relatively elastic demands, and thus new technologies for the production of these commodities tend to favor producers. Many commodities that are basic staples in the diet have relatively inelastic demands, as discussed in Chapter 3. The benefits of research on these commodities flow largely to consumers through lower prices.

The poor spend a higher proportion of their income on food, and so benefit more than others from any decline in food prices due to research-induced increases in food supplies. This benefit is received by both the urban and the rural poor. The rural poor are often landless laborers, who purchase food, or small owner-operators or tenants, who retain a large part of their output for home consumption. Scobie and Posada found in Colombia, for example, that while the lower 50 percent of Colombian households received about 15 percent of total national household income, they captured nearly 70 percent of the net benefits of the rice research program.[7] These benefits to consumers flow

[6] J.S. Sarma and Vasant P. Gandhi, Production and Consumption of Foodgrains in India: Implications of Accelerated Economic Growth and Poverty Alleviation, International Food Policy Research Institute Research Report No. 81, Washington, D.C., 1990, pp. 17–34.

[7] Grant M. Scobie and Rafael Posada T., "The Impact of Technical Change on Income Distribution: The Case of Rice in Colombia," *American Journal of Agricultural Economics*, vol. 60, no.1 (February 1978), pp. 85–92.

across regions, especially where adequate transportation exists, and dampen the interregional disparities to producers mentioned above.

Land, Labor, and Capital: New technologies allow the same output to be produced with fewer resources, thus freeing up those resources to be used elsewhere in the economy. The dual-economy model described in Chapter 6 illustrated the potential for labor released from agriculture to become a fundamental source of industrial growth. However, the effect of technical change on the demand for resources is influenced by the inherent nature of the technology and by the nature of product demand.

Some new technologies result in proportionate savings of all inputs, while others save labor and use land or vice versa. For example, a new machine to cultivate the land may save labor and require a farmer to use more land to justify the cost. A higher-yielding rice variety may require more labor but produce more per unit of land. If a technology is neutral with respect to its effect on land and labor use, and if the demand for the product is elastic, the demand for both land and labor may grow proportionately following adoption of the technology. The reason is that, with elastic demand, total revenue increases with a shift out in the supply curve, providing increased returns to all resources. On the other hand, if product demand is inelastic, a neutral technical change can reduce the demand for all inputs proportionately.

BOX 12-2.
THE GREEN REVOLUTION

The term *green revolution* was coined in 1968 by William S. Gaud, former Administrator of the U.S. Agency for International Development, to describe the dramatic wheat harvests that had been achieved in 1966 to 1968 in India and Pakistan. The term gained further publicity in 1970 when Norman Borlaug was awarded the Nobel Peace Prize for his research that produced the high-yielding, semi-dwarf Mexican wheats that had performed so well in Asia and Latin America. At the same time that the semi-dwarf wheats were making their dramatic entry, IRRI released new semi-dwarf rice with the same dramatic effect.

The big innovation of the green revolution was developing varieties of wheat and rice that would not fall down (lodge) when nitrogen fertilizers were applied. These new lines of plants also tended to be earlier maturing, to produce many shoots (tillers), and to be less sensitive to day length.

Source: Donald L. Plucknett, "Saving Lives Through Agricultural Research," Consultative Group on International Agricultural Research, Issues in Agriculture Paper No. 1 (Washington, D.C., May 1991), pp. 9–10.

Most new technologies are biased toward the use of one resource or another. Many of the higher-yielding varieties that comprised the "Green Revolution" (see Box 12-2) require significantly more labor input per unit of land. As a result, strong poverty-reducing impacts of the green revolution were transmitted through labor markets. In countries where markets are highly competitive and input prices reflect true input scarcity, the induced-innovation model presented in Chapter 11 predicts that new technologies will be developed to save the relatively scarce resources. However, if input prices are distorted, externalities exist, or transactions costs are high, technical change will not necessarily be biased in a direction that saves the scarcest resources; this ''inappropriate'' bias will thus reduce the rate of overall agricultural growth below its potential.

Because so many factors influence the effect of new technologies on resource use, it is difficult to generalize about the effect of research on employment, on the long-run returns to land, and so on. One implication is that agricultural research is a relatively blunt instrument for implementing a policy of distributing income to particular resources.

Nutritional Implications: Agricultural research can influence human nutrition through several mechanisms. First, if new technologies are aimed at poor farmers, a high proportion of the resulting income streams will be spent on improving the diet. If the technologies are aimed at commodities produced and consumed at home, the effect will be direct. If the technologies affect export crops produced by small farms, the extra income may be spent on buying food from others. Even if the new technologies are suitable only for large farms producing export crops, the influence on nutrition of the poor may be positive if the demand for labor increases. However, this employment effect is not at all certain and depends on the factor biases discussed above.

An important nutritional effect of research comes from the increased availability of food at lower prices. As supply shifts out against a downward sloping demand curve, all consumers benefit from lower food prices that improve their real wages.

Research can be used to reduce fluctuations in food supply, prices, and income and thereby alter nutrition. Some of the severest malnutrition occurs in rural areas during years of low incomes due to lower than normal production. Research on drought-tolerant varieties can help reduce production fluctuations and help lower malnutrition.

It is difficult to draw conclusions about the nutritional implications of a particular portfolio of research activities because the sources of nutritional impacts identified above can act counter to one another. For example, a labor-saving technology used to produce export crops

might lower wages and not induce changes in food supply, thus making landless laborers worse off. Some concern has been voiced about the nutrition effects of research devoted to export-crop production. If numerous producers switch from food crops to export crops, then there is potential for domestic food prices to rise, and such a rise would hurt the urban and landless poor. However, there is little empirical evidence of this switch, and nutritional levels are perhaps most influenced by research that generates the largest income gains, particularly if those gains are realized by low-income producers. Therefore, focusing research disproportionately on commodities with high nutritional content may result in less income than if the research were focused on other commodities. For example, improving the productivity of a vegetable export crop in Guatemala may improve the family's nutrition more than improving the productivity of its maize crop, because the former will lead to a greater increase in farm income and therefore the family's ability to buy food.

Environmental Effects of Research

Concerns over environmental degradation in developing countries were discussed in Chapter 9. Deforestation, soil erosion, desertification, pesticide pollution, etc., have become serious problems in many countries, and research can play a significant role in their solution.

First, new technologies for mitigating soil erosion, providing alternative energy sources, and substituting for chemical pesticides can be generated through research. Second, research can be used to design improved government policies that provide increased incentives to adopt management practices and help sustain the integrity of the natural resource base. Third, the higher incomes generated through research-induced productivity increases will put downward pressure on population growth in the long run. Fourth, higher income streams will also reduce the pressures to abuse the environment in the short run just to obtain food and fuel. Finally, income growth will create more demand for environmental quality. Thus agricultural research is critically important for encouraging environmentally sound and sustainable agricultural growth.

Research organizations have been criticized in the past for devoting too many resources to research related to modern inputs such as fertilizer, pesticides, and irrigation. Excessive and improper use of these inputs can cause environmental damage. An additional criticism has been that too little research is aimed at resource-conserving technologies, such as integrated pest management and methods for reducing soil erosion. There is some truth in these claims, although research on

sustainable farming practices has accelerated (see Box 12-3). Also, market failures tend to cause an undervaluation of environmental services, as discussed in Chapter 9. Because of this undervaluation, producers and consumers often do not demand resource-conserving technologies. In the long run, one of the best ways to combat forces leading to environmental degradation is to raise incomes and reduce poverty. Research can be an effective means of raising incomes, though in the short run, more agricultural research should, perhaps, be aimed at conserving environmental resources.

Other Research Issues

Institutional Change: Much agricultural research results in new or improved technologies that are embodied in inputs or methods of production. However, agricultural research can be directed toward the design of new or improved policies or institutional changes. In other words, agricultural research can help lower the cost of adjusting institutions to the changing physical, natural resource, economic, and biological environments. A static or distorted institutional environment can be as great a hindrance to agricultural development as can a static technology base.

Credit policies, marketing and pricing policies, land tenure rules, and natural resource policies are examples of institutional arrangements

BOX 12-3.
RESEARCH and the ENVIRONMENT:
THE CASE of the CASSAVA MEALYBUG

The cassava mealybug was accidentally introduced from Latin America into Africa in the early 1970s and soon began causing severe damage to cassava crops. Because some 200 million Africans depend on cassava as a staple food, this damage became a deep concern.

Researchers at the International Institute of Tropical Agriculture (IITA) in Africa, in collaboration with those at the International Center for Tropical Agriculture (CIAT) in Latin America, found a means of biological control. Importation and distribution of the parasitic wasp *Epidinocasis lopez*, a natural enemy of the mealybug from Latin America, has led to dramatic reductions in African mealybug populations with biological methods. No extensive pesticides are required, and the small-scale African farmers are freed from a damaging pest by nature itself.

Source: John Walsh, *Preserving the Options: Food Productivity and Sustainability*, Consultative Group for International Agricultural Research, Issues in Agriculture, No. 2 (Washington, D.C., 1991), pp. 7–8.

that can be improved through research. Institutional changes that improve the flow of market information and reduce externalities are particularly important.

Public versus Private Sector Research: Just because agricultural research is important to development does not imply that the public sector must carry it out. Typically, the public sector is heavily involved in agricultural research in both developed and developing countries, but the private sector is heavily involved in many countries, and increasingly so. Why does the private sector not provide all the needed research? There are three basic reasons. First, individual farms are too small to do all their own research, although they often cooperate with public research institutions and certainly do a great deal of experimenting. Second, and most important, for many types of research it is difficult for one firm to exclude other firms from capturing the benefits from the research; in other words, a firm may incur substantial costs in conducting research but, once the research is completed, other firms can make use of the results without incurring much cost. Thus, the firm has little incentive to do the research in the first place. Third, many types of research are highly risky, so that many firms are hesitant to take the risk for fear of incurring a substantial loss.

Certain types of research, particularly applied research related to mechanical and chemical innovations, are less risky and potentially patentable and thus attract sizable private research activity. Some types of biological and soils research, on the other hand, have historically been more difficult to patent and have thus been primarily conducted in the public sector. However, the patentability of biological research has increased in recent years and has played a major role in the development of new, genetically modified crops and animals. As a country develops, the research role of the private sector typically increases in developing and marketing improved seeds as well as in mechanical and chemical innovations. However, there is often a time lag between the development of public sector research and the establishment of substantial private sector research activity. One action that a country can take to promote private research is to establish enforceable property rights (patents, licenses, etc.) over research results, not just for mechanical and chemical technologies but for biological technologies as well.

Intellectual Property Rights: Intellectual property rights (IPRs) refer to legal protections, granted for a defined period of time, to scientific, technological, and artistic inventions. Copyrights, trademarks, patents, plant breeders' rights, and trade secret laws are examples of ways that intellectual property rights are granted. Legal systems differ

by country and hence the types, extent, and duration of rights granted vary as well. Patents and plant breeders' rights are the most important forms of intellectual property protection for agricultural research results and technologies. Over time, copyrights are becoming more important as well because the databases that contain information about plant genes can often be copyrighted.

Patents are the strongest type of intellectual property, as the patent holder can exclude all others from making, using, selling, or offering to sell the invention in the country while the patent is in force (unless others purchase a license to use it). To be patentable, an invention must be new, useful, not obvious, and be disclosed so that others can pay a license to use and replicate it. Plant Breeders' Rights (PBRs) grant protection to crop varieties that are new, distinct, uniform, and stable. Patents and PBRs give a monopoly on commercializing the invention or variety for a defined period of time, which allows the inventor or breeder to recover their costs. This protection therefore gives them incentives to invent or breed that they otherwise would not have.

Many developing countries are still in the process of developing and implementing an intellectual property protection system for plants and animals. Details of IPR systems vary from country to country, but those who lag behind run the danger that private firms and individuals will be reluctant to develop or sell products with new technologies embedded in them in their countries. Developing countries have grown fearful that as more and more technologies (including genes) are covered by IPRs, their people and firms will be discouraged from using the technologies and resulting products because of the high costs of licensing the technologies or paying for the higher-cost products. This issue has been a topic of discussion and action in multilateral trade negotiations since the early 1990s, and is discussed more in Chapter 17.

NATURE, ORGANIZATION, and TRANSFER of RESEARCH

Some research is very ''applied'' and yields immediate practical results. Other research is more "basic" or fundamental and may not yield results for many years. Research systems themselves are organized in a variety of different ways. Let's consider the major categories of agricultural research and organizational arrangements.

Categories of Agricultural Research

Agricultural research can be categorized into basic research, applied research, adaptive research, and testing**.** ***Basic*** research develops knowledge with little or no specific use in mind. Studies of evolution, genetics, biochemical processes, and so on, may discover fundamental

principles of substantial significance to more applied researchers, but the specific end use of the research results are often difficult to identify prior to the research. Most basic research is carried out in developed countries or in the largest of the developing countries.

Applied agricultural research is aimed at solving particular biological, chemical, physical, or social science problems affecting one or more countries or areas in a state or region. Development of new plant varieties, methods for controlling specific insects and diseases in plants or animals, and animal nutrition research are examples of applied research. Applied research may take place at international research centers or in national research systems.

Adaptive research takes the results of applied research and modifies or adapts them to local conditions within a country or region. A plant variety developed for a broad area may need to be modified for a specific microclimate. Fertilizer recommendations, methods for controlling soil erosion, and many other technologies require adaptation to the local setting. Most of this research takes place on local experiment stations or on farms.

Ecuadorian scientists recording disease data in an applied pest management experiment on plantain.

Testing research is conducted on local experiment stations or on farms to assess whether research results from other locations are suitable for solving local problems. Improved pesticides, management practices, or plant varieties are examples of research results that may be tested. All countries conduct some testing research, but for very small countries with limited resources, testing may represent a large portion of total research. Much testing is conducted by farmers themselves.

These categories of research are linked and dependent on each other. A research center may be involved in several categories.

Biotechnology

Much applied and adaptive agricultural research involves what has been called *biotechnology* research. *Traditional biotechnology* research includes well-established techniques in plant breeding, biological control of pests, conventional animal vaccine development, and many other types of research. *Modern biotechnology research* includes use of recombinant DNA, monoclonal antibodies, and novel bio-processing techniques, among others.

Modern biotechnology provides new tools and strategies for increasing agricultural production. The tools for improving agricultural output range from novel approaches to cell and tissue culture to the genetic manipulation of biological material. Modern biotechnology is based on several new technologies. One of them, recombinant DNA, often called *genetic engineering*, enables the essential genetic material in cells, DNA, to be manipulated. It offers the possibility of transferring genetic material from one species to another, thereby transferring a useful genetic trait. Such a transfer is also called *transgenics*.

Another biotechnology technique, monoclonal antibodies, is used to detect individual proteins produced by cells, thereby providing a method for rapid and specific diagnosis of animal and plant diseases. A third, novel bio-processing technique involves new cell and tissue culture technologies that enable rapid propagation of living cells. These techniques provide improved methods for large-scale production of useful compounds by the microbial or enzymatic degradation of various substrates.

Modern biotechnology is also used to map out the location and functions of genes in individual species. By identifying whether "markers" on a chromosome exist for a specific gene or genes that control a trait of interest, a process called *marker-assisted breeding* can be used to speed up the breeding process to incorporate a useful trait in a new variety.

The types of products that modern biotechnology can potentially produce include new plant varieties, new animal breeds, plant and animal growth hormones, bio-pesticides, bio-fertilizers, diagnostic reagents for plant and animal diseases, and enzymes and food additives. They may improve the tolerance of plants and animals to particular pests and stresses such as drought, and increase the efficiency with which plants and livestock utilize nutrients, or increase a plant's nutritional quality (for example, rice with increased vitamin A or iron). They may reduce the need for agrichemicals.

Modern biotechnologies are on the cutting edge of science, and if developing countries are to be successful in developing their own modern biotechnologies, or adapting technologies produced elsewhere, they will need scientists trained in microbiology and biochemistry. These countries will need to integrate modern biotechnology into traditional biotechnology research programs. They will need to put in place or refine bio-safety rules, and to resolve rules on intellectual property rights, as the rights to many aspects of the technologies are patented and owned by private companies.

Benefits and Costs of Modern Biotechnology: Concerns have been expressed by some about the health and environmental safety of modern biotechnologies, especially for the technologies that involve transferring genes across species. All technologies involve some risks, and each country needs to develop and implement a regulatory system that allows it to test and monitor the safety of its new agricultural technologies. The risks associated with modern biotechnologies are thought to be relatively low, and many of the technologies can have positive effects on health and the environment through effects on reducing pesticide use. However, there can be no certainty that adverse health and environmental effects will not occur. Consumers, especially in Europe, have expressed strong reservations about consuming foods produced with the use of biotechnology. One concern has been the possibility that genes, say, from a herbicide-tolerant crop, might transfer through pollen to another species, creating perhaps a super-weed that would be difficult to control with a herbicide. Gene transfer across species does occur frequently, although odds of creating a super-weed are slim. Another concern is whether people may have an allergy to a transgenic crop. A third concern is whether people should be attempting to alter nature, although many types of agricultural research in addition to genetically modified organisms could be subject to this same concern.

Economic concerns have also been raised with respect to whether a few companies might end up controlling many of the intellectual property rights associated with the genes and to the transformation

processes, thereby gaining some monopoly power. If they did gain such power, they might charge farmers a high price for their seeds. Countries, however, can regulate companies and have their public research systems enter into joint ventures with the private sector to ensure freedom of access to seeds at reasonable prices.

Biotechnologies are just one of many potential means of increasing agricultural productivity in developing countries, and perhaps the greatest danger is that developing countries forgo the food and income growth that the technologies may afford them.[8] In 2008, approximately 125 million hectares of transgenic crops — about 8 percent of the total crop area in the world — were grown in 25 countries, 15 of them developing countries. However, planting of transgenic crops in Africa has been limited to South Africa and Burkina Faso to date.

Some have feared that the new seeds will cost too much for farmers in developing countries, as private firms attempt to capture their research costs through only selling seeds of crops that are hybrids or that have a "terminator gene" embedded in them. Hybrids or terminator genes would force farmers to purchase new seeds each time they plant or the seeds will not grow. Due to the concerns being raised on this issue, seed companies have not employed the terminator gene, although they have emphasized hybrids to protect their investment. The public sector has also been involved in biotechnology research in many countries to help ensure that transgenic seeds are available at a reasonable price or for open-pollinated varieties for which seeds can be saved and replanted.

Several studies have documented potentially large economic benefits that would accrue from increased use of biotechnologies in developing countries.[9] These benefits would be realized by consumers through lower food prices and through increased nutritional quality. Producers might also gain through lower costs of production. If developing countries do not pursue agricultural biotechnologies, they may be placed at a competitive disadvantage compared to countries that do pursue them. However, transgenic technologies are certainly not the only means of improving crop productivity, and many others such as

[8] See Per Pinstrup-Andersen and Ebbie Schioler, *Seeds of Contention* (Baltimore, Johns Hopkins University Press, 2000) for a more detailed discussion of issues surrounding biotechnologies and developing countries.

[9] See, for example, Clive James, *Global Status of Commercialized Biotech/GM Crops: 2008 ISAAA Brief No. 39* (Ithaca, N.Y.: ISAAA, 2008) and Guy Hareau, George Norton, Bradford Mills, and Everett Peterson, "Potential Benefits of Transgenic Rice in Asia: A General Equilibrium Analysis," *Quarterly Journal of International Agriculture*, vol. 44 (2005), pp. 229–46.

marker-assisted breeding will also be increasingly important in the future, both because they are less controversial but also because regulatory costs related to ensuring bio-safety are lower.

Organization of Agricultural Research

Public agricultural research systems in developing countries have a variety of organizational structures. Often there is a central station and several substations located in different geo-climatic zones. Research may be conducted at universities, but the proportion of agricultural research conducted at colleges and universities tends to be much less than in developed countries such as the United States.

The structure of the research system is influenced by historical forces including, among others, colonial history and major foreign assistance projects. Much agricultural research in developing countries is organized along commodity program lines: for example, a maize program, a rice program, a wheat program, or a sheep and goats program. Other cross-cutting research areas such as soil fertility, socioeconomics, and even plant or livestock protection, may have separate programs.

Some agricultural research systems have a mandate for extension or other programs designed to reach out to farmers. Even if extension is not included in the mandate of the national research institution, that institution still needs a mechanism to obtain information on the current problems facing farmers and for testing new technologies under actual farm conditions. This mechanism may involve on-farm research.

Each research system must determine the appropriate mix of on-farm and experiment-station research. Experiment station research is needed so that experiments can be run under controlled conditions that enable particular components of new technologies to be developed and tested without the confounding of numerous and possibly extraneous factors. However, the real-world robustness, profitability, and cultural acceptability of new technologies cannot be assessed without testing under actual farm conditions. Frequent contact between scientists and farmers increases the likelihood that constraints and problems facing farmers will be included in the development and evaluation of new technologies. Because extensive on-farm interaction is expensive and scientific resources are scarce in developing countries, each research system assesses at the margin the appropriate mix of on-farm or on-station research.

International Agricultural Research Centers: The 1960s saw the emergence of a set of international agricultural research centers (IARCs) that has now grown to a network of 15 institutions located primarily in Africa, Asia, Latin America, and the Middle East, as shown in Figure

12-3. The funding and operation of these "Future Harvest" centers is coordinated through the Consultative Group for International Agricultural Research (CGIAR), headquartered at the World Bank in Washington, D.C. Although the first center, The International Rice Research Institute (IRRI), was founded in 1960, the international center model drew on the historical experiences of the colonial agricultural research institutes that were effective in increasing the production of export crops such as rubber, sugar, and tea. The model also drew on the experiences in the 1940s and 1950s of the Rockefeller Foundation's wheat and maize programs in Mexico and the Ford and Rockefeller foundations' rice program in the Philippines. The results of the research and training programs of the centers are aimed not just at the country where the center is located, but at the neighboring region or even the world.

The first IARCs, IRRI and CIMMYT (International Center for Maize and Wheat Improvement), produced new varieties of rice and wheat that substantially increased yields, especially for rice in Asia. The first of several rice varieties, (IR-8), released by IRRI and cooperating national programs, responded to high rates of fertilizer and water application by producing more grain and less straw. Subsequent research has focused as well on improving grain quality, incorporating disease and insect resistance, and developing varieties for drier upland areas. The substantial yield boost experienced in parts of Asia in the late 1960s resulting from these new technologies was termed the Green Revolution (see Box 12-2).

The success of the green revolution in increasing yields and incomes in many areas led to the expansion of the international agricultural research center concept to the other commodities and regions identified in Figure 12-3. Maize, millets, tropical legumes, cassava, livestock, potatoes, and many other commodities have received emphasis. The research results from these newer centers have not been as spectacular as the early gains in rice and wheat, but these centers too have made significant contributions. For example, disease-resistant beans, cassava, and millet varieties are now being grown in several countries. These centers also provide a public link between research being undertaken in the private sector on modern biotechnology and national agricultural research systems in developing countries to help ensure that these national systems are not left behind.

To some extent, the dramatic breakthroughs in yields in the early years of the green revolution created unrealistic expectations that these gains would be repeated with regularity. Agricultural research is, in fact, a continuous process that generally produces small gains from year to year.

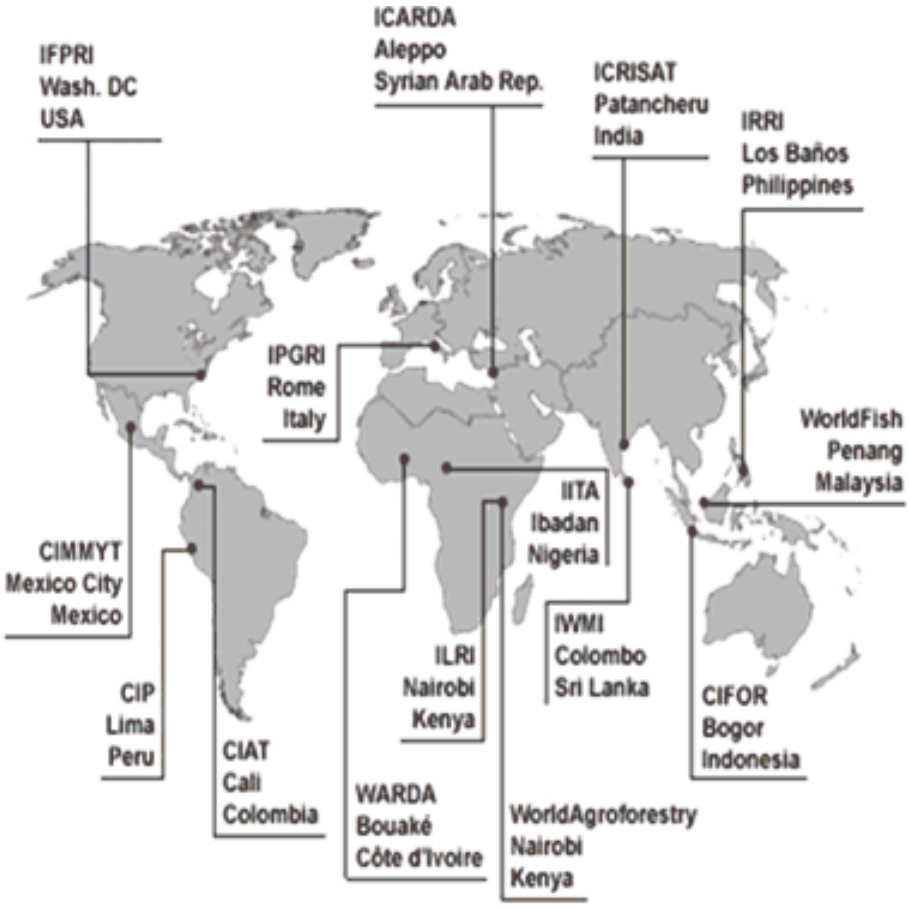


Figure 12-3. The "Future Harvest" International Agricultural Research Centers. (See facing page.)

The overall program and core funding for all 15 centers is managed by an organization called the Consultative Group for International Agricultural Research (CGIAR) whose members include the World Bank, the Food and Agricultural Organization of the United Nations (FAO), the United Nations Development Program (UNDP), and several national governments, regional banks, and foundations. These institutions provide the funds for the centers. The CGIAR, founded in 1971, is centered at the World Bank. The total budget for the 15 Future Harvest Centers was $520 million in 2007 when all funding sources are considered. In addition to these centers, there are a few related international research centers that play a similar role such as the World Vegetable Center in Taiwan, and the International Center for Insect Physiology and Ecology in Kenya.

Research Center – See Figure 12-3.	**Research Coverage**
Africa Rice (formerly WARDA)	Rice and rice-based cropping systems in Africa
Bioversity (formerly IPGRI)	Conservation of plant genetic material; bananas and plantain
CIAT — Centro Internacional de Agricultura Tropical	Phaseolus beans, cassava, rice, tropical pastures
CIFOR – Centre for International Forestry Research	Forest systems and forestry
CIMMYT – Centro Internacional de Mejoramiento de Maiz y Trigo	Wheat, barley, maize, high-altitude sorghum
CIP – Centro Internacional de la Papa	Potato, sweet potato, other root crops
ICARDA – International Center for Agricultural Research in Dryland Areas	Crop and mixed farming systems research, with emphasis on sheep, wheat, barley, broad beans
ICRISAT – International Crops Research Institute for the Semi-Arid Tropics	Sorghum, pearl millet, pigeon pea, chickpea, groundnuts
IFPRI – International Food Policy Research Institute	Food Policy
IITA – International Institute for Tropical Agriculture	Farming systems: Cereals, grain legumes, roots and tubers
ILRI – International Livestock Research Institute	Livestock diseases and production systems
IRRI – International Rice Research Institute	Rice
IWWI – International Water Management Institute	Irrigation
World Agroforestry	Agroforestry
World Fish Center	Fisheries and other living aquatic resources

Transfer of Research Results

The discussions of research categories, of national and regional experiment stations and on-farm research, and of international agricultural research centers all imply that research results may be transferred from one location to another. These transfers can occur internally in a country or across national boundaries. Let us examine the possibility and advisability of transferring new technologies or institutions.

Prior to the 1960s, little attention was focused on the importance of indigenous agricultural research in developing countries. It was thought that the possibilities for transferring technologies from developed countries were substantial and that, therefore, extension programs were needed to assist in this transfer. The relative lack of success with direct transfer of machinery, plant varieties, and other materials from developed to developing countries led to the realization that improved developing-country research capacity was essential. The desire to improve location-specific research was one of the driving forces behind the development of the IARCs mentioned above. However, many research results are regularly transferred from one country to another. What types of research results are transferable and what determines their transferability?

Materials such as improved seeds, plants, and animals; scientific methods, formulas, and designs; genes; and basic research output are all potentially transferable to some extent.[10] Each country must decide whether to simply screen these items and attempt to directly transfer them, to screen them and then modify and adapt them to their own environment, or to undertake a research program that is comprehensive enough to produce its own technologies.[11]

The choice among these transfer and research options will depend first on the relative costs of direct transfer of technology and of adaptive and comprehensive research. Transfer of research results involves costs of information and screening or testing. There may also be license costs or fees for patented items. Most of these transfer costs increase with the physical size and environmental diversity of the country. A country's own research costs are somewhat independent of size; for that reason, it may be more cost effective for larger countries to conduct their own research than for smaller countries.

Second, the complementarity between screening transferred technologies and conducting in-country research can come into play. It takes some scientific capacity just to bring in and screen research results from outside the country. Therefore, it may be cost-effective to have these scientists do some of their own adaptive research.

[10] See Yujiro Hayami and Vernon W. Ruttan, *Agricultural Development: An International Perspective* (Baltimore: Johns Hopkins University Press, 1985), pp. 260–62.

[11] See Robert E. Evenson and Hans P. Binswanger, "Technology Transfer and Research Resource Allocation," in Hans P. Binswanger and Vernon W. Ruttan, eds., *Induced Innovation: Technology, Institutions, and Development* (Baltimore: Johns Hopkins University Press, 1978), chapter 6. This section draws heavily on the ideas in Evenson and Binswanger.

On-farm potato variety trial of the International Potato Center (CIP).

Third, if the natural resource base in one developing country is similar to that in another country where the new technology is produced, then the chances of transfer will increase. New wheat varieties, for example, are often transferred from Argentina to Uruguay because those countries have similar wheat-growing regions. These similarities tend to reduce the cost of transfer and to increase the likelihood that the transferred technology will be physically and economically viable.

Fourth, some technologies are more environmentally sensitive than others are. For example, new plant and animal materials may be more environmentally sensitive than more basic research results, formulas, designs, etc. The International Agricultural Research Centers attempt to produce plant and animal materials that have broad environmental suitability. In many cases, it is necessary for the receiving country to then adapt these materials more specifically to its microclimates. Relatively basic advances in modern biotechnology have the potential for widespread applicability if the scientific and institutional capacities are created in developing countries to enable them to effectively utilize the research results.

Fifth, the availability of research results to transfer in is also important. For example, if a country has low labor costs and high capital and land costs, yet the technologies available to transfer in are large machines suitable for a resource environment with high labor costs and

abundant land, then the country will not find the outside technology suitable.

In summary, a developing country must assess several factors in deciding whether to transfer in research results from another country or from an international center. Agricultural research is a long-term investment. Research takes time, adoption of new technologies takes time, and research results eventually depreciate as insects and diseases evolve, the economic environment changes, and so on. Developing countries often attempt to bring in research results from other countries during the early stages of development in order to shorten this process and meet critical needs. Perhaps a 1 percent productivity growth rate can be accomplished through a relatively simple transfer process, though such productivity will depend on the conditions previously mentioned.[12] However, the requirements of modern rates of growth in food demand, often in the 3 to 6 percentage range, require the coexistence of at least some indigenous agricultural research capacity, and this capacity may be a combination of public and private.

Agricultural development today requires a research system with internal and external linkages that bring in appropriate technologies; screen, adapt, and produce new technologies and institutions; and perform both on-station and on-farm testing. The major components of such a research system are illustrated diagrammatically in Fig. 12-4. National and local experiment stations must interact with on-farm research and extension. This national research system also must maintain ties with the international research centers. Research in the larger national systems feeds into both the international centers and the smaller national research systems. If any of these linkages is weak or missing, agricultural productivity growth will be slowed.

Agricultural Research Spending

Spending on agricultural research occurs in both the public and private sectors. In the developing countries, the public sector undertakes more than 90 percent of agricultural research, with the bulk of that research occurring in the Asia and Pacific region (see Table 12-3). In 2000, more than $23 billion was spent in developed and developing countries on public agricultural research, with roughly a third ($7.5 billion) of those expenditures occurring in the developing countries in the Asia and Pacific region. In contrast, only a little over 6 percent of the total was spent in Africa, and the percentage spent there has been declining since 1980. Total spending on agricultural research in Africa has increased only

[12] Hayami and Ruttan, *Agricultural Development*, p. 260.

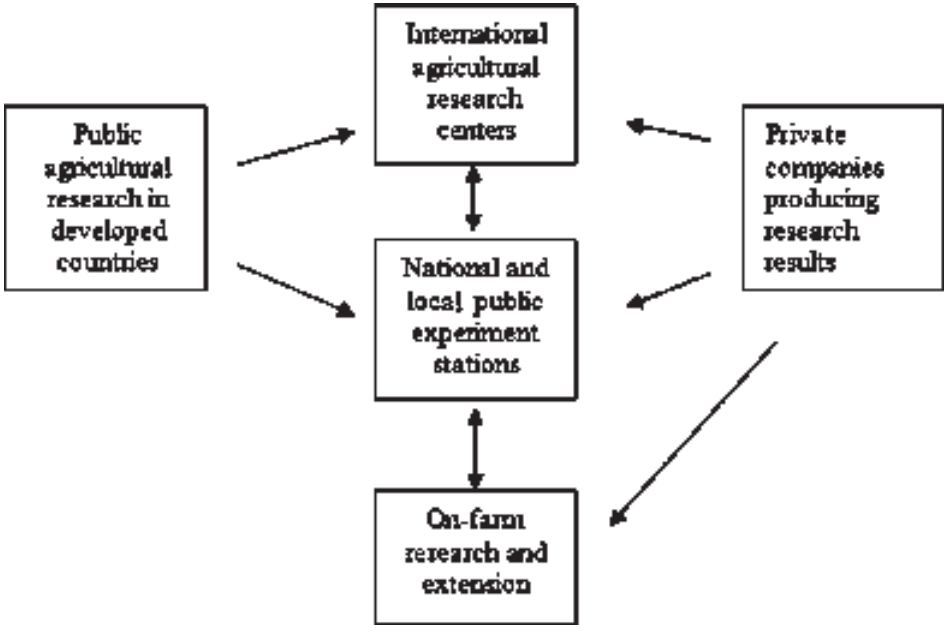


Figure 12-4. Components of a well-linked agricultural research system for developing countries.

TABLE 12-3. Total Public Agricultural Research Spending by Region

	Agricultural R&D spending (millions 2000 dollars)		Shares in global total (percentages)	
	1981	2000	1981	2000
Asia and Pacific (28 counties)	3,047	7,523	20.0	32.7
Latin America and Caribbean (27 countries)	1,897	2,454	12.5	10.8
Sub-Saharan Africa (44 countries)	1,196	1,461	7.9	6.3
West Asia and North Africa (18 countries)	764	1,382	5.0	6.0
Subtotal developing countries (117 countries)	6,904	12,819	45.4	55.8
Subtotal high income countries (22 countries)	8,293	10,191	54.6	44.2
Total (139 countries)	15,197	23,010	100.0	100.0

Source: CGIAR Science Council. *Science for Agricultural Development; Changing Contexts and New Opportunities.* (Rome, Italy: Science Council Secretariat, 2005.)

about one percent per year over the past several years despite increased malnutrition in the region.[13]

Agricultural research has become increasingly concentrated in a handful of countries worldwide.[14] The United States, Japan, France, and Germany accounted for more than two-thirds of the agricultural research in developed countries in 2000, while China, India, Brazil, Thailand, and South Africa accounted for more than half of the developing country total. If private support for agricultural research is included, the disparities in funding identified above are even sharper, with Africa accounting for less than one percent of total funding on agricultural research.[15] These numbers place increased importance on the technology transfer issues raised above.

ROLE of EXTENSION EDUCATION

Countries unable to develop the skills and knowledge of their farmers and their families find it difficult to develop anything else. The utilization of new technologies and institutions is critically dependent on a workforce that is aware of them and understands how to use them. Agricultural extension education can help motivate farmers toward change, teach farmers improved decision-making methods, and provide farmers with technical and practical information. Extension is complementary to other sources of information because it speeds up the transfer of knowledge about new agricultural technologies and other research results. It helps farmers deal with technological and economic change. Thus, as agriculture in a country moves from a traditional to a more dynamic, science-based mode, the value of extension education increases.

In extension education, farmers are the primary clientele and the programs are mostly oriented toward production problems they face. Extension accelerates the dissemination of research results to farmers and, in some cases, helps transmit farmers' problems back to researchers, Extension workers provide training for farmers on a variety of subjects and must have technical competence, economic competence, farming competence, and communication skills. Thus extension workers require extensive training and retraining to maintain their credibility with farmers.

[13] CGIAR Science Council, Science for Agricultural Development.
[14] CGIAR Science Council, Science for Agricultural Development.
[15] See Philip G. Pardey, Nienke Beitema, Steven Dehmer, and Stanley Wood, *Agricultural Research: A Growing Divide* (Washington, D.C.: IFPRI, 2006), p. 1.

Organization of Extension

Many types of organizational structures for extension exist in developing countries. A highly structured approach encouraged by the World Bank and applied in several countries is called the *training and visit (T&V) system.* The T&V system includes a single line of command, a set schedule of visits to farmers' groups, regular and continuous training of extension officers and workers by subject-matter specialists, and no non-extension responsibilities.[16] The T&V system facilitates discipline, accountability, and research linkages and experienced apparent success in some countries for a period of time.

Another, more common, extension structure is the village agent model that assigns extension "agents" to live in villages and provide one-on-one and group training of farmers on a variety of agricultural topics. An example that illustrates this structure is the extension service of the Colombian National Coffee Federation. That service has extension agents who operate on a fixed schedule of visits to farmers' groups, and who spend one day a week in an office receiving farmers and scheduling individual farm visits that coincide with days when they are visiting a particular location. Village extension agents are supported by regional subject matter specialists who also spend most of their time visiting farmers' groups and individual farms. Village extension agents are drawn from coffee farms and receive three years of training after high school. Extension programs are planned six months ahead and are developed jointly between the farmers' group and the agent.

Unfortunately, both the T&V and the village agent structures for extension have an uneven history of success. The T&V system suffers from its high cost and the disadvantage of not having local agents who can respond to farmer concerns as they arise. The village system suffers from the difficulty of funding a sufficient number of agents and adequately supporting them with supervision and training. Too often extension agents are poorly trained and little-motivated. They may not visit enough farms, and they become diverted into non-extension activities. The extension service itself may become politicized, corrupt, and unconnected to research. A well-functioning system needs clear lines of authority, adequate training, and financial rewards for personnel, or the system becomes relatively ineffective. Research and extension linkages are also essential and are facilitated if research and extension are housed in the same institution. Unfortunately, often they are not.

[16] See Daniel Benor, James A. Harrison, and Michael Baxter, "Agricultural Extension: The Training and Visit System," World Bank, Washington, D.C., 1989 for more details.

In recent years, many public extension services, especially in Latin America, have been eliminated or seen their funding cut drastically. These cuts were caused by a combination of budgetary pressures and perceptions that the extension services were not particularly effective. As a result of these and other inadequacies in publicly supported extension systems, non-governmental organizations (NGOs) are increasingly involved in agricultural extension. NGOs exist outside financial support from governments, with support from private individuals and groups in other countries or on private local support. In addition, private firms that sell products such as improved seeds and chemicals are heavily involved in technology transfer associated with their specific products.

Extension Methods

A variety of methods are employed to transfer research knowledge and technologies to producers. Individual farm visits, regularly scheduled group meetings, technology demonstrations that may involve a field day when hundreds of farmers are invited to observe the latest research results, and transfer of information through mass media are just some of the methods. Some technologies are transferred more effectively through intensive methods such as regular meetings, other are amenable to transfer through less intensive (and usually less expensive) methods such as field days and mass media. Each country must decide what is most cost effective for its public extension system, and each NGO will decide which approach allows it to best achieve its objectives. There is no one method that works best in every situation. Extension costs and effectiveness will depend on the type of technology, typography of the country, access to mass media, cultural and social factors, and many other variables.

SUMMARY

Agricultural research generates new or improved technologies and institutions that increase agricultural productivity, moderate food prices, generate foreign exchange, and reduce pressures on the natural resource base. Most studies have found the economic returns on public agricultural research investments to be high. Agricultural research can have distributional effects by farm size and tenure, by region, by income level, by factor of production, and so forth. Consumers, particularly low-income consumers, are major beneficiaries of agricultural research, as the poor may spend 80 percent of any income increases on food and food prices tend to fall as productivity increases. Agricultural research can influence nutrition by raising farm incomes, lowering food prices,

Extension field day in Peru.

and reducing the variability in food production. Agricultural research can generate technologies, institutional changes, and higher incomes that lead to reduced pressures on the environment. The public sector has a role to play in agricultural research because the private sector has inadequate incentives to conduct a sufficient amount of socially beneficial research, in part because often private firms conducting research cannot capture enough of the benefits. Intellectual property rights can help in creating incentives for private research investment.

Agricultural research can be classified into basic, applied, adaptive, and testing research. These categories are linked and dependent on each other. Research is conducted on national and local experiment stations and, to be effective, must contain an on-farm component. Since 1960, a system of International Agricultural Research Centers (IARCs) has provided new technologies and institutional changes suitable to several developing countries. These institutions helped to produce a green revolution that greatly increased the production of maize, rice, and wheat. Research can be transferred across national borders, but the ease of transfer depends on the type of research, the relative cost of transfer and indigenous research, the natural resource base, and other factors. Use of modern biotechnology has grown around the world in recent years but is yet to be widely adopted in developing countries.

Many types of extension systems exist, some more structured than others. Training for extension workers, incentives, clear lines

of authority, and strong linkages to research are each critical for an effective extension service.

IMPORTANT TERMS and CONCEPTS

Adaptive research
Agricultural education
Agricultural extension
Agricultural productivity
Agricultural research
Applied research
Basic research
Biotechnology
Experiment stations
Green revolution
Intellectual property rights
International agricultural research centers
Scale-neutral technology
Technology transfer
Testing research
Training and visit system

Looking Ahead

This chapter considered technical factors that can influence development of the agricultural sector. The following several chapters address sets of institutional issues that are equally important if agriculture is to progress in developing countries. We begin in the next chapter discussing land and labor policies.

QUESTIONS for DISCUSSION

1 What is the purpose of agricultural research in developing countries?
2 How does research influence agricultural productivity and food prices?
3 Under what conditions might research on a nonfood export crop have as much or greater positive effect on nutrition than research on a food crop?
4 Why might agricultural research tend to benefit large farms more than small farms?
5 Why might agricultural research increase the regional disparity in income in a developing country?
6 Why are consumers, especially poor consumers, often the major beneficiaries of agricultural research?
7 What factors influence the returns to particular factors of production following research?
8 How might agricultural research help improve the environment?
9 How might research result in institutional change?
10 Why should the public sector get involved in research? Why not leave it to the private sector?

11 Distinguish among basic, applied, adaptive, and testing research.
12 What is modern biotechnology?
13 What are the International Agricultural Research Centers and how does their work tie into the agricultural research systems in developing countries?
14 What is the "green revolution," when did it occur, and where?
15 What role does extension play in agricultural development?
16 How might research, education, and extension be complementary activities?
17 How can intellectual property rights influence production of agricultural technologies?

RECOMMENDED READINGS

Alston, Julian M., George W. Norton, and Philip G. Pardey, *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting* (Ithaca, N.Y.: Cornell University Press, 1995).

Benor, Daniel, James Q. Harrison, and Michael Baxter, "Agricultural Extension: The Training and Visit System,." World Bank, Washington. D.C., 1989.

CGIAR Science Council, *Science for Agricultural Development: Changing Contexts and New Opportunities.* Rome, Italy: Science Council Secretariat, 2005.

Masters, William A., "Paying for Prosperity: How and Why to Invest in Agricultural Research and Development in Africa," *Journal of International Affairs*, vol. 58(2), 2005), pp. 35–64.

Pardey, Philip P., Nienke Beitema, Steven Dehmer, and Stanley Wood, *Agricultural Research: A Growing Divide* (Washington, D.C.: IFPRI, 2006).

Pinstrup-Andersen, Per and Ebbe Schioler, *Seeds of Contention* (Baltimore: Johns Hopkins University Press, 2000).

Ruttan, Vernon W., *Agricultural Research Policy* (Minneapolis: University of Minnesota Press, 1982).

Scobie, Grant M. and Rafael Posada T., "The Impact of Technical Change on Income Distribution: The Case of Rice in Colombia," *American Journal of Agricultural Economics*, vol. 60, February 1978, pp. 85–92.

CHAPTER 13

Land and Labor Markets

> The distribution of rights in land relates to the distribution of power, income, social status, and incentives. A land reform that changes this distribution is by definition a change that shakes the roots and not the branches of a society. — Philip M. Raup[1]

THIS CHAPTER

1. Discusses the meaning of land tenure and land reform
2. Explains why land reform and flexible land tenure systems are often necessary for agricultural development, yet difficult to achieve, and what the requisites are for a well-functioning land market
3. Describes the nature of agricultural land and labor markets in developing countries

MEANING of LAND TENURE and LAND REFORM

Land and labor are fundamental inputs into agricultural production, and while land is often distributed unequally, labor is not. Therefore we see large farms with land concentrated in the hands of a few, and small farms with excess labor. Typically a market develops in which labor is hired to work on larger farms or land is leased to small-scale landholders for rent or for a share of the output. An alternative is to subdivide large holdings through land reform or market-based redistribution efforts. In this chapter, we consider determinants and consequences of alternative land tenure systems and labor market structures. Well-functioning land and labor markets are crucial to agricultural development because land is a major input into production and poorly

[1] Philip M. Raup, "Land Reform Issues in Development," Staff Paper P75-27, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, 1975, p. 1.

functioning markets will lead to misallocation and inefficient use of this valuable resource. Evidence shows that the rural poor, particularly those with little or no land, will benefit more from an additional unit of land than will the rich: mechanisms to reallocate land can increase productivity and reduce poverty.

Land rights determine social and political status as well as economic power in developing countries. Secure access to land can enhance incomes, provide an important insurance function, and increase access to financial and non-financial services. *Land tenure* is a term used to refer to those rights or patterns of control over land. Land rights include rights to use and to exclude use, rights to output from the land, and rights to transfer the land or its output to others.

As population density increases, farming techniques change, and markets for agricultural products grow, pressures often develop to change existing land tenure arrangements. In societies where land has been held in common, permanent and enforceable individual rights to land may evolve. In countries where ownership patterns are highly skewed with a few people owning much and many owning little or no land, pressures often are exerted on the government to undertake a land reform or eliminate constraints to more equal land distribution by establishing well-functioning land markets. These pressures may arise from peasants who desire increased economic well-being or from those in power who hope that minimal concessions to the peasants will diffuse political unrest. A land reform is a dramatic attempt to change the land tenure system through public policies. Land reform may change not only rights and patterns of control over the land resource, but also the mode of production (whether semi-feudalistic, capitalistic, or socialist) and the agrarian class structure. Consequently, few subjects related to agricultural development are as controversial. In recent years, more attention has been focused on rights to land and how secure rights facilitate development of functioning land markets. Market-based measures have supplanted administrative approaches to land reallocations.

Land Ownership and Tenure Systems

A wide array of land ownership and tenure systems exists in the world. These systems reflect differences in historical influences, levels of income, culture, political and legal systems, climate, and other factors. The systems vary in size and organization of land holdings, they affect incentives to produce and invest, and they influence the distribution of benefits from agricultural growth. Examples of average size of landholdings from around the world are presented in Table 13-1. The larger holdings in Latin America compared to Asia and Africa are

Table 13-1. Median Holding Size, by Region

Region	Median Holding Size (Ha)	Gini Coeffient
East Asia	2.07	.51
Sub-Saharan Africa	2.18	.49
South Asia	2.32	.59
Mideast and North Africa	6.05	.66
Eastern Europe	8.69	.62
Latin America	17.70	.81

particularly evident. However, information on *average* land holdings masks important difference within countries; these differences are shown in Table 13-1 as gini coefficients.[2] While average holdings, for example, in Latin America are quite high, many landless and near landless families can be found in rural areas of the region. Latin America has the most unequal distribution of land in the world, while the distribution in Asia and Africa is relatively equal (see Table 13-1). In Latin America, as elsewhere in the world, the colonial past still influences land ownership patterns today (see Box 13-1).

Family farms, corporate farms, state farms, and group farms are major types of farm ownership, but organization of farm enterprises within these types can vary substantially. In many cases the owner of the farm is also the operator. In other cases, those who operate or work on the farm may earn a fixed wage or pay rent in cash or in a share of the farm output to the owner.

Small subsistence or semi-subsistence family farms are common in developing countries. Families often provide most of the labor, and cultivation is labor-intensive. Much of the output is consumed on the farm where it is produced. However, not all small family farms are subsistence or semi-subsistence farms; many are commercial farms producing substantial surpluses for sale. Those farmers that do consume most of what they produce are usually very poor. In some cases, family members work on other farms or in non-farm employment. The latter can lead to the small farms becoming part-time operations, especially as development proceeds over time with job opportunities growing in the non-farm sector.

Large-scale commercial family farms sell most of what they produce. While in developed countries these farms are highly mechanized

[2] The gini coefficient is a widely used measure of inequality that ranges from 0 (complete equality) to 1 (complete inequality).

BOX 13-1.
COLONIALISM and LANDOWNERSHIP

Many of the landownership patterns found in developing countries are the vestiges of colonial rule. The *latifundia* or extensive large-scale farms that currently exist in Central and South America alongside *minifundia,* or very small farms, are a direct descendent of colonial rule. The Spanish and Portuguese colonizers allocated large tracts of land to elites who formed tropical plantations or large haciendas. Both types of landholding were made possible through the direct enslavement of indigenous populations, the importation of slaves from Africa, or the *encomienda* system that gave indirect control over local populations to certain elites.

Some of the richest agricultural lands in Africa have landownership patterns that were established during the periods of European colonization. Because European countries coveted exotic tropical products, such as cocoa, coffee, tea, and tropical fruits, agricultural production in Africa was reorganized to help ensure production of these products. Large landholdings were allocated to European settlers, such as the tea and coffee plantations in eastern Africa; rarely were the land's original inhabitants compensated. In many instances, the land's original inhabitants were resettled to areas with lower agricultural potential, poor rainfall, and inadequate infrastructure. Areas that had been self-sufficient in food production became exporters of goods to Europe, while much of the indigenous population relied on rain-fed agriculture in marginal areas. An adequate labor supply was maintained sometimes through enslavement and sometimes through economic coercion.

In Asia, colonial rule led to similar forms of plantation agriculture. Japanese colonies in Korea and Taiwan produced for export to Japan; the Dutch colonized Indonesia; Spanish plantations existed in the Philippines; the British colonized much of the Indian sub-continent and other regions.

Following the end of colonial rule, many of these landownership patterns persisted, because of the political powers of the landed elite. Some of the land reforms undertaken prior to 1970 were designed to remove the less desirable aspects of these landholding patterns. Implicit forms of enslavement of labor, such as through the maintenance of indebtedness, were prohibited. In many countries, the result of these reforms has been to reduce labor use, increase mechanization, and leave the distribution of land largely unchanged. The legacy of colonial landholding patterns has been pervasive rural poverty in many regions of the world.

and often involve only a small amount of non-family labor, in developing countries the operations are usually more labor-intensive and use a high proportion of hired labor. The owner frequently does not live on the farm, but pays a manager to oversee day-to-day operations.

Corporate farms often produce a limited number of commodities in large-scale units. These farms may have their own processing and marketing systems. This type of farm is more prevalent in developed than in developing countries, but there are numerous examples of large corporate farms in developing countries. The fruit plantations found in Central American countries, banana plantations of the Philippines, and cocoa plantations of West Africa are a few examples.

State farms are usually large, owned and operated by the government, and run by hired labor. Managers are responsible to a government-planning agency that may set targets for production and direct the timing and method of key farming operations. Examples have existed recently in parts of China and the former Soviet Union. State farms usually suffer from inadequate incentives and ill-advised management decisions.

Group farms are communes, kibbutzim, collectives, or other types of farms that are operated by a group of people who work and manage the farm jointly. These group operations may also involve non-agricultural activities. Often, collectivized farms are characterized by over-investment in labor-saving capital-intensive technologies, since individuals do not receive the full returns from their labor. Special arrangements may be devised (for example a point system) to provide incentives for individual members to work harder. The kibbutzim of Israel are an example of a group farm system. *Cooperative* farms exist in some parts of the world, but cooperative purchase of inputs and marketing of outputs is a more common organization. The Mennonites in the Paraguayan Chaco are an example of privately held land whose owners organize cooperatives for input purchases and product marketing.

Not only do many types of land ownership and organization exist, but also types of tenancy or leasing arrangements. Farm families may lease all or a part of their land for a specified amount of cash or for a share of the production from the land. A farmer may be allowed to farm a piece of land in exchange for his or her labor on another part of the owner's land. In some countries, the village, tribe, or national government may own the land and grant use rights to individual families. This system is common in Africa where social groups allocate land to individuals who maintain control over it and its output as long as they cultivate it.

Tenancy arrangements affect the risk and transactions costs borne by tenants and landlords and influence incentives to work or apply inputs. A share lease, for example, spreads the production risk between the landlord and tenant, while a cash lease concentrates the risk on the

Cows feeding at a Kibbutz in Israel.

tenant. A cash lease implies lower transactions costs for the landlord than a share lease, since the amount received under the share lease has to be measured, and production has to be monitored. A tenant may have less incentive to apply additional fertilizer or even labor under a share lease than under a cash lease. To circumvent this disincentive, the landlord may share the cost of the fertilizer or place conditions on the amount of labor applied. In such cases, the landlord bears the transactions costs associated with monitoring input use and measuring the value of output. Thus, the use of a particular land- or labor-contracting mechanism may be a response to the presence of risk or transactions costs. These factors can explain why the land market may not dictate a single type of tenancy system even within a single country (see Box 13-2).

Types of Land Tenure Reform

Because many types of land tenure systems exist in the world, there are many types of land tenure reform. Prior to the 1970s, many if not most land reforms involved a movement away from feudalistic and semi-feudalistic land tenure arrangements toward capitalist or socialist ownership modes.[3] Feudalism was characterized by large-scale estates controlled by the traditional landed-elite with labor bonded to the estates through peonage or extra-economic forms of coercion.

Anti-feudal land reforms have eliminated feudalism in most of the world, and the farm types described above have replaced feudal

[3] See Alain de Janvry, "The Role of Land Reform in Economic Development: Policies and Politics," *American Journal of Agricultural Economics*, vol. 63 (May 1981), pp. 384–92.

BOX 13-2.
TENANCY, RISK, and TRANSACTIONS COSTS: THE CASE of SHARECROPPING

Sharecropping is a widely practiced form of tenancy whose existence can be attributed to risk sharing and transactions costs. Because agricultural production is risky, and both tenants and landowners desire to share risks, sharecropping represents a compromise between fixed-rent contracts, where the renter bears all the risk, and wage employment, where the landowner bears all the risk. Sharecropping also represents a response to the costly supervision of workers. Since under a wage system the worker receives wages based on hours worked rather than effort expanded, there is a tendency to shirk. Supervision is necessary, yet costly. Sharecropping returns some of these incentives to the tenant and also allows risk sharing.

models. In many countries, however, this post-feudal order has resulted in some large capitalist farms or estates controlled by an elite well-to-do class and a coexisting small-farm sector. In a few countries (for example, South Korea and Taiwan), the post-reform agricultural sector consists primarily of small family farms. And, in a few, such as Cuba, socialist farms still predominate. The form of the post-reform agrarian structure depends largely on the motivation and political ideology behind the reforms.

Land tenure reform today generally does not refer to the types of anti-feudal reforms instituted in many countries prior to the 1970s. In those reforms, prohibition of bonded labor and reductions in labor exploitation were achieved, but in many cases a significant redistribution of land was not. As de Janvry notes, countries like Colombia, Ecuador, and India had successful anti-feudal land reforms but very little redistribution of land.[4] Land tenure reform as a policy issue today usually relates to seeking a shift in the distribution of lands from large to medium-size and smaller landholdings. It also involves creation of more secure rights to land. Improved security empowers households to make better decisions, more effectively manage risks, and participate on a more equal basis in markets. Land tenure reform often involves market-based efforts to increase access to land, and well-defined, secure rights to land are needed for a well-functioning land market.

In the few remaining countries where socialist or group farms predominate (as opposed to capitalist farms of whatever type), future land reforms may involve a transition to increased capitalism as these countries struggle with the incentive problems that have plagued many types

[4] Alain de Janvry, "The Role of Land Reform in ..."

of group farms (see Box 13-3). Land reforms in socialist countries are difficult to achieve without a fundamental restructuring of the political system. The change in China from the socialized agricultural system to the market-based Household Responsibility System in 1979 was accompanied by political and economic upheaval.

Transactions Costs and the Agrarian Structure

No form of land tenure is universally efficient. Differences in natural resource endowments, in the availability of new technologies, and in institutional arrangements all influence risk, transactions costs, and the farmer's opportunity to exploit his or her managerial ability. If there were well-defined private property rights and a reasonably equitable distribution of land, perfect information, and zero transactions costs (especially the cost of enforcing contracts), markets would work perfectly and it would not matter as much what type of agrarian structure prevailed. Bargaining would occur among landowners, renters, and laborers; neither the returns to labor nor the overall economic efficiency of the agricultural system would depend on the type of agrarian structure.

In the real world, however, risk varies from country to country. Markets are not perfect. The cost of acquiring information and of negotiating, monitoring, and enforcing contracts can be high. People are willing to exploit others, labor hired on a time-rate basis may shirk (increasing the cost of supervision), the price of land may decline as farm size grows (due to fixed costs associated with land transactions), and larger landowners may have better access to markets and information.

Many of these risk and transactions cost factors confer an economic advantage to large farms. Owners of larger holdings can gain additional political advantage through collective action and can reinforce their advantage through the tax laws and pressures on the types of new technologies produced by the public research system. Owners of larger holdings have easier access to agricultural credit because the costs of administering a loan can be spread over more land, thus making the cost per hectare of large-scale loans lower than small-scale loans. The result can be additional gains for the elite, but reduced economic efficiency for the agricultural sector and the country as a whole. Land tenure reform may be needed in these cases.

ACHIEVING SUCCESSFUL LAND REFORM

A country can desire land tenure reform for a variety of economic, social, and political reasons, yet land reform, whether it involves change in land tenancy or ownership, is always difficult to achieve. Let's

BOX 13-3.
LAND REFORM IN EASTERN EUROPE

Following the collapse of Soviet-style models of central economic planning and control and the movement toward democracy in the late 1980s, governments in Eastern Europe were faced with the problem of how to reform their agricultural sectors. The organization of the agricultural sectors in these countries was rather similar: approximately one-third of the farms were state farms, and two-thirds were collectives (cooperatives). Most farm employees managed a household plot of about one-half hectare, while the state farms and collectives were large, about 2000 to 3000 hectares. Two paths of reform are illustrative of general trends in the region: Romania and Bulgaria.

In both countries, the rights of landowners prior to collectivization were recognized by parliamentary decree in February 1991. These decrees also established procedures for reclaiming these property rights. In Romania, land redistribution proceeded quickly. Local land commissions were established to hear household claims for up to 10 hectares. Some proof of the claim was needed. Whenever possible, claimants were given back the land actually owned, and when not, an alternative of equal size and quality was returned. Once in possession, the owner could sell it immediately, or purchase more land. Thus, a market for titled land, with very few institutional restrictions, was established. There was not an attempt to create farms of optimal size.

The Bulgarian redistribution proceeded much more slowly. Administrative delay hindered progress, and local commissions were very slow in forming. The laws implementing the distribution were very rigid, and the construction of "appropriate size holdings" through administration was attempted. The local commissions adjudicated claims, but a planning team reassigned plots. The law prohibited the purchase and sale of land for three years, which hindered development of a land market.

In both cases, most of the new landowners remained integrated into the collective management system. In Romania, the formation of a land market opened a period of holdings consolidation and resale, but actual exit from the collective was delayed until the infrastructure for individual management was developed. The slowness of the redistribution in Bulgaria guaranteed the existence of collective systems for many years.

Source: Karen Brooks, J. Luis Guasch, Avishay Braverman, and Csaba Csaki, "Agriculture and the Transition to Market," *Journal of Economic Perspectives,* vol. 5(4), Fall 1991, pp. 149–62.

examine briefly why land redistribution may be desired, why it may be difficult to achieve, how a country can measure whether a reform has succeeded, and what factors improve the chances of achieving successful land tenure reform.

Need for More Equitable Access to Land

The broad economic and development goals of most societies include desires for improved income growth (efficiency), equity (income distribution), and security (political and economic stability). A more equitable access to land and more secure rights to land can contribute to all three of these goals.

A skewed distribution of landholdings can hamper economic efficiency for several reasons. Large landholdings may not be farmed intensively, even in very densely populated countries; in fact, an *inverse* relationship between farm productivity and farm size has been found in many developing country settings.[5] Some landowners hold land for speculative reasons. Others are absentee landlords who provide little supervision of those working on the farm. If the farm is owned by the government, planning and management may be centrally and poorly controlled, and individual incentives may be stifled since farms are forced to respond to output and input quotas. Large farms may substitute machinery for labor, exacerbating an unemployment problem. Large farmers facing labor supervision problems often demand capital-ntensive innovations from the agricultural research system. As a result, new technologies are generated that do not reflect the true scarcity values of land, labor, and capital in the country.

Countries with large landholdings often have a coexisting sector of farms that are too small to provide an adequate living. These very small holdings of one or two hectares or less may have labor employed to the point at which its marginal product is very low. Thus, reducing the size of large farms and increasing the size of very small farms may be the only way to raise the marginal product of labor in agriculture, and thereby raise income per worker.

As discussed earlier, other land tenure problems, including the need for tenancy reform, may have to be solved to improve entrepreneurial incentives and to reduce risks facing farmers. For example, as population density increases, property rights for land pastured in common may need to be redefined to avoid overgrazing. Share or cash rents may need to be changed as new technologies become available. Lease lengths may need to be more securely established to encourage capital investment.

Apart from growth or efficiency concerns, land redistribution often is needed for equity reasons. The number of landless laborers is growing rapidly in many countries, along with associated poverty and

[5] See Dwayne Benjamin, "Can Unobserved Land Quality Explain the Inverse Productivity Relationship?" *Journal of Development Economics*, vol. 46 (1995), pp. 51–84.

malnutrition. The principal resource these people control is their labor, whose value is depressed by under-use of labor on large farms. Providing land resources to these people can be an effective means of raising incomes. As large farms are broken up, even those poor who do not receive land can benefit due to increased economy-wide demand for labor. Large farms convey political power to a small group. This group may distort economic policies in a direction that hinders overall economic growth and creates severe hardship on the poorest segments of society. Thus, to achieve development as defined in Chapter 1, addressing the land distribution problem may be necessary.

In addition to growth and equity concerns, land redistribution can enhance political and economic security or stability. In fact, expropriations of land and partial land reforms experienced in many countries in the past have probably occurred primarily for purposes of political stabilization. This stabilization can have positive and negative impacts on economic growth and equity. To the extent that land redistribution dampens political unrest and reduces the chances of revolution, it reduces the chances of a country's experiencing the extremes of death and suffering that can accompany a revolution. However, to the extent that a partial land reform achieves political stability without redistributing enough land or economic power to generate widespread growth and fundamentally reduce economic hardship and hunger, it may only perpetuate a status quo of chronic suffering.

Why Redistribution of Access to Land is Difficult to Achieve

Because of the political and economic power that accompanies landownership in many countries, it is difficult to conduct a meaningful redistribution of land. Historically, land reforms have most often been made possible only after significant social upheaval caused by revolution, the overthrow of colonial powers, or war. In the former Soviet Union and China, social revolutions destroyed the power of the landed elite prior to the institution of collectivizing land reforms. An army of occupation enforced the socialist reforms in Eastern Europe following World War II. The extreme economic, political, and social turmoil of the 1970s in China and of the 1980s and 1990s in the Soviet Union and Eastern Europe, once again created the conditions for land reforms in those countries. In capitalist countries such as Japan, the Republic of Korea, and Taiwan, defeats in war or occupation were followed by redistributive reforms.[6]

[6] See Clive Bell, "Reforming Property Rights in Land and Tenancy," W*orld Bank Research Observer*, vol. 5, (July 1990), pp. 143–66.

In countries with capitalist forms of social and economic relationships, land reforms are difficult to achieve because those holding the land rights also have strong political power. Urban consumers often align with landowners. Because large farms frequently have large marketed surpluses, consumers fear that steep food price increases may follow a dramatic reform. Small changes may be supported as a means of political stabilization, but large-scale restructuring of property rights is difficult. Occasionally, governments support redistributive land reforms in response to strong revolutionary pressures, such as Mexico (1940 to 1977) or the Philippines (1972 to 1975). Or, land reforms result following military overthrows of the government, such as in Peru (1969 to 1975). Land reforms within capitalist agriculture are usually slow to occur because compensation is required if they are to be accepted by those losing land. Unless the government's budget has a large fiscal surplus, which is rare in developing countries, or substantial foreign aid, gainers cannot compensate the losers sufficiently for the land reform to be politically viable.

Resistance to large-scale administrative land reforms has been strong, so that such reforms often only follow major upheavals. Decision makers in many countries, however, realize that an inequitable distribution of land is not conducive to broad-based economic growth. As a result, we see more experimentation with land market reforms, which begin with legislative steps to increase security of private land holdings. Over time, markets are created and land may move from less to more productive uses through sales or rentals.

Many countries have had land reforms in the sense that changes in the land tenure system have occurred. The mere fact that a change has taken place does not necessarily imply that a *successful* land reform has transpired. Many national leaders are interested in land reform because the reform may lead to increased political stability. However, unless there is evidence that incentives have been created for farmers to undertake hard work and increase their capital investment and unless poverty has been reduced and social status improved for the rural poor, a successful land reform has not occurred.

A successful land tenure reform should alter the incentive structure in rural areas. It should provide secure property rights that are recognized by all. Whether this structure has been altered is perhaps best measured by evidence of increased and continuous capital accumulation by small farmers in the form of livestock, farm buildings, equipment, and other improvements in land resources. Because these investments may be small in any one year, it usually takes a generation,

BOX 13-4.
LAND RESETTLEMENT and REFORM in ZIMBABWE

Prior to its invasion in 1890, land in Zimbabwe was held under communal tenure, and tribal leaders allocated rights to land. Members of Cecil Rhodes' Pioneer Columns were promised 3,000-acre holdings in exchange for assistance in colonizing the area. During the subsequent colonial period, Native Africans were relocated to low-rainfall, low-productivity land and were barred from landownership outside these tribal reserves. Large-scale resettlement without compensation continued through the early 1950s.

In 1965, the minority white government declared independence from Great Britain and continued enforcing restrictive conditions against Native Africans. The subsequent war of independence, which raged in the bush with increased intensity through the 1970s, used the "land question" as a uniting principal. Overcrowding and dwindling production on communal lands led to widespread rural poverty. The Lancaster House Agreements, which paved the way for independence in 1980, formed a basis for post-independence land reform. The British government allocated £44 million for purchase on a "willing seller, willing buyer basis." Robert Mugabe won the first free election and promised to resettle blacks on purchased white lands. Resettlement reduced civil conflict, provided opportunities for war victims and the landless, and relieved some population pressures on communal lands.

Between 1980 and 1990, the government obtained some 3 million hectares for resettlement and resettled roughly 54,000 households. The pace of resettlement slowed through the 1980s as attention moved towards providing agricultural services to communal areas. Farms in resettlement schemes had variable performance; many of those under private management did relatively well, while those that were managed under cooperative schemes performed less well. Critics of the resettlement program, however, noted that the most productive farm areas had been "resettled" by the President's political supporters.

The Lancaster House Agreements expired in 1990, effectively ending donor support of resettlement. Through the mid-1990s, few farms were resettled and government attention turned toward restoring macroeconomic balance and dealing with adverse consequences of severe drought. Following a major currency devaluation in late 1997, unrest grew and independence war veterans began to demand access to land. Government responded by listing some large-scale commercial farms for "compulsory" resettlement. Although owners would be compensated, the method of compensation was unclear and abandonment of the "willing buyer-willing seller" principle caused unease among owners of land and donors. "Listed" farms were said to be "underproductive," although government critics disputed many of these assertions. Between 1997 and 2000, resettlement became more contentious as rural interest groups increased pressure on the government through protests and forced seizure of white

BOX 13-4, continued

farms. In response to internal political pressure, government began a "fast track" resettlement process; between 2000 and 2003, government acquired more than 75 % of the nearly 4,500 white-owned commercial farms. By the end of 2003, fewer than 300 white farmers continued to farm.

Resettlement in Zimbabwe provides a number of lessons. Inequitable land access can create strong political forces, particularly following political change. The issue of compensation for lands remains complicated. While some white farmers obtained their lands through ancestral succession (their forebears had received land at no cost), many had purchased their land from others and were due fair compensation for their investments. As internal political pressure and the economic crisis grew, the Mugabe government felt increasing urgency for resettlement while resources to finance land purchase became scarcer.

Land reforms of the type practiced in Zimbabwe can have huge unsettling effects. As commercial farmers were forced out, agricultural production and export earnings dropped by more than 50%, further exacerbating economic problems and contributing to near famine conditions. Neighboring countries absorbed many of the displaced white farmers, spreading social problems around the region. The politicization of the process damaged the credibility of government and undermined popular support (at home and among donors) for the program.

Source: William Masters, *Government and Agriculture in Zimbabwe* (Westport, Conn.: Praeger, 1994); updated by press reports.

perhaps 25 to 30 years, to truly evaluate the success of a change in land tenure or redistribution.

Agricultural productivity also should increase in the long run. However, in the first five years following a land reform, productivity may stagnate for a couple of reasons. First, the mix of commodities produced may shift toward food crops and away from a heavy reliance on cash crops. This shift and other disruptions to the normal input and output marketing channels, credit flows, changes in technologies needed from the agricultural research system and so forth, can hinder productivity growth in the short run.

Marketable surpluses may decrease because the poorer segments of the rural population, who benefit from the land reform, have a high income elasticity of demand for food. As their incomes increase through more access to land, they consume more, and the aggregate marketed surplus may decline. Thus, short-term increases in agricultural productivity or marketable surpluses are not good measures of the success of land reform.

A land reform also can affect capital formation in the public sector. Countries with land tenure systems in need of reform often have poor rural schools and other public infrastructure. Large-scale landowners typically hesitate to tax themselves to support schools, roads, and so on. Countries in need of land reform usually find it easier to collect public revenues by taxing export crops or by placing tariffs on imports. Governments implementing land reform have an opportunity to restructure the tax system. The new owners of small plots have increased ability to pay taxes and may do so willingly if they see that the tax system is honest and the proceeds will be used for schools, roads, and other local infrastructure.

Peasant associations and other farm groups also are likely to be formed after a successful land reform. These associations can play an important role in promoting the development and adoption of new technologies for agriculture, improving marketing channels and so forth. The formation of these associations therefore is another test of a successful land reform.

Alternatives to Land Reform

The cost and political difficulty of attaining an effective land reform have led to alternatives to large-scale, administrative redistribution of lands. There is now an increasing body of evidence showing that market-based reforms are effective at increasing investments, increased productivity and more equitable outcomes.[7] Examples of market-based land redistribution efforts include fortification of sales and rental markets, encouraging cooperatives to redistribute lands to their members, sales or transfer of government lands, and creation of land banks.[8] These efforts generally require three complementary steps: (i) legal definition and assignment of property rights; (ii) creating the legal framework for efficient functioning of the markets themselves; and (iii) insuring that complementary markets, particularly finance and insurance, function efficiently. These steps can be costly and difficult, and a market-based reform that does not address all will likely fail in its objectives — to redistribute land toward more efficient users.

[7] See Klaus Deininger and Songquing Jin, "Tenure Security and Land-Related Investment: Evidence from Ethiopia," *European Economic Review*, vol. 50 (July 2006), pp. 1245–77; and Klaus Deininger and Songquing Jin, "Land Sales and Rental Markets in Transition: Evidence from Rural Vietnam,"*Oxford Bulletin of Economics and Statistics*, vol. 70 (February 2008), pp. 67–101 for examples.

[8] These changes have been called "Phase III" of the process of land reform by Alain de Janvry, Marcel Fafchamps and Elisabeth Sadoulet in "Peasant Household Behavior with Missing Markets: Some Paradoxes Explained," *Economic Journal*, vol. 101, no. 409 (1991): 1400–17.

Definition and assignment of property rights involves surveying lands, titling them, and creating a land registry so that perspective participants can examine the land's history of transactions including liens and competing claims. Legal reforms include determining who can participate in transactions, means of contract enforcement, removal on implicit or explicit restrictions on rental and transfer, etc. Implicit restrictions to rental, for example, may occur because without an adequate legal framework, squatters may possess strong claims to ownership. Land owners may be reluctant to rent to others because they fear losing claims to ownership. Weak and corrupt legal systems make it difficult to enforce property ownership rights and may slow the development of land markets. Issues such as women's rights to own and transfer lands can have efficiency and equity effects of subsequent market processes.

Finally, while land markets have the potential to efficiently redistribute lands, in the presence of distortions in credit and insurance markets, creation of land markets alone may not solve the problem of inequitable distribution. For example, if banks or other creditors are unwilling to lend money in relatively small amounts due to transactions costs associated with such loans, then the poor may not be able to finance purchase or rental of the small amounts of land they seek. Unequal distribution of productive assets such as capital can exacerbate such problems because the poorest may not have collateral to support a loan. Insurance markets are important because the poorest of the poor may be less willing to risk their assets as collateral.

AGRICULTURAL LABOR MARKETS

Labor is often the most valuable resource the rural poor possess. This labor can be used to cultivate their own lands, to process and market products after harvest, to produce non-agricultural goods, some for own consumption and others to be sold in markets, for child-care, cooking and other household activities. Alternatively, this labor may be sold or rented to others, both farm and non-farm employers. Agricultural labor markets exist because land markets alone can not balance out differences in land and labor endowments. Small-scale land owners or landless individuals supply labor to large-scale landowners who need more than their own family labor to carry out their farming operations. Labor markets help allocate resources into their most valuable uses by transmitting signals about resource scarcity across space and time. As labor is an important input to production and a key asset held by the poor, the conduct and performance of labor markets are especially important for broad-based agricultural growth.

BOX 13-5.
REFORM of CAPITALIST AGRICULTURE in COLOMBIA

Colombia presents an example of some of the pitfalls associated with land reforms in many countries. In the 1930s, there was a public outcry, mostly by urban consumers who desired cheaper foods, over the lack of productivity on the large landholdings of the rural elite. In 1936, Law 200 was passed that said that potentially productive but poorly cultivated or abandoned large holdings were to be expropriated by the government. This threat caused land productivity to rise for a short time, and virtually no land was confiscated. During the 1950s, there was a long period of civil conflict known as "La Violencia" that hastened the destruction of traditional social relations and weakened the political powers of the old agrarian oligarchy.

Following a peace pact, a new phase of land reform began. Law 135 of 1961 set forth an ambitious reform package that included full compensation to existing landholders. The gradualist approach doomed the package from the start. Political pressure from landed groups allied with urban consumer interests successfully diverted inputs, often with substantial subsidies, to large-scale farms. Land values on favored farms increased dramatically, making compensation financially impossible. By 1972, only 1.5 percent of all land in large farms had been redistributed.

Law 4 in 1973 declared an end to this redistributive reform and returned the country to the principles of Law 200. At the same time, a political coalition between large-scale farmers, a small but substantial family-farm sector, and urban consumers formed and created pressure for a rural development program that favored the first two groups. Landless and marginal farmers were politically and economically excluded.

The conditions for a successful land reform never really existed in Colombia. Shifting alliances between urban and rural power groups diminished the political will. A lack of clear conviction for redistribution, combined with the slow pace of reform, further inhibited the efforts. Policies favoring large farms, largely intended to diffuse political opposition, had the effect of destroying any prospects for real reform.

Casual versus Permanent Labor

Labor may be hired on a *casual* or temporary basis by the day or for some other short period of time such as for the harvest or weeding period. Alternatively, labor may be hired on a more permanent or longer-term basis, perhaps for months or years. Casual labor is usually paid in cash and in kind (for example food; many day labor wages include a meal for the worker). Laborers may be paid daily or on a piece-rate basis for certain tasks. Women are often paid less than men, even for the same task. Casual labor is characterized by strong *seasonality;* work-

ers tend to be hired during planting and harvest, when agricultural labor demands are highest. Longer-term labor may have supervisory responsibilities or perform tasks that require special care such as applying farm chemicals. Formal or informal contracts may be developed to handle seasonal fluctuations and risks associated with agricultural production.

Transactions Costs, Asset Inequality, and Labor Markets

Labor markets in developing countries often contain imperfections due to power imbalances, imperfect information and transactions costs. Power imbalances emerge when a single or small number of employers exist in an area. In such cases, the employers may exercise monopsony (single buyer) power over their employees and use fewer workers at lower wages than would exist in a competitive labor market. Large-scale plantations, such as those existing in Central America and in cocoa-producing areas in West Africa, may exhibit such power. Imperfect information and transactions costs also constitute major sources of labor market imperfections. Labor must be hired, with corresponding costs of search and contracting, and supervised. Supervision involves costs of monitoring and enforcement. Such costs may distort incentives for hiring and use of different types of labor

Given information imperfections, employers may be unaware of the reliability of workers, some of whom shirk their duties. As a result, costly supervision or other contractual mechanisms must be undertaken to ensure the worker performs his or her duties as expected. Share cropping and piece-work contracts are two such mechanisms commonly found in less-developed countries. One study of the effectiveness of such contractual arrangements conducted in the Philippines found that piece-rate and shared cultivation were associated with significantly higher worker effort than time-wage contracts.[9] Contracts that tie together labor, land use agreements, credit and other inputs together often represent responses to imperfect information, transactions costs and risk sharing.

Wages in agriculture, whether on a casual or a full-time basis, are relatively low. Throughout the developing world, people who rely on agricultural employment as their main source of income tend to be poor. Poverty rates are high among tobacco-estate workers in Zimbabwe and Malawi, day laborers on the Indian sub-continent, and among coffee

[9] See A. Foster and M. Rosenzweig, "A Test for Moral Hazard in the Labor Market: Contractual Arrangements, Effort, and Health, *Review of Economics and Statistics*, vol. 76 (1994): 213–27.

and other plantation workers in Central America. Government interventions into labor markets are often justified based on this observed poverty. Minimum-wage legislation for farm workers has been tried in a number of countries including Zimbabwe, South Africa, and several Central American countries. Minimum wages for farm workers tend to be difficult to enforce also because of high transactions and enforcement costs, and imperfect information endemic in rural areas of less developed countries. Other interventions include establishment of labor enforcement standards, provision of labor market information, investments in education and schooling to increase worker productivity, and promotion of non-agricultural job opportunities that compete with agricultural employment. As noted in Chapter 7, non-farm employment constitutes a large and growing share of the rural labor markets. As agriculture develops over time, it must compete with alternative employment opportunities in rural labor markets.

SUMMARY

Land tenure refers to the rights and patterns of control over the land resource. Land rights determine social and political status as well as the economic power of a large proportion of the population in developing countries. A land reform is an attempt to change the land tenure system through public policies. Land tenure systems vary in farm size and organization, affect incentives to produce and invest, and influence the distribution of benefits from agricultural growth. Family farms, corporate farms, state farms, and group farms are major types of farm ownership. Many types of tenancy or leasing arrangements also exist.

The post-feudal order has resulted in some large capitalist farms and a coexisting small farm sector in many countries. No form of land tenure is universally efficient. Land tenure reform is difficult to achieve because those holding the land rights have political power. Land tenure reform, including more secure rights over land, is needed for improved economic efficiency, equity, and political and economic stability. Unless there is evidence that incentives have been created for farmers to undertake hard work and increase their capital investment, and, unless poverty has been reduced and social status improved for the rural poor, a successful land tenure reform has not occurred. Changes in land tenure and more secure property rights should be accompanied by credit, marketing and other services, and new land owners should be taxed to support development. Market-based land redistribution efforts include fortification of sales and rental markets, encouraging cooperatives to redistribute lands to their members, reduced government ownership, and creation of land banks.

Labor is often the most valuable resource the rural poor possess. Labor markets in developing countries often contain imperfections due to power imbalances, imperfect information, and transactions costs. Government interventions into labor markets are often justified based on this observed poverty.

IMPORTANT TERMS and CONCEPTS

Capitalistic agriculture
Casual labor
Compensation
Corporate farms
Entrepreneurial incentives
Family farms
Group farms
Land reform
Land tenure
Marketable surplus
Permanent labor
Political stabilization
Property rights
Public capital formation
Semi-feudal land tenure
Socialist agriculture
Stale farms
Successful land reform
Tenancy reform
Transactions costs

Looking Ahead

In this chapter, we considered institutional changes related to land and labor. In the next chapter, we consider institutional changes related to inputs and credit policies. Governments often intervene in input and credit markets. We will examine the nature and advisability of these interventions.

QUESTIONS for DISCUSSION

1 What is land tenure?
2 What are the major ways farms are organized?
3 What are the major types of tenancy arrangements?
4 What is land reform?
5 How does an anti-feudal land reform differ from land reforms within a capitalist or socialist agrarian structure?
6 Why is a land reform often necessary?
7 Why is a land reform difficult to achieve?
8 Why are large land holdings in a densely populated country bad?
9 What are the requisites of a successful land reform?
10 What pressures might population growth or new technologies place on existing land tenure arrangements?
11 What alternatives exist to administrative land reforms?
12 How can more secure land rights improve agricultural productivity?

13 What distinguishes casual labor from permanent labor and why do both exist?

14 Why are transactions costs a problem in labor markets?

RECOMMENDED READINGS

Bell, Clive, "Reforming Property Rights in Land and Tenancy," *World Bank Research Observer,* vol. 5(2) (July 1990), pp. 143–66.

Berry, Albert, and William Cline, *Agrarian Structure and Productivity in Developing Countries* (Baltimore: Johns Hopkins University Press, 1979).

de Janvry, Alain, "The Role of Land Reforms in Economic Development: Policies and Politics," *American Journal of Agricultural Economics*, vol. 63 (1981), pp. 384–92.

Deininger, Klaus, and Hans Binswanger, "The Evolution of the World Bank's Land Policy: Principles, Experience, and Future Challenges," *World Bank Research Observer*, vol. 14, no. 2 (August 1999), pp. 247–76.

Deininger, Klaus, and Songquing Jin, "Tenure Security and Land-Related Investment: Evidence from Ethiopia," *European Economic Review*, vol. 50 (July 2006), pp. 1245–77.

Feder, Gershon, and Klaus Deininger, "Land Institutions and Land Markets," *World Bank Policy Research Working Paper Series*: 2014, 1999.

Ray, Debraj, *Development Economics* (Princeton: Princeton University Press, 1998), chapters 12–13.

Wortman, Sterling, and Ralph W. Cummings, Jr., *To Feed This World: The Challenge and the Strategy* (Baltimore: Johns Hopkins University Press, 1978), pp. 271–88.

CHAPTER 14

Input and Credit Markets

> To take maximum advantage of technological advances in farming systems, farmers must have access to recommended production inputs at the specific times and in the quantities and qualities needed; (and) access, if necessary, to outside sources of finance to purchase these inputs…
>
> — Sterling Wortman and Ralph W. Cummings[1]

THIS CHAPTER

1. Explains why it is important for farmers to have access to purchased inputs and to credit
2. Describes the nature of rural money markets and the determinants of rural interest rates
3. Discusses why governments tend to subsidize input prices and credit and why these subsidies are generally inadvisable

IMPORTANCE of NEW INPUTS

Successful agricultural development in most developing countries today requires increased output per hectare and per worker. This agricultural intensification depends in part on the availability and financing of new, often manufactured, inputs. Fertilizers and pesticides, new seeds, irrigation systems, mechanical power, and supplemental minerals and nutrients for animals are examples of these inputs. Uptake of these inputs links farmers with national and international markets and exposes them to the associated risks and rewards. As energy prices increase and demands for food grow over time, the cost of production and relative returns of different input mixes will be affected by internationally determined forces. Governments must address a series of issues related to production, distribution, pricing, financing, and

[1] Sterling Wortman and Ralph W. Cummings, Jr., *To Feed This World: The Challenge and the Strategy* (Baltimore: Johns Hopkins University Press, 1978), p. 343.

regulation of inputs, and to the identification and encouragement of optimal on-farm input usage.

Role of Manufactured Inputs

Manufactured inputs have an important role to play in agricultural development because the potential for expanding the land resource is limited in most countries. This scarcity or inelastic supply of land means that its price tends to increase over time, both absolutely and relative to the price of labor. The induced-innovation theory described in Chapter 11 indicates that farmers will seek new agricultural technologies that will enable them to substitute lower cost inputs for those whose scarcity and price are rising. Agricultural research, described in detail in Chapter 12, will create the plant varieties that are responsive to these inputs. New, higher-productivity inputs include new seeds, fertilizer, irrigation, and pesticides, many of which will be produced domestically, but their prices will be affected by international events. Seeds, fertilizer, irrigation, and pesticides tend to be highly complementary inputs. To be more productive than traditional varieties, new varieties of wheat, rice, corn, and other food crops require more fertilizer and better water control than would be used under traditional practices. Water and fertilizer tend to induce lush plant growth and an environment favorable to weeds and other pests, thus raising the profitability of pesticides as well. If this package of inputs is available to farmers together with the necessary financing and information on usage, land and labor productivity can be raised. The result is an increase in output per hectare and per unit of labor applied, at least in those areas where the new inputs are suited and adopted. A description of these inputs will help better define their potential and limitations.

Seed. Seeds of high-yielding varieties are usually a relatively low-cost input. However, seed of superior varieties must be developed or identified, tested, produced and multiplied, monitored for quality, and distributed to farmers. The government often has a role to play in the development, testing, quality monitoring, and production of basic seed. Private firms can be involved in the multiplication of seeds and distribution to farmers. The exact roles of public and private bodies in a particular country may change as the seed industry develops. As hybrid seeds continue to spread for crops such as maize, rice and eggplant, the importance of the seed industry grows as farmers planting hybrids can not save and use their seed from the previous crop if they expect to maintain productivity. One of the concerns with genetically modified crops is that one or a few seed companies may own the intellectual

property rights associated with the new seeds and therefore may charge a significant seed premium (see Chapter 12 for further discussion). The government has a role to play in ensuring no undue exercise of monopoly power by seed companies.

Fertilizer. Higher-producing varieties require additional fertilizer, particularly nitrogen, phosphate, and potash. These nutrients can be obtained from natural fertility in the soil, animal and plant wastes, and leguminous plants that can fix nitrogen from the air. These natural sources often, but not always, must be supplemented by chemical fertilizers to provide the necessary quantities and precise mixtures required. In areas where the supply of natural fertilizers is relatively inelastic, as commercial fertilizers become less expensive and are available in relatively elastic supply, their use can be expected to increase.

World fertilizer prices can be volatile, and between 2002 and 2008 they trended upward, placing cost stresses on developing-country producers. Upward pressures on prices are caused by world-wide demand growth; increased costs of raw materials — especially natural gas, which is used to produce nitrogen, the main ingredient in all nitrogen fertilizers; and rising transportation costs due higher energy costs. Demand for fertilizers has grown throughout the world, partly due to income and population growth, and partly the result of more corn being planted in developed countries for use in ethanol bio-fuels. Fertilizer prices may remain high in the future as all of these factors continue to influence the market.

Water. Availability of irrigation water is a major determinant of the number of crops grown per land area per year, the inputs used, and hence production. Higher levels of fertilizer application require more and better-timed water input. Drainage is also important because few crops can tolerate excessive standing water or salinization. Several important factors complicate irrigation decisions. Irrigation infrastructure requires large financial investments, and governments often provide funds or encourage private entities to provide funds for such endeavors. Efficient water management requires proper pricing mechanisms: private users of water might over- or under-use irrigation water if it is not properly priced. Proper pricing is, however, complicated by difficulty in measuring the amount of water used. Water system management can have important direct effects on human health; malaria and schistosomiasis are common tropical diseases whose vectors thrive in standing water. Because of these considerations, development and management of irrigation and drainage systems often require a combination of public and private initiatives. Governments can seek to

expand and modernize irrigation and drainage facilities. They can design rules of water pricing to encourage economically sound water use. Farmers and villages themselves can develop smaller, often well-based, systems and the necessary canals for distribution on farms along with rules for water distribution.

Efficient water use is likely to grow in importance in many areas of the world as looming water shortages result from over-use of aquifers, damming of major river systems, and from climate change which affects rainfall patterns and temperature-based rates of evaporation. Several water danger zones are emerging in the developing world, including the Sahel region of Africa, the Horn of Africa, the entire Middle East, the Indo-Gangetic Plains in India and Pakistan, and the North China Plain.[2] In these areas, growth in demand or dwindling supplies or both is likely in the future to be associated with shortages and, unless solutions are found, dwindling agricultural production. Solutions include better management of existing supplies and new efficiency-enhancing technologies such as drip irrigation and drought-resistant plant varieties.

Pesticides. Farmers often find using pesticides (insecticides for insects, fungicides for diseases, and herbicides for weeds) highly profitable, as agricultural production intensifies through increased use of new seeds, fertilizer, and water. Sometimes these pesticides are applied as a preventative treatment and other times after a major pest problem develops.

Pesticides can have serious drawbacks, however. Some pesticides are toxic to humans and animals and result in poisonings in the short run or chronic health problems in the longer term. Applications with improper equipment or inadequate protective clothing exacerbate health problems. Improper storage and handling can create adverse health consequences. Chemical pollution can spread beyond the area where the pesticide is applied, with particularly deleterious effects on fisheries. Some pesticides kill insects that are beneficial to agriculture. Often, when pesticides are applied over a period of time, the target insects, diseases, or weeds develop resistance, making increased pesticide amounts necessary to maintain the same level of effectiveness.

Pesticides, despite these problems, will likely be needed for some time until new pest-resistant varieties, biological and cultural practices, and other substitute methods for pest control can be further developed.

[2] See Jeffrey D. Sachs, *Common Wealth: Economics for a Crowded Planet* (New York: Penguin Books, 2008), pp. 121–37.

BOX 14-1.
INTEGRATED PEST MANAGEMENT in ECUADOR'S HIGHLANDS

Potato producers in the Ecuadorian highlands face a number of important pests including Late Blight, Andean Weevil, and the Central American Tuber Moth. Late Blight is controlled through heavy applications of fungicides, while the latter two pests are controlled by spraying Carbofuran, a highly toxic pesticide. Farmers combine pesticides into a mixed "cocktail" containing as many as 12 chemical agents and spray their fields with up to eight applications in a single season. These cocktails are mixed without knowledge of interactions between active ingredients or of potential human health impacts. Farmers complained about the high financial cost of these applications and the health costs associated with chemical misuse IPM techniques were developed through a USAID-sponsored research project (IPM-CRSP) and included identifying and screening Late Blight-resistant varieties, use of insect traps, more targeted spraying of a low-toxicity alternative, field sanitation and cultural techniques, and the use of biological control alternatives. Local farmers were invited to participate in Farmer Field Schools and field days to learn about the techniques. Pesticide applications were reduced by half, and experience on farmer fields showed that the IPM package yielded more than $600 per hectare in net benefit compared to alternative practices. This example shows that IPM technologies can be profitable at the same time they reduce exposure to harmful chemicals.

Source: Alwang et al., "Developing IPM Packages in Latin America," in *Globalizing Integrated Pest Management: A Participatory Process*, ed. G.W. Norton, E.A. Heinrichs, G.C. Luther, and M.E. Irwin (Ames, Iowa: Blackwell Publishing, 2005).

Several of these methods, called integrated pest management or IPM, have already been developed and implemented for certain pests on certain crops in certain locations (see Box 14-1). Much additional research is needed, however, to make these practices more widely available in developing countries. Weed control is especially important to intensified production in Africa where labor for weeding is less abundant than in other regions.

Animal Inputs. As discussed in Chapter 7, livestock play an important role in farming systems in developing countries. Animal productivity is often low, and new inputs related to disease control, supplementary minerals and other feed supplements, improved shelter, and, in some cases, better breeds can make a difference. Inputs for controlling diseases and parasites are perhaps the most important; the significance of feed supplements, shelter, and new breeds varies from

country to country and by type of livestock. Because indigenous livestock have been adapted to their specific environments, the transfer in of new breeds is particularly complex, except perhaps for poultry.

Mechanical Inputs Agricultural mechanization is frequently a controversial subject. Tilling, planting, cultivating, and harvesting are still done by hand in large parts of the developing world, particularly in Sub-Saharan Africa and in hilly regions on other continents. In many areas of Asia and Latin America, animals are an important source of power. Even in countries where farming is more mechanized, power tillers and tractors are often restricted to tillage and a few other operations.[3] The controversy arises because machinery usually substitutes for labor or animals. In many developing countries, labor is abundant and its cost is low. Alternative employment opportunities outside agriculture are limited, so that labor displacement is undesirable; therefore, mechanization is most profitable in countries where land is abundant, labor is scarce, and capital is cheap; this situation would seem to exist in relatively few countries.

Does this mean that there is little role for agricultural mechanization? Not necessarily, but the types of mechanization should be different from what is observed in most western developed countries. Highly productive cropping systems, whether on small or large farms, can benefit from more precise planting depths and fertilizer placement, mechanically pumped irrigation water, mechanical threshing (but usually not harvesting unless labor is scarce), transport, power spraying of pesticides, and tilling when timing is critical for multiple cropping. Many of these mechanical devices, however, may be hand-held (e.g., sprayers) or stationary (e.g., pumps and threshers). Even in areas where labor is usually abundant, shortages can occur in certain seasons, which, if relieved through mechanization, could increase the overall demand for labor.

Individual farmers will consider the private profitability when deciding whether to invest in a machine. If very large farms exist in countries with surplus labor in agriculture, operators of these farms may prefer labor-saving machinery because it allows them to deal with fewer employees, and, given the transactions costs and capital subsidies that may exist, it may be more privately profitable to follow large-scale mechanization even if society as a whole would be better off without it. Such behavior is one of the reasons that land reform is so important to many developing countries (see Chapter 13).

[3] See Hans Binswanger, "Agricultural Mechanization: A Comparative Historical Perspective," *World Book Research Observer*, vol. 1 (January 1986), pp. 27–56.

Governments and foreign assistance agencies must be careful not to encourage non-optimal mechanization (from society's viewpoint) through ill-advised subsidies or other means. Mechanization is inevitable over time, but the type of mechanization should be appropriate given the relative endowments of land, labor, and capital. Certain government policies, such as those influencing exchange rates, indirectly affect the prices of capital-intensive inputs such as machinery. Impacts on relative prices of inputs should be considered during policy formulation.

Input Markets

Developing countries often subsidize the purchase of seeds, fertilizers, irrigation water, pesticides, and occasionally mechanical inputs. Is this a good idea? Generally speaking, it is not. Such subsidies can lead to losses in economic efficiency for the country as a whole, can be costly to the government, can discourage private-sector competition in the provision of these inputs, and, particularly in the case of pesticides, may lead to environmental damages from over-application.

Governments frequently become involved in multiplying and selling improved seeds to farmers at or below cost. In some cases, scarce research resources are diverted to multiplying seeds rather than developing new varieties. In other cases, research systems are forced to focus on selling seeds to pay for operating costs for the system. As a result, private firms, unable to compete with the government treasury, do not take on the function of multiplying and selling seeds. Without development of these private firms, the government must continue to be responsible for this function.

Fertilizer subsidies can be used in selected situations in which governments desire to increase the adoption of new inputs by groups of farmers that might not otherwise adopt them. Unfortunately, in many countries these subsidies are necessitated by the artificially low prices imposed on agricultural outputs for the purpose of keeping food prices down for urban consumers. Input subsidies help compensate farmers for income losses from these policies. While this combination of policies can have the desired effect, at least in the short run, high costs to the government and potential fiscal problems result in the long run, making the policies non-sustainable. Also, the economic efficiency losses associated with these policies can be substantial. Finally, studies show that from the farmer's perspective access to inputs can be more important than their prices. Subsidy policies and government involvement in input markets often lead to shortages of inputs and their rationing, which are harmful to long-run growth.

BOX 14.2.
MODERN INPUTS and ECONOMIC GROWTH

New technologies and inputs help achieve increases in agricultural output and income in rural areas of developing countries. This income is spent by the households on goods and services, some of which are produced locally and others which are imported into the region. These expenditures induce income growth in the non-farm economy, the so-called *multiplier effects*. By far, the largest portion of these multipliers is caused by household expenditures on consumer goods and services, though the effects resulting from increased use of farm inputs and in processing, marketing, and transportation of farm output are substantial contributors to regional growth.

Linkages between farms and suppliers of inputs also create spillovers into the local economy. Though seeds, agrichemicals, irrigation supplies, and farm machinery usually are not produced in agricultural regions, input supply services including technical advice, machinery repair, and a large proportion of irrigation construction and maintenance can be produced locally. These activities create opportunities for non-farm employment and income that is in turn spent locally. The creation and deepening of backward linkages from agriculture are important contributions to rural economic development.

Efficiency losses are also a problem for water and pesticide subsidies. The latter can create excessive use of toxic chemicals and can result in all the deleterious effects described earlier. In summary, input subsidies are generally inadvisable. The government can play a more constructive role by ensuring the availability of these inputs (including the improvement of rural roads), publishing price information to encourage competition, setting quality standards for seeds and fertilizers, requiring and enforcing labeling of input containers, and regulating use of toxic pesticides and transgenic seeds.

Role of Credit

Access to credit becomes important as a developing country moves from traditional to more modern agriculture. Credit helps farmers purchase inputs such as seeds, fertilizers, and chemicals. It facilitates purchase of durable productive inputs such as machinery, and helps households better manage their resources. Credit can be used for input purchases, investment, marketing, and consumption. Without credit, even high-return investments, long- or short-term, would be infeasible for many farmers. Loans enable farmers to better manage risks since they can borrow during bad years and pay back the loans during good years.

Even within cropping seasons, short-term credit is used to smooth consumption and provide cash at times of acute needs.

Without widespread access to credit, inputs associated with improved technologies can be purchased only by wealthier farmers. Capital formation and improvements on smaller farms can be hampered. Fewer farmers are able to purchase or even rent land. In cases where produce marketing requires cash outlays, lack of credit can disrupt marketing activities. Well-functioning rural financial institutions are essential to improving economic efficiency, reducing income risk, and meeting income distribution goals.

NATURE of RURAL MONEY-MARKETS and DETERMINANTS of RURAL INTEREST RATES

Finance in rural areas consists of three components: credit (borrowing and lending), saving, and insurance. These components frequently overlap, as savings can be used for capital purchases (and hence substitute for credit) or as a safety net or insurance substitute. Developing-country households use complex strategies to increase their productive capacity, share risk, and manage purchases of food and other goods over time. Access to finance helps determine the suitability of such strategies. Better understanding of rural financial markets requires consideration of the three components, and efforts to strengthen one component may be compromised by weaknesses in others.[4]

Credit facilitates the temporary transfer of purchasing power from one individual or organization to another. However, many types of lenders or *money-markets* exist, and credit institutions may or may not adequately serve the needs of a developing agriculture. Credit is often viewed as an oppressive or exploitive device in developing countries. We need to examine both the types of lending sources found in developing countries and the evidence of exploitive behavior associated with these money-markets.

Types of Money-Markets

Rural money-markets consist of two broadly defined lending sources: organized (or formal) and informal. Private commercial banks, government-controlled banks, cooperative banks, and credit societies are called organized credit sources. Public or private, these lending sources usually are regulated by the government and are open to audit and

[4] See Manfred Zeller and Richard L. Meyer, *The Critical Triangle of Microfinance: from Vision to Reality* (Baltimore: Johns Hopkins University Press, 2003) for more details.

inspection. In addition to credit, they may provide other financial services such as savings and certain forms of insurance. In general, formal money markets have historically not served well the needs of small- and medium-scale farmers in developing countries. As a result, over time many developing-country governments have intervened to promote better access to formal financial services, primarily credit. These programs were largely unsuccessful for many reasons, one of which was that they did not recognize alternative, informal credit sources that are found throughout the developing world.

Informal or unorganized credit sources include moneylenders, merchants, pawnbrokers, landlords, friends, and relatives. Some credit sources — e.g., landlords and merchants — combine other economic activities with lending. Except for absentee landlords, the relationship between borrower and informal lender is generally marked by personal contact, simple accounting, and low administrative costs.

Informal lenders are important sources of funds in many rural areas. These lenders usually know the borrowers personally, require little collateral, make consumption as well as production loans, are accessible at all times, and usually are flexible in rescheduling loans. However, these informal lenders also tend to charge high rates of interest and are frequently accused of exploitive activities. In cases where lenders are landlords, merchants, or both, they have been accused of using their position to tie borrowers to themselves by forcing their clients to rent from, borrow from, buy from, and sell to them. Thus, these agents are said to extract monopoly profits from their clients. Are borrowers consistently being exploited? It is important to examine this question because it has important implications for the role of more formal private and public credit institutions.

Do Informal Money-Markets Exploit Borrowers?

The issue of borrower exploitation revolves around the existence of usury or monopoly profits earned by the lenders. Hence we need to consider the factors that determine the interest rates charged by these lenders. The major components of rates of interest on loans are: (1) administrative costs, (2) the opportunity cost of lending, (3) a risk premium due to the probability of default in repayment, and (4) monopoly profit.

Administrative costs should not be too high for moneylenders, given simple contracting procedures and personal knowledge of clients. Many loans with small amounts of money per loan increase administrative costs, but these costs are probably not excessive. Opportunity costs of lending are low in rural areas because interest rates offered

by organized money markets tend to be low. Therefore, the critical factor in determining whether interest rates are generating monopoly profits in the informal money market is the risk premium or the probability of default. The risk premium for loans to small-scale, particularly tenant, farmers can be high. These farmers are close to the margin of subsistence, and a streak of bad weather or a serious illness can spell disaster. Without formal collateral, the risk of default grows. Because weather tends to affect all farmers in a given area, a spell of bad weather creates potential for simultaneous default of many borrowers. Therefore one would expect relatively high interest rates just to cover the risk factor. Exploitive situations do exist in which moneylenders extract monopolist gains. However, careful empirical studies seem to indicate that monopoly profits may not be as prevalent or large in informal credit markets as is often believed.[5] The reason is competition. The amounts of the loans are often small, and start-up costs required to become a moneylender are low. This ease of entry serves to keep interest rates at an appropriate level given the level of risk, administrative costs, and the opportunity cost of capital. If profit margins become large, incentives are created for new moneylenders to enter the business and compete away those profits.

High risks associated with loans to subsistence farmers, however, mean that lenders have incentives to maintain tight control over borrowers. Moneylenders who are also landlords or merchants have means of tying their clients to themselves through leases, consumer credit, and so forth. Other moneylenders may be hesitant to lend to someone who already owes substantial sums or who has defaulted to another. In summary, it appears that some exploitation by moneylenders does occur, particularly if the moneylenders control the land or the market. However, the magnitude of this exploitation may not be as great as is often believed. Evidence of high interest rates on rural loans is alone not sufficient to conclude that moneylenders are exploitive, since there are high costs associated with making these loans. Informal sources of credit serve a vital function in most developing countries because, without them, most small farmers would not have access to credit.

Organized Money-Markets and Transactions Costs

Why are small farmers in developing countries not better served by organized money-markets? Both private and public financial institutions

[5] See, for example, P. Bardham and A. Rudra, "Interlinkage of Hand Labor and Capital Relations: An Analysis of Village Survey Data in East Asia," *Economic and Political Weekly* (1978), pp. 367–84.

find that transactions costs are high. Loans, savings, and insurance needs are small, and the paperwork and time spent evaluating potential clients, collecting payments, and supervising loans in order to reduce risks of default are costly. In many cases, the government regulates the maximum interest allowed, and that rate will fail to cover the administrative costs and risk. Thus, where private and public sources of finance exist, they tend to deal with larger-scale farmers to reduce administrative costs and the chances of default (see Box 14-3).

The magnitude of these transactions costs is illustrated by a relatively successful bank that has provided credit for many years to the rural poor in Bangladesh. The Grameen Bank of Bangladesh targets households that own less than 0.5 acres of cultivable land.[6] The bank organizes its clients into groups and associations, provides credit without collateral, and supervises utilization of the loans. A maximum amount (the equivalent of about $150) is lent to individuals within a group of five members. Nearly three-fourths of the borrowers are women. Peer pressure together with close supervision ensures repayment rates of more than 90 percent. The interest rate charged is roughly 16 percent a year and the default rate has historically been less than 2 percent. The bank is subsidized, however, by the State Bank of Bangladesh and by the International Fund for Agricultural Development (IFAD). The interest on the loans would be around 5 to 10 percent higher than it is if the bank had, to break even, to borrow at the same rate as the other financial institutions in the country.[7] Because the default rate and the opportunity cost of capital are low, it is clear that most of the interest charged is to cover administrative cost. The bank could lower this cost with less supervision, but the default rate would likely rise and offset the cost saving.

The Grameen Bank also lends very little money for activities associated with crop production. In general, this type of *microcredit* lending serves mostly for livestock and poultry, for small-scale processing and manufacturing, and for trading and shop keeping. These activities are less risky than crop production. The Grameen Bank model has been improved upon through sequential experimentation, and micro-finance

[6] See Mahabub Hossain, "Credit for Alleviation of Rural Poverty: The Grameen Bank of Bangladesh," International Food Policy Research Institute Research, Report No. 65 (Washington, D.C., February 1988), for an excellent discussion of the Grameen Bank; see also Mark M. Pitt and Shahidur Khandker, "The Impact of Group-based Credit Programs on Poor Households in Bangladesh: Does the Gender of Participants Matter?" *Journal of Political Economy* (1998), pp. 958–96, for information on the impacts of such programs.

[7] Hossain, "Credit for the Alleviation of Rural Poverty," p. 11.

BOX 14-3.
ADMINISTRATIVE COSTS and LOAN SIZE

The cost of lending to farmers includes relatively large fixed costs to pay for administration and bookkeeping. To cover these costs, interest rates must be higher for smaller loans, even if all borrowers have equal risk of default. For example, if the variable cost of capital is 10 percent but the bank incurs a fixed cost of $10 to administer each loan, for the bank to break even on each loan it must charge a total of 20 percent interest to those who want to borrow $100 for repayment after one year. In contrast, those who want to borrow $1000 would have to pay only 11 percent.

organizations around the world are now flourishing without subsidization. These organizations and some of their organizing principles are discussed below.

One can see that small agricultural loans are costly and, as a result, most commercial lenders lend to larger farmers where the risk and administrative costs are lower. Government-supported credit programs often have subsidized interest rates in developing countries, but these rates tend to encourage loans to large farmers (many micro-finance institutions are an exception).

Transactions costs for private or public loan transactions can also be high because of fraud, favoritism, or embezzlement of funds from within the system. This situation arises most frequently when loans are subsidized, creating excess demand for credit and incentives for bribery.

GOVERNMENT-ASSISTED CREDIT PROGRAMS

Many governments use credit programs as part of their development program, and many international donors support these programs. Government-supported credit is based on the notions that (1) credit is critical to the adoption of new technologies, (2) moneylenders exploit farmers and public credit can provide them with competition, (3) credit can be combined with supervision and education to increase the capacity of farmers to use modern inputs, (4) subsidized credit can offset disincentives to production created by other policies that discriminate against agriculture, and (5) government-supported credit programs can lessen inequities in the rural sector.[8]

Subsidized credit provides an easy vehicle for transferring public funds to the rural sector. Examples of subsidized credit programs

[8]See Yujiro Hayami and Vernon Ruttan, *Agricultural Development: An International Perspective* (Baltimore: Johns Hopkins University Press, 1985), pp. 398–403.

Bangladesh families have benefited from Grameen Bank loans.

abound in every region of the developing world. Dale Adams points to a number of studies of such programs in Honduras, Sudan, Jamaica, and elsewhere that demonstrate how ill-advised subsidized credit is from a development perspective.[9] Adams finds that while evaluations of subsidized credit programs often find favorable impacts on individual borrowers, a broader examination of the net effects of these programs usually finds few positive effects on economic development. They also can compromise the viability of the rural financial system.

Effects of Subsidized Credit

Subsidized credit creates excess demand for credit by lowering interest rates. In many cases, because interest rates are negative after controlling for inflation, the demand for credit is infinite. Subsidized credit erodes the capital available in financial markets and undermines rural financial institutions. Private banks cannot cover expenses (administrative costs, defaults, etc.) at low interest rates, yet they are forced to lower interest rates in order to remain competitive with public credit sources, even if not required to lower them by law. Thus, the survival

[9] See Dale W. Adams, "The Conundrum of Successful Credit Projects in Floundering Rural Financial Markets," *Economic Development and Cultural Change*, vol. 36 (January 1988), pp. 355–67.

of these private institutions is threatened. If they fail, additional government involvement and additional budget outlays will be needed. An equally important effect of subsidized loan rates is that they lower all interest rates and, hence, discourage private savings. If agricultural development is to be able to generate capital, then viable rural financial institutions are needed to both provide loans and mobilize savings.

Because subsidized credit generates excess demand for loans, credit is rationed and almost inevitably goes to the larger farms for which the administrative costs are lower. The phenomenon of successful impacts of subsidized credit on individual borrowers yet negligible effects on overall development exists because rationed credit means that few people are touched by the programs. Seldom is more than 5 percent of the potential credit recipients reached. Because the subsidized loans are valuable, the credit system can become politicized as large landowners offer favors to bank managers to obtain loans or financially support politicians to encourage continuation of the program. In addition to these distributive effects, default rates on subsidized loans tend to be high. Public sector lenders may be less familiar with the borrowers than are the lenders in the private sector. Because there are pressures to lend to larger borrowers, the productive potential of the loan may not be considered, leading to high default tales.

Innovations in Rural Finance

Since the early 1970s, a gradual revolution in lending to the poor has been occurring in a number of developing countries. As countries learn from their failures with subsidized credit programs, and as experience grows with targeted small, group-loan programs such as the Grameen Bank in Bangladesh, the large-scale provision of small loans to low-income people has expanded. As of 2001, more than 1,500 micro-finance institutions (MFIs) with 54 million members existed in 85 developing countries.[10] The Grameen Bank, however, while demonstrating that poor people can be good credit risks given a credit program structured with proper incentives, has remained somewhat constrained by its inability to operate entirely without subsidy. Since the late 1980s, the *poverty lending* approach of banks such as the Grameen Bank has been challenged by a more commercially-oriented *financial systems* microfinance approach.[11] While both approaches focus on the poor,

[10] Cecile Lapenu and Manfred Zeller, Distribution, Growth and Performance of Microfinance Institutions in Africa, Asia, and Latin America, IFPRI FCND Discussion Paper 114 (Washington, D.C.,2001), p. 111.

[11] See Marguerite S. Robinson, *The Micro Finance Revolution: Sustainable Finance for the Poor* (Washington, D.C.: The World Bank, 2001), p. 7.

the latter emphasizes savings services to the poor as well as loans.[12] A financial systems approach enables banks to generate sufficient resources to not only be sustainable but to provide opportunity for the economically active poor (as opposed to the extremely poor) to save and invest at a decent return during times when they are able to save. Examples of such micro-credit banking systems that have proven profitable are found in countries as diverse as Bolivia and Indonesia. Micro-financial institutions are also experimenting in offering the third component of the finance trinity: micro-insurance. Micro-finance institutions have incentives to help their clients manage risks, since a poor outcome may lead to default on loans.

These new experiences in providing finance to small-scale and poor farmers have been built on a number of principles. The first principle is recognition that credit, savings, and insurance are interlinked and efforts to provide one component should consider impacts on the others. Second, funds are fungible and can be used for things other than input purchases, such as consumption and other emergency needs. By better enabling risk management, access to financial services can improve income generation over time. A third principle is that for sustainability, credit providers should charge what the loans cost, which is usually more than is charged to large commercial borrowers because of the transactions costs on many small loans. Some of those costs arise from the necessity of screening credit applicants. The key innovation of microfinance is the use of joint group liability; loans are made to groups and if one member of the group defaults, the entire loan is considered to be in default. sing group liability, groups use local knowledge to screen members and moral suasion to enforce repayment. These factors reduce transactions costs and improve loan repayment rates. Commercially-oriented micro-finance provides formal competition for informal money lenders, and hence is most likely to succeed in precisely those areas where moneylender profits are excessive due to local monopoly power.

Lessons for Credit Policies

Several lessons emerge from the applied research on rural credit. First, adoption of new technologies often requires purchase of modern inputs. Consequently, credit availability has been found to be more important to development than the interest rate charged, and there is a

[12] Lapenu and Zeller, Distribution, Growth and Performance of Microfinance Institutions in Africa, Asia, and Latin America; note that of the 54 million members of MFIs world wide, 44 million are savers and 23 million are borrowers.

tradeoff between credit availability and subsidized interest rates. Second, the viability of rural financial institutions is jeopardized by subsidized credit. This weakening of rural financial markets can constrict both the supply of and demand for credit. The rural poor are penalized on their deposits as well as their loans.[13] Third, credit is *fungible*: in other words, it may not be used for its intended purpose. It's easy for subsidized production credit to be used for consumption items or nonproductive assets. This fungibility is not necessarily bad unless it raises the default rate, but should at least be understood by policymakers. Fourth, a key to reducing market interest rates is to reduce agricultural risk (and hence defaults) and the transactions costs associated with lending and borrowing. Higher income levels associated with economic development may help reduce the risk of defaults, as may certain crop insurance and other government policies discussed in Chapter 15. Improved roads and other means of communication, and in some cases, group borrowing and guarantee of loans, can help reduce transactions costs.

Because administrative costs per dollar lent to small farms are higher than to large farms, banks either must charge higher interest rates (or other hidden charges) to small farms than large, or give loans mainly to large farms. Thus, many countries need to pursue policies to make land more widely available to the poor or the credit system will also work against the poorest farmers.

SUMMARY

Successful agricultural development requires increased output per hectare and per worker. This agricultural intensification depends on the availability of new, often manufactured, inputs. Seed, fertilizer, pesticides, irrigation, mechanical power, and supplementary minerals and feeds are examples of these inputs. Manufactured inputs can substitute for inelastic supplies of land to increase production at a lower per-unit cost. A variety of issues must be resolved by each country, however, with respect to externalities associated with certain inputs such as pesticides, the appropriate types of mechanization, and the role of the government in producing, distributing, and financing inputs. Governments often subsidize inputs. These subsidies can discourage private competition for input supply, can be costly to the government, and may encourage overuse of inputs such as pesticides that create externalities.

[13] See Adams, "The Conundrum of Successful Credit Projects in Floundering Rural Financial Markets," p. 366.

Credit is essential as a country moves from traditional to modern agriculture. Credit from informal sources such as moneylenders is often viewed as oppressive. However, risks and administrative costs of loans to small farms are high and, given the typical competition among moneylenders, monopoly profits may not be as prevalent or as high as often portrayed. When moneylenders are also landlords or merchants, the chances of exploitation are greater. Formal private and public lenders do not serve a high proportion of the farmers because risks and transactions costs are high. Because governments frequently subsidize interest rates, rationed credit tends to go to the larger farms. The subsidies erode the capital in the financial system and, thus, the number of farms served. Low interest rates also discourage deposits and reduce the ability of formal private banks to compete. Credit, savings, and insurance are interlinked, and efforts to provide one component should consider impacts on the others.

IMPORTANT TERMS and CONCEPTS

Administrative costs
Exploitation
Fertilizers and pesticides
Fungibility
Grameen Bank
Group lending
Informal credit sources
Input subsidies
Integrated pest management
Irrigation systems
Mechanical power
Microfinance
Moneylenders
Money-markets
Monopoly power
New seeds
Opportunity costs of lending
Organized credit sources
Purchased inputs
Risk of default
Subsidized credit

Looking Ahead

Governments often intervene in agricultural markets to influence prices. In the next chapter we examine why governments intervene and the effects of those interventions. Efficient marketing systems are essential for agricultural development, and we consider the role that governments can play in improving the marketing system.

QUESTIONS for DISCUSSION

1 Why are manufactured agricultural inputs usually necessary for agricultural development?
2 What are some of the key manufactured inputs needed?
3 In what manner are agricultural inputs complementary in nature?

4 What are the advantages and disadvantages of pesticides?
5 Why is mechanization a controversial issue?
6 Why do governments subsidize the purchase of manufactured inputs?
7 Why is agricultural credit important to agricultural development?
8 How do organized and informal sources of credit differ?
9 Why might bankers be biased against small farmer loans in developing countries?
10 What factors would you examine if you were trying to assess whether interest rates charged in informal money-markets were exploiting borrowers?
11 What are subsidized interest rates? Are they a good idea for getting agriculture moving?
12 What might be one problem associated with the fact that credit is fungible?
13 Why do governments support credit programs?
14 How might transactions costs associated with rural financial markets be reduced?

RECOMMENDED READINGS

Adams, Dale W., "The Conundrum of Successful Credit Projects in Floundering Rural Financial Markets," *Economic Development and Cultural Change,* vol. 36 (January 1988), pp. 355–67.

Adams, Dale W., Douglas H. Graham, and J. D. Von Pischke, eds., *Undermining Rural Development with Cheap Credit* (Boulder, Colo.: Westview Press, 1984).

Binswanger, Hans, "Agricultural Mechanization: A Comparative Historical Analysis," *World Bank Research Observer*, vol. 1 (January 1986), pp. 27–56.

Bouman, F. J. A. and R. Houtman, "Pawnbrokering as an Instrument of Rural Banking in the Third World," *Economic Development and Cultural Change*, vol. 37 (October 1988), pp. 69–99.

Hayami, Yujiro and Vernon W. Ruttan, *Agricultural Development: An International Perspective* (Baltimore: Johns Hopkins University Press, 1985), pp. 398–403.

Hossain, Mahabub, "Credit for Alleviation of Rural Poverty: The Grameen Bank in Bangladesh," International Food Policy Research Institute, Research Report No. 65, Washington, D.C., February 1988.

Pingali, Prabhu, Yves Bigot, and Hans P. Binswanger, *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa* (Baltimore: Johns Hopkins University Press, 1987).

Robinson, Marguerite, *The Micro Finance Revolution: Sustainable Finance for the Poor* (Washington, D.C.: The World Bank, 2001).

Sachs, Jeffrey D. *Common Wealth: Economics for a Crowded Planet* (New York: Penguin Books, 2008).

Von Pischke, J. D., Dale W. Adams, and Gordon Donald, *Rural Financial Markets in Developing Countries: Their Use and Abuse* (Baltimore: Johns Hopkins University Press, 1983).

Yaron, Jacob, "What Makes Rural Financial Institutions Successful?" *World Bank Research Observer*, vol. 9 (1; 1994), pp. 49–70.

Zeller, Manfred and Richard L. Meyer, *The Critical Triangle of Microfinance: from Vision to Reality* (Baltimore: Johns Hopkins University Press, 2003)

CHAPTER 15

Pricing Policies and Marketing Systems

> The links between price polices and food marketing take the food policy analyst to the very core of an economy and the most basic issues concerning the consequences of market organization for economic efficiency and income distribution. — C. Peter Timmer

THIS CHAPTER

1 Discusses the nature of markets, how and why governments tend to intervene in agricultural markets to affect prices, and the results of those interventions

2 Explains the importance of efficient marketing systems and describes how marketing systems have changed over time in developing countries

3 Considers the role that government can play in providing marketing infrastructure, market information, marketing services, and regulations

PRICING POLICIES

Food and agricultural prices are major determinants of producer incentives and real incomes in developing countries. These prices are influenced by government policies and by the efficiency of marketing systems. Pricing policies and marketing systems have changed significantly over the past thirty years, especially in response to domestic budgetary and global market pressures. The roles of government, processors, wholesalers, and retailers are changing. Governments in some

[1] C. Peter Timmer, "The Relationship Between Price Policy and Food Marketing," in *Food Policy: Integrating Supply, Distribution, and Consumption*, ed. J. Price Gittinger, Joanne Leslie, and Caroline Hoisington (Baltimore: Johns Hopkins University Press, 1987), p. 293.

developing countries continue to adopt pricing policies that reduce food prices for urban consumers even if farmers are forced to bear the costs. In other developing countries, increased integration into global markets has resulted in freeing up of prices and in new approaches to processing, marketing, and regulating farm commodities and products. Ironically, in many developed countries where farmers are a much smaller proportion of the population, government price interventions continue to support agricultural prices, often at the expense of taxpayers and consumers, and in some cases with deleterious effects on developing countries. Why do we observe these policies? How are they implemented, and what are their short- and long-run effects? These questions are addressed below, followed in the next section by a discussion of the roles of agricultural marketing systems and how those systems have changed over time.

Reasons for Price Intervention

Governments intervene into agricultural price formation for two major reasons: to change the outcomes in agricultural markets themselves, and to raise revenue to pay for roads, police, and other public services. These interventions have a large influence on the welfare of both farmers and non-farmers. Sometimes government policies reflect the long-run interest of society as a whole, helping to stabilize and raise income for many people, but often they reflect more narrow or short-run political objectives.

The long-run interest of most societies calls for policies that (1) contribute to economic growth, (2) improve income distribution or at least meet minimum nutritional needs of citizens, and (3) provide a certain measure of food security or stability for the country over time. Governments vary widely in what they actually do, and their choice of policies helps explain the wide differences in economic outcomes across countries and over time. The choice of policy is much influenced by how governments respond to key interest groups. Urban consumers want lower food prices, particularly the poor who spend a large fraction of their income on food. Employers also prefer low food prices, which allow them to pay lower money wages. But low food prices hurt agricultural producers, and reduce investment in agriculture, which lowers farm productivity over time.

In most developing countries, the balance of political power favors urban consumers and employers. Although farmers are in the majority, they are usually poorer, are often illiterate, and are geographically dispersed across the countryside. Thus, political power with respect to food prices is centered in urban-industrial areas.

As development proceeds and incomes grow, several factors may cause the balance of political power within countries to shift towards helping farmers, if necessary at the expense of consumers. First, food prices become less important in household budgets because the proportion of income spent on food declines with higher incomes. Second, the declining relative size of the agricultural sector makes it less costly for the government to succumb to pressures from farmers, while at the same time the reduced number and increased specialization of farms improves the ability of farmers to organize for collective action. Third, governments in richer countries have easier access to other sources of tax revenue outside the farm sector.

The form of government interventions into agricultural commodity markets also shifts as development proceeds. In the poorest countries, interventions often focus on international trade because that is easiest to control. Governments typically tax both imports and exports, and since poor countries often export farm goods and import manufactures, the result is a tax on farmers and protection for local industries. In somewhat higher-income developing countries, governments often introduce food-price subsidies, and increasingly try to support farm income as well. At the highest levels of economic development, perhaps the most important transition is towards increasingly well-targeted government programs that meet their political objectives with fewer side effects. For example, food price subsidies may be restricted to benefit only the poorest consumers, while farm subsidies may be made less distorting.

During early stages of development, agricultural policies are often highly inefficient, partly because governments have limited administrative capacity, but also because citizens who lose from bad policy may be unable to organize against them. Inefficiencies remain over time, but policies can improve as development proceeds, due partly to the structural transformation of the underlying economy but also to improvements in political accountability.

Methods of Price Intervention

Governments intervene to influence agricultural prices in several ways. They set price ceilings or floors and enforce them with commodity subsidies or taxes, manipulation of foreign exchange rates, commodity storage programs, restrictions on quantities traded, and/or other policy instruments. Let's examine how a few of these instruments work.

Suppose the government wants to lower the price of rice, an important food in the diet. The supply of rice must therefore be increased in the market relative to demand. Additional supplies can be created

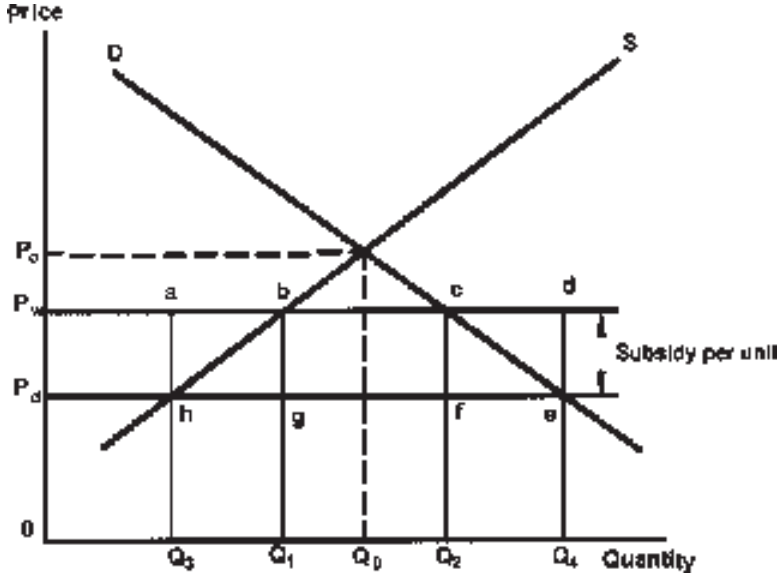


Figure 15-1. Economics of a price ceiling and consumer subsidy to lower agricultural prices.

by increasing imports or by stimulating domestic production. In either case, government revenues must be used to bridge the gap between the initial price and the desired *price ceiling*. Figure 15-1 presents an illustration of how the price ceiling and subsidy might work.

The supply and demand schedules would intersect at price P_0 and quantity Q_0 if there were no trade in rice. However, the country in this example is assumed to be a rice importer, so the world price of rice, P_w, is below P_o. Initially, at P_w and without government intervention, quantity Q_1 is produced domestically, Q_2 is demanded by consumers, and the difference, Q_2, – Q_1, is met by imports. If the government desires to artificially create a domestic price for rice, P_d, below the world price, it must pay a subsidy per unit of rice equal to the difference between the world price and the desired domestic price ($P_w - P_d$). This subsidy could be paid on a per-ton basis to commercial importers to cover their losses for importing rice at a price below what they pay on the world market, or it could be paid to a government agency that imports rice.[2] In either case, the direct cost to the government of the subsidy is ($P_w - P_d$) times

[2] C. Peter Timmer, *Getting Prices Right: The Scope and Limits of Agricultural Price Policy* (Ithaca, N.Y.: Cornell University Press, 1986), p. 36.

($Q_4 - Q_3$), which equals area *adeh* in Figure 15-1. This kind of price ceiling program is common in many African and Asian countries. Consumers benefit but rice producers are hurt by the lower price of rice.

Sometimes the government prefers not to allow scarce foreign exchange to be spent on increased imports. In this case, farmers may be legally forced to sell their commodity to the government at a low price. For example, the government might force farmers to deliver Q_3 units of rice at P_d. Although nothing is imported, the demand for rice (Q_4) exceeds its supply (Q_3). The government must then ration rice to consumers. The shortage in the market provides incentives for farmers to sell their crop illegally on the *black market* for a higher price. Even if the government allows adequate imports to meet the projected demand at the lower price, if the price of the product is higher across the border, farmers will (usually illegally) sell in a neighboring country, thus further reducing domestic supplies.

One means to avoid reducing domestic production and illegal sales while at the same time supporting farm incomes is for the government to administer a two-price scheme in which producers are paid the world price but consumers pay only the subsidized price. This type of system is illustrated in Figure 15-1. Rather than paying *adeh* to importers, the government would pay $P_w bgP_d$, or a subsidy of ($P_w - P_d$) times ($Q_1 - 0$) to producers and a subsidy of *bdeg*, or ($P_w - P_d$) times ($Q_4 - Q_1$), to importers. Producers would still receive P_w, while consumers would face a price of P_d, thus the name *two-price scheme*. Of course an even higher subsidy could be paid to producers to further reduce imports and increase the producer price. The obvious difficulty with this scheme is its impact on the government budget. The subsidy costs have to be paid for by some means. Because of this cost, few major commodities are subsidized this way in developing countries, although related schemes are common in developed countries such as the United States and Japan, and in Europe. Two-price wheat programs have been operative, however, at various times in Brazil, Egypt, Mexico, and a few other low-income countries. Table 15-1 lists examples of past food subsidy programs in developing countries.

Developing countries often have food subsidy programs that are targeted toward the poor or to nutritionally vulnerable groups. These subsidies can be implemented through ration shops, ration cards, food stamps, or other means. Usually only the very poor are eligible, to keep the cost down, but in some cases ration shops, which sell basic grains and other staples, are located in poor neighborhoods under the theory that only the poor will frequent them. Alternatively, self-targeting can be achieved by subsidizing foods that the poor tend to buy, such as

TABLE 15-1. EXAMPLES of EXISTING or PREVIOUS CONSUMER PRICE SUBSIDY PROGRAMS in DEVELOPING COUNTRIES

Country	Principal foods subsidized	Type of program	Food distribution	Actual coverage (implicit targeting)
Bangladesh	Wheat and rice	Price subsidy	Targeted & rationed	Mostly urban
Brazil	Wheat	Price subsiidy	General	Total population
China	Rice	Price subsidy	General	Mostly urban
Colombia	Selected processed food	Food stamps	Targeted & rationed	Poor households with pre-schoolers or women who are pregnant or lactating
Egypt	Wheat	Price subsidy	General	Total population
Egypt	Rice	Price subsidy	Rationed	Mostly urban
Egypt	Sugar, tea, frozen meats fish, and certain other foods	Price subsidy	Rationed	Total population
India	Wheat and rice	Price subsidy	Rationed	Total population
Mexico	Maize and certain other foods	Price subsidy	General	Mostly urban
Morocco	Wheat	Price subsidy	General	Total population
Pakistan	Wheat	Price subsidy	Rationed	Mostly urban
Philippines	Rice and oil	Price subsidy	Targeted & rationed	All households in areas selected for high level of poverty
Sri Lanka				
(up to 1977)	Rice	Price subsidy	Rationed	Total population
(from 1979)	Rice	Food stamps	Targeted & rationed	50 percent of population biased toward the poor
Sudan	Wheat	Price subsidy	General	Mostly urban
Thailand	Rice	Price subsidy	General	Total population
Zambia	Maize	Price subsidy	General	Mostly urban

Source: Per Pinstrup-Andersen, *Food Subsidies in Developing Countries* (Baltimore: Johns Hopkins University Press, 1988), p. 6.

starchy staples or maize. Substantial savings can result from targeting: in Sri Lanka, targeting and program modification reduced outlays for consumer food subsidies from 15 percent of total government expenditures to less than 3 percent.[3] The impact of targeted subsidies on agricultural prices and incentives depends on how they are financed, but food subsidies need not have adverse effects on agricultural incentives.

Another common price-policy instrument in developing countries is the export tax. The purpose of an export tax is to raise government revenues or reduce domestic commodity prices. The effects of the tax are illustrated in Figure 15-2. Because the country exports the commodity, the world price, P_w, is shown above the price, P_0, which would have prevailed domestically if there were no trade. If exports were freely allowed, this world price would prevail in the domestic market, and a total quantity of Q_2 would be produced domestically, Q_1 would be demanded by domestic consumers, and the difference ($Q_2 - Q_1$) would be exported. Then, if an export tax equal to $P_w - P_d$ were imposed, the domestic price would fall to P_d, consumers would increase con-sumption to Q_3, producers would reduce the quantity supplied to Q_4, exports would decline to $Q_4 - Q_3$, and the government would earn an export tax revenue of ($P_w - P_d$) times ($Q_4 - Q_3$) or the area *bcfg* in Figure 15-2. Poor countries may impose export taxes because they lack an alternative source of revenue. In the Figure 15-2 example, the country is unable to influence the world price P_w, because it is a small producer in the world market for the commodity. Domestic producers pay the cost of the tax through lower prices. If the country is a large producer, such as Brazil in the coffee market, its exports and any export tax influence the world market price. Therefore, part of the burden of the export tax can be passed on to consumers in other countries.

Governments follow many types of pricing policies; those described above are among the most common and direct pricing instruments employed in developing countries. Another common direct-pricing policy is the attempt to stabilize commodity prices through a *buffer-stock* program. With such a program, supplies are purchased by the government if the price drops below a certain minimum floor level, and then dumped on the market if the price rises above a certain ceiling level. The purpose of the program is to stabilize short-run prices rather than alter the long-run price.

[3] Per Pinstrup-Andersen, "The Social and Economic Effects of Consumer-Oriented Food Subsidies: A Summary of Current Evidence," *Food Subsidies in Developing Countries* (Baltimore: Johns Hopkins University Press, 1988), Chapter 1, pp. 13–14.

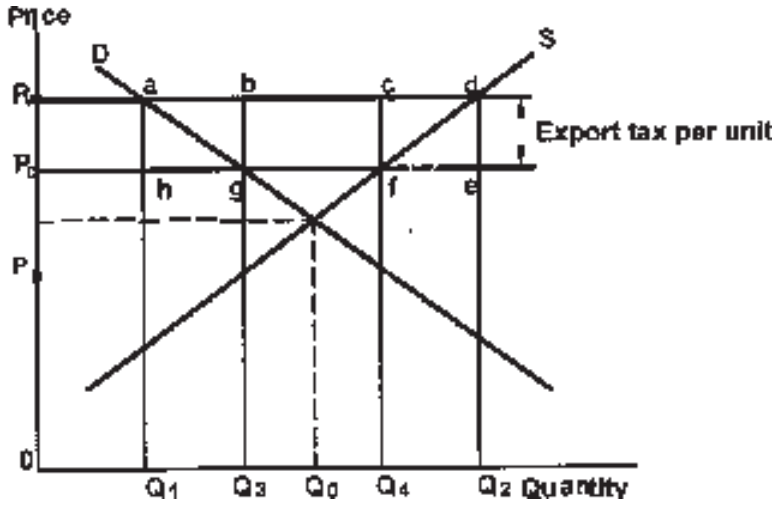


Figure 15-2. Economics of an export tax to raise revenue.

Perhaps the most common indirect pricing policy in developing countries is to overvalue the foreign exchange rate. The foreign exchange rate is the value of the country's currency in relation to the value of foreign currency: for example, the number of Mexican pesos that equal one U.S. dollar. If the official foreign exchange rate implies that the local currency is worth more than it actually is, and if exports occur at the official rate, then this overvalued exchange rate acts as an implicit export tax. However, it does not provide tax revenue to the government. More discussion of the trade effects of direct and indirect pricing policies is found in Chapters 16 and 18.

Interventions to shift either the supply of, or demand for, agricultural products also affect prices. Income transfer and employment programs are examples of policies to shift demands. Policies that steer investments into different sectors, credit programs, agricultural research, and land reforms all affect supplies. The net effect is to change equilibrium prices in markets. Governments can examine price trends and shifts and treat them as indicators of an underlying problem. In some cases, the problem is induced domestically but, in other cases, it is driven by international forces. For example, the rapidly increasing food prices experienced by most developing countries in 2008 were driven more by international than domestic supply and demand factors.

Prices provide important indicators of sector performance. However, policies that attack the symptom — such as rapidly rising prices — by, perhaps, directly imposing price controls, can create long-run

damage to economic growth. A preferred price intervention would be to address the causes of the problem by either investing in productivity-enhancing technologies or by making more imports available. If demand lags behind supplies, then programs to stimulate demands, such as food stamps, might be contemplated. In general, it is preferable to directly address the causes of undesirable price trends rather than to directly intervene in the price formation process, for reasons discussed below.

Short- and Long-Run Effects of Pricing Policies

A few of the direct, short-run effects of food and agricultural pricing policies are illustrated in Figures 15-1 and 15-2. As producer and consumer prices are raised or lowered, changes in production and consumption occur. Producer incomes, foreign exchange earnings, price stability, and government revenues are also directly influenced by price policies. These and other direct and indirect, short- and long-run effects of pricing policies are summarized in Table 15-2.

An important short-term effect of many price policies is to transfer income from producers to consumers. Within consumer groups, the poor tend to be the most sensitive to food prices, since they spend proportionately more income on food. The poor are usually targeted either indirectly because a food they eat is subsidized, or directly by being provided food stamps or access to ration shops. However, studies show

TABLE 15-2. SUMMARY of PRICE POLICY EFFECTS

Direct short-run effects of price policies

1. Changes in consumer and producer prices
2. Changes in quantities produced and consumed
3. Changes in exports, imports, and foreign exchange earnings
4. Income transfers between and among consumer and producer groups
5. Government budget effects
6. Price stability effects
7. Changes in marketing margins and their effects on efficiency of resource allocation

Indirect and long-run effects of price policies

1. Employment changes
2. Incentives for capital investment
3. Incentives for technical change
4. Changes in health and nutrition
5. Long-run changes in allocation of resources in production, storage, transportation, and processing

that even well-targeted price subsidy programs are associated with large "leakages" to the non-poor. These leakages imply higher program costs to the government and create distortions.

A major feature of both direct and indirect effects of many price policies is the influence of those policies on efficiency of resource allocation, depending on the program. In the short run, resources are diverted to less-productive uses because of the subsidy or tax. Additional indirect or long-run misallocation of resources can result as investments and structural changes occur that expand less-efficient sectors of the economy at the expense of more-efficient ones. In addition, efficiency losses occur due to the resource costs associated with collecting taxes or administering the policy. Food stamp and ration shop programs have fewer distortionary impacts because they shift food demands among recipient groups rather than working through price signals.

Distortions in the normal price differences for a commodity across locations, between points in time, and at different levels of processing can influence storage, transportation, and processing of the commodity. For example, urban prices are normally expected to be higher than rural prices for the same food commodity because of transportation costs. If the government sets a ceiling price that is equal in both rural and urban areas, transporting the good from the rural to the urban area may no longer be profitable. In fact, in some cases governments have been known to set urban food prices lower than rural prices, with the result that food, supplied by imports, is transported from urban areas to rural areas.

Likewise, ceiling prices can discourage the normal seasonal storage of a crop if prices are not allowed to rise to cover storage costs. Also, if a government reduces the price margin allowed between farm and retail levels, processors and marketers can be forced out of business.

Pricing policies may be implemented through government procurement agencies with *monopsonistic* (single buyer) power. Thus, opportunities are created for illegal garnering of rents by government employees, and inefficiencies can arise that may force additional reductions in farm prices. These often unintended results of pricing policies can be particularly severe in countries with poor communications and underdeveloped legal systems.

Other indirect effects of pricing policies include employment changes, incentives to develop and adopt new technologies, and changes in health and nutrition. If total revenues for one sector or commodity are raised through pricing policies, more people may be employed. Also, producer incentives to press private firms or public research agencies

for new technologies as well as incentives to adopt technologies may be enhanced. Consumer price subsidies can have important impacts on health and nutrition. In cases where they are financed through government tax revenues and not by depressing producer prices, they can be an effective means of transferring income to targeted groups.

Once price policies are instituted, they are difficult to repeal. Urban consumers in numerous countries have reacted in negative and sometimes violent manners to government attempts to lower subsidies. In summary, price-policy effects are pervasive and influence the efficiency of the production and marketing systems.

MARKETING FUNCTIONS and DEFICIENCIES

Marketing transforms products over time, space, and form through storage, transportation, and processing. Through marketing, goods are exchanged and prices are set. Markets communicate signals to producers, processors, input suppliers, and consumers about the costs of buying, selling, storing, processing, and transporting. These major marketing functions and their linkages to price policies are summarized in Figure 15-3.

In the earliest stages of development and in remote areas, a high proportion of the population lives on farms and is relatively self-sufficient. The demand for agricultural marketing services is limited. As development proceeds, with resulting increased living standards and urbanization, the size and efficiency of the marketing system become more important. Unless marketing services are improved concurrently with the development and spread of new technologies, improvements in education and credit, and the other factors discussed in this section of the book, economic development will be hindered. An inefficient marketing system can absorb substantial private and public resources and result in low farm-level and high retail-level prices.

Marketing System Deficiencies in Developing Countries

Private marketing systems in many developing countries operate relatively well, in that prices are influenced by underlying supply and demand conditions. Products are stored, transported, processed, and exchanged in roughly the amounts expected given prevailing costs, except where governments have intervened with price policies. Price rigging by opportunistic marketing agents is generally not a serious problem. However, because marketing costs can be high and some price distortions do occur, marketing system deficiencies may retard the rate of agricultural growth and influence the distribution of the benefits of

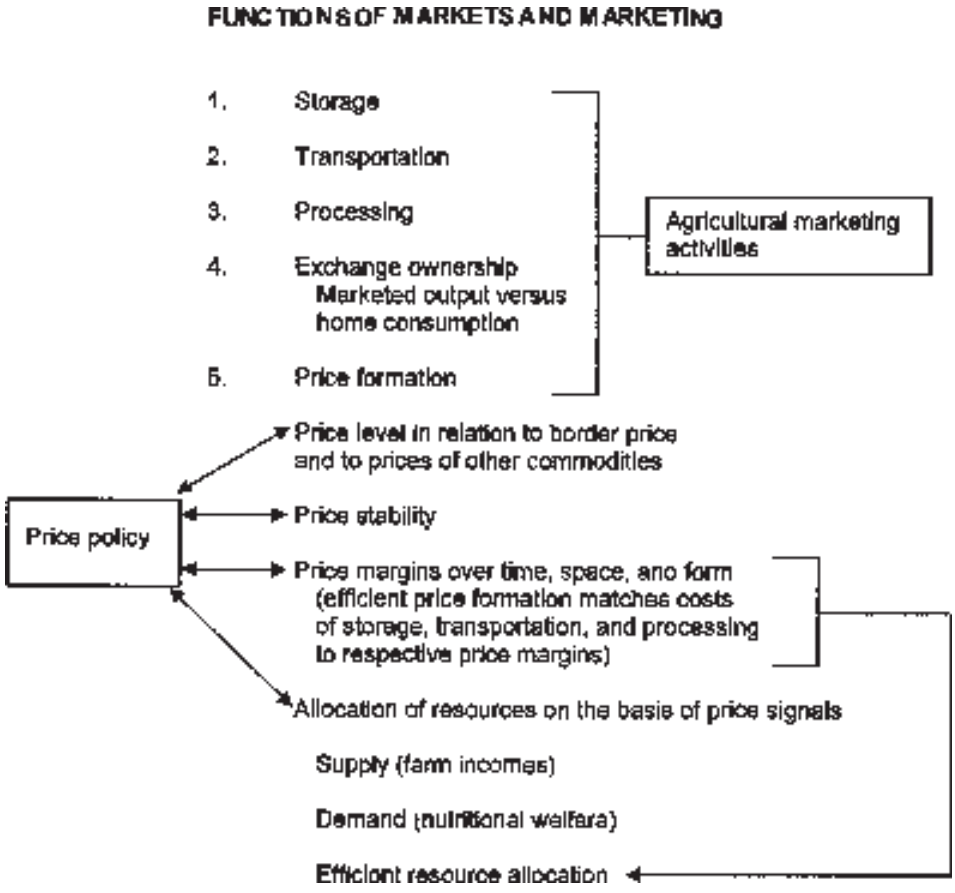


Figure 15-3. Links between agricultural price policy and agricultural marketing. (*Source*: C. Peter Timmer, "The Relationship Between Price Policy and Food Marketing," in *Food Policy: Integrating Supply, Distribution, and Consumption*, ed. J. Price Gittinger, Joanne Leslie, and Caroline Hoisington (Baltimore: Johns Hopkins University Press, 1987), p. 294.)

that growth. Let's consider the nature of these deficiencies before turning in the following section to the possible public role in solving them.

The principal weaknesses in marketing systems in developing countries are: (1) infrastructure deficiencies which raise the cost of transport, (2) producers' lack of information, (3) the weak bargaining position of producers of certain commodities, and (4) government-induced market distortions. The magnitude of each of these deficiencies differs across regions and by country, and is changing for the better in many

countries, but severe problems are found in some countries, particularly in Sub-Saharan Africa. The most visible effect of these weaknesses is to create a large spread between the prices producers are paid for their products and the retail prices. Marketing system deficiencies also create wide variations in producer prices within countries and within years. Examples of producer/retail price spreads and of intra-country price variations are presented in Table 15-3 for selected countries in Africa and Asia. The Sub-Saharan African countries have larger price spreads than do the Asian countries, indicating **more-deficient** marketing systems.

Good communications (e.g., roads, railroads, telephones, postal services) and storage infrastructure are crucial to a well-functioning agricultural marketing system. The availability and quality of rural roads, in particular, have a strong influence on marketing costs and on the willingness of farmers to adopt new technologies and sell any surplus production. A farmer who has only a few hectares may still have to market several tons of output to generate revenue needed to apply new seeds, fertilizers, and other modern inputs. Telephones, postal services, radio stations, and so on, increase access to information. Modern storage facilities are important, to minimize rodent, insect, and water damage while commodities are being held. Most storage occurs on the farm or at facilities owned by private traders. Storage may also be provided by the government for buffer stocks and food distribution programs.

Producers require information to improve market efficiency and reduce transactions costs, as discussed in Chapter 11. Unequal access to information can give a competitive advantage to particular groups of farmers or traders who have more information. When roads, basic telecommunications, and news services are lacking or are available only to a few, those with better information on market prices, crop prospects, prospective changes in international forces, and so on, can earn higher profits, and in some cases, gain political power as well. Thus, access to information is of fundamental importance for agricultural development. The wireless communications revolution is having a profound effect on information availability and, hence, marketing efficiency. Low-cost cell-phones are widely available in developing countries, even in relatively remote rural areas. Vegetable producers from China to Brazil now receive price information through cell-phones. Coffee producers in the Guatemalan highlands use beeper technology to receive up-to-the-minute price information. These innovations lower the cost of attaining information, enable farmers to retain more value on their

TABLE 15-3. PRODUCER/CONSUMER and REGIONAL PRICE SPREADS, SELECTED AFRICAN and ASIAN COUNTRIES

Country	Commodity	Producer/consumer[a] Price spread	Regional[b] spread
Nigeria	Maize	54.5	35.6
	Rice	57.0	72.9
	Sorghum	59.8	45.9
Malawi	Maize	48.2	21.9
	Rice	55.1	68.2
Tanzania	Maize	38.2	25.7
	Rice	56.6	61.3
	Sorghum	48.1	35.5
Kenya	Maize	42.0	30.0
Sudan	Sorghum	61.2	48.2
	Wheat		52.1
Indonesia	Rice	84.0	71.9
India	Rice	82.0	68.9
	Wheat	79.5	65.9
	Sorghum	80.0	63.5
Bangladesh	Rice	79.0	75.0
Philippines	Rice	87.8	82.7
	Maize	71.5	64.2

[a]Producer price/retail price X 100 [b]Lowest price/highest price X 100

Source: Raisuddin Ahmed, "Pricing Principles and Public Intervention in Domestic Markets," Chapter 4, in *Agricultural Price Policy for Developing Countries*, ed. John W. Mellor and Raisuddin Ahmed (Baltimore: Johns Hopkins University Press, 1988), p. 67.

farms, and enhance planning for deliveries, lowering waste and improving efficiency.

The structure of agricultural markets is usually such that the number of middle agents is smaller than the number of producers. Economists hold differing views on whether relatively fewer such intermediaries result in monopolistic power on the part of the intermediary and an unfair bargaining advantage. One needs to be cautious in drawing

Roadside market in Bangladesh.

conclusions. Because the more efficient traders and processors tend to deal in large volumes, there are naturally fewer of these people than there are producers. On the other hand, in most countries with private marketing systems, ease of entry is such that there are still enough processors and other middle agents to provide competition for each other. Examples of collusion and monopolistic power, however, undoubtedly exist for certain products, particularly in isolated areas, where information is costly, and where social and cultural factors play a contributing role. This form of market power is undergoing pressure from the telecommunications revolution described above.

A common marketing problem for producers of major commodities in some developing countries is a situation in which government-controlled marketing organizations (often called *parastatals*) are given monopolistic power and legal authority to purchase all of a product while setting its price as well (see Box 15-1). As discussed in the price-policy section, these tightly controlled markets can have negative effects on producer incentives and market efficiency. Agricultural economic systems are inherently complex. A large amount of information is transmitted through market signals, and decisions made by central marketing boards and parastatal agencies can create serious market distortions. If these types of government agencies are a cause of, rather than a solution to, marketing problems in developing countries, how might the public sector improve marketing efficiency? This issue is addressed in the following section.

THE ROLE of the PUBLIC SECTOR in AGRICULTURAL MARKETING

The primary role of the government is to provide the infrastructure required for an efficient marketing system, particularly roads; a market information system; a commodity grading system; and regulations to ensure the rights of all participants. The underlying rationale for government involvement is the presence of public goods and market failures creating externalities. Public goods provide benefits to society as a whole but would be supplied in less than the socially desirable amounts by the private sector alone. Externalities involve often unintended positive or negative effects of the actions of one person (firm) or persons (firms) on other people.

BOX 15-1.
COMMODITY MARKETING BOARDS in SUB-SAHARAN AFRICA

In some Sub-Saharan African states, publicly-sanctioned monopolies still purchase and export agricultural goods. These marketing boards serve as the sole buyers of major exports, purchase crops at administratively determined prices, and sell them at prevailing world market prices. These state marketing agencies are vestiges of the colonial period, and their origins and histories vary considerably. Many were established during the Great Depression of the 1930s or World War II. Their official mandates were almost invariably to benefit producers by reinvesting revenues in agriculture and, especially, stabilizing producer prices.

As the colonial governments were confronted with growing needs for revenues, they quickly found ways of diverting marketing board funds away from agricultural development and into general revenue coffers. Following independence, African governments continued to use the commodity marketing boards as extensions of their normal revenue-generating arms, and the initial purposes of the boards were ignored. Examples are found in Ghana and Nigeria immediately following independence.

Since colonial times, these boards have been used to transfer resources from agriculture into "modernizing" and mostly urban development. They have served political objectives by raising revenues, increasing employment of favored groups, and keeping primary commodity prices low to benefit urban and industrial concerns. The boards never really fulfilled their mandate to improve and stabilize conditions in agriculture. In combination with other policy distortions, they contributed to the stagnation and decline of agriculture in many African countries.

Provision of Infrastructure

The private sector can be expected to build many of the required storage facilities, processing plants, and so on, but investments in roads, seaports, airports, and, in most cases, telecommunications, will require government involvement. One firm, or even a small group of firms, will lack the incentives to build sufficient roads, not just because of their high cost but because of the difficulty of excluding others from or charging for their use. Roads are a public good that serve all industries, consumers, and national defense.

Several studies have estimated the economic importance of roads to agriculture in developing countries. For example, Spriggs estimated a benefit/cost ratio of 8 for surfaced roads in the eastern rice regions of India.[4] Ahmed and Hossain estimated that incomes were roughly one-third higher for villages with better infrastructure, compared to those with poor infrastructure, in Bangladesh.[5] Fan and Chan-Kang found that even low-quality rural roads in China are excellent investments, with a 5-1 benefit cost ratio.[6] The evidence in numerous countries suggests that investments in infrastructure have greatly narrowed farm-retail margins.

Provision of Information

Provision of accurate crop and livestock reports requires investments in data collection and dissemination. Production and consumption data may be poor quality, but accurate data on marketed quantities, qualities, and prices can give essential information for formulating agricultural policies and for decisions by individual economic agents.

To ensure equal access to information, data need to be collected in all-important markets and disseminated on a regular basis. Information on current market prices, crop prospects, and factors influencing demand can be spread through radio broadcasts and newspapers once the government reports are released. An efficient, competitive market requires widespread access to information. Otherwise, a small group

[4] John Spriggs, "Benefit-Cost Analysis of Surfaced Roads in the Eastern Rice Region of India," *American Journal of Agricultural Economics*, vol. 59 (May 1977), pp. 375–79.

[5] Raisuddin Ahmed and Mahabub Hossain, Developmental Impact of Rural Infrastructure in Bangladesh, International Food Policy Research Institute, Research Report No. 83 (Washington, D.C., October 1990), p. 70.

[6] See Shenggen Fan and Connie Chan-Kang, Road Development, Economic Growth and Poverty Reduction in China, International Food Policy Research Institute, Research Report No. 138)Washington, D.C., 2005). Chapter 4 in this research report contains an extensive review of research findings about infrastructure and income growth in developing countries.

of large-scale farmers, traders, or processors can gain market power at the expense of small farmers, particularly those in remote areas. These agents can then use the resulting profits to influence political and economic policy to favor themselves. The result is both efficiency losses (reduced economic growth) and distributional inequities.

In economies highly oriented toward subsistence production, markets offer few premiums for higher-quality products. As interregional communication, and particularly export trade, develops, quality standards increase in importance because buyers need to compare the products of many different sellers, often without seeing the product before the sale. In markets using modern technology, purchases are often made electronically or over the phone, something that can only happen with a recognized system of grades and standards.

Threshing, drying, cleaning, storage, and processing practices for crops and feeding, slaughtering, storage, and other practices for livestock influence the quality of the final product. Unless grades and standards are established with corresponding price differentials, then producers and processors have little incentive to incur the costs of producing higher quality goods.

Regulations

Market regulations related to factors affecting health and safety, but also to weighing practices and other legal codes that influence the enforceability of contracts, are important to a well-functioning marketing system. The purposes of many of these regulations are to ensure basic honesty and reduce transactions costs in marketing. As discussed in Chapter 11, development brings with it a reduction in personal exchange and associated social and cultural constraints on behavior. Increased impersonal exchange requires new institutional arrangements to substitute for the rules of behavior that had been imposed previously by a more personal society.

The importance of market regulations does not imply a need for heavy involvement of government marketing boards or other public trading agencies. Banning private marketing activities does not improve the welfare of either farmers or consumers. While there is a role for the government in the activities discussed above and perhaps in implementing a price stabilization scheme, more extensive public monopolization of domestic marketing functions tends to produce high marketing costs and large market distortions.

THE CHANGING STRUCTURE of FOOD MARKETS

At the retail level in developing countries, there has been a restructuring in urban areas, which began in earnest during the 1990s, toward increased involvement of large wholesalers and supermarkets in food marketing. In a few cases, the supermarkets are owned by multinational companies and, in most cases, the result has been higher quality products and more efficient (lower-cost) marketing. These markets are, however, increasingly forcing small-scale retailers out of business just as they did in many developed countries. Before the advent of supermarkets, local brokers or small-scale wholesalers brought relatively undifferentiated commodities from the rural areas to small shops or central markets in the urban areas. In most of the developing world, this structure still predominates. However, increasingly, large and often specialized wholesalers bring products from the rural areas to larger processors, supermarkets, and food service chains in urban areas.[7]

As market structures change, they do so unevenly in the developing world, with urban retail markets changing before rural markets, and certain geographic areas undergoing a more rapid transformation than others. For example, according to Reardon and Timmer, the degree of transformation is greatest in South America, East Asia outside of China, and North-central Europe. The second wave of market change is occurring in Central America and Mexico, Southeast Asia, South-central Europe, and South Africa, and the third wave is just beginning in South Asia, China, Eastern Europe, and parts of Africa.[8]

The market transformation tends to include five sets of changes: (1) a shift from raw commodities to more specialized products, (2) rapid organizational change involving consolidation in the processing and retail segments of the food system with the rise of supermarkets, (3) institutional change in the markets with the rise of contracts and private grades and standards for food quality and safety, (4) rapid technological and managerial change among suppliers, wholesalers, and retailers, and (5) distributional and technological impacts of the wholesale and retail market changes back on farmers.

Efforts are needed to prepare poor and small-scale producers to access these new marketing channels; improve quality, adhere to size

[7] See Thomas Reardon and C. Peter Timmer, "Transformation of Markets for Agricultural Output in Developing Countries Since 1950: How Has Thinking Changed?" Chapter 13 in *Handbook of Agricultural Economics, Volume 3: Agricultural Development: Farmers, Farm Production, and Food Markets,* ed. R.E. Evenson, P. Pingali, and T.P. Schultz (Amsterdam: Elsevier, 2006).

[8] Reardon and Timmer, "Transformation of Markets for Agricultural Output..."

and other standards, and develop organizational and contracting skills. Off the farm, impacts of this retail revolution on participants in traditional supply and retailing channels are not well-understood, but may be substantial. Reardon and Timmer provide a detailed synopsis of what has occurred in food markets in developing countries since the 1950s, and the reasons for those changes.[9]

The growth in demand for horticultural products that has occurred as incomes have grown over time, especially in Asia, has produced opportunities for small-scale producers if they can organize intermediate-level assembly of high quality products to fill contracts with wholesalers and even retailers. Efforts to organize small vegetable and fruit producers into cooperatives and other group associations for this purpose, has the potential to significantly raise incomes. The public sector can assist by providing information to meet the demands in the market chain for these relatively high value products (see Box 15-2).

BOX 15-2.
DEVELOPMENT of VEGETABLE MARKET INTERMEDIARIES in NEPAL

Marketing of horticultural products is a major challenge in Nepal because of the large number of smallholder producers in geographically isolated areas with poor infrastructure. High transaction costs in aggregating production to marketable volume and limited market information constrain efficient and competitive marketing. The large number of small producers hinders quality control and coordinated production scheduling. Abundant family labor reduces labor supervision costs, but a mechanism is needed to coordinate product marketing beyond the farm level. With public support, a series of local marketing and planning committees (MPCs) have been established to manage community market collection centers. Through these collection centers, produce is sold to traders who have access to larger, more lucrative markets than are available locally. This institutional mechanism has been highly successful and grown rapidly since 2003. The MPCs provide information to help their members plan market-led production and they provide loans for agricultural inputs. They also lobby the government to influence policy. Each MPC has representatives from five to 12 farmer groups, each of which has 15-20 members. When an MPC is well-established, it can register as a cooperative and gain legal backing that makes available more attractive financing options.

[9] Reardon and Timmer, "Transformation of Markets for Agricultural Output..."

SUMMARY

Food and agricultural prices are major determinants of producer incentives and of real incomes in developing countries. Governments in those countries often adopt pricing policies to reduce food prices for urban consumers at the expense of producers. Political leaders devise policies to meet society's objectives and the demands of interest groups, to generate revenue, and, in some cases, to line their own pockets. Governments can influence agricultural prices by setting price ceilings or floors and enforcing them with subsidies, taxes, manipulation of exchange rates, storage programs, quantity restrictions, and other policy instruments. These interventions influence producer and consumer prices and incomes, production and consumption, foreign exchange earnings, price stability, government revenues, the efficiency of resource allocation, employment, capital investment, technical change, health and nutrition, and marketing margins.

Marketing refers to the process of changing products in time, space, and form through storage, transportation, and processing. Goods are exchanged and prices are determined in markets. The importance of these functions increases as markets become more commercialized. Developing countries often have marketing systems characterized by deficient infrastructure, inadequate information, weak bargaining position for producers for certain commodities, and government-induced distortions. The government can help solve certain marketing deficiencies, particularly the lack of roads and information. The public sector can provide a system of grades and standards as well other regulations. These contributions can help reduce transactions costs that rise as markets become less personal. Governments should avoid the larger parastatal marketing agencies that tend to introduce marketing distortions.

Private marketing systems have gradually evolved over the past 50 years in developing countries, with many countries currently experiencing a shift from raw commodities being sold in small shops to more differentiated food products being assembled and processed by larger wholesalers. Supermarkets are increasingly opening in the urban areas of the richer developing countries. This market consolidation is likely to continue at a fast pace in the future, and will have profound impacts on producers, consumers, and middle agents.

IMPORTANT TERMS and CONCEPTS

Buffer-stock programs
Competitive market
Export tax
Externalities
Foreign exchange rate
Grading system
Infrastructure
Interest groups
Market information
Market regulations
Marketing board
Marketing functions
Marketing margin
Middle agents
Monopsony
Parastatal
Price ceiling
Price distortions
Price floor
Price formation
Pricing policies
Public good
Resource allocation efficiency
Supermarkets
Time, space, and form
Two-price programs

Looking Ahead

This chapter concludes the discussion of technical and institutional factors that can influence development of the agricultural sector. The following set of chapters moves beyond the agricultural sector and considers international trade, macroeconomic forces, international capital flows, and other policies that feed back on agricultural development. We begin in the next chapter by considering the importance of international trade. Problems faced by developing countries with respect to agricultural trade, and potential solutions to those problems, are explored.

QUESTIONS for DISCUSSION

1. Why do developing country governments frequently set agricultural prices below market levels?
2. Why do governments get involved in stabilizing prices?
3. What are the direct short-run effects of price policies in agriculture?
4. What are the indirect and long-run effects of price policies in agriculture?
5. Draw a graph to illustrate the effects on supply and demand of a price ceiling set above the market equilibrium price.
6. Draw a graph to illustrate the effect of a price support to farmers set above the market equilibrium price.
7. What are the major food marketing functions? Why are these functions necessary to get agriculture moving in developing countries?
8. What are the major deficiencies in agricultural marketing systems in developing countries?

9 What role might the government play in improving an agricultural marketing system?
10 Discuss the potential role of buffer stocks in an agricultural development program in a developing country.
11 Why might government marketing boards and parastatals create inefficiencies in resource use?
12 Why do governments in developing countries use export taxes on agricultural commodities more frequently than do governments in more developed countries?
13 Why does the increasing impersonal exchange that accompanies development imply a need for increased government regulation?
14 Why are marketing grades and standards important?
15 Why does increased market information improve marketing efficiency?
16 What has happened to the growth of supermarkets in developing countries over the past few years and why?

RECOMMENDED READINGS

Anderson, Kym, and Yujiro Hayami, *The Political Economy of Agricultural Protection* (Sydney: Allen and Unwin, 1986).

Byerlee, Derek, and Gustavo Sain, "Food Pricing Policy in Developing Countries: Bias Against Agriculture or for Urban Consumers?" *American Journal of Agricultural Economics,* vol. 68 (November 1986), pp. 961–69.

Fan, Shenggan, and Connie Chan-Kang, *Road Development, Economic Growth and Poverty Reduction in China,* International Food Policy Research Institute, Research Report No. 138 (Washington, D.C., 2005).

Gittinger, J. Price, Joanne Leslie, and Caroline Hoisington, eds, *Food Policy: Integrating Supply, Distribution, and Consumption* (Baltimore: Johns Hopkins University Press, 1987).

Krueger, Anne O., Maurice Schiff, and Alberto Valdes, "Agricultural Incentives in Developing Countries: Measuring the Effects of Sectoral and Economywide Policies," *World Bank Economic Review,* vol. 2 (September 1988), pp. 255–71.

Pinstrup-Andersen, Per, ed., *Food Subsidies in Developing Countries* (Baltimore: Johns Hopkins University Press, 1988).

Reardon, Thomas, and C. Peter Timmer, "Transformation of Markets for Agricultural Output in Developing Countries Since 1950: How Has Thinking Changed?" Chapter 13 in *Handbook of Agricultural Economics, Volume 3: Agricultural Development: Farmers, Farm Production, and Food Markets,* ed. R.E. Evenson, P. Pingali, and T.P. Schultz (Amsterdam: Elsevier, 2006).

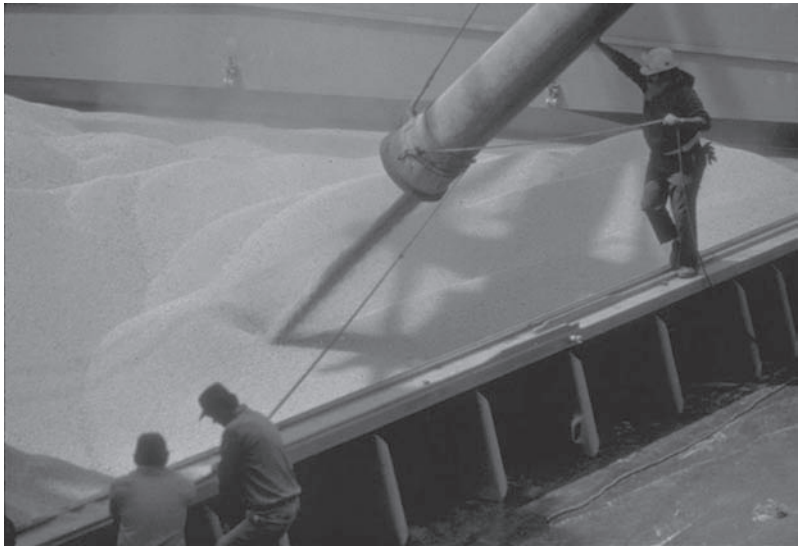
Streeten, Paul, *What Price Food? Agricultural Price Policies in Developing Countries* (Ithaca, N.Y.: Cornell University Press, 1987).

Timmer, C. Peter, *Getting Prices Right: The Scope and Limits of Agricultural Price Policy* (Ithaca, N.Y.: Cornell University Press, 1986).

Timmer, C. Peter, Walter P. Falcon, and Scott R. Pearson, *Food Policy Analysis* (Baltimore: Johns Hopkins University Press, 1983), Chapter 4.

PART 5

Agricultural Development in an Interdependent World



Wheat being loaded on a ship.

CHAPTER 16

Agriculture and International Trade

> The evidence over the past four decades is suggestive … that improved trade opportunities for developing countries … could make an important contribution to growth and hence poverty reduction over time.
>
> — William R. Cline[1]

THIS CHAPTER

1 Explains why countries trade
2 Describes the recent experience of developing countries with trade and why trade patterns change as economic development occurs
3 Discusses problems that impede developing countries from realizing their trade potential with respect to agriculture

WHY COUNTRIES TRADE

The role of international trade in economic development was one of the first questions ever addressed by economists, and has been hotly debated throughout history (see Box 16-1). Today, despite some views to the contrary, most scholars agree that relatively open trade is helpful for successful economic development, and that government trade restrictions generally make growth slower and less sustainable. In this chapter, we ask why open trade facilitates growth, and also why so many governments choose to restrict trade despite its potential economic benefits.

Need for Imports and Exports

Trade facilitates development because it helps a country obtain greater benefits from its productive resources by exporting what it

[1] William R. Cline, *Trade Policy and Global Poverty* (Washington, D.C.: Institute for International Economics, 2004), p. 45.

BOX 16-1.
HISTORICAL ROOTS of INTERNATIONAL TRADE DEBATE

Trade among countries has existed for thousands of years, most of that time in a very loosely structured system. By the sixteenth and seventeenth centuries, money, goods, and credit markets had developed to facilitate trade and colonial expansion. An economic doctrine known as *mercantilism* encouraged exports but discouraged imports. The preferred form of payment was gold rather than goods. A wide range of restrictive trade policies was implemented including tariffs, licenses, export subsidies, and general state control of international commerce. As the Industrial Revolution spread in the late 1700s, mercantilist ideas were increasingly questioned. Raw materials for expanding factory output were imported, and markets for the output were sought abroad. Technological advances in transportation and communications further stimulated trade.

A strong movement toward economic liberalization began in the early 1800s. Perhaps the most important factor in the movement was the unilateral removal of trade restrictions in the United Kingdom. The world's leading economic power at the time, the United Kingdom, repealed its Corn Laws in 1846, ending the world's first major price-support program for agricultural commodities. Britain then sought worldwide trade liberalization, with some success. World trade was relatively free until World War I, although several countries, including the United States and Germany, followed selective protectionist policies. World War I changed the trading environment. Industries, including agriculture, that had expanded during the war, suffered slack demand and falling prices afterward. Governments attempted to protect these industries by introducing protectionist policies during the 1920s and 1930s that the world is still struggling to remove today. Persistent protectionist policies for agricultural products are especially evident.

can produce relatively easily and importing items that are relatively more difficult to produce. Most countries import and export the same goods year after year, but especially in agriculture there can be wide fluctuations in the quantities traded due to temporary shortages or surpluses. Absorbing change through fluctuations in trade volume can help keep domestic prices more stable than they would be with no change in quantities traded. Furthermore, most countries also run persistent trade surpluses or deficits from year to year, with offsetting flows of capital into or out of the country. Net inflows of foreign investment are matched by trade deficits, and net outflows are linked to trade surpluses. When investment flows change, there may be a sudden need to alter trade patterns accordingly.

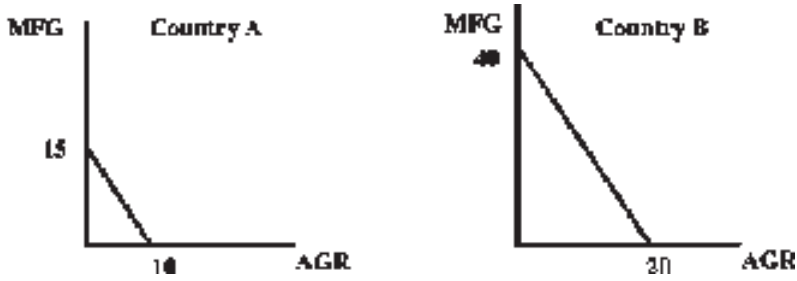
Comparative Advantage

Surprisingly, the rationale for trade does not depend on absolute cost differences between countries. Absolute cost differences determine a country's wealth, not its pattern of trade. Trade is driven by *relative* cost differences among goods within each country, as countries export goods whose cost is relatively low in terms of other goods. This *principle of comparative advantage*, first articulated by David Ricardo in 1817, states that it is best for each country to export those goods for which it has the greatest relative cost advantage and to import goods which are relatively more costly. The principle implies that one country could produce all goods at lower cost than other countries, yet it would still raise its standard of living through trade, exporting what it produces relatively best (see Box 16-2). What counts is the *opportunity cost* in terms of *other goods*.

Despite the logic of comparative advantage and the historical evidence of gains from trade, governments routinely intervene to limit imports and exports. Contemporary economists usually explain these interventions in terms of differences in lobbying power among those who gain and those who lose from these interventions, as described in the next section. Other observers, however, may argue that trade restrictions are actually in the country's national interest. Proponents of trade restrictions often claim that trade opens the economy to increased exploitation by the more-developed countries, by multinational corporations and other actors in international markets, and by the wealthy elites within their own countries. Another important argument against open trade has been that the terms of trade, or the prices received for exports from developing countries compared to the prices paid for imports, tend to decline over time (see Chapter 6 for a discussion of this "structuralist" perspective). Prices for developed-country products are also said to be high because of monopolistic behavior by sellers of developed-country products that are imported by developing countries, and protectionist measures by governments in the more-developed countries. Some have also argued that dependence on international markets for food endangers national security since international markets are volatile and unpredictable. Finally, advocates for trade restrictions have argued that "infant industries" may need to be protected from international competition in order to survive. The solutions to these perceived problems are import-substitution policies that try to move a country towards self-sufficiency. Examples of these policies are direct import restrictions, setting of foreign exchange rates above the market equilibrium (which discourages exports for reasons discussed below),

BOX 16-2.
ILLUSTRATION of the PRINCIPLE of COMPARATIVE ADVANTAGE

To illustrate the principle of comparative advantage, consider two countries, each of which can choose how much to produce of two kinds of outputs: manufacturing (MFG) and agriculture (AGR). The production possibilities frontier (PPF) for each country is shown below, indicating the maximum (or total) amount of MFG and AGR that each country can produce given their resources and technology. For simplicity, both PPFs are shown as straight lines. In our example, country A can produce 15 units of MFG and no AGR, or 10 units of AGR and no MFG, and any combination in between such as 7.5 MFG and 5 AGR. Country B can produce up to 40 units of MFG and no AGR, or 20 units of AGR and no MFG, or any combination in between.



Each country can potentially gain from trade by exporting what it can produce at a lower relative cost as compared to the other country. In this example, the relative cost of production is shown by the slopes of the PPF lines. In country A, each unit of AGR costs 1.5 unit of MFG to produce, whereas in country B that same unit would cost 2 units of MFG. As a result, a trader could buy a unit of AGR in country A for a bit more than 1.5 units of MFG, and sell it to someone in country B for a bit less than 2 units of MFG, producing a total gain from trade of almost .5 units of MFG per unit of AGR that is exported from A to B.

How the gains from trade are divided between the countries depends on the relative bargaining power and the demands for MFG and AGR in each country, but the overall size of the gains and the direction of trade depend only on differences in relative costs. It does not matter whether A is always less productive than B, or AGR is always less productive than MFG. Country A can still exploit its comparative advantage, in this case by specializing in and exporting AGR to obtain more of both goods than it could produce in self-sufficiency. Likewise, Country B can exploit its comparative advantage (relative cost advantage) in MFG by specializing in and exporting MFG to Country A.

and export taxes that discourage exports and stimulate production for the local market instead.

Although most economists favor freer trade, there are debates within economics regarding (1) the degree to which any gains from trade will, in fact, be retained in the developing country and be relatively broadly distributed; and (2) the magnitude of the efficiency losses resulting from attempts to become relatively self-sufficient through import-substitution policies. Few dispute the *potential* for gains from trade, most desire that any gains be broadly distributed, and most agree that increased trade can result in both gainers and losers even if total gains are larger than total losses.

In recent decades most countries have chosen to be relatively open to international trade, with some variation in the degree of openness. Most empirical evidence supports the view that trade restrictions typically limit economic development. In fact, when the world or a group of countries wants to punish a nation, the first step taken is often to refuse to trade with it.

Gainers, Losers, and the Politics of Trade Policy

Despite the potential for significant economic gains from trade and accompanying specialization, international trade policies are a frequent topic of bitter dispute. Policy makers, farm groups, consumer advocates, labor leaders, and environmental groups constantly debate the benefits and costs of trade restrictions that affect exports, imports, the balance of payments, prices, jobs, and the environment. A major reason for such contentiousness is that some people will lose from freer trade even as others gain. Much of the tendency for governments to restrict trade stems from the fact that trade restrictions can generate highly concentrated and easily visible gains, while spreading their cost broadly among the population over time. For example, protecting a particular industry generates immediate high-wage employment and other benefits in that sector, at a cost that is spread over many other activities in the country. Advocates for the protection can readily identify the winners and tell their story, whereas the losses can be seen only through abstract reasoning and aggregate statistics.

The groups which are best able to act collectively and lobby policy makers tend to see trade policies enacted in their favor, even though doing so may impose even greater costs on other, less influential groups. Agricultural lobbies are particularly strong in Europe and Japan, and have obtained relatively large income transfers from other sectors. Within the United States, some commodity groups such as those for sugar and cotton have been particularly successful in securing

government benefits over time. Representatives of various sectors may lobby together for favorable policies, forming coalitions either within or across larger political parties and interest groups.

An important fact about trade policy is that, while the debate often focuses on foreign countries, the actual effect of a policy change occurs mainly within the restricting country. Any trade restriction may have some impact on world prices and hence economic conditions in foreign countries, but most of its effect is on domestic prices and income transfers among the country's own citizens.

DEVELOPING COUNTRY EXPERIENCE with TRADE

During the 1950s and 1960s, import-substitution policies predominated in many developing countries. These inward-oriented policies helped produce a decline in the ratio of exports to GDP in many developing countries until the early 1970s. Since that time, the ratio of exports to GDP has generally increased, paralleling an overall expansion in world trade. However, many developing countries still pursue import-substitution policies. Countries that followed these policies for several years, for example Argentina, India, and Egypt, tended to grow more slowly than those that followed more open-trading regimes, for example Malaysia, South Korea, and Botswana. While it is difficult to generalize based on a few cases, studies that have examined the overall statistical significance of trade restrictions have generally found a negative impact on economic growth.

It is often difficult to classify a country as relatively open or relatively restricted because policies change over time. Many African governments, for example, imposed increasingly restrictive agricultural trade policies on themselves in the 1970s, and then moved to more open agricultural trade in the 1990s.[2] The Mexican economy was quite closed until 1985, but has been relatively open since then. Even South Korea, which is often cited as an example of a successful export-oriented economy, has imposed substantial restrictions on trade from time to time. Trade intervention is usually a matter of degree.

Changing Structure of Trade

Total trade has grown for developing countries over the past 30 years. But the share of agricultural exports in developing country trade has declined steadily from about 60 percent of total exports in 1955 to about 20 percent in recent years. This lower share partly reflects the import-

[2] For details see Kym Anderson and William A. Masters, eds., *Distortions to Agricultural Incentives in Africa* (Washington, D.C.: The World Bank, 2008).

substitution policies mentioned above, but it mainly reflects the impact of income growth, with faster increases in both demand and supply of manufactures than of agricultural products at the global level, as well as increased domestic demand for food within developing countries. Nevertheless, several developing countries still depend on a few agricultural exports for a major share of their foreign exchange earnings.

The dramatic shift in export composition towards manufactures is best illustrated by Southeast Asian countries such as Indonesia, Malaysia, The Philippines, Singapore, and South Korea, with the data shown in Table 16-1. As these countries invested in human and physical capital, their comparative advantage in exports shifted from land-intensive and low-skill labor-intensive activities such as agriculture, to more skill-intensive and capital-intensive products such as manufactures. Agricultural exports were often a very important source of foreign exchange earnings in the past, but other sectors grew faster over time.

As countries develop, their agricultural sectors do not disappear, but tend to become more specialized. Tropical countries have a natural comparative advantage in relatively heat-tolerant tree crops such as coffee, cocoa, tea, rubber, and bananas, or other crops that grow year-round such as sugar. Technological change can affect where crops grow best, as shown for example by the increased exports of citrus and soybeans from developing countries.

Increased demand by more-developed countries for many of the agricultural exports of developing countries are limited due to relatively small income elasticities of demand for those commodities, and in some cases, to the development of synthetic substitutes (e.g. for rubber, jute, sisal, cotton). On the other hand, domestic demand for food within the developing countries often increases rapidly with development. Not only are populations growing, but a high proportion of any income increases are spent on food. The quantity consumed increases, and the mix of foods shifts toward more expensive products (often meats and vegetables, wheat, and certain other grains rather than roots). As a result, the more rapidly growing, middle-income countries have actually become less self-sufficient in food production over the past two decades, even as their agricultural production and incomes have risen. Their increased imports have come partly from other developing countries, and partly from high-income food exporters such as the United States.

Some countries have reacted to increased domestic demand for food by setting artificially low prices for food commodities and overvaluing their exchange rates to tax exports and lower the prices of imports. These policies tend to be counterproductive, as they discourage

TABLE 16-1.
STRUCTURE of EXPORTS for SELECTED SOUTHEAST ASIAN COUNTRIES, 1965–2005

	Percentage share of total merchandise exports									
	Agricultural Commodities					Manufactured Products				
Country	1965	1975	1985	1995	2005	1965	1975	1985	1995	2005
Indonesia	46	12	6	7	5	0	1	13	51	47
Malaysia	50	34	18	6	2	5	17	27	75	75
Philippines	25	10	5	1	1	6	12	27	41	89
Singapore	26	12	4	1	0	30	42	51	84	81
South Korea	9	2	1	1	1	59	81	91	92	91

Note: Indonesia data for 1965 are missing; values shown are for closest available year (1962).
Source: World Bank, World Development Indicators 2009 (online at www.worldbank.org/data).

production. The effects of exchange rate manipulation are discussed in more detail in Chapter 18.

Trade, Employment, and Capital Interactions

Employment growth is crucial for economic development. While few people are totally idle, there is clearly underemployment in most developing countries. By underemployment we mean people working only part-time or in very low-productivity jobs. Several possible linkages exist between trade and employment. One such linkage is the effect of trade on overall growth through more efficient resource allocation, assuming faster growth entails more employment. A second linkage is that export industries in countries in early stages of development tend to be labor-intensive, consistent with the Factor Endowment Theory of Trade (see Box 16-3). Thus, increased exports might lead to greater employment. A third possible linkage is that trade policies might influence the degree of labor intensity in all industries. For example, trade policies might encourage capital-intensive industries through subsidized capital-goods imports.

Empirical evidence suggests that increased exports from developing countries, including agricultural exports, have positive employment implications. Those countries that have followed import-substitution policies (e.g. India) have suffered greater employment problems than more open economies. Research in several countries by the International Food Policy Research Institute (IFPRI) indicates that an export-oriented agriculture increases the demand for hired labor, raises family incomes, and benefits both landowners and landless laborers.[3] Small-scale farmers who produce sugarcane, non-traditional vegetables, and other cash crops for export usually maintain some production of subsistence crops as insurance against market and production risk, but these farmers also benefit from the additional income from the cash crops.

The Role of Trade in Agricultural Development

Agriculture has many roles to play in economic development, and trade can affect the relative importance of these different roles. In fact, an outward-looking trade orientation helps solidify the role of agriculture in development, especially if the outward orientation is accompanied by an agriculture- and employment-based growth strategy. Removal of impediments to trade will facilitate exports, and thus will enhance

[3] Several studies conducted by Joachim Von Braun and others at the International Food Policy Research Institute involved farm and household surveys in Guatemala, The Gambia, Rwanda, and elsewhere.