FOURTH EDITION

PLACES AND REGIONS IN GLOBAL CONTEXT

Human Geography

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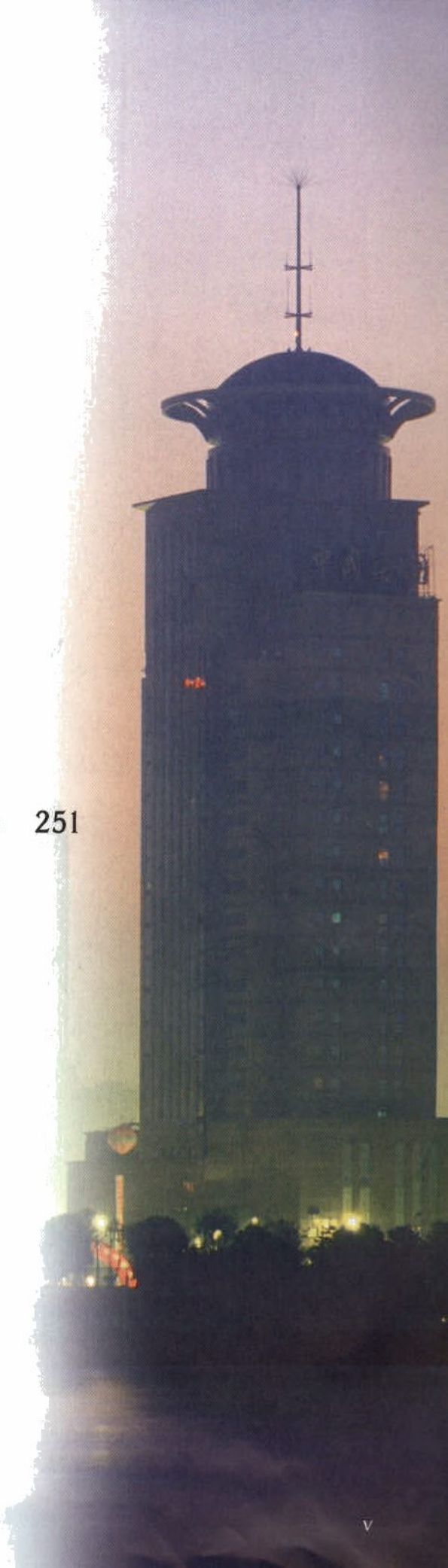

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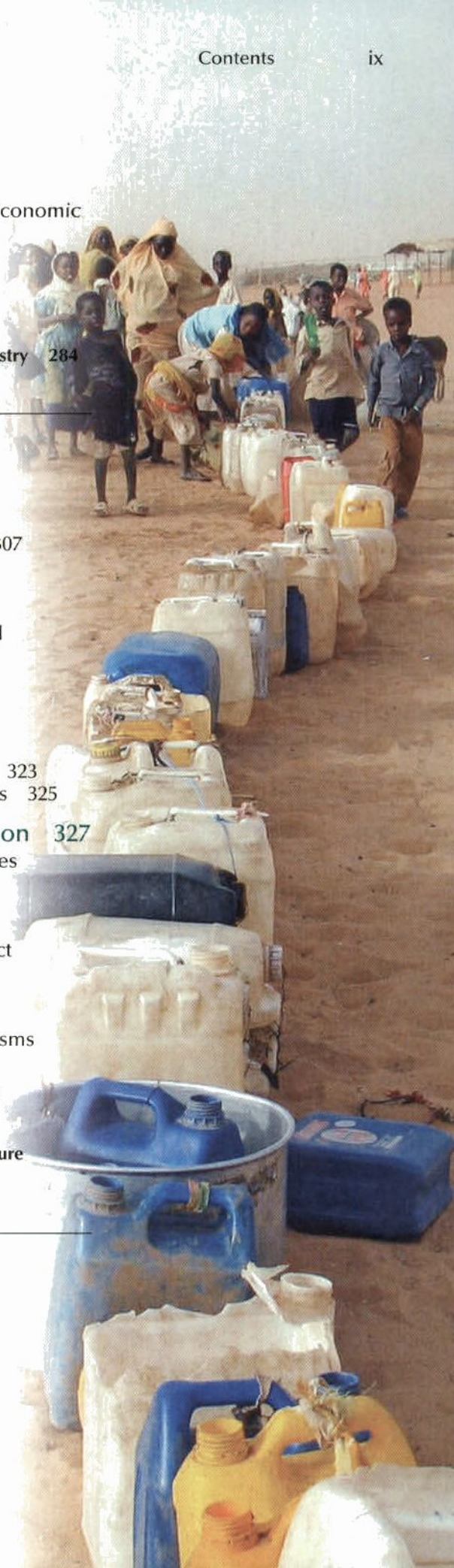

8 Agriculture and Food Production

MAIN POINTS

- Agriculture has been transformed into a globally integrated system; the changes producing this result have occurred at many scales and have had many sources.
- Agriculture has proceeded through three revolutionary phases, from the domestication of plants and animals to the latest developments in biotechnology and industrial innovation.
- The introduction of new technologies, political concerns about food security and self-sufficiency, and changing opportunities for investment and employment are among the many forces that have dramatically shaped agriculture as we know it today.
- The industrialized agricultural system of today's world has developed from—and largely displaced—older agricultural practices, including shifting cultivation, subsistence agriculture, and pastoralism.
- The contemporary agro-commodity system is organized around a chain of agribusiness components that begins at the farm and ends at the retail outlet. Different economic sectors, as well as different corporate forms, have been involved in the globalization process.
- Transformations in agriculture have had dramatic impacts on the environment, including soil erosion, desertification, deforestation, and soil and water pollution, as well as the elimination of some plant and animal species.

According to the most recent agricultural census, over 8.5 billion chickens were sold in the United States in 2002 (roughly 30 plus per person). In 1991 chicken consumption per capita exceeded beef for the first time, in a country that has had something of an obsession with red meat. The fact that each U.S. man, woman, and child currently consumes roughly 1.5 pounds of chicken each week reflects a complex vectoring of social forces in postwar United States. First, a change in taste was driven by a heightened sensitivity to health matters, especially the heart-related illnesses associated with red meat consumption. Second, the cost of chicken meat has in real terms *fallen* since the 1930s (a century ago U.S. residents would eat steak and lobster when they could not afford chicken). Finally, to a growing extent, chicken is consumed in a panoply of forms (Chicken McNuggets, say) which did not exist 20 years ago and which are now delivered to us by the massive fast-food industry—a fact pointing to the reality that people in the United States eat more and more food outside of the home (food consumption "away from home" is, by dollar value, 40 percent of the *average* household food budget). The United States is also the world's largest producer and exporter of poultry meat.

The vast majority of chickens sold and consumed are broilers (young chickens), which are rather extraordinary creatures. In the 1880s there were only 100 million chickens in the United States. The average live bird weight has almost *doubled* in the last 50 years, while the labor input in broiler production has fallen by 80 percent. Disease control and regulation of physiological development have fully industrialized the broiler to the point where it is really a cyborg: part nature, part machine (think *Terminator*). Our understanding of chicken nutrition now exceeds that of any other animal, *including* humans!

Broilers are overwhelmingly produced by family farmers in the United States, but they are farmers under contract to enormous transnational corporations—referred to as "integrators" in the chicken business—who provide the chicks and feed. The growers (who are not organized into unions and have almost no bargaining power) must borrow heavily in order to build the broiler houses and the infrastructure necessary to meet contractual requirements. Growers are not independent farmers at all. They are little more than underpaid workers—what we might call "propertied laborers"—of the corporate producers who also dominate the processing industry.

Jobs in the poultry processing industry, in which the broilers are slaughtered, dressed, and packaged into hundreds of products, are some of the most underpaid and dangerous in the country (a recent government report found almost two-thirds of all poultry processing plants violated overtime payment procedures). Immigrant labor—mostly Vietnamese, Laotian, and Hispanic—represents a substantial proportion of workers in the industry.

The largest 10 companies account for almost two-thirds of broiler production in the United States. Tyson Foods, Inc., the largest producer, accounts for 124 million

Broiler farm, Mississippi

■ The biggest issues food-policy experts, national governments, consumers, and agriculturalists face revolve around the availability and quality of food in a world where access to safe, healthy, and nutritious foodstuffs is unevenly distributed.

pounds of chicken meat per week and controls 21 percent of the U.S. market, with sales of over $5 billion (two-thirds of which go to the fast-food industry). Don Tyson, the CEO of Tyson Foods, says his aim is to "control the center of the plate for the American people."

The United States is the largest producer and exporter of broilers, with a sizable market share in Hong Kong, Russia, and Japan, but it faces intense competition from Brazil, China, and Thailand. The newly global chicken industry is driven by the lure of the massive Chinese market and by the newly emerging and unprotected markets of Eastern Europe and the post-Soviet states. Actually, the world chicken market is highly segmented: Americans prefer breast meat, while U.S. exporters take advantage of foreign preference for leg quarters, feet, and wings to fulfill the large demand from Asia. The chicken is a thoroughly global creature—in its own way not unlike the global car or global finance.[1]

In this chapter, we examine the history and geography of agriculture from the global to the household level. We begin by looking at traditional agricultural practices and proceed through the three major revolutions of agricultural change. Much of the chapter is devoted to exploring the ways geographers investigate the dramatic transformations in agriculture since the middle of the twentieth century and the effects of globalization on agricultural systems.

TRADITIONAL AGRICULTURAL GEOGRAPHY

The study of agriculture has a long tradition in geography. Because of geographers' interest in the relationships between people and land, it is hardly surprising that agriculture has been of primary concern. Research on agriculture is strongly influenced by geography's commitment to viewing the physical and human systems as interactively linked. Such an approach combines an understanding of spatial differentiation, the importance of place, and the fact that practices such as agriculture affect and are affected by processes occurring at different scales. It also provides geographers with a powerful perspective for understanding the dynamics of contemporary agriculture.

One of the most widely recognized and appreciated contributions that geographers have made to the study of agriculture is the mapping of the factors that shape agriculture. They have mapped soil, temperature, and terrain, as well as the areal distribution of different types of agriculture and the relationships among and between agriculture and other practices or variables.

Major changes in agriculture worldwide have occurred in the last four decades. Of these, the decline in the number of people employed in farming in both the core and the periphery is perhaps the most dramatic. Meanwhile, the use of chemical, mechanical, and biotechnological innovations and applications has significantly intensified farming practices (**Figure 8.1**). Agriculture has also become increasingly integrated into wider regional, national, and global economic systems at the same time that it has become more directly linked to other economic sectors, such as manufacturing and finance (**Figure 8.2**). The repercussions from these profound changes range from the structure of global finance to the social relations of individual households.

By examining agricultural practices, geographers have sought to understand the myriad ways humans have learned to modify the natural world around them to sustain themselves, their kin, and ultimately the global community. In addition to understanding agricultural systems, geographers are also interested in investigating the lifestyles and cultures of different agricultural communities. They and other social scientists often use the adjective **agrarian** to describe the way of life that is deeply embedded in the demands of agricultural production. *Agrarian* not only defines the culture of distinctive agricultural communities but also refers to the type of tenure (or landholding) system that determines who has access to land and what kind of cultivation practices will be employed there.

Agriculture is a science, an art, and a business directed at the cultivation of crops and the raising of livestock for sustenance and profit. The unique and ingenious methods by which humans have learned to transform the land through agriculture are an important reflection of the two-way relationship between people and their environments (**Figure 8.3**). Just as geography shapes our choices and behaviors, so we are able to shape the physical landscape. Most introductory textbooks give considerable attention to tracing the origins of agriculture and the distribution of different agricultural practices across the globe. Although agricultural origins are important, the impact of twentieth-century political and economic changes in agriculture are so transformative that in this textbook we focus on the state of global agriculture at the beginning of the new millennium.

[1]After M. Watts, "Commodities," *Introducing Human Geographies*, P. Clorke, P. Crang, M. Goodwin (eds.). Arnold: London, pp. 306–308.

Figure 8.1 Pesticide spraying, Nicaragua Pictured here is a plantation in Nicaragua where this group of workers is getting ready to apply pesticides to the crops.

While there is no definitive answer as to where agriculture originated, we know that before humans discovered the advantages of agriculture, they procured their food through hunting (including fishing) and gathering. **Hunting and gathering** characterizes activities whereby people feed themselves by killing wild animals and gathering *fruits*, *roots*, *nuts*, *and* other edible plants. Hunting and gathering are considered subsistence activities in that people who practice them procure only what they need to consume. Subsistence agriculture replaced hunting and gathering activities in many parts of the globe when people came to understand that the domestication of animals and plants could enable them to settle in one place over time rather than having to go off frequently in search of edible animals and plants (**Figure 8.4**). **Subsistence agriculture** is a system in which agriculturalists consume all they produce. While the practice of subsistence agriculture is declining, it is still practiced in many areas of the globe.

Figure 8.2 Agricultural Floor of the Chicago Board of Trade Farming has always been tied up with trading. Pictured here is the main site for the global trading of agricultural commodities in operation since 1885. While trade remains an important aspect of agricultural production, it is finance that has had one of the most significant impacts on farming over the last several decades in the core as well as in peripheral countries moving it from a household production form to a corporate one. Agricultural finance provides mortgages and credit for farm expansion, land acquisition, and refinancing of debt and is made available through everything from transnational commercial banks and local credit institutions to federal and international agencies and pension funds.

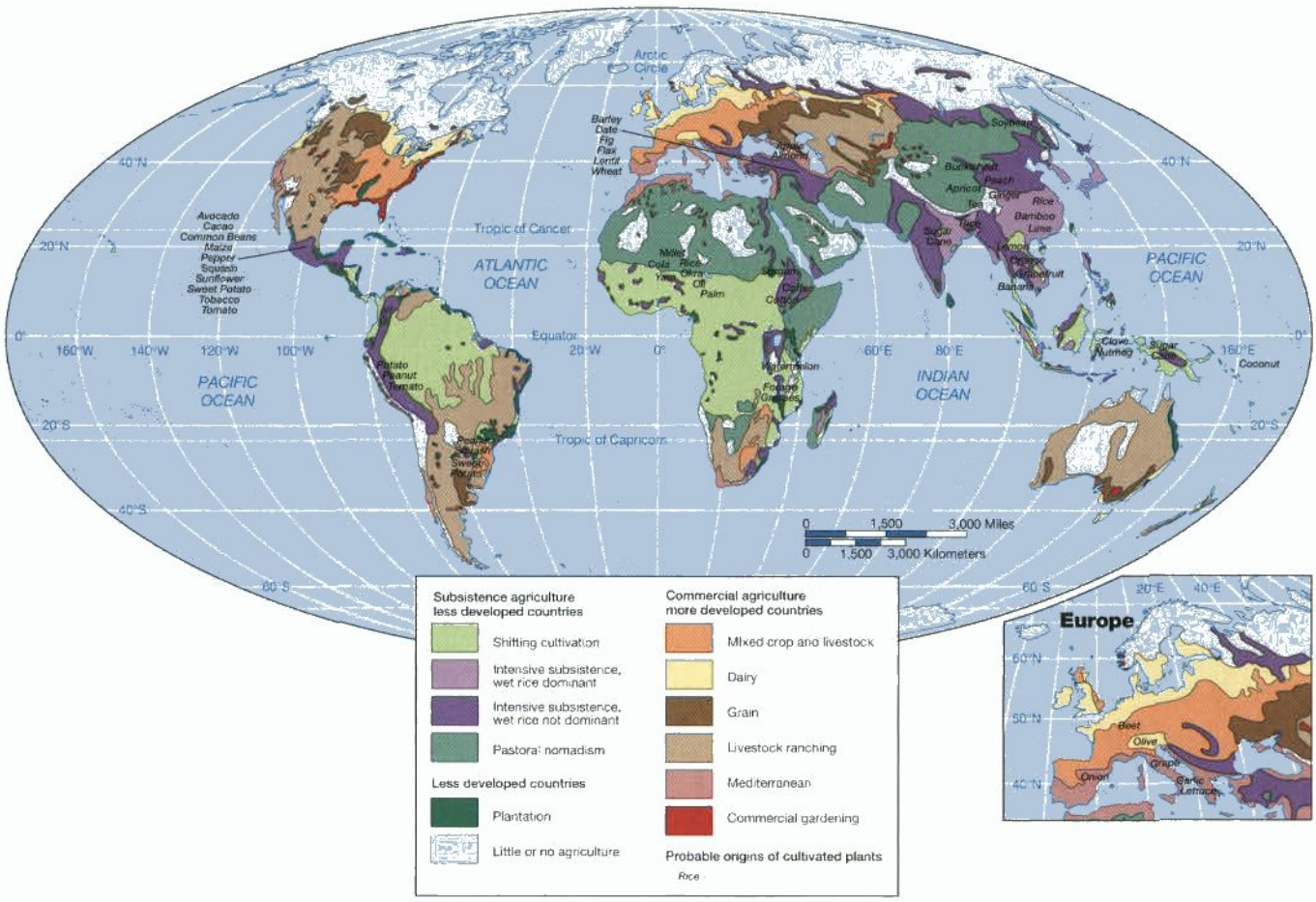

Figure 8.3 Global distribution of agriculture, 2005 The global distribution of agricultural practices is illustrated in this map. Notice the dramatic differences between core and periphery with respect to commercial versus subsistence agriculture. The periphery, though it does contain commercial agriculture, is largely dominated by forms of subsistence, while the core countries contain virtually none. The origins of cultivated plants can also be seen here as they are spread across both the Old World and the New. (After H. Veregin (ed.), *Goode's World Atlas*, 21st ed. Rand McNally, 2005, pp. 38–39.)

During the twentieth century, the dominant agricultural system in the core countries became **commercial agriculture,** a system in which farmers produce crops and animals primarily for sale rather than for direct consumption by themselves and their families. Worldwide, subsistence agriculture is diminishing as increasing numbers of places are irresistibly incorporated into a globalized economy with a substantial commercial agricultural sector. Still widely practiced in the periphery, however, subsistence activities usually follow one of three dominant forms: shifting cultivation, intensive subsistence agriculture, and pastoralism. Although many people in the periphery rely on these traditional practices to feed themselves, traditional practices are increasingly being abandoned or modified as peasant farmers convert from a subsistence and barter economy to a cash economy.

Shifting Cultivation

In **shifting cultivation,** a form of agriculture usually found in tropical forests, farmers aim to maintain soil fertility by rotating the fields they cultivate. Shifting cultivation contrasts with another method of maintaining soil fertility, **crop rotation,** in which the fields under cultivation remain the same but the crops planted are changed to balance the types of nutrients withdrawn from and delivered to the soil.

Shifting cultivation is globally distributed in the tropics—especially in the rain forests of Central and West Africa; the Amazon in South America; and much of Southeast Asia, including Thailand, Burma, Malaysia, and Indonesia—where climate, rainfall, and vegetation combine to produce soils lacking nutrients. The practices involved in shifting cultivation have changed very little over thousands of years (**Figure 8.5**). As a land rotation system, shifting cultivation requires less energy than modern forms of farming, though it can successfully support only low population densities.

The typical agrarian system that supports shifting cultivation is one in which small groups of villagers hold land in common tenure. Through collective agreement or a ruling council, sites are distributed among village families and then cleared for planting by family members. As villages grow, tillable sites must be located farther and far-

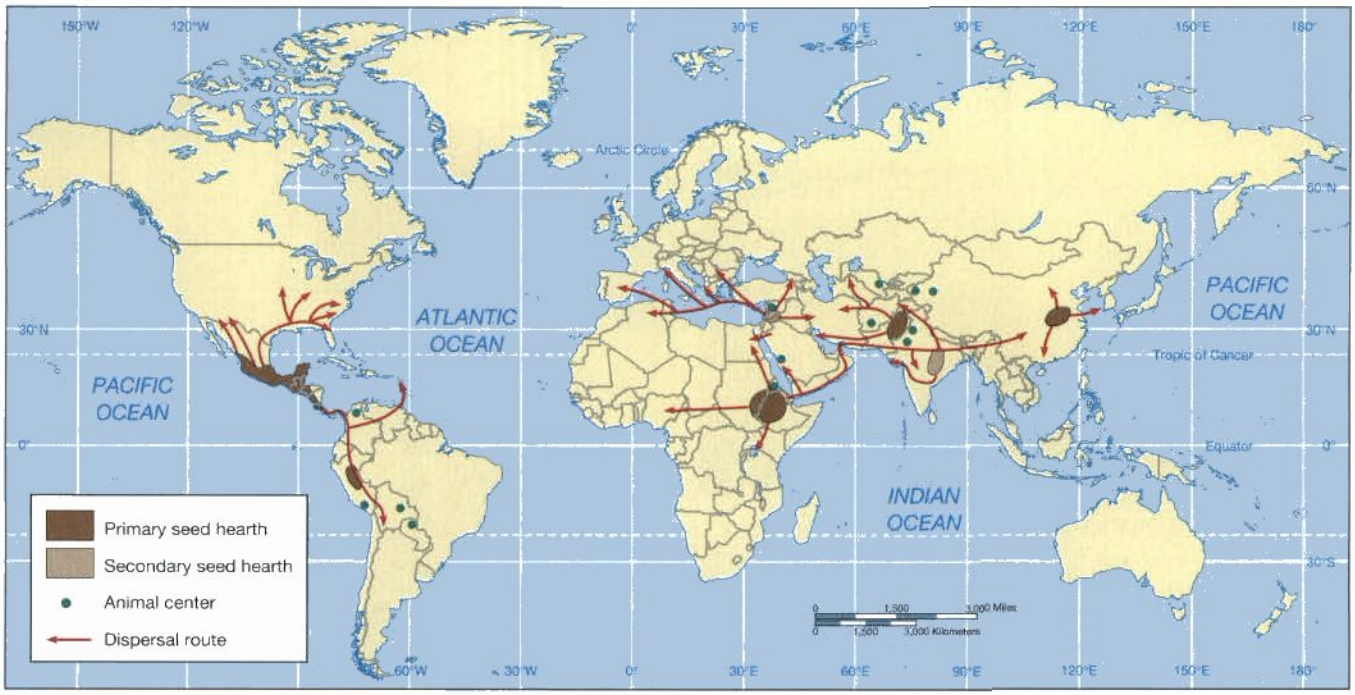

Figure 8.4 Areas of plant and animal domestication Plant and animal domestication did not predominate in any one continent but was spread out across the globe. The origins of plant and animal domestication, however, are not definitively known, and much of what is represented on this map is speculative. Archaeological evidence to date supports the distribution shown here and developed in the mid-twentieth century by Carl Sauer. (After J. M. Rubenstein, *The Cultural Landscape: An Introduction to Human Geography,* 7th ed., Prentice Hall © 2003, p. 319.)

ther away from their center. When population growth reaches a critical stage, several families within the village normally split off to establish another village in one of the more remote sites.

Because tropical soils are poor in nutrients, the problem of the rapid depletion of soil fertility through cultivation means that fields are actively planted for less than five years. The biggest culprits in soil depletion are the cultivated plants and the heavy tropical rains that draw off and wash out the few nutrients that are present in the soil. Once the soil nears exhaustion, a new site is identified and the process of clearing and planting, described in the next paragraph, begins again. It may take over two decades for a once cleared and cultivated site to become tillable again, after decomposition returns sufficient organic material to the soil. When this occurs, the site is reintegrated into cultivation.

Figure 8.5 Shifting cultivation Shifting cultivation is usually practiced in tropical forests. It is a system of agriculture that maintains soil fertility by rotating the fields within which cultivation occurs. This photograph shows a plot under cultivation as well as the burned stumps of the trees that used to occupy the site. Corn and bean shoots are scattered throughout the plot.

The typical method for preparing a new site is through slash-and-burn agriculture, in which existing plants are cropped close to the ground, left to dry for a period, and then ignited (**Figure 8.6**). The burning process adds valuable nutrients to the soil, such as potash, which is about the only readily available fertilizer for this form of agricultural practice. Once the land is cleared and ready for cultivation, it is known as **swidden** (see Chapter 2).

The practice of shifting cultivation usually occurs without the aid of livestock or plow to turn the soil. Thus, this type of agriculture relies largely on human labor, as well as extensive acreage for new plantings because old sites are abandoned frequently when soil fertility is diminished. Although a great deal of human labor is involved in cutting and clearing vegetation, once the site is planted, there is little tending of crops until harvest time.

From region to region the kinds of crops grown and their arrangement in the swidden varies depending upon local taste and plant domestication histories. In the warm,

Figure 8.6 Slash-and-burn agriculture Slash-and-burn is a process of preparing low-fertility soils for planting. In this practice, plants are cleared from a site through cutting, and then the remaining stumps are burned. The burning process helps to add minerals to the soil and thereby improve the overall fertility. Slash-and-burn is a form of agricultural practice that is most effective with low levels of population.

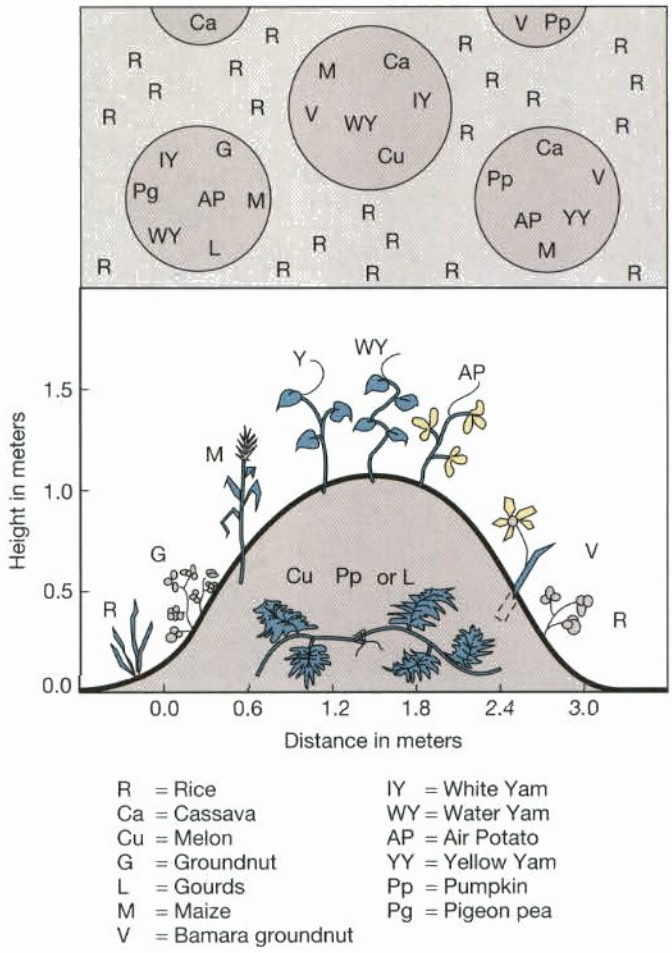

Figure 8.7 Intertillage Planting different crops together in the same field has many benefits, not the least of which are the spreading out of food production over the farming season, reduction of disease and pest loss, greater protection from loss of soil moisture, and control of soil erosion. This diagram provides an illustration of what an intertilled site might contain and how the planting is arranged. Hill-planted seeds have tall stalks and a deeper root system, while those planted on flat earth tend to be spreading plants that produce large leaves for shading.

humid tropics, tubers—sweet potatoes and yams—predominate, while grains such as corn or rice are more widely planted in the subtropics. The practice of mixing different seeds and seedlings in the same swidden is known as **intertillage** (**Figure 8.7**). Not only are different plants cultivated but their planting is usually staggered so that harvesting can continue throughout the year. Such staggered planting and harvesting reduce the risk of disasters from crop failure and increase the nutritional balance of the diet.

Shifting cultivation also involves a gender division of labor that may vary from region to region (**Figure 8.8**). For the most part, men are largely responsible for the initial tasks of clearing away vegetation, cutting down trees, and burning the stumps. Women are usually involved with sowing seeds and harvesting crops. Research on shifting cultivation indicates that the actual division of tasks between men and women (and sometimes children) results from traditional cultural practices, as well as the new demands placed upon households by globalization (recall the discussion of Sudanese children in Chapter 6). For instance, many women have found it necessary to complement their subsistence agricultural activities with craft production for local tourist markets. Their absence from routine agricultural activities means those tasks must be taken up by other household members.

Although heralded by many as an ingenious, well-balanced response to the environmental constraints of the tropics and subtropics, shifting cultivation is not without limitations. Its most obvious limitation is that it can be effective only with small populations. Increasing populations cause cultivation sites to be located farther from villages, with the result that cultivators expend as much energy traveling to sites as they garner energy from the crops they produce. Indeed, at any one time, it is not unusual for land closest to the village to be entirely fallow or unseeded because the soil is exhausted from previous plantings.

Increasingly, population pressures and ill-considered government policies are undermining the practicality of shifting cultivation, resulting in irreparable damage to the environment in many parts of the world. In Central and South America, for example, national governments have used rural resettlement programs to address urban population pressures. In some cases, individuals not familiar with shifting cultivation techniques have employed them improperly. In others, individuals have been relocated to areas unsuitable for such cultivation practices. In parts of the Brazilian Amazon, for example, shifting cultivators have acted in concert with cattle grazers, resulting in accelerated environmental degradation.

Figure 8.8 Gender division of labor Pictured here are women thinning rice plants by hand while a machine plow operated by a man is used to till the earth along the Mekong River, Vietnam. It is not unusual to find women having different access to technology—whether it be agricultural or information—than men in both the core and the periphery. Differential access to technology, training and jobs all help to constitute a gender division of labor in workplaces as well as at home.

Despite its negative impacts on the environment, shifting cultivation can be an elegant response to a fragile landscape. The fallow period, which is an essential part of the process, is a passive and perfectly effective way of restoring plant nutrients to the soil. The burning of stumps and other debris makes the soil more workable, and seeding can proceed with a minimum of effort. Intertillage mimics the natural pattern of differing plant heights and types characteristic of the rain forest. It also helps protect the soil from leaching and erosion. Shifting cultivation requires no expensive inputs (except possibly where native seeds are not available) because no manufactured fertilizers, pesticides, herbicides, or heavy equipment—mechanical or otherwise—are necessary. Finally, the characteristically staggered sowing allows for food production throughout the year. Although shifting cultivation was likely once practiced throughout the world, population growth and the greater need for increased outputs per acre have led to its replacement by more intensive forms of agriculture.

Intensive Subsistence Agriculture

The second dominant form of subsistence activity is **intensive subsistence agriculture,** a practice involving the effective and efficient use of a small parcel of land in order to maximize crop yield; a considerable expenditure of human labor and application of fertilizer is also usually involved. Unlike shifting cultivation, intensive subsistence cultivation often can support large rural populations. While shifting cultivation is more characteristic of low agricultural densities, intensive subsistence normally reflects high agricultural density. Consequently, intensive subsistence usually occurs in the region of the world where agricultural densities are especially high: Asia, and especially India, China, and Southeast Asia.

While shifting cultivation involves the application of a relatively limited amount of labor and other resources to cultivation, intensive subsistence agriculture involves fairly constant human labor in order to achieve high productivity from a small amount of land. With population pressures fierce and the amount of arable land limited, intensive subsistence agriculture also reflects the inventive ways in which humans confront environmental constraints and reshape the landscape in the process. In fact, the landscape of intensive subsistence agriculture is often a distinctive one, including raised fields and hillside farming through terracing (**Figure 8.9**).

Intensive subsistence agriculture is able to support large rural populations. Unlike shifting cultivation, fields are planted year after year as fertilizers and other soil enhancers are applied to maintain soil nutrients. For the most part, the limitations on the size of plots have more to do with demography than geography. In Bangladesh and southern China, for example, where a significant proportion of the population is engaged in intensive subsistence agriculture, land is passed down from generation to generation—usually from fathers to sons—so that each successive generation, where there are multiple male offspring, receives a smaller and smaller share of the family holdings. Yet each family must produce enough to sustain itself.

Under conditions of a growing population and a decreasing amount of arable land, it is critical to plant subsistence crops that produce a high yield per hectare. Different crops fulfill this need, depending on the regional climate. Generally speaking, the crops that dominate intensive subsistence agriculture are rice and other grains.

Rice production predominates in those areas of Asia—South China, Southeast Asia, Bangladesh, and parts of India—where summer rainfall is abundant. In drier climates and where the winters are too cold for rice production, other sorts of grains—among them wheat, barley, millet, sorghum, corn, and oats—are grown for subsistence. In both situations the land is intensively used. In fact, it is not uncommon in milder climates for intensive

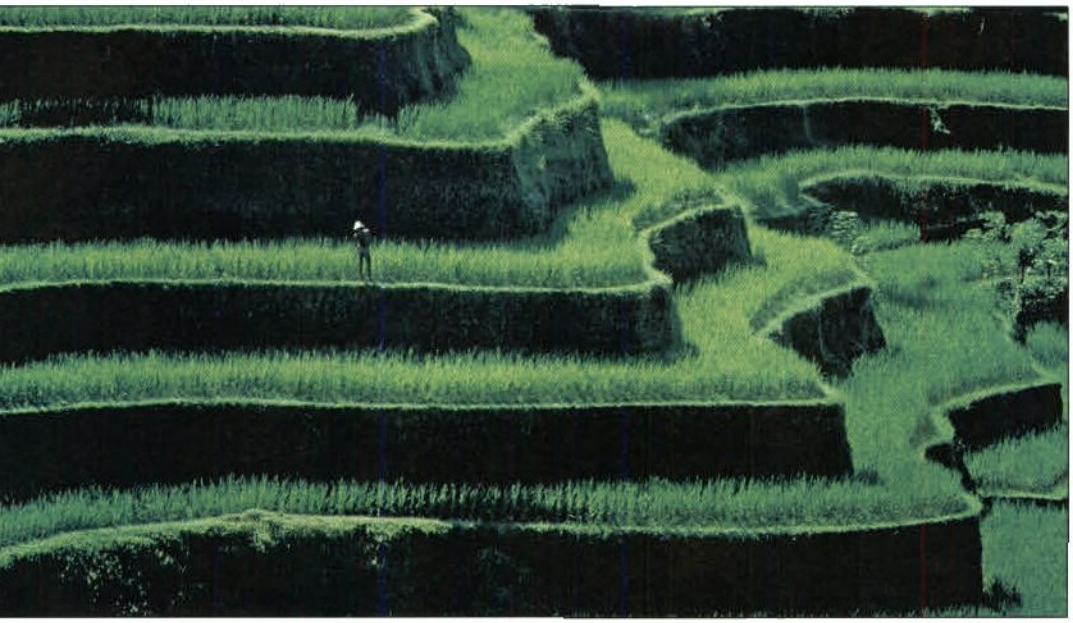

Figure 8.9 Intensive subsistence agriculture Where usable agricultural land is at a premium, agriculturalists have developed ingenious methods for taking advantage of every square inch of usable terrain. Landscapes like this one—of a terraced rice field in Bali, Indonesia—can be extremely productive when carefully tended, and can feed relatively large rural populations.

subsistence fields to be planted and harvested more than once a year, a practice known as **double cropping.**

Pastoralism

Although not obviously a form of agricultural production, pastoralism is a third, dominant form of subsistence activity associated with a traditional way of life and agricultural practice. **Pastoralism** involves the breeding and herding of animals to satisfy the human needs for food, shelter, and clothing. Usually practiced in the cold and/or dry climates of savannas (grasslands), deserts, and steppes (lightly wooded, grassy plains), where subsistence agriculture is impracticable, pastoralism can be either sedentary (pastoralists live in settlements and herd animals in nearby pastures) or nomadic (they travel with their herds over long distances, never settling in any one place for very long). Although forms of commercial pastoralism exist—the regularized herding of animals for profitable meat production, as among Basque Americans in the basin and range regions of Utah and Nevada and among the gauchos of the Argentinean grasslands—we are concerned here with pastoralism as a subsistence activity.

Pastoralism is largely confined to parts of North Africa and the savannas of central and southern Africa, the Middle East, and central Asia. Pastoralists generally graze cattle, sheep, goats, and camels, although reindeer are herded in parts of Eurasia. The type of animal herded is related to the culture of the pastoralists, as well as the animals' adaptability to the regional topography and foraging conditions (**Figure 8.10**).

As a subsistence activity, nomadism involves the systematic and continuous movement of groups of herders, their families, and the herds in search of forage. Most pas-

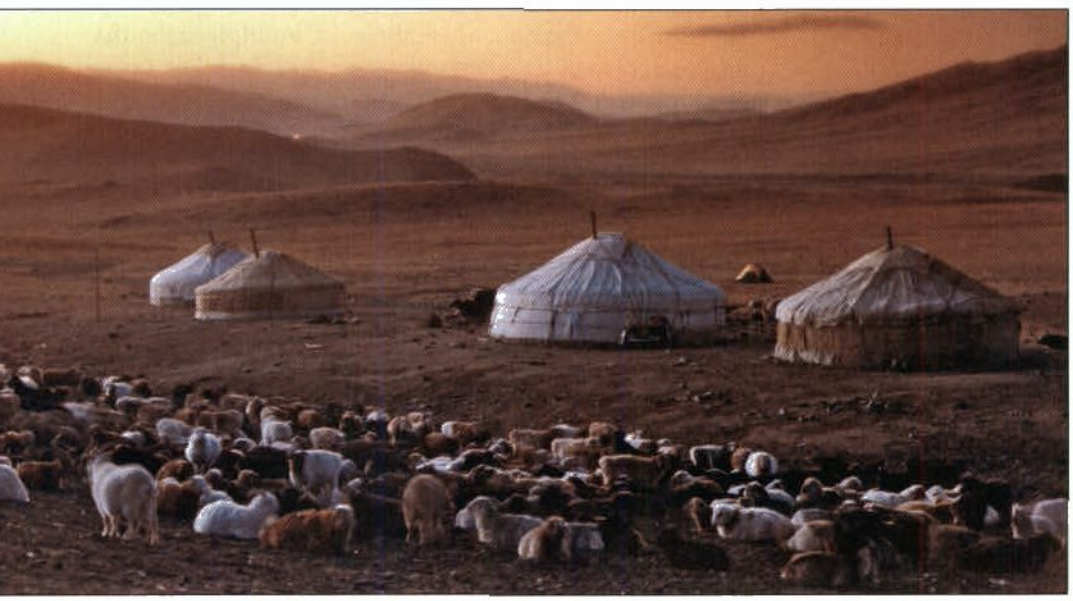

Figure 8.10 Pastoralism In this image, sheep forage near the summer settlement of yurts—circular tent of felt or skins on a collapsible framework—at the base of Tsaast Uul mountain in Mongolia, where pastoralism is the main livelihood. Note the dryness of the landscape. Pastoralism usually occurs where agriculture is not feasible.

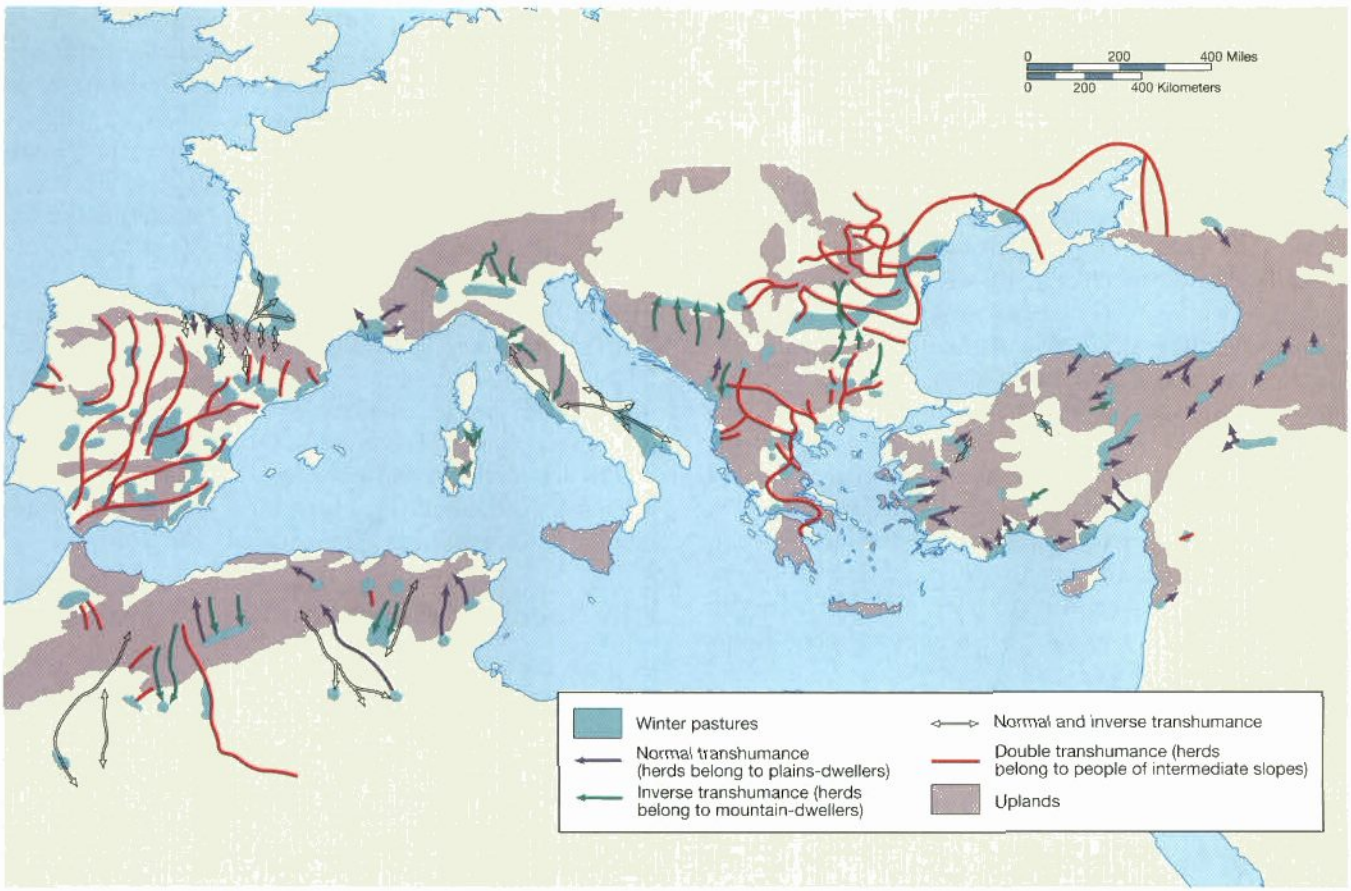

Figure 8.11 Mediterranean transhumance routes Herders in and around the Mediterranean region take their animals between summer and winter pastures by established seasonal routes. Transhumance is an effective adaptation to temporal rhythms. Just as environmental conditions shape herding practices, so do herding practices shape the landscape through the emplacement of identifiable trails. (After "Transhumance" (Figure 7) Map from *The Mediterranean and the Mediterranean World in the Age of Philip II*, Volume I, by Fernand Braudel. Copyright © Librairie Armand Colin, 1966. English translation copyright © by Wm. Collins Sons Ltd. and Harper & Row Publishers, Inc.)

toralists practice **transhumance,** the movement of herds according to seasonal rhythms: warmer, lowland areas in the winter, and cooler, highland areas in the summer (**Figure 8.11**). Although the herds are occasionally slaughtered and used directly for food, shelter, and clothing, often they are bartered with sedentary farmers for grain and other commodities. Women and children in pastoralist groups may also be involved with cultivation. They usually split off from the larger group and plant crops at fixed locations in the spring. The women and children may tend the crops throughout the growing season, or they may rejoin the group and return to the fields when the crops are ready for harvesting. The distinguishing characteristic of pastoralists is that they depend on animals, not crops, for their livelihood.

Like the two other traditional forms of agriculture previously mentioned, pastoralism is not simply a subsistence activity but part of a social system as well. Pastoralists consist of groups of families who are governed by a leader or chieftain. Groups are divided into units that follow different routes with the herds. The routes are well known, with members of the group intimately conversant with the landscape, watering places, and opportunities for contact with sedentary groups. Not surprisingly, pastoralism as a subsistence activity is on the decline as more and more pastoralists have become integrated into a global economy that requires more efficient and regularized forms of production. They have also been forced off the land by competition from other land uses and the state's need to track citizens for taxation and military reasons.

AGRICULTURAL REVOLUTION AND INDUSTRIALIZATION

For a long time human geography textbooks treated the differences in agricultural practices worldwide as systems to be described and cataloged, as we have just done. In the last 25 to 30 years, however, new conceptual approaches to the agricultural sector have transformed the ways we view it. Agriculture has become less a human activity to be described through classification and more a complex component of the global economic system to be explained. Indeed, while the importance and persistence of traditional agricultural forms are acknowledged, such description must be balanced with an understanding of the

ways in which new commercial practices are undermining and otherwise changing the older forms.

Increasingly, geographers and others have come to see world agricultural practices as having proceeded through "revolutionary" phases, just as manufacturing did. As in manufacturing, practices have not been transformed everywhere at the same time; consequently, some parts of the world are still largely unaffected by certain aspects of agricultural change. By seeing agriculture in this new light, we can recognize that, as in manufacturing, the changes that have occurred in agricultural practices have transformed geography and society as the global community has moved *from predominantly* subsistence to predominantly capital-intensive, market-oriented practices.

To understand the new agricultural geography, it is necessary to review the history of world agriculture. This history has proceeded in alternating cycles: long periods of very gradual change punctuated by short, explosive periods of radical change. Geographers and others have divided the history of world agriculture into three distinct revolutionary periods.

The First Agricultural Revolution

The first agricultural revolution is commonly recognized as having been founded on the development of seed agriculture and the use of the plow and draft animals (**Figure 8.12**). Aspects of this transformation have been discussed in Chapters 2 and 4. The emergence of seed agriculture through the domestication of crops such as wheat and rice, and animals such as sheep and goats, replaced hunting and gathering as a way of living and sustaining life. In fact, seed agriculture occurred during roughly the same period in several regions around the world. The result was a broad belt of cultivated lands across Southwest Asia, from Greece in the west into present-day Turkey and part of Iran in the east, as well as in parts of Central and South America, northern China, northeast India, and East Africa.

The domestication of plants and animals allowed for the rise of settled ways of life. Villages were built, creating different types of social, cultural, economic, and political relationships than those that dominated hunter-gatherer societies. Especially important were floodplains along the Tigris, Euphrates, and Nile rivers, where complex civilizations were built upon the fruits of the first agricultural revolution (***Figure 8.13***). Over time the knowledge and skill underlying seed agriculture and the domestication of plants diffused outward from these original areas, having a revolutionary impact throughout the globe.

The Second Agricultural Revolution

A great deal of debate exists among historians as to the timing and location of the second agricultural revolution. Though most historians agree that it did not occur everywhere at the same time, they disagree over which elements

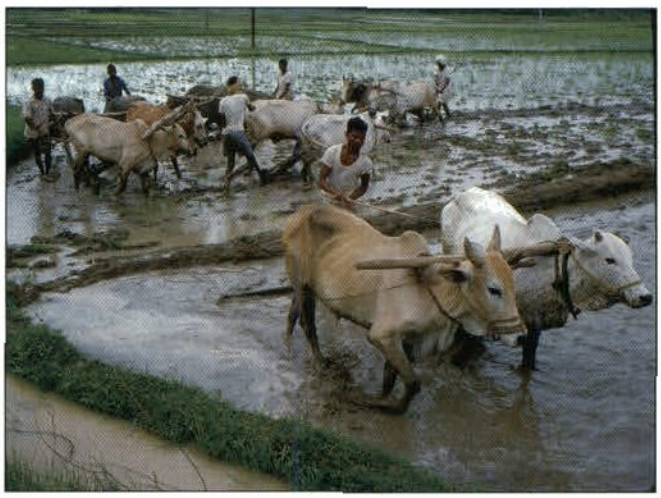

Figure 8.12 Yoked-oxen–drawn plow In many parts of the world, agriculturalists rely on draft animals to prepare land for cultivation. Using animals to assist in agricultural production was an important element in the first agricultural revolution. By expanding the amount of energy applied to production, draft animals enabled humans to increase food supplies. Many contemporary farmers view draft animals as their most valuable possessions. Pictured here are men and oxen tending to rice plants in Malaysia.

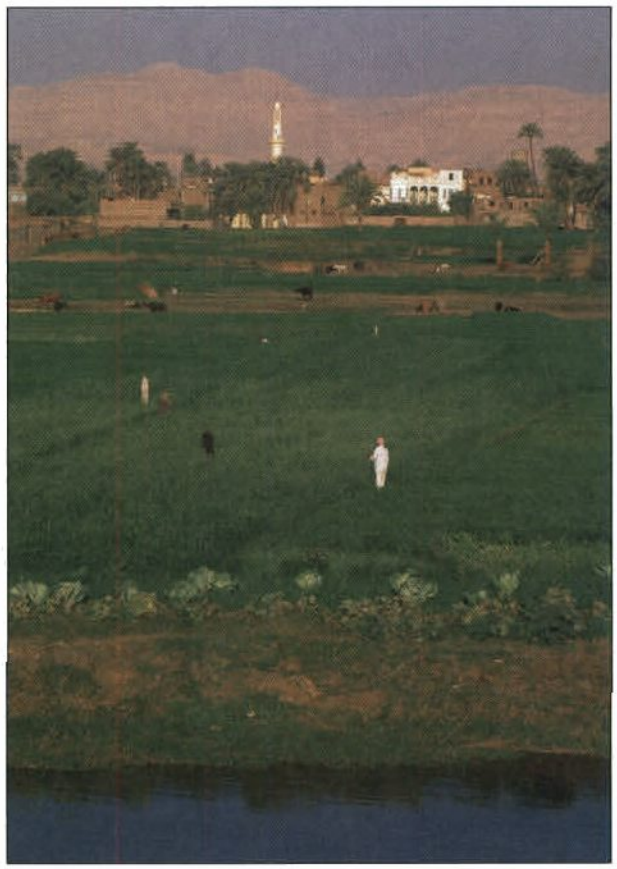

Figure 8.13 Present-day agriculture along the Nile Agriculture along the Nile River dates far back into prehistory. The Nile floodplain was one of the important cultural hearths for sedentary agriculture, providing the foundation for the growth of complex civilizations in Egypt. The Nile floodplain remains a remarkably productive area.

were essential to the fundamental transformation of subsistence agriculture. Important elements included:

- dramatic improvements in outputs, such as crop and livestock yields;
- such innovations as the improved yoke for oxen and the replacement of the ox with the horse; and
- new inputs to agricultural production, such as the application of fertilizers and field drainage systems.

The apex of the second agricultural revolution coincided historically and geographically with the Industrial Revolution in England and Western Europe. Although many important changes in agriculture preceded the Industrial Revolution, none had more of an impact on everyday life than the rise of an industrialized manufacturing sector, the effects of which spread rapidly to agriculture.

On the eve of the Industrial Revolution—in the middle of the eighteenth century—in Western Europe and England, subsistence peasant agriculture was predominant, though partial integration into a market economy was under way. Many peasants were utilizing a crop-rotation system that, in addition to the application of natural and semiprocessed fertilizers, improved soil productivity and led to increased crop and livestock yields. Additionally, the feudal landholding system was breaking down and yielding to a new agrarian system, based not on service to a lord but on an emerging system of private-property relations. Communal farming practices and common lands were being replaced by enclosed, individually owned land or land worked independently by tenants or renters.

Such a situation was logical in response to the demands for food production that emerged from the dramatic social and economic changes accompanying the Industrial Revolution. Perhaps most important of all these changes was the development—through the creation of an urban industrial workforce—of a commercial market for food. Many innovations of the Industrial Revolution, such as improvements in transportation technology, had substantial impacts on agriculture. Innovations applied directly to agricultural practices, such as the new types of horse-drawn farm machinery, improved control over—as well as the quantity of—yields.

By helping to usher in the second agricultural revolution, the Industrial Revolution changed rural life as profoundly as the sedentary requirements of seed agriculture had transformed a hunting and gathering society. As geographer Ian Bowler writes, this revolution moved rapidly from Europe to other parts of the world:

> From its origins in Western Europe, the new commercialized system of farming was diffused by European colonization during the nineteenth and twentieth centuries to other parts of the world. A dominant agrarian model of commercial capitalist farming was established, based on a structure of numerous, relatively small family farms. From this period can be traced both the dependence of agriculture on manufacturing industry for many farm inputs, and the increasing productivity of farm labor, which released large numbers of workers from the land to swell the ranks of factory workers and city dwellers. Moreover, the production of food surplus to domestic demand enabled international patterns of agricultural trade to be established.[2]

The Third Agricultural Revolution

The third agricultural revolution is a fairly recent one that, unlike the previous two, emanates mostly from the New World. Scholars identify the third agricultural revolution as beginning in the late nineteenth century and gaining momentum throughout the twentieth century. Each of its three important developmental phases originated in North America. Indeed, the globalization trends framing all of our discussions in this text are the very same ones that have shaped the third agricultural revolution. The difference between the second and third agricultural revolutions is mostly a matter of degree, so that by the late twentieth century, technological innovations have virtually industrialized agricultural practices (see Box 8.1: "The Blue Revolution and Global Shrimp").

The three phases of the third agricultural revolution are mechanization, chemical farming with synthetic fertilizers (**Figure 8.14**), and globally widespread food manufacturing. **Mechanization** is the replacement of human farm labor with machines. Tractors, combines, reapers, pickers, and other forms of motorized machines have, since the 1880s and 1890s, progressively replaced human and animal labor inputs to the agricultural production process in the United States (**Figure 8.15**). In Europe, mechanization did not become widespread until after World War II. **Figure 8.16** shows the global distribution of tractors as a measure of the mechanization of worldwide agriculture.

Chemical farming is the application of synthetic fertilizers to the soil—and herbicides, fungicides, and pesticides to crops—to enhance yields. Becoming widespread in the 1950s in the United States, chemical farming diffused to Europe in the 1960s and to peripheral regions of the world in the 1970s. The widespread application of synthetic fertilizers and their impact on the environment is what Rachel Carson wrote about in her pathbreaking book, *Silent Spring*, which we discuss in Chapter 4 (**Figure 8.17**).

Food manufacturing also had its origins in late-nineteenth-century North America. **Food manufacturing** involves adding economic value to agricultural products through a range of treatments—processing, canning, refining, packing, packaging, and so on—occurring off the farm and before the products reach the market (**Figure 8.18**). The first two phases of the third revolution affected inputs to the agricultural production process, whereas the final phase affects agricultural outputs. While the first

[2] I. Bowler (ed.), *The Geography of Agriculture in Developed Market Economies*. Harlow, England: Longman Scientific and Technical, 1992, pp. 10–11.

(*text resumes on page 316*)

The Blue Revolution and Global Shrimp

Written by
Brian J. Marks

The first decade of the twenty-first century was a disastrous one for shrimp fishers across the U.S. Southeast, even before the devastating hurricanes of 2005. The price of shrimp has dropped precipitously: Between 2000 and 2003, average Gulf of Mexico dockside prices fell between 38 and 57 percent, depending on shrimp size. Much of this decline occurred in just a few months in 2001. As a result, almost half the Gulf shrimp fleet stopped fishing; ice houses, processing plants, and docks closed; and coastal communities dependent on shrimp for revenues were economically depressed. Fishers responded by intensifying their fishing effort, diversifying their labor into other means of earning income, and replacing hired deckhands on their boats with the unpaid labor of family members (**Figure 8.A**). Some people left the fishery altogether, and others held on, though at a much reduced standard of living.

The cause of this calamity was not because of declining shrimp populations in the Gulf or reduced consumer demand: shrimp landings have been stable and people in the United States are eating more shrimp than they used to. From 1999 to 2003 alone, per capita consumption increased from three to four pounds per person, and has almost tripled since 1980.[1] Why then the price collapse? To find the answer, one has to look at everything from the workings of the international economy to the microbiology of shrimp. The reasons for the price collapse are many, and speak to the global nature of the contemporary food system and how it is complexly affected by *economics*, *politics*, ecology, and technology.

Shrimp have been both fished from the ocean and farmed in ponds for hundreds of years. Commercial shrimp fisheries in the United States first developed in Louisiana as an export industry of dried shrimp to Asia and to Asian immigrants in the United States, then into canned products. Around World War II frozen shrimp began to predominate, tapping into the growing affluence of the U.S. domestic market as more people went out to eat more often and infrastructures for frozen foods (home freezers, refrigerated transport, cold storage warehouses, etc.) both for restaurant service and in homes became commonplace. This paralleled the overall shift in core countries' food systems at that time in terms of household labor (particularly of women), food processing, and production, a process researchers David Goodman and Michael Redclift refer to as "food into freezers: women into factories."[2]

Also after World War II, many countries in Latin America, Asia, and Africa received considerable investment from the United States, Western Europe, and Japan to modernize their economies. Much of this assistance took the form of loans and grants directed at modernizing agriculture (the so-called "Green Revolution" discussed in Box 8.2, pp. 318–320) which

[1]Statistics for this piece are drawn largely from the following: National Marine Fisheries Service *Draft Shrimp Business Options: Proposals to Develop a Sustainable Shrimp Fishery in the Gulf of Mexico and South Atlantic*. Silver Spring, MD: National Oceanic and Atmospheric Administration, 2004; and National Marine Fisheries Service *Current Fisheries Statistics No. 2004-2: Imports and Exports of Fishery Products—Annual Summary, 2004*. Silver Spring, MD: National Oceanic and Atmospheric Administration.

[2]Goodman, D. and M. Redclift, *Refashioning Nature: Food, Ecology, and Culture*. London: Routledge, 1991.

Figure 8.A Louisiana shrimpers Pictured here are fishers harvesting and sorting wild-caught shrimp near Bayou Lafourche, Louisiana.

Figure 8.B Shrimp farm Phang-Nqa Province, Thailand Shrimp aquaculture is based on the use of ponds where shrimp larvae can be introduced and tended. Many of the ponds are built on coastal farmlands, mangrove swamps, or other wetlands.

brought chemical fertilizers, pesticides, agricultural machinery, and new hybrid strains of crops to farmers. Alongside the Green Revolution, came a "**Blue Revolution**" which was the introduction of motorized and larger boats, processing technology and infrastructure, and new production techniques into peripheral country fisheries. A prominent component of the Blue Revolution is **aquaculture,** which is the growing of aquatic creatures in ponds on shore or in pens suspended in water (**Figure 8.B**). Both the Green and Blue Revolutions moved primary sector activities toward a greater dependence on capitalized inputs—like tractors, boats, diesel engines, and petroleum—instead of basic human labor. On the one hand, the Blue and Green Revolutions increased food production in many places; on the other they engendered conflict over how the new practices redistributed power and wealth among producers.

Aquaculture claimed to be an answer to feeding the periphery a cheap form of protein. Advances in farming fish like carp and tilapia in countries like China has increased the availability of fish for millions of people in producing countries. Yet, to date aquaculture has found its biggest economic successes in catering to the demand of affluent consumers in the core for products like shrimp and salmon. Modern shrimp aquaculture both created new shrimp farming industries where none had existed before and revolutionized wild shrimp fisheries and old forms of aquaculture already in place.

The growth of shrimp trade and aquaculture was rapid. From one-twentieth of global shrimp supply in 1980, aquaculture amounted to over one-third by 2001. The majority of world shrimp production of all types was exported in 2001, while approximately only one-quarter was exported in 1980. The major consumers of shrimp are the United States, Japan, and the European Union (**Figure 8.C**). In 2001 Thailand, India, Indonesia, Vietnam, and Mexico were the top five exporting countries by volume. Shrimp is big business, the most consumed seafood in the United States, and a major source of foreign exchange for many countries.

The global shrimp industry is also a major source of controversy. Fisherpeople and other coastal residents of exporting countries have long denounced shrimp exports, both caught at sea and raised in ponds, for damaging their catches of fish for local consumption, for destroying coastal wetlands and agricultural land to build shrimp ponds, and by using wild fish stocks to make fish meal to feed shrimp. There have been many incidents of violence, even killings, of people opposed to shrimp farming in their communities by shrimp farming interests. The so-called "Pink Gold Rush" of shrimp exports has come with a high social and ecological cost.

The industry also faces another problem: that of its own success. Aquaculture means that the limits on biological production from the ocean have been partially overcome so that production can increase much faster than demand, depressing prices. According to a National Marine Fisheries Service report, by volume world shrimp trade increased by 240 percent between 1980 and 2001, but only by 70 percent in terms of value. Global oversupply relative to demand, contributed to the fragility of the shrimp industry in the early 2000s that led to the price collapse felt on the Gulf Coast.

The immediate triggers of the decline in prices were many. In the mid- to late 1990s, the U.S. economy was strong, fueling high demand for shrimp. That demand drove global increases in production of shrimp at the same time that there were stagnant markets in Japan and the European Union. New exporting countries, like Vietnam and Brazil, dramatically accelerat-

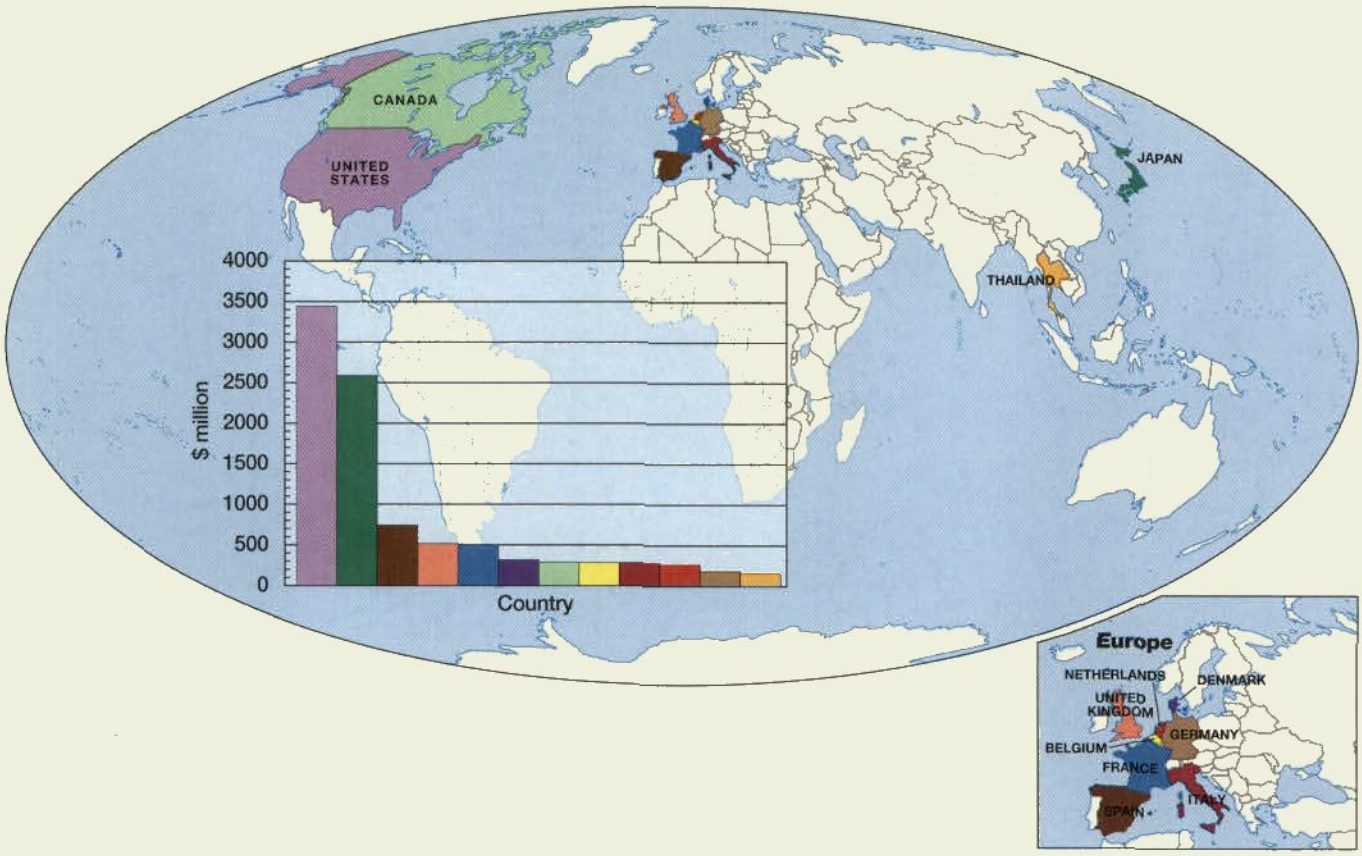

Figure 8.C Leading importers of shrimp, 2004 As this graph makes clear, imported shrimp is a luxury enjoyed almost exclusively by core countries.

ed their production to get their share of the profits. An international economic order that stressed earning foreign exchange in order to service debt and fund development projects was an added incentive to exporting countries to invest heavily in shrimp farming. Shrimp exports to the United States brought in dollars, which were very valuable at that time relative to other major world currencies, allowing these countries to buy more with the proceeds from each pound of shrimp they sold.

This growth in exports might have continued at stable prices if it were not for the faltering of the U.S. economy beginning in 2001 while demand remained flat in other consuming countries. As U.S. demand declined, shrimp exports had nowhere else to go, and as a result inventories started to pile up and prices began to fall. Other markets were not as desirable to shrimp exporters for a variety of reasons. For example, the U.S. market had no significant tariffs on imported shrimp, unlike Japan and Europe, which imposed between 6 and 12 percent tariffs on many countries.

Global economics does not explain everything that occurred in 2001 in the shrimp industry, however. Part of the answer can be found in changing attitudes about health and diet in the consuming countries. The "low-fat" and "low-carb" diet crazes fit well with increased shrimp consumption. Menus promoting healthier eating offered shrimp on salads, in fajitas, or on its own as an alternative to red meat or chicken. The promotion of seafood as a health food in the reconfiguration of the U.S. diet was a big part of the increase in demand for the product, and as prices fell, shrimp became even more attractive as a part of restaurant menus and frozen-food aisles.

The politics of food safety also played a part. The European Union (EU) had much more stringent food inspection requirements than the United States on imported seafood and detected and rejected numerous shipments of imported shrimp in 2001 and 2002 containing chloramphenicol, a powerful antibiotic used to control outbreaks of disease in shrimp ponds that is potentially dangerous to human health and illegal for use in food. In the wake of the chloramphenicol scare in Europe, much shrimp destined for the EU was rerouted to the United States, where standards were not as strict and the chances of detection were smaller.

The ecology of shrimp also contributed to the price collapse. Shrimp raised in ponds are susceptible to many forms of disease, which is why antibiotics are sometimes used on farmed shrimp, causing the food safety concerns mentioned above. This is especially true for farmers using "intensive" techniques, which means they stock high densities of shrimp, feed them processed feeds, and use other technological methods to increase production and profitability. Diseases enter ponds from wild caught or hatchery raised larval shrimp used to stock ponds and from the effluent from nearby already infected ponds. In an effort to reduce outbreaks caused by local wild caught larvae, farms increased their use of shrimp from hatcheries. This attempt backfired as hatcheries, which sell larvae internationally, helped rapidly spread diseases by unknowingly exporting infected shrimp to previously unaffected countries. The white spot syndrome virus outbreak in 1999–2001 is estimated to have reduced global farmed production for a time by about 25 percent and destroyed the majority of some countries' production. The unpredictable increases and decreases in supply caused by expansion of shrimp farming and disease led to considerable price volatility in the late 1990s. High prices caused by temporary disruptions in supply and strong demand led to waves of new investment in the industry, which flooded the market and caused price declines, leading to a boom–bust cycle that accelerated global overproduction. 2000 was one such boom year. The strong U.S. economy and declining production from some exporters due to disease drove prices to very high levels. Many U.S. fishers responded by making new investments in boats, sometimes taking on new debts in order to do so. Shrimp exporters also saw an opportunity to invest and increased production. In 2001, when the U.S. economy slowed down, disease outbreaks in shrimp ponds had been declined, and new exporters entered the market, the result was a crash in the price of shrimp that caught many fishers off guard, leading to the economic hardships that have been experienced since then.

The situation of shrimp is not very different from many other primary commodities, such as coffee, sugar, and cocoa, which have seen dramatic declines in price in recent decades. For example, nominal cocoa prices have declined from a $2,832/ton average in 1980 to $1,190/ton in 2002, a 58 percent decline. When 1980 prices are adjusted for inflation to 2002 dollars using the U.S. Consumer Price Index (reflecting the actual purchasing power of the good over time), the decline is more dramatic, $6,174 versus $1,190, or an 81.8 percent decrease in real value.[3] In comparison, average nominal Gulf of Mexico shrimp prices were $1.63 in 1980 and $1.43 in 2003. Real 1980 prices adjusted using the CPI (1982–2003 = 100) were $3.64 on average. Thus, the real buying power of the earnings from shrimp fell by over 60 percent; shrimp fishers were in effect working for less than half the money they were almost a quarter century earlier. Shrimp was one of several commodities (so-called nontraditional crops) people were encouraged to produce by governments and international development agencies to gain higher prices than those of established products whose values have collapsed. Now it appears that shrimp may be headed in the same direction as other commodities. While U.S. imports of shrimp increased by 49.8 percent from 345,000 tons to 517,000 between 2000 and 2004, the value of that shrimp actually *declined* by $100 million, from $3.8 billion to $3.7 billion. Per pound, the price of imports declined by 35 percent from $5.50 to $3.57 over the same period.

Prosperity from primary commodity production has been ephemeral, highly unequally distributed, and often lacking altogether for those that engage in it. This is true in both core and peripheral countries. Many proposals have been forwarded for addressing the widening gap between the price of primary commodities and cost of living and production for commodity producers, such as increasing international aid or market-based schemes, like fair trade coffee. Reestablishing supply management agreements to support prices, while it would run against deep-seated opposition from core country governments and international financial institutions strongly committed to the unfettered liberalization of trade and investment, may be one of the more promising options.

As domestic U.S. shrimp production accounts for barely 10 percent of U.S. shrimp supply (as of 2003, declining from around 20 percent in the mid-1990s), imports will continue to make up the majority of consumption. Stopping imports is not an option. Domestic shrimp fishers need better prices in order to maintain their livelihoods; fishers and farmers abroad likewise need the earnings from exports. Controlling supplies by means of quotas, floor prices, or other means could achieve higher prices for all producers, more stability in the international market, and an ability to address some of the negative consequences to people and the environment from shrimp production.

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[3] P. Robbins, *Stolen Fruit: The Tropical Commodities Disaster*. London: Zed Books, 2003, pp. 8–9

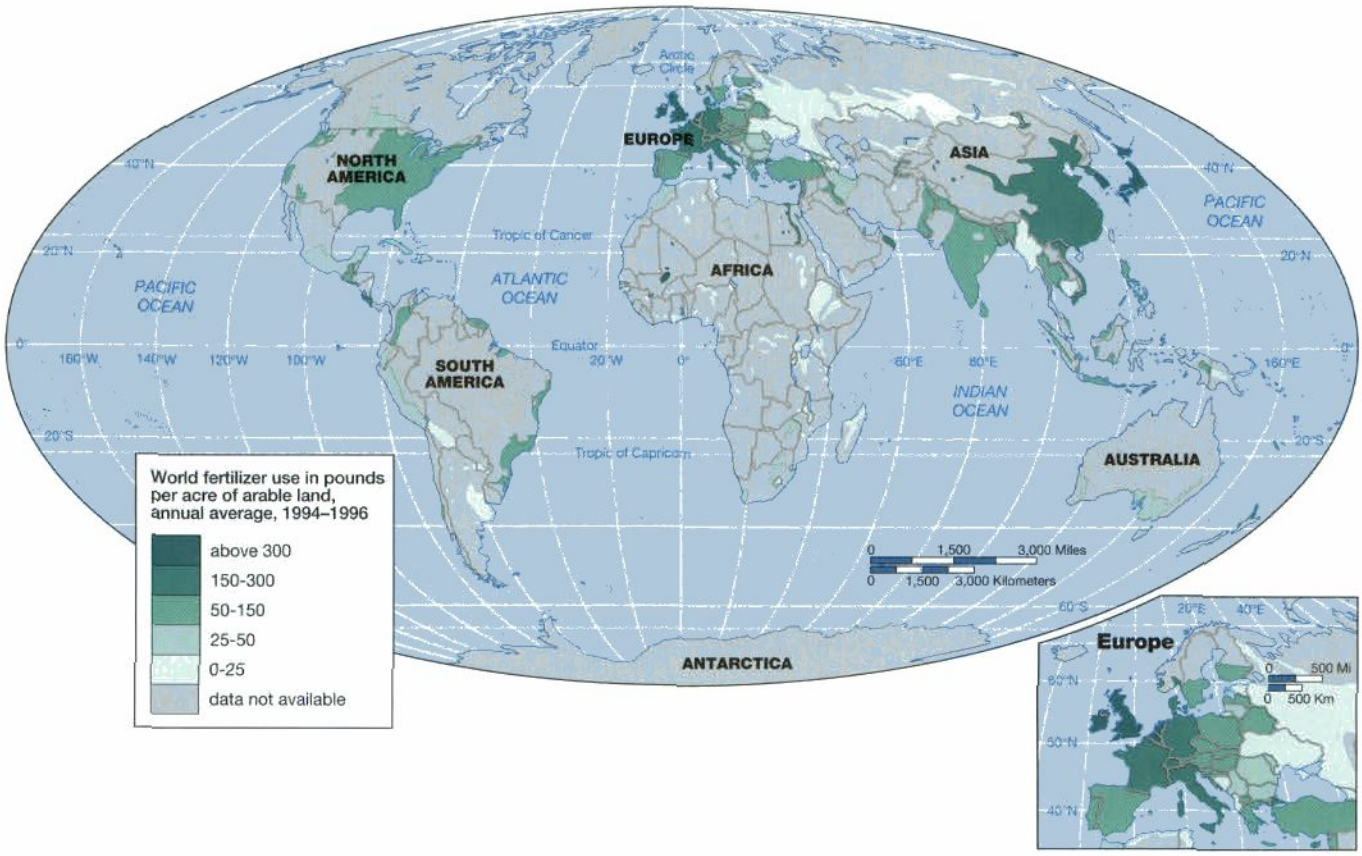


Figure 8.14 Global distribution of fertilizer use, 1992–1996 Western Europe, Egypt, Saudi Arabia, and Japan are among the largest users of fertilizers, with the United States and much of Asia close behind. While they have rapidly growing populations, many African countries cannot afford expensive agricultural inputs, such as fertilizers. The United States and other core European countries export a great deal of food products, and fertilizers enable them to do so. (After J. Hudson and E. Espanshade (eds.), *Goode's World Atlas,* 20th ed., Rand McNally, 2000, p. 49.)

two are related to the modernization of farming as an economic practice, the third involves a complication of the relationship of farms to firms in the manufacturing sector, which had increasingly expanded into the area of food early in the 1960s. Considered together, these three developmental phases of the third agricultural revolution constitute the industrialization of agriculture.

The Industrialization of Agriculture

Advances in science and technology—including mechanical as well as chemical and biological innovations—have determined the industrialization of agriculture over time. As with industrialization, more generally the industrialization of agriculture has unfolded as the capitalist economic system became more advanced and widespread. We regard **agricultural industrialization** as the process whereby the farm has moved from being the centerpiece of agricultural production to being one part of an integrated multilevel (or vertically organized) industrial process including production, storage, processing, distribution, marketing, and retailing. Experts in the study of agriculture have come to see it as clearly linked to industry and the service sector, thus constituting a complex agro-commodity production system.

Geographers have helped demonstrate the changes leading to the transformation of an agricultural product into an industrial food product. This transformation has been accomplished not only through the indirect and/or direct altering of agricultural outputs, such as tomatoes or wheat, but also through changes in rural economic activities. Agricultural industrialization involves three important developments:

- changes in rural labor activities as machines replace and/or enhance human labor;
- the introduction of innovative inputs—fertilizers and other agrochemicals, hybrid seeds, and biotechnologies—to supplement, alter, or replace biological outputs; and
- the development of industrial substitutes for agricultural products (Nutrasweet instead of sugar, and artificial thickeners instead of cornstarch or flour, for example).

Recall, however, that the industrialization of agriculture has not occurred simultaneously everywhere throughout the globe. Changes in the global economic

Figure 8.15 Old and new farm machines In the late nineteenth and early twentieth centuries, agriculture in the United States became increasingly linked with mechanization. (a) This photograph shows a young Vassar College student driving a tractor to plow a field in 1917. It helps to illustrate how transformations in personal transportation diffused to agriculture. (b) This photograph shows contemporary harvesting equipment on a farm in the midwestern United States. While both machines are operated by humans, the contemporary machinery relies on computer chips to send and receive information about the multiple operations of the vehicle.

system affect different places in different ways as different states and social groups respond to and shape these changes. For example, the use of fertilizers and high-yielding seeds occurred much earlier in core-region agriculture than in the periphery, where many people still farm without them. Beginning in the late 1960s, however, core countries exported a technological combination of fertilizers and high-yielding seeds to regions of the periphery (largely in Asia and Mexico) in an attempt to boost agricultural production. In a development known as the **green revolution,** this combination also included new machines and institutions, all designed to increase global agricultural productivity, as described in Box 8.2: "A Look at the Green Revolution."

GLOBAL RESTRUCTURING OF AGRICULTURAL SYSTEMS

When geographers talk about the globalization of agriculture, they are referring to the incorporation of agriculture into the world economic system of capitalism. A useful way to think about the term **globalized agriculture** is to recognize that, as both an economic sector and a geographically distributed activity, modern agriculture is increasingly dependent on an economy and set of regulatory practices that are global in scope and organization.

Forces of Globalization

Several forces, institutions, and organizational forms play a role in the globalization of agriculture. Recall that technology, the economy, and politics have played a central role in propelling national and regional agricultural systems to become global in scope. One important way these forces of change have been harnessed for global transactions is through new institutions, especially trade and financial organizations. The result has been a virtually unprecedented form of production that is built upon an integrated, globally organized agro-production system.

As a result of these forces, the globalization of agriculture has dramatically changed relationships among and within different agricultural production systems. Important outcomes of these changed relationships have been the elimination of some forms of agriculture and the erosion or alteration of some systems as they are integrated

A Look at the Green Revolution

The green revolution was an attempt by agricultural scientists to find ways to feed the world's burgeoning population. The effort began in 1943, when the Rockefeller Foundation funded a group of U.S. agricultural scientists to set up a research project in Mexico aimed at increasing that country's wheat production. Only seven years later scientists distributed the first green revolution wheat seeds. The project was eventually expanded to include research on maize as well. By 1967 green revolution scientists were exporting their work to other parts of the world and had added rice to their research agenda (**Figure 8.D**). Norman Borlaug, one of the founders of the green revolution, went on to win the Nobel Peace Prize in 1970 for an important component of the project: promoting world peace through the elimination of hunger.

The initial focus of the green revolution was on the development of seed varieties that would produce higher yields than those traditionally used in the target areas. However, in developing new, higher yielding varieties, agricultural scientists soon discovered that plants were limited in the amount of nitrogen they could absorb and use. The scientists' solution was to increase the nitrogen absorption capacity of plants by delivering nitrogen-based fertilizers in water (this led to the need to build major water and irrigation development projects). Then the scientists discovered that the increased nitrogen and water caused the plants to develop tall stalks. The tall stalks, with heavy heads of seed on top, fell over easily, thus reducing the amount of seed that could be harvested. The scientists went back to the drawing board and came up with dwarf varieties of grains that would support the heavy heads of seeds without falling over. Then another problem arose: The short plants were growing in very moist conditions, which encouraged the growth of diseases and pests. The scientists responded by developing a range of pesticides.

Thus, the green revolution came to constitute a package of inputs: new "*miracle seeds*," water, fertilizers, and pesticides. Farmers had to use all of the inputs—and use them properly—to achieve the yields the scientists produced in their experimental plots (**Figure 8.E**). Green revolution crops, if properly watered, fertilized, and treated for pests, can generate yields two to five times larger than those of traditional crops. In some countries, yields are high enough to engage in export trade, thus generating important sources of foreign exchange. Furthermore, the creation of varieties that produce faster maturing crops has allowed some farmers to plant two or more crops per year on the same land, thus increasing their individual production—and wealth—considerably.

Thanks to green revolution innovations, rice production in Asia grew 66 percent between 1965 and 1985. India, for example, became largely self-sufficient in rice and wheat by the 1980s. Worldwide, green revolution seeds and agricultural techniques accounted for almost 90 percent of the increase in world grain output in the 1960s and about 70 percent in the 1970s. In the late 1980s and 1990s at least 80 percent of the additional production of grains could be attributed to the use of green revolution techniques. **Figure 8.F**

Figure 8.D The CIYMMT headquarters The Centro International de Mejorimiento de Maiz y Trigo (CIMMYT) (International Center for the Improvement of Maize and Wheat) in Texcoco, Mexico, is involved in plant breeding and research. High-yield-variety seeds were developed here for the Green Revolution. The center holds the world's premiere collection of corn and wheat germplasm. Modern, refrigerated storage vaults store many thousands of varieties. Today, in addition to the static, cold storage, scientists are working with farmers to preserve seeds dynamically.

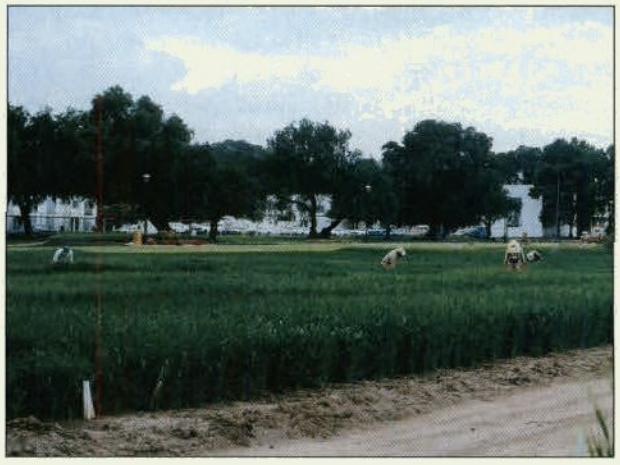


Figure 8.E Green revolution experimental plots The CIMMYT includes numerous plots for breeding and testing seed varieties.

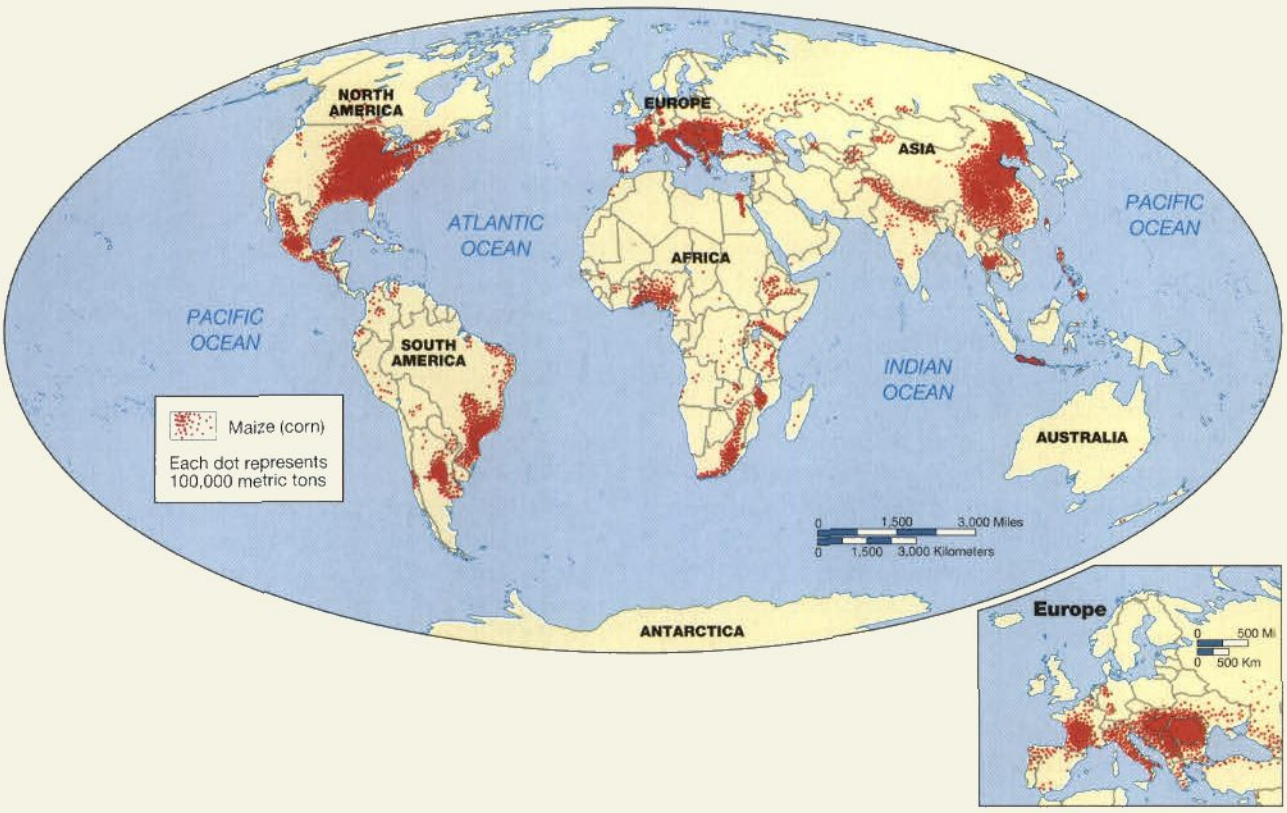


Figure 8.F Global distribution of maize production The widespread production of grains throughout the globe, particularly maize, has been one of the successes of the green revolution (After J. P. Goode, J. C. Hudson, and E. P. Espanshade, Jr., *Rand McNally's Goode's World Atlas*, 20th ed., Rand McNally, 2000, p. 41.)

shows the distribution of maize production worldwide. Thus, although hunger and famine persist, many argue that they would be much worse if the green revolution had never occurred.

The green revolution, however, has not been an unqualified success everywhere in the world. One important reason is that wheat, rice, and maize are unsuitable as crops in many areas, and research on more suitable crops, such as sorghum and millet, has lagged far behind. In Africa poor soils and lack of water make progress even more difficult to achieve. Another important factor is the vulnerability of the new seed strains to pest and disease infestation, often after only a couple of years of planting. Whereas traditional varieties often have a built-in resistance to the pests and diseases characteristic of an area, the genetically engineered varieties often lack such resistance.

Another problem is that green revolution technology has decreased the need for human labor. In southeastern Brazil machines replaced workers, creating significant unemployment. Green revolution technology and training have also tended to exclude women, who play important roles in food production. In addition, the new agricultural chemicals, especially pesticides, have contributed to ecosystem pollution and worker poisonings, and the more intensive use of irrigation has created salt buildup in soils (*salinization*) and water scarcity.

Yet another criticism is that the green revolution has magnified social inequities by allowing more wealth and power to accrue to a small number of agriculturalists while causing greater poverty and landlessness among poorer segments of the population. In Mexico a black market developed in green revolution seeds, fertilizers, and pesticides when poorer farmers, who were coerced into using them, accrued high debts that they could not begin to repay. Many ended up losing their lands and becoming migrant laborers or moved to the cities and joined the urban poor. Some critics who have monitored the effects of the green revolution suggest that political and economic conditions may, in fact, be more important than levels of production with regard to a country's food security.

Even regarding quality, the green revolution crops often fall short. The new seed varieties may produce grains that are less nutritious, less palatable, or less flavorful. The chemical fertilizers and pesticides that must be used are derived from fossil fuels—mainly oil—and are thus subject to the vagaries of world oil prices. Furthermore, the use of these chemicals, as well as monocropping practices, has produced worrisome levels of environmental contamination and soil erosion. In many countries these practices have posed substantial threats to public health, especially among farm workers who are frequently exposed to poisonous (if

not lethal) chemicals. Water developments have benefited some regions, but less well-endowed areas have experienced a deterioration of already existing regional inequities. Worse, pressures to build water projects and to acquire foreign exchange to pay for importation of green revolution inputs have increased pressure on countries to grow even more crops for export, often at the expense of production for local consumption.

In recent years scientists have endeavored to develop seeds with greater pest and disease resistance and more drought tolerance. The new focus is best revealed in Africa. The International Institute of Tropical Agriculture in Ibadan, Nigeria, focuses on foods for the humid and subhumid tropics of Africa, including cassava (imported to Africa from South America by the Portuguese in the sixteenth century), yams, sweet potatoes, maize, soybeans, and cowpeas. The International Crops Research Institute for the Semi-Arid Tropics (located in Hyderabad, India, but with a major research center near Niamey, Niger) focuses on researching staples of the Sahel region, such as sorghum, millet, pigeonpea, and groundnut. Research in Africa on new varieties emphasizes testing under very adverse conditions (such as no plowing or fertilizing). New varieties are chosen not just for good yield but because they will provide stable yields over good and bad years. A focus also exists on developing plants that will increase production of fodder and fuel residues, as well as of food, and that give optimal yields when intertilled—a very common practice in Africa. In the Sahel, scientists are working on crops that mature more quickly to compensate for the serious drop in the average length of the rainy season recently experienced in the region.

There are two final criticisms that have raised concern about the overall benefits of the green revolution. The first is that it has decreased the production of biomass fuels—wood, crop residues, and dung—traditionally used in many peripheral areas of the world. For example, in India, as tractors have replaced draft animals, less dung is produced and thus less is available as fuel. Instead, a greater reliance is being placed upon oil to fuel both tractors and other energy needs; this means that if farmers are to be successful, they increasingly must depend upon the most costly of energy resources. The second is that the green revolution has contributed to a worldwide loss of genetic diversity by replacing a wide range of local crops and varieties with a narrow range of high-yielding varieties of a few crops. Planting single varieties over large areas (monocultures) has made agriculture more vulnerable to disease and pests.

Although the green revolution has come under much justified attack over the years, it has focused attention on finding innovative new ways to feed the world's peoples. In the process the world system has been expanded into hitherto very remote regions, and important knowledge has been gained about how to conduct science and how to understand the role that agriculture plays at all geographical scales of resolution, from the global to the local (**Figure 8.G**).

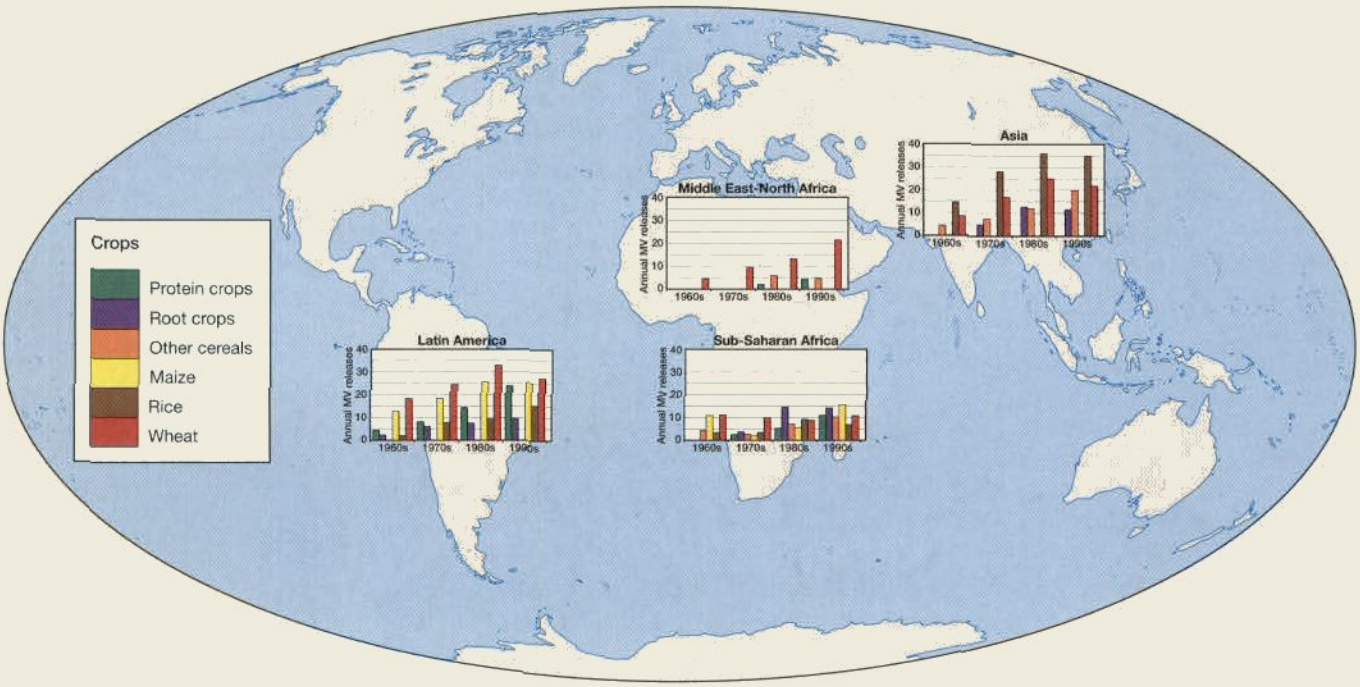


Figure 8.G Effects of the green revolution This map illustrates the increased yields of protein crops, root crops, other cereals, maize, rice and wheat brought about by the green revolution in selected countries in Latin America, Asia, Sub-Saharan Africa and the Middle East and North Africa. (Data from: R. E. Evenson and D. Gollin, "Assessing the Impact of the Green Revolution, 1960–2000," *Science, 300* (2 May 2005), p. 759.)

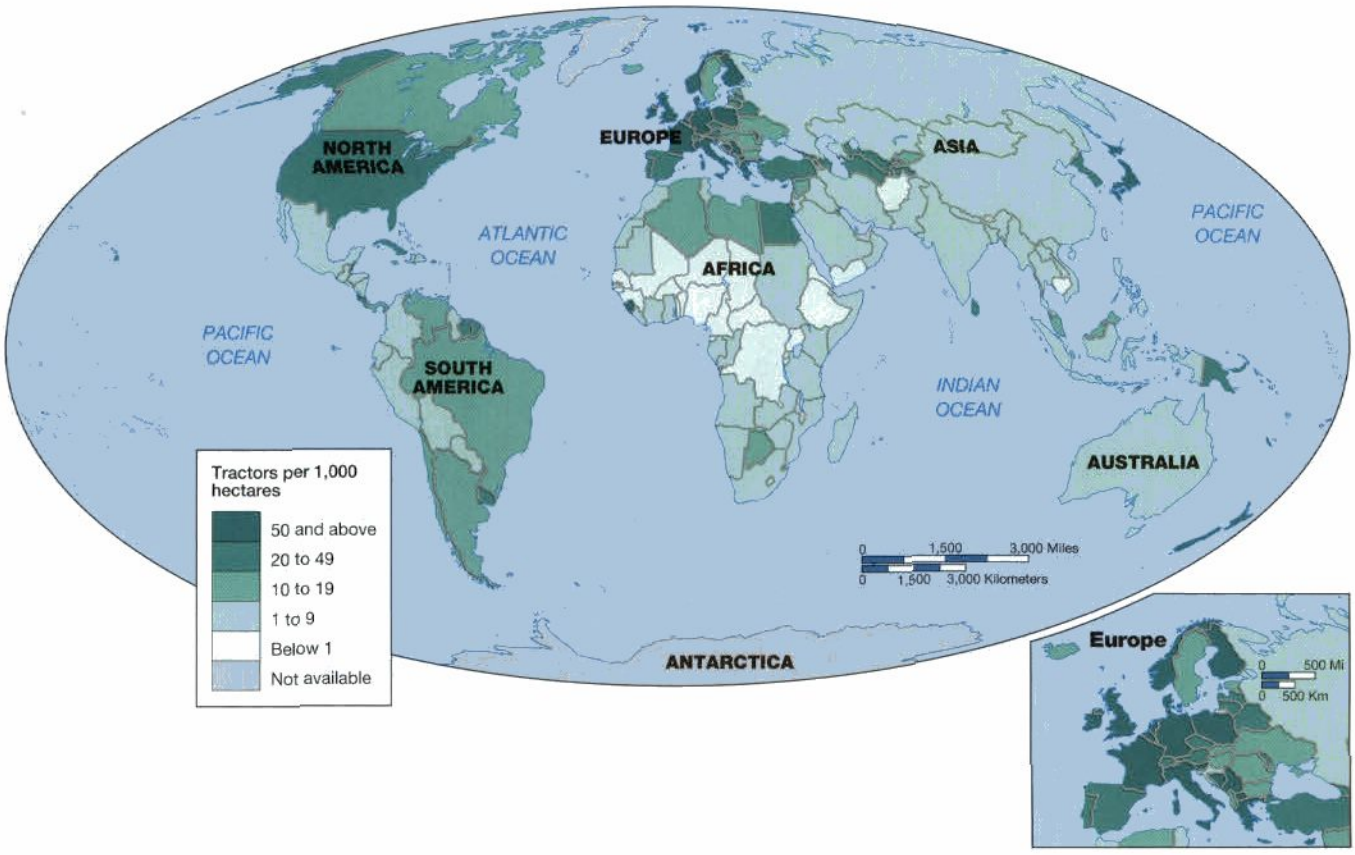


Figure 8.16 Tractors per 1,000 hectares Tractor use, a measure of the mechanization of agriculture, is highest in the core countries. Mechanized farming is an expensive undertaking requiring not only machines but the ability to afford fuels and repairs. Mechanization, however, also allows for more extensive areas of land to be brought into cultivation. (Reprinted with permission of Prentice Hall, from J. M. Rubenstein, *The Cultural Landscape: An Introduction to Human Geography,* 6th ed., © 1999, p. 341.)

into the global economy. Two examples include the current decline of traditional agricultural practices, such as shifting cultivation, and the erosion of a national agricultural system based on family farms (**Figure 8.19**).

Agriculture is one part of a complex and interrelated worldwide economic system. Consequently, important changes in the wider economy—whether technological, social, political, or otherwise—affect all sectors, including agriculture. National problems in agriculture, such as production surpluses, soil erosion, and food price stability, affect agriculture as well as other economic sectors globally, nationally, and locally in different ways. The same is true of more global factors—such as the price and availability of oil and other petroleum products critical to com-

Figure 8.17 Chemical farming An aircraft sprays fungicide on an orange grove near Ft. Pierce, Florida. The fungicide (trade name Kocide) is mixed with a solution to make it stick to the leaves. Planes spray the fungicide at windless times to minimize drift beyond the groves.

Figure 8.18 Food manufacturing Pictured here are tomatoes being processed through an assembly line operation. Food processing is one of the ways that economic value is added to agricultural products before they reach the market.

mercialized agriculture, the stability of the dollar in the world currency market, and recessions or inflationary tendencies in the economy.

Because of the systemic impact of many problems, integration and coordination of the global economy is needed to anticipate or respond to them. In the last several decades, global and international coordination efforts among states have occurred. These include policies advanced by the World Trade Organization (WTO), as well as the formation of supranational economic organizations such as the European Union (EU) and the Association of Southeast Asian Nations (ASEAN). Moreover, these new forms of cooperation are not without their opponents, as the protest against the WTO in Seattle in 1999 made very clear (see also Chapter 12).

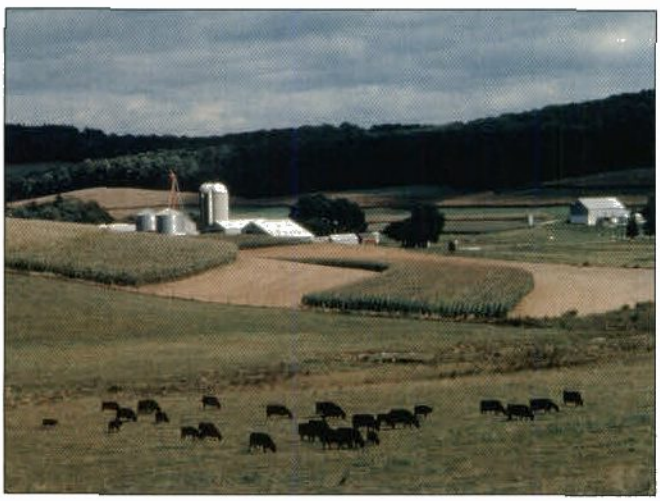


Figure 8.19 Family farm Pictured is an idyllic scene of a prosperous U.S. family farm. Since the third agricultural revolution, the number of family farms in the United States and other core countries has declined dramatically as more corporate forms of farming have emerged. In 1920, about one in every three U.S. citizens lived on farms. By 1978 that number had dropped dramatically, to about one in 28. This drastic change in the U.S. farm population has caused some commentators to observe that the family farm in the United States is now just a myth, because many family farms have been bought out by larger corporations and family farms themselves have become incorporated.

At the same time that supranational organizations and coordination efforts have been addressing global problems, states continue to be essential in mediating crises at national levels. By changing public policy, the state attempts to regulate agro-industries in order to maintain production, consumption, and corporate profits. One way that states try to maintain the profitability of the agricultural sector while keeping food prices affordable is through *direct and indirect subsidies to agricultural producers*. For example, the U.S. government subsidizes agriculture in a number of ways. One is by paying farmers not to grow certain crops that are expected to be in excess supply. Another is by buying up surplus supplies and guaranteeing a fixed price for them.

Subsidies, however, while perhaps stabilizing agricultural production in the short term, can lead to problems within the larger national and international agricultural system. For instance, guaranteeing a fixed price for surplus food can act as a disincentive for producers to lower their production, so the problem of overproduction continues. Once in possession of the surplus, governments must find ways to redistribute it. The U.S. government often sells or donates its surplus to foreign governments, where the "dumping" of cheap foodstuffs may undermine the local price structure for food, as well as reduce economic incentives for farmers to farm. Billions of dollars are paid out each year in agricultural subsidies, the effects of which are complex and global in impact.

Many reasons exist for state intervention in agriculture. Economic interests can be both internally and externally driven. At the internal level, governments routinely intervene in one economic sector or another in order, for instance, to correct wider problems of inflation

or depression. In the 1930s the U.S. government attempted to address the problem of economic depression through policies intended to reduce overproduction—policies that were initiated over a century ago.

States can also intervene in the agricultural sector with respect to consumers' interests. Because of subsidies to farm income, the real cost of food may be quite high, but many states in both the developed and less developed world also subsidize the price of food in the marketplace. Such policies are meant to keep the workforce well fed and healthy, as well as to avoid problems of civil unrest should food prices exceed the general population's ability to pay. Nineteenth-century bread riots—a response to the high cost of flour and bread—were a common occurrence in Europe, and similar forms of civil unrest in response to food prices are not uncommon today in many peripheral countries, where states lack the capital to provide adequate subsidies or where subsidies have been eliminated.

In addition to the internal regulation and assistance of agricultural practices within a country, countries—especially in the core—are also involved directly and indirectly in the agricultural sectors of other countries, primarily those in the periphery. Food as well as agricultural development aid are widespread and popularly accepted ways in which core states intervene in the agricultural sector of peripheral states. Such intervention is one way that peripheral states are incorporated into the global economy. In addition to straightforward food aid, core states also attempt to improve the capacity of the agricultural sector of peripheral states (**Figure 8.20**). Unsuccessful agricultural development projects—whether because of poor design, implementation, or some other reason—as well as successful ones illustrate the many ways in which global forces produce different local consequences and reactions from local people. International development organizations and institutions like the World Bank and the Food and Agriculture Organization (FAO) have been involved in agricultural development projects in the periphery for nearly five decades.

A close look at Latin America helps explain how different international and national agricultural policies can shape productivity in a particular region. While Latin America provides a useful illustration of changing agricultural development policy, its experience is not necessarily the same as that of other regions of the world, whose histories, economies, politics, and culture have shaped the receipt and implementation of development programs in different ways.

Agricultural Change and Development Policies in Latin America

During the first part of the twentieth century, the yields of most agricultural crops in Latin America were very low (less than 1 ton per hectare), and farmers with small plots of land could not produce enough to feed themselves, let alone sell in the market. As population and urban consumption demands increased, countries such as Mexico and Brazil had to import basic food crops, such as wheat and corn. The legacy of large landholdings from the colonial period was compounded by the accumulation of land by the wealthy and by foreign companies in the late nineteenth century. This led to widespread rural poverty, landlessness, and frustration that aided

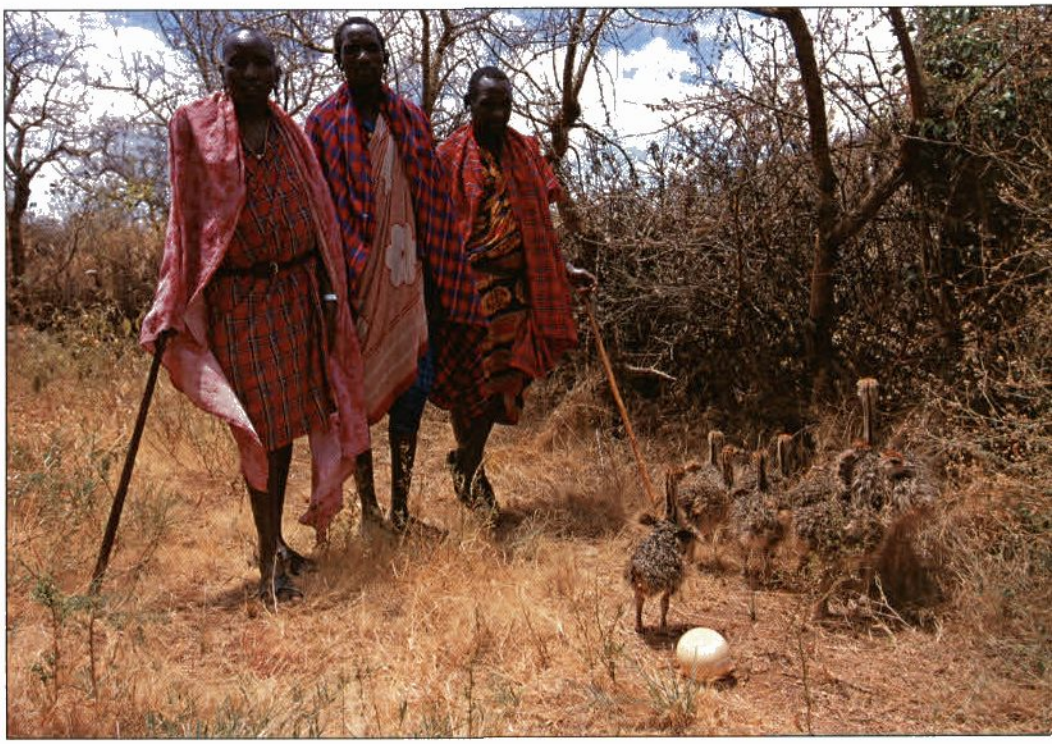


Figure 8.20 Ostrich rearing project, Kenya The men pictured here are Masai who once were nomadic but are now involved in an international development project focused on ostrich rearing and ecosystem management. The ostriches are a rare species that is under threat because of habitat destruction and bush meat trade.

uprisings such as the Mexican and Cuban revolutions and the election of socialist governments in Chile and Guatemala. In addition, many large landholdings were used for extensive ranching or for export or low-productivity crops and were not contributing to the food needs of the growing urban populations.

Land reform, which is the redistribution of land by the state with a goal of increasing productivity and reducing social unrest, was seen as a solution and was implemented by revolutionary governments and others seeking to reduce the risk of rural uprising. Mexico's post-revolutionary land reform redistributed expropriated and government lands to 52 percent of rural households between 1917 and 1980. In many cases, the land was distributed in the form of **ejidos,** communal lands given to groups of landless peasants who could farm collectively or as individuals but could not rent or sell the land outside the ejido. The government of Bolivia redistributed land to 79 percent of rural households between 1953 and 1975. The socialist governments of Guatemala (1952), Chile (1972), and Nicaragua (1979) distributed land to at least 20 percent of rural households, but some of those lands were subsequently returned to large landholders under military or more conservative governments.

Pressure for land reform continues throughout the region. For example, in Brazil the landless movement *Movimiento sim terra* has forced land redistribution by occupying more than 20 million hectares (nearly 50 million acres) and then demanding legal rights and political change with considerable public support. The question of whether land reform in Latin America has been successful or not is hotly debated. Some believe the reform sector is inefficient and that communal lands should be privatized, while others argue that land reform has increased rural stability and agricultural production. Most have recognized that land reform is ineffective unless it is part of an overall agrarian reform package that also provides technical advice, inputs, credit, and market access to the new landowners.

A second solution to low productivity and poverty in rural areas was the green revolution (see Box 8.2: "A Look at the Green Revolution"). Mexico was a global center for green revolution technology, hosting the International Center for Wheat and Maize Improvement near Mexico City. Scientists at the center, funded by the Rockefeller Foundation as well as the Mexican and U.S. governments, have used advanced plant-breeding techniques to produce new varieties of grains that resist disease and respond to fertilizer and irrigation with very high yields. Farmers, especially in irrigation districts in northern Mexico, were quick to adopt the new crop varieties, and national production of corn and wheat soared, turning Mexico into a major grain exporter by the 1970s. Other Latin American countries, such as Argentina and Brazil, also promoted green revolution agricultural modernization, including other key crops, such as rice and soybeans.

As described in Box 8.2, a second stage of the green revolution is now under way, involving crops engineered using biotechnology to resist pests and diseases and to produce even higher yields. This research is opposed by some who fear unanticipated consequences from such efforts, exemplified by concern that bioengineered corn pollen is harming monarch butterflies in Mexico.

Economic crises, a reduction in government programs, and reduced trade barriers have slowed the progress of the green revolution in many countries, not just in Latin America. Fertilizer use in countries such as Brazil and Mexico has declined with high prices, fewer subsidies, and increased competition from imported corn and wheat, especially from the United States. Many governments have shifted from giving top priority to self-sufficiency in basic grains to encouraging crops that are apparently more competitive in international trade, such as fruit, vegetables, and flowers. These **nontraditional agricultural exports (NTAEs)** (new export crops that contrast with traditional exports, such as sugar and coffee) have become increasingly important in areas of Mexico, Central America, Colombia, and Chile, replacing grain production and traditional exports, such as coffee and cotton. These new crops obtain high prices but also require heavy applications of pesticides and water to meet export-quality standards and fast refrigerated transport to market. They are vulnerable to climatic variation and to the vagaries of the international market, including changing tastes for foods and health scares about pesticide or biological contamination.

Fisheries are another important component of Latin American food and export systems, and activities range from subsistence fisheries in small coastal villages to large-scale commercial exploitation of offshore fisheries. The overall catch was more than 10 million metric tons in 1994, contributing on average about 10 percent of the overall food supply and making a significant contribution to exports in Chile, Ecuador, and Costa Rica. Aquaculture (the cultivation of fish and shellfish under controlled conditions, usually in coastal lagoons) has been growing rapidly and has resulted in the clearing of coastal mangroves and an increase in exports, especially of shrimp from countries such as Honduras. Food production sufficient to meet the needs of its population continues to be a significant political, economic, social, and environmental issue throughout Latin America and other parts of the periphery.

The Organization of the Agro-Food System

While the changes that have occurred in agriculture worldwide are complex, certain elements help reduce the complexity and serve as important indicators of change. Geographers and other scholars interested in contemporary agriculture have noted three prominent and nested

forces that signal a dramatic departure from previous forms of agricultural practice: agribusiness, food chains, and integration of agriculture with the manufacturing, service, finance, and trade sectors. Box 8.3: "The New Geography of Food and Agriculture in New Zealand" illustrates the deployment of these practices in one country.

The concept of agribusiness has received a good deal of attention in the last two decades, and in the popular mind it has come to be associated with large corporations, such as ConAgra or DelMonte. Our definition of agribusiness departs from this popular conceptualization. Although multi- and transnational corporations (TNCs) are certainly involved in agribusiness, the concept conveys more than a corporate form. **Agribusiness** is a system rather than a kind of corporate entity. It is a set of economic and political relationships that organizes food production from the development of seeds to the retailing and consumption of the agricultural product. Defining agribusiness as a system, however, does not mean that corporations are not critically important to the food production process. In the core economies the transnational corporation is the dominant player, operating at numerous strategically important stages of the food production process. TNCs have become dominant for a number of reasons, but mostly because of their ability to negotiate the complexities of production and distribution in many geographical locations. That capability requires special knowledge of national, regional, and local regulations and pricing factors.

The concept of a food chain (a special type of commodity chain) is a way to understand the organizational structure of agribusiness as a complex political and economic system of inputs; processing and manufacturing; and outputs. A **food chain** is composed of five central and connected sectors (inputs, production, processing, distribution, and consumption) with four contextual elements acting as external mediating forces (the state, international trade, the physical environment, and credit and finance). **Figure 8.21** illustrates these linkages and relationships, including how state farm policies shape inputs, product prices, the structure of the farm, and even the physical environment.

The food chain concept illustrates the complex connections among producers and consumers and regions and places. For example, important linkages connect cattle production in the Amazon and Mexico, the processing of canned beef along the United States–Mexico border, the availability of frozen hamburger patties in core grocery stores, and the construction of McDonald's restaurants in Moscow. Because of complex food chains such as this, it is now common to find that traditional agricultural practices in peripheral regions have been displaced by expensive, capital-intensive practices (**Figure 8.22**).

That agriculture is not an independent or unique economic activity is not a particularly new realization. Beginning with the second agricultural revolution, agriculture began slowly but inexorably to be transformed by industrial practices. What is different about the current state of the food system is the way in which farming has become just one stage of a complex and multidimensional economic process. This process is as much about distribution and marketing—key elements of the service sector—as it is about growing and processing agricultural products.

Food Regimes

A **food regime** is a specific set of links that exists among food production and consumption and capital investment and accumulation opportunities. Like the agricultural revolutions already described, food regimes have developed out of different historical periods, during which different political and economic forces are in operation. While a food chain describes the complex ways in which specific food items are produced, manufactured, and marketed, the concept also indicates the ways in which a particular type of food item is dominant during a specific temporal period. Although hundreds of food chains may be in operation at any one time, agricultural researchers believe that only one food regime dominates a particular period.

During the decades surrounding the turn of the nineteenth century, an independent system of nation-states emerged and colonization expanded (see Chapters 2 and 9). At the same time, the industrialization of agriculture began. These two forces of political and economic change were critical to the fostering of the first food regime, in which colonies became important sources of exportable foodstuffs by supplying the industrializing European states with cheap food in the form of wheat and meat. The expansion of the colonial agriculture sectors, however, created a crisis in production. The crisis was the result of the higher cost-efficiency of colonial food production, which undercut the prices of domestically produced food, put domestic agricultural workers out of work, and forced members of the agricultural sector in Europe to look for new ways to increase cost-efficiency. The response was to industrialize agriculture, which helped to drive down operating costs and restabilize the sector (reducing even more the need for farm workers) while moving toward the integration of agriculture and industry (also known as agro-industrialization).

While a wheat and livestock food regime characterized global agriculture until the 1960s, researchers now believe that a fresh fruit and vegetable regime has emerged. This new pattern of food consumption and production has been called the "postmodern diet" because it represents an important shift away from grains and meats to the more perishable agro-commodities of fresh fruits and vegetables. Integrated networks of food chains, using integrated networks of refrigeration systems, deliver fresh fruits and vegetables from all over the world to the core regions of Western Europe, North America, and Japan. Echoing the former food networks that characterized nineteenth-century imperialism, peripheral production systems supply

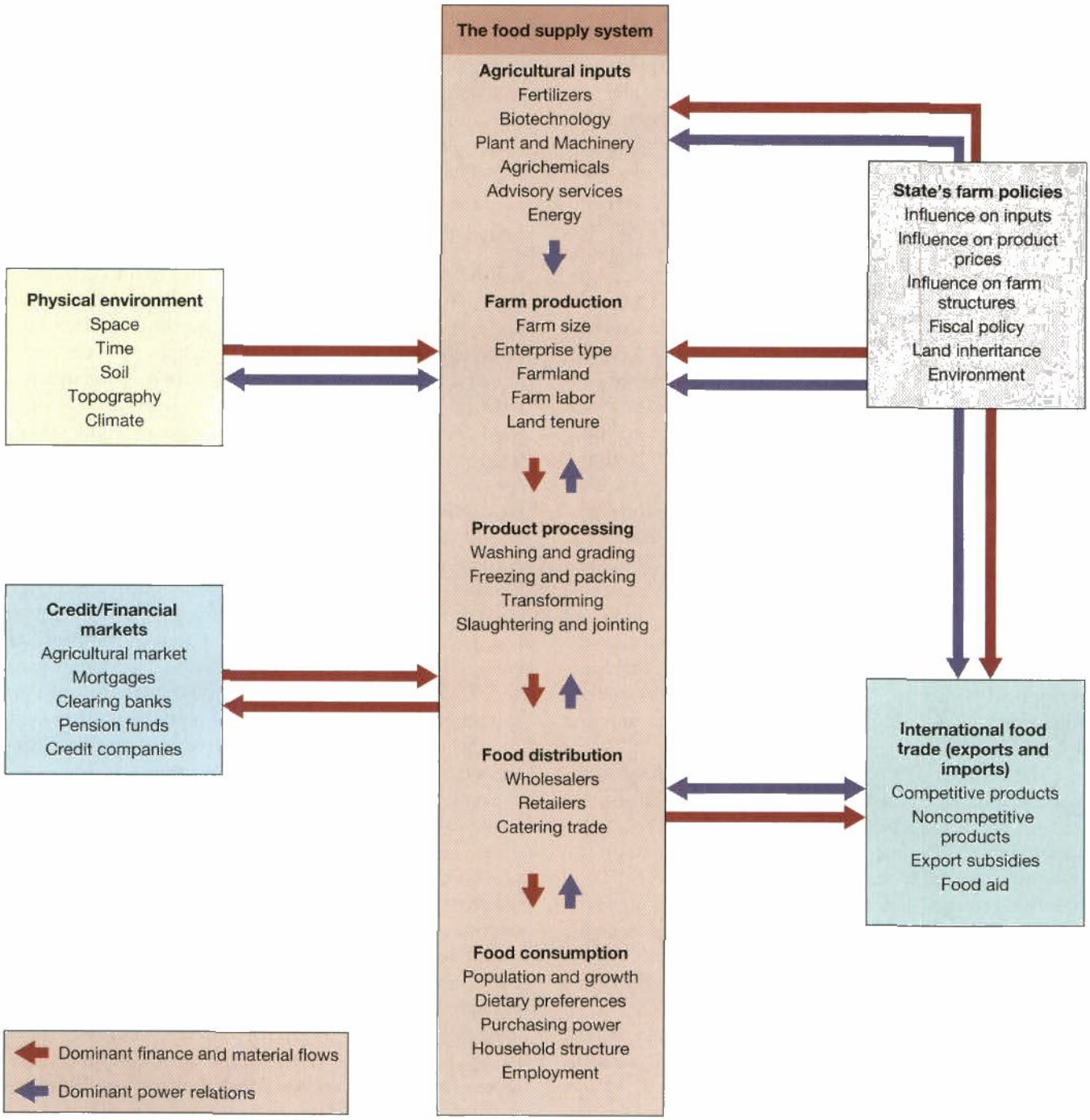


Figure 8.21 The food-supply chain The production of food has been transformed by industrialization into a complex system that comprises distinctly separate and hierarchically organized sectors. Mediating forces (the state, the structure and processes of international trade, credit and finance arrangements, and the physical environment) influence how the system operates at all scales of social and geographical resolution. (After I. Bowler (ed.), *The Geography of Agriculture in Developed Market Economies*. New York: J. Wiley & Sons, 1992, p. 12.)

core consumers with fresh, often exotic and off-season produce. Indeed, consumers in the core regions have come to expect the full range of fruits and vegetables to be available year-round in their produce sections, and unusual and exotic produce has become increasingly popular.

This emergence of a new food regime based on fresh fruit and vegetables has been helped by retailers, who provide symbolic cues and incentives to shoppers to consume the more exotic products. Store managers have introduced them by providing associations between the fruit or vegetable and prevailing ideas about health, class attachment, and epicurean eating. Thus, the transformation of agricultural practices at the global level has enabled the emergence of a new food regime, accompanied by new cultural

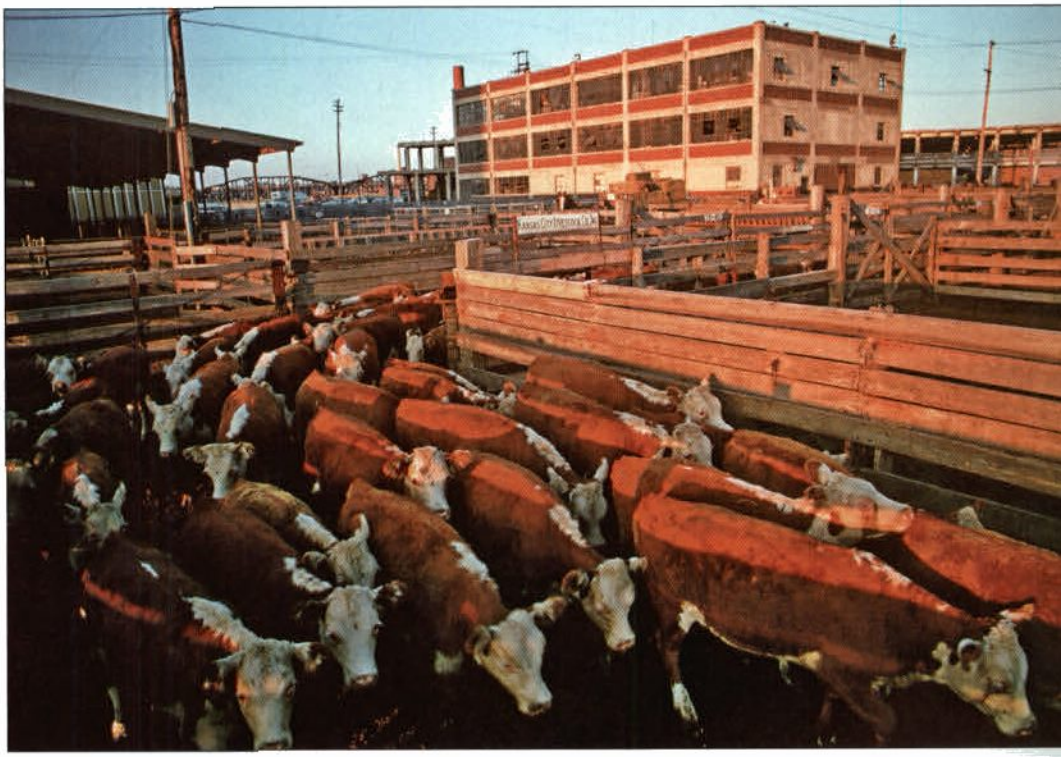


Figure 8.22 Kansas City Stockyards Grain-fed beef have become characteristic of beef production not only in the core but also in the periphery. Grain-fed beef is far more expensive to raise than cattle that graze in open fields on grasses. The grain itself must be produced through applications of seed, fertilizers, and water and then harvested and processed. Grasses grow naturally with little or no commercial inputs. The cattle pictured here come from all over the U.S. Midwest and are offered for auction at the Stockyards.

messages that promote and persuade at the local level. Furthermore, just as traditional agricultural practices worldwide have been affected by globalization trends, so too are the mainstream eating habits of consumers in core as well as peripheral regions.

SOCIAL AND TECHNOLOGICAL CHANGE IN GLOBAL FOOD PRODUCTION

In preceding sections of this chapter, we have tried to show how the globalization of agriculture has been accomplished through the same kinds of political and economic restructuring that have characterized the globalization of industry. Technological change was of particular importance to agriculture over the last half of the twentieth century as mechanical, chemical, and biological revolutions altered even the most fundamental agricultural practices. And just as restructuring in industry has not occurred without innumerable rounds of adjustment and resistance, the same is true of agriculture.

Besides generating economic competition, the newly restructured agro-commodity production system also fosters conflict and competition within sociocultural systems. For instance, in core and peripheral locations, men and women, landowners and peasants, different tribal groups, corporations, and family farmers struggle to establish or maintain control over production and over ways of life.

Two Examples of Social Change

The impact of a government development scheme to introduce irrigated rice production into the Gambia River Basin illustrates the many ways globalization of agricultural production has affected gender relations among and within households. The Gambian government, with the help of the West African Rice Development Association, launched a program in the 1980s to grow rice along the banks of the Gambia River.[3] The objective of the project was for Gambia to develop its own rice-producing sector and thereby decrease its dependence on imported rice. Through local agents employed by the project, the government distributed a package of high-yielding rice varieties, fertilizers, and pesticides in the hope that 2,000 peasant households distributed among 70 villages could attempt a double-cropping rice cultivation program (**Figure 8.23**). Husbands and wives were involved in the project.

The success of the project required a redistribution of labor, as well as the restructuring of land and crop rights. Incorrect assumptions that women's labor was constantly available and that there was no cost to that labor were made, however. These incorrect assumptions led to serious problems between spouses when it became apparent that women were not free to work during the season in which they were most needed to participate in the development scheme and that their participation required

[3]Adapted from J. Carney, "Converting the Wetlands, Engendering the Environment: The Intersection of Gender with Agrarian Change in the Gambia." *Economic Geography* 69(4), 1993, pp. 329–349.

Figure 8.23 Gambian women harvesting rice Development schemes have created problems within Gambian households because women wanted to control their own time and labor to produce rice for family consumption and local markets.

them to forgo other opportunities to increase household financial resources. Husbands and wives also disagreed about who controlled which pieces of land and the crops that were harvested. Thus, traditional ways of farming as well as gender relations were significantly challenged. The disagreements became so severe that the success of the project was compromised.

Lest it seem that only the economies and societies of the periphery are affected by the globalization of agriculture, a case closer to home can be instructive. In the 1980s the United States experienced what has become known as the **farm crisis**, the financial failure and eventual foreclosure of thousands of family farms across the Midwest. The agricultural sector of the state of Nebraska, highly specialized in grain production, was particularly hard hit when the international grain market collapsed in 1985. Soaring land prices, a decline in manufacturing employment, a rapid rise in farm bankruptcies, and decreasing revenues from crops sent entrepreneurs looking for ways to overcome the impact of this event on the state's economy. Meatpacking was identified as an alternative generator of economic growth. State-provided tax abatements and other corporate incentives caused IBP, Inc., a giant food conglomerate, to locate a meatpacking plant in Lexington, which at the time was a small rural town of 6,601 people.[4]

IBP, Inc., opened its plant at the end of 1992 with more than 2,000 workers employed. Most of these workers were *immigrants, primarily Mexican* and Central American men and women who were actively recruited by the company as a cost-reduction strategy. Such strategies are widespread among large American meatpacking companies. The arrival of so many new residents to the town created social and economic problems, however, which led to ethnic tension between the established residents—mostly of European descent—and the newcomers.

Also as a result of the new plant, the town experienced a severe housing crunch; had to build its first homeless shelter; had to raise new monies to expand the capacities of the school system; and had to build a new and larger jail. A rapid increase in the number of births, *especially those* not covered by health insurance, also occurred. In 1993 Lexington had the highest crime rate in Nebraska.

Examining the farm crisis is a useful way of demonstrating how core economies—especially farm households—experienced and responded to changes in U.S. agriculture.

Biotechnology Techniques in Agriculture

Ever since the nineteenth century, when Austrian botanist Gregor Mendel identified hereditary traits in plants and French chemist Louis Pasteur explained fermentation, the manipulation and management of biological organisms has been of central importance to the development of agriculture. The most recent manifestation of the influence of science over agriculture is exemplified by biotechnology. **Biotechnology** is any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific uses. Recombinant DNA techniques, tissue culture, cell fusion, enzyme and fermentation technology, and embryo transfer are some of the most-talked-about aspects of the use of biotechnology in agriculture (**Figure 8.24**).

The most common argument for applying biotechnology to agriculture is the belief that it helps reduce agricultural production costs, as well as acting as a kind of resource-management technique (where certain natural

[4]Adapted from L. Gouveia, "Global Strategies and Local Linkages: The Case of the U.S. Meatpacking Industry," in A. Bonanno et al. (eds.), *From Columbus to ConAgra: The Globalization of Agriculture and Food*. Lawrence: University of Kansas Press, 1994, pp. 125–148.

Figure 8.24 Biotechnology Biotechnology laboratories are typically high-technology greenhouses where plants are raised under carefully monitored conditions, from the implanting of special seeds to the applications of fertilizers and water and light. Biotechnology offers both benefits and costs. While the benefits include increased yields and more pest-resistant strains, too often the costs of such technology are too high for the world's neediest populations. In this photograph a Monsanto Corporation worker is extracting corn embryo for the development of a genetically modified crop.

resources are replaced by manufactured ones). Biotechnology has been hailed as a way to address growing concern for the rising costs of cash crop production; surpluses and spoilage; environmental degradation from chemical fertilizers and overuse; soil depletion; and related challenges now facing profitable agricultural production.

Indeed, biotechnology has provided impressive responses to these and other challenges. For example, biotechnological research is responsible for the development of "super plants" that produce their own fertilizers and pesticides, can be grown on nutrient-lacking soils, are high-yielding varieties, and are resistant to disease or the development of microorganisms. Additionally, biotechnologists have been able to clone plants—that is, take cells of tissues from one plant and use them to form new plants. The tissue culture may be no more than one cubic centimeter in size, but it has the potential to produce millions of identical plants. Such a procedure decreases the time needed to grow mature plants ready for reproduction.

While such technological innovations can seem miraculous, there is a downside to biotechnological solutions to agricultural problems. For example, cloned plants are more susceptible to disease than natural ones, probably because they have not developed tolerances. This susceptibility leads to an increasing need for chemical treatment. And while industry may reap economic benefits from the development and wide use of tissue cultures, farmers may suffer because they lack the capital or the knowledge to participate in biotechnological applications.

Biotechnology has truly revolutionized traditional agriculture. Its proponents argue that it provides a new pathway to the sustainable production of agricultural commodities. By streamlining the growth process with such innovations as tissue cultures, disease- and pest-resistant plants, and fertilizer-independent plants, optimists believe that the biorevolution can maximize global agricultural production to keep up with global requirements of population and demand.

Just as with the green revolution, however, biotechnology may have deleterious effects on peripheral countries (and on poor laborers and small farmers in core countries). For example, biotechnology has enabled the development of plants that can be grown outside of their natural or currently most suitable environment. Yet cash crops are critical to economic stability for many peripheral nations—such as bananas in Central America and the Caribbean, sugar in Cuba, and coffee in Colombia and Ethiopia (**Figure 8.25**). These and other export crops are

Figure 8.25 Workers in an Ethiopian coffee plantation harvesting beans For many peripheral countries, the production of cash crops is a way to boost exports and bring in needed income for the national economy. In Ethiopia, coffee has for decades been a cash crop grown for export. Luxury exports such as coffee generate some of the capital needed to import staple foods such as wheat.

WINDOW ON THE WORLD

The New Geography of Food and Agriculture in New Zealand

Geographers who study agriculture and food are using several new approaches to understand the way the restructuring of international trade, the activities of transnational corporations, and rapid shifts in government policies are affecting agriculture and the rural landscape in different countries. For example, agriculture has been transformed through horizontal integration in which smaller enterprises are merged to create larger units (for example, when adjacent farms are consolidated into one large landholding, resulting in the disappearance of small family-run farms) and through vertical integration, in which a single firm takes control of several stages in the production process (when a company owns the fertilizer and seed companies as well as the food-processing plant and supermarkets). The international corporation ConAgra, which owns grain companies, feedlots, meatprocessing, and wholesale distribution facilities is an agribusiness that organizes food production from the manufacturing of chemical inputs and the genetic manipulation of animal breeds or crop varieties to the processing, retailing, and consumption of the agricultural product.

Geographers such as Richard Le Heron and Guy Robinson have written extensively about how New Zealand agriculture has changed in response to the restructuring of the global food system. They document how New Zealand's agricultural system evolved during the nineteenth century with an orientation to exports of wool and lamb based on a pastoral landscape and a guaranteed market in the core economy of the United Kingdom. After World War II a second regime developed that included dairy cows on small farms and processing of products such as butter for export using refrigerated shipping. By the mid-twentieth century the New Zealand government was heavily involved in the agricultural system through "marketing boards" that mediated farmers' relationship with international markets through quality controls, price supports, and marketing.

In the 1970s the shock of the oil crisis (increasing the cost of agricultural inputs) and the loss of the imperial preference market when Britain joined the European Community resulted in further state support for producers, with price supports, incentives, and subsidies for inputs such as fertilizers providing more than a third of farm revenues. However, even these institutional supports could not fully buffer farmers against the increasing cost of inputs and loss of markets for the staples of wool, meat, and dairy, and some farmers began to *diversify* into nontraditional exports, such as venison, produced on deer farms, and fruit such as kiwi and Asian pears, responding to a new global food regime of specialty foods and the export of fruit and vegetables (**Figure 8.H** and **Figure 8.I**).

A dramatic change in agricultural policies in 1984 abruptly removed most price supports, trade protections, and farm subsidies, and required farms to pay for extension services, water, and quality inspections. Farm income fell by up to half, debt increased, 10 percent of farms were sold, herds were significantly reduced, and 10,000 farmers protested in front of Parliament. New Zealand agriculture was thrown into a global free market and the full impact of what has been called the "international farm crisis," while most other developed countries, including the United States, Canada, and those in Europe, maintained considerable state regulation and support for their agricultural systems. Although New Zealand farmers coped by adjusting herd sizes and changing crop mixes, some went out of business and their properties were horizontally integrated into larger farms. But New Zealand was also one of the first countries to adopt certification for organic agricultural products, and there is a thriving domestic market for

threatened by the development of alternate sites of production. Transformations in agriculture have ripple effects throughout the world system. As an illustration, **Table 8.1** compares the impacts of the biorevolution and the green revolution on various aspects of global agricultural production.

The availability of technology to peripheral nations is limited because most advances in biotechnology are the property of private companies. For example, patents protect both the process and the end products of biotechnological techniques. Utilizing biotechnological techniques requires paying fees for permission to use them, and the small farmers of both the core and the periphery are unlikely to be able to purchase or utilize the patented processes. The result of private ownership of biotechnological processes is that control over food production is removed from the farmer and put into the hands of biotechnology firms. Under such circumstances

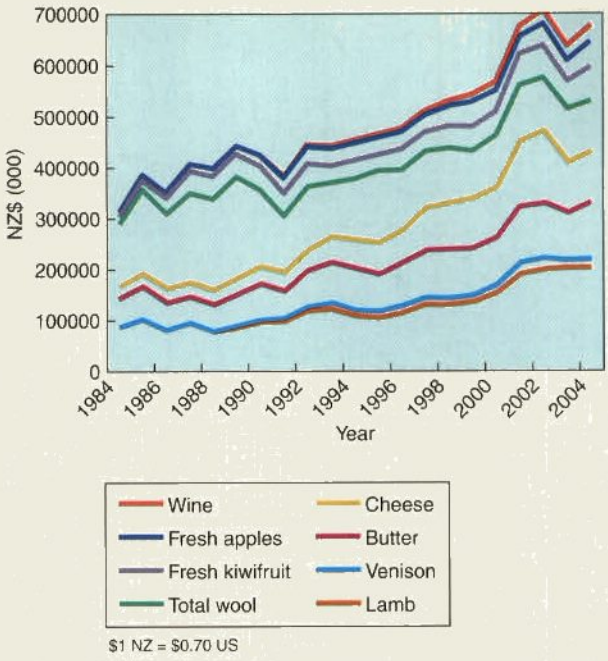


Figure 8.H New Zealand agricultural production The structure of New Zealand agricultural exports has changed in response to the restructuring of global agricultural trade and demand. Although the traditional exports of lamb meat and butter have remained high, wool exports have fallen. Exports of nontraditional crops such as kiwi, berries, avocados, wine, and venison have increased considerably.

sustainably grown foods. Transnational agribusiness firms, such as H.J. Heinz, purchased New Zealand agricultural processing enterprises with the goal of supplying growing Asian markets. Michael Moore, the New Zealander who had spearheaded his country's plunge into the free market as minister of trade, became the head of the World Trade Organization, charged with reducing barriers to trade worldwide.

Many geographers are reexamining agriculture in the context of global restructuring and changing government policies and contributing important insights into the ways in which the new international geography of food and agriculture is changing the economy and environments of countries such as New Zealand. The geographic perspective allows us to link international trade, regulation, and corporations to the decisions of national and local governments and to the impacts on and responses of agricultural regions, communities, and farm families.

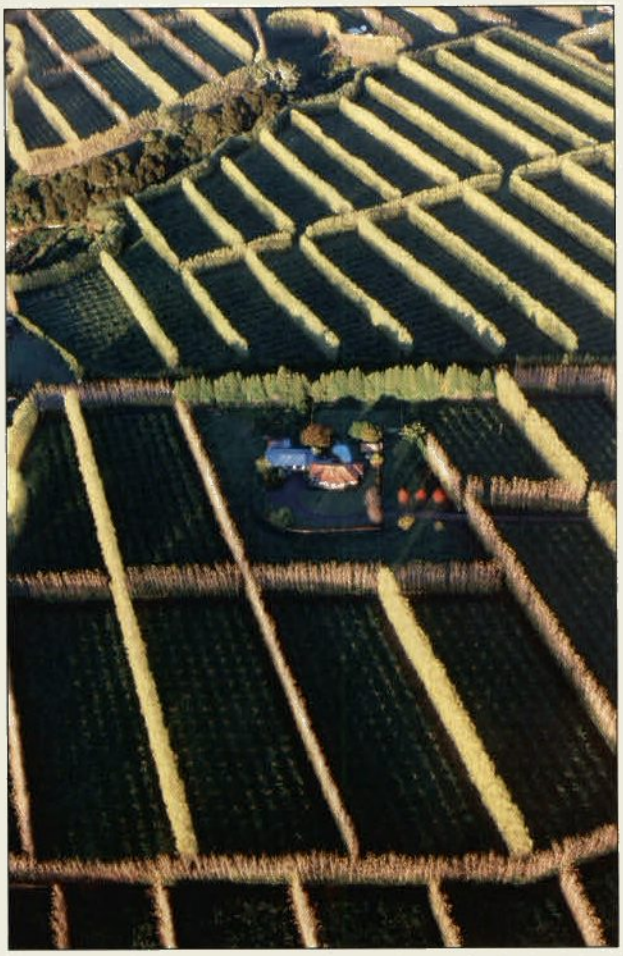


Figure 8.I Kiwi production These kiwi orchards on the North Island of New Zealand are surrounded by lines of trees that protect the delicate fruit from strong winds.

it becomes possible for world food security to be controlled not by publicly accountable governments, but by privately held biotechnology firms. Finally, with the refinement and specialization of plant and animal species, laborers who are currently employed in ancillary activities could face the loss of their jobs. For example, if a grower chooses to plant a bioengineered type of wheat that does not require winnowing (the removal of the chaff, a normally labor-intensive process), laborers who once were involved in that activity are no longer needed.

The biorevolution in agriculture is so recent that we are just beginning to understand both its negative and positive impacts. At this point it seems quite clear that these impacts will be distributed unevenly across countries, regions, and places and certainly across class, race, and gender lines.

TABLE 8.1 Biorevolution Compared with Green Revolution

Characteristics	Green Revolution	Biorevolution
Crops affected	Wheat, rice, maize	Potentially all crops, including vegetables, fruits, agro-export crops, and specialty crops
Other sectors affected	None	Pesticides, animal products, pharmaceuticals, processed food products, energy, mining, warfare
Territories affected	Some developing countries	All areas, all nations, all locations, including marginal lands
Development of technology and dissemination	Largely public or quasi-public sector, international agricultural research centers (IARCs), R&D millions of dollars	Largely private sector, especially corporations, R&D billions of dollars
Proprietary considerations	Plant breeders' rights and patents generally not relevant	Genes, cells, plants, and animals patentable as well as the techniques used to produce them
Capital costs of research	Relatively low	Relatively high for some techniques, relatively low for others
Access to information	Restricted due to privatization and proprietary considerations	Relatively easy, due to public policy of IARCs
Research skills required	Conventional plant breeding and parallel agricultural sciences	Molecular and cell biology expertise as well as conventional plant-breeding skills
Crop vulnerability	High-yielding varieties relatively uniform; high vulnerability	Tissue culture crop propagation produces exact genetic copies; even more vulnerability
Side effects	Increased monoculture and use of farm chemicals, marginalization of small farmer, ecological degradation. Increased foreign debt due to decrease in biomass fuels and the increasing reliance on costly, usually imported, petroleum	Crop substitution replacing Third World exports; herbicide tolerance; increasing use of chemicals; engineered organisms might affect environment; further marginalization of small farmer

Source: Adapted from M. Kenney and F. Buttel, "Biotechnology: Prospects and Dilemmas for Third-World Development," *Development and Change 16* (1995): 70; and H. Hobbelink, *Biotechnology and the Future of World Agriculture: The Fourth Resource* (London: Red Books, 1991).

THE ENVIRONMENT AND AGRICULTURAL INDUSTRIALIZATION

Agriculture always involves the interaction of biophysical as well as human systems. In fact, this relationship makes agriculture distinct from forms of economic activity that do not depend so directly on the environment. This relationship also requires determining how best to manage the environment in order to facilitate the continued production of food. Because the relationships between the human system of agriculture and the biophysical system of the environment are highly interactive, it is important to look at the ways each shapes the other.

The Impact of the Environment on Agriculture

Farmers have increasingly managed the environment over the course of the three agricultural revolutions. In fact, the widespread use of fertilizers, irrigation systems, pesticides, herbicides, and industrial greenhouses suggests that agriculture has become an economic practice that can ignore the limitations of the physical environment (**Figure 8.26**).

Yet it is exactly because agriculture is an economic activity that management of the environment in which it occurs becomes critical. As geographer Martin Parry writes:

> Soil, terrain, water, weather and pests can be modified and many of the activities through the farming year, such as tillage and spraying, are directed toward this. But these activities must be cost-effective; the benefits of growing a particular crop, or increasing its yield by fertilizing, must exceed the costs of doing so. Often such practices are simply not economic, with the result that factors such as soil quality, terrain and climate continue to affect agriculture by limiting the range of crops and animals that can profitably be farmed. In this way the physical environment still effectively limits the range of agricultural activities open to the farmer at each location.[5]

Though the impact of the environment on industrialized agricultural practices may not at first seem obvious, the reverse is more readily observable. In fact, there are

[5]M. Parry, "Agriculture as a Resource System," in I. Bowler (ed.), *The Geography of Agriculture in Developed Market Economies*. Harlow, England: Longman Scientific and Technical, 1992, p. 208.

Figure 8.26 Modern irrigation system A self-propelling irrigation system can be electronically programmed to deliver different amounts of water at different times of the day or days of the week. Irrigation is just one way that humans can alter the environment to serve their agricultural needs. In many parts of the core, water prices are heavily subsidized for agricultural users in order to ensure food supplies. For many parts of the periphery, however, access to water is limited to the amount of rain that falls and can be stored behind small dams and in impoundments. (After Agricultural Research Service, USDA.)

Figure 8.27 Poisoned crane, Hungary In spring 2005, carcasses of more than hundred cranes were found in an area 150 kilometers southeast of Budapest. Experts say the birds of passage on their way to the northern regions of Europe were apparently poisoned by eating grain containing toxic pesticides.

many contemporary and historical examples of the ways that agriculture destroys, depletes, or degrades the environmental resources on which its existence and profitability depend.

The Impact of Agriculture on the Environment

As discussed in Chapter 4, one of the earliest treatises on the impact of chemical pesticides on the environment was Rachel Carson's *Silent Spring*, which identified the detrimental impacts of synthetic chemical pesticides—especially DDT—on the health of human and animal populations (**Figure 8.27**). Although the publication of the book and the environmental awareness that it generated led to a ban on the use of many pesticides in most industrialized nations, chemical companies continued to produce and market them in peripheral countries. While some of these pesticides were effective in combating malaria and other insect-borne diseases, many were applied to crops that were later sold in the markets of developed countries. Thus, a kind of "circle of poison" was set into motion, encompassing the entire global agricultural system.

One of the most pressing issues facing agricultural producers today is soil degradation and denudation, which are occurring at rates more than a thousand times natural rates. Although we in the United States tend to dismiss soil problems such as erosion as an artifact of the 1930s Dust Bowl, the effects of agriculture on worldwide soil resources are dramatic, as **Table 8.2** illustrates. Unfortunately, most forms of agriculture tend to increase soil degradation. Although severe problems of soil degradation persist in the United States—which has a federal agency devoted exclusively to managing soil conservation—more severe problems are occurring in peripheral countries.

The loss of topsoil worldwide is a critical problem because it is a fixed resource that cannot be readily replaced. It takes, on average, 100 to 500 years to generate 10 millimeters (one-half inch) of topsoil, and it is estimated that nearly 50,000 million metric tons (55,000 million tons) of topsoil are lost each year to erosion. The quantity and quality of soil worldwide are thus important determining factors in the quantity and quality of food that can be produced.

Soil erosion due to mismanagement in the semiarid regions of the world has led to desertification, in which topsoil and vegetation losses have been extensive and largely permanent. As explained in Chapter 4, desertification is the spread of desertlike conditions in arid or semiarid lands resulting from climatic change or human influences. Desertification means not only the loss of topsoil but possibly the deterioration of grazing lands and the decimation of forests (**Figure 8.28**). In addition to causing soil degradation and denudation problems, agriculture affects water quality and quantity through the over-withdrawal of groundwater and the pollution of the same water through agricultural runoff contaminated with herbicides, pesticides, and fertilizers. Deforestation can also result from poor agricultural practices.

Poor land-use practices and the destruction of complex ecosystems through over- or misuse led in the 1980s

TABLE 8.2 Global Degraded Soils (million hectares)

Region	Overgrazing	Deforestation	Agricultural Mismanagement	Other	Total	Degraded Areas as Share of Total Vegetated Land
Asia	197	298	204	47	746	20%
Africa	243	67	121	63	494	22%
South America	68	100	64	12	244	14%
Europe	50	84	64	22	220	23%
North and Central America	38	18	91	71	158	8%
Australia, New Zealand, and the South Pacific	83	12	8	0	103	13%
World	679	579	552	155	1,965	17%

Source: L. R. Brown et al., *State of the World.* New York: W. W. Norton and Company, 1994, p. 10.

to an innovation called "debt-for-nature swaps." In these swaps a core environmental organization, such as the World Wildlife Fund, retired some part of the foreign debt of a peripheral country, contingent upon the country's agreeing to implement a conservation program to save ecologically sensitive lands from abuse. This usually meant turning the land into a national park or extending the boundaries of an existing park. Funds generated by the swaps were to be used to administer the parks, train personnel, research habitats, and carry out environmental education.

For much of the 1980s, environmental organizations were extremely optimistic about the possible implications of debt-for-nature swaps for both the affected country and worldwide environmental degradation. It turns out, however, that the swaps were not able to address the fundamental causes of environmental degradation in peripheral regions—including extreme poverty, government subsidies for forest clearing, and insecure land tenure. As a result, the debt-for-nature swaps are now seen as mere Band-Aid solutions to extremely complex social, economic, political, and ecological problems.

The nature-society relationship discussed in Chapter 4 is very much at the heart of agricultural practices. Yet as agriculture has industrialized, its impacts on the environment have multiplied and in some parts of the globe have reached crisis stage. While in some regions the agricultural system leads to overproduction of foodstuffs, in others the quantity and quality of water and soil severely limit the ability of a region's people to feed themselves.

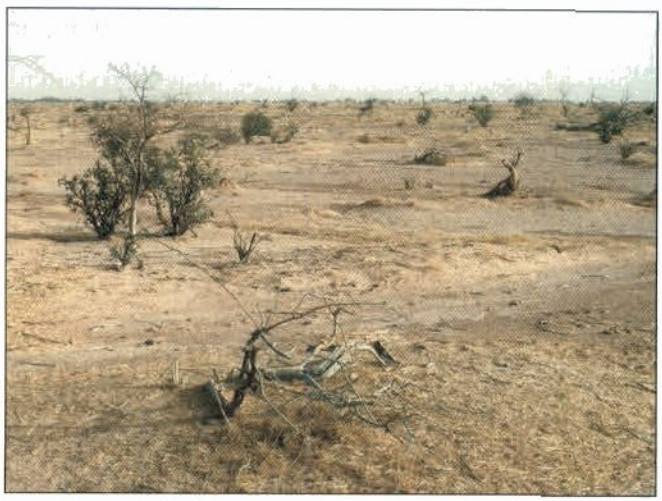


Figure 8.28 Desertification in Sahelian Africa Severe and largely permanent loss of vegetation and topsoil may result from human activities such as overgrazing or excessive deforestation. The ravaged landscapes of desertification are a compelling testimony to the need for humans to consider the implications of their actions more closely—not always an easy thing to do when ill-informed government policies and grinding hunger and poverty are daily facts of life.

PROBLEMS AND PROSPECTS IN THE GLOBAL FOOD SYSTEM

The future of the global food system is being shaped at this very moment in food science laboratories, in corporate boardrooms, on the street in organized protests, and in homely settlements throughout the world. The biggest issues food policy experts, national governments, consumers, and agriculturalists face revolve around the availability and quality of food in a world where access to safe, healthy, and nutritious foodstuffs is unevenly distributed. For the periphery, the most pressing concern is adequate food supplies to feed growing populations. For the core, there are concerns about food quality in a system that is increasingly industrialized and biologically engineered. Sometimes the solutions to one problem for one population become a new problem for another population.

In this final section we examine two problematic issues in the world food system, as well as an encouraging prospect. These cases certainly do not illuminate the myriad challenges and possibilities facing food producers and policymakers today, but they do provide a broad sense of the range.

Famine and Undernutrition

We have spent most of this chapter describing the ways food is cultivated, processed, engineered, marketed, financed, and consumed throughout the world. What we have yet to do is talk about access to this most essential of resources. While there is more than enough food to feed all the people who inhabit Earth, access to food is uneven, and many millions of individuals in both the core and the periphery have had their lives shortened or harmed because war, poverty, or natural disaster has prevented them from securing adequate nutrition. In fact, hunger is very likely the most pressing problem facing the world today.

Hunger occurs in two basic ways: chronic or acute. Chronic hunger is nutritional deprivation that occurs over a sustained period of time: months or even years. Acute hunger is short term and is often related to catastrophic events—personal or systemic. Chronic hunger, also known as **undernutrition**, is the inadequate intake of one or more nutrients and/or of calories. Undernutrition can occur in individuals of all ages, but its effects on children are dramatic, leading to stunted growth, inadequate brain development, and a host of other serious physical ailments.

Perhaps the most widely publicized examples of acute hunger are famines, especially those that have occurred in parts of the periphery over the last few decades. **Famine** is acute starvation associated with a sharp increase in mortality. The most widely publicized famines of the late twentieth century occurred in Bangladesh in 1974 and Ethiopia in 1984–1985. The causes of these two famines (and the other twentieth-century famines that preceded them) were complex. The crisis of starving people so often publicized by the news media is usually just the final stage of a process that has been unfolding for a far longer period, sometimes years or even decades. Experts who study famine argue that there are at least two critical factors behind longstanding vulnerability to famine. The first has to do with a population's command over food resources in terms of their livelihood (for instance, rural laborer or farmer). The second has to do with a trigger mechanism, which may be a natural phenomenon like drought or a human-made situation such as civil war.

The famine in Bangladesh resulted from a sharp rise in food prices combined with a drop in employment opportunities that resulted in part from a very serious flood that had wiped out crops in lowland areas (but left highland agricultural production intact). Adequate food supplies were still available, but individuals who labored in the countryside to produce, distribute, or process the lowland crops could not afford them. Exacerbating the problem was the fact that negotiations between the Bangladeshi government and foreign-aid donors had broken down to such an extent that the distribution of food aid to needy individuals was seriously impaired. The lesson to be drawn from the Bangladesh famine is that when access to livelihood collapses, famine can result, even when overall levels of food availability are adequate.

People who study famine and other forms of hunger have come to conceptualize vulnerability in terms of the notion of food security. **Food security** means that a person, a household, or even a country has assured access to enough food at all times to ensure active and healthy lives. And while famine is a dramatic reminder of the precarious nature of food security, it is important to appreciate that chronic hunger resulting from food insecurity is a far more widespread and devastating problem than famine, which tends to be shorter in duration and more contained geographically.

Globally, 24,000 people a day die from the complications brought about by undernutrition. Today in the United States, where food is abundant and overeating is a national problem, 10 percent of the population is undernourished or experiences food-security problems at one time or another each year. In the periphery, where food availability is more limited than in core countries like the United States, undernutrition is far more pervasive. Food-security experts agree that undernutrition is the result of an overarching set of factors ultimately caused by poverty. Wealthy people, whether they live in the core or the periphery, rarely if ever go hungry. But impoverished people everywhere are likely to have experienced short-term or long-term undernutrition, if not both. Thus, in a world where there is more than enough food to adequately and consistently nourish every man, woman, and child, many go hungry because they simply do not possess the livelihoods adequate to gain sufficient access to food resources. Furthermore, as the example of the famine in Hausaland in Nigeria in 1982 made clear, in some parts of the world, among some social classes, there are higher levels of undernutrition among women and girls than among men and boys. This is largely because different cultural and social norms favor men and boys, who eat first, leaving the leftovers for women, or who eat certain high-status foods, such as proteins like meat or fish, that women are not allowed to eat.

The most important point to take away from this discussion of hunger is that it is a problem that can be solved. Because neither short-term nor long-term hunger involves inadequate supply, the solution must lie in improving access to those supplies. This could occur, under a radical scenario, through a massive redistribution of wealth that would give all the world's people access to the same amount of food resources. Barring such a dramatic restructuring of the current economic system, the solution to the problem of hunger lies in improving access to livelihoods that pay well enough that adequate nutrition becomes a human right and not dependent upon the vagaries of economic or natural systems.

Genetically Modified Organisms and the Global Food System

In 1999 protesters in London, Chicago, and Seattle dressed up as monarch butterflies and informed passers-by that genetically modified corn might be posing a threat

to that insect. Shouting chants like, "Hey, hey, ho, ho, Frankenfoods have got to go!" these protesters represented a growing global movement that opposes the production and sale of genetically modified food products—or demands, at the very least, that these foods be labeled as such (**Figure 8.29**). In Brazil a federal judge banned the sale of Monsanto Corporation's Ready Roundup genetically engineered soybean seeds. Japan recently announced it would require that all genetically engineered food be labeled. In the United States, however, the Food and Drug Administration has made regulation of genetically engineered food voluntary: Companies can decide for themselves whether they want the agency to review their product. Since these early protests, popular opposition to GMOs has continued to grow.

A **genetically modified organism**, or **GMO** as it is more commonly known, is any organism that has had its DNA modified in a laboratory rather than through cross-pollination or other forms of evolution. Examples of GMOs are a bell pepper with DNA from a fish added to make it more drought-tolerant, a potato that releases its own pesticide, and a soybean that has been engineered to resist fungus.

Genetic modification has both critics and supporters. Proponents argue that it allows great advances in agriculture (for instance, making plants more resistant to certain diseases or of water shortages), as well as allowing other beneficial creations, such as the petroleum-eating bacteria that can help clean up oil spills. Opponents worry that genetically modified organisms may have unexpected and irreversible effects on human health and the environment, causing maturation problems in children or mutant plant and animal species.

In the United States genetic modification is permitted, on the principle that there is no evidence yet that it is dangerous. GMO foods are fairly common in the United States, and estimates of their market saturation vary widely. It is not, however, easy to recognize GMOs in the grocery store, as there are no labeling requirements. While the food-safety establishment in the United States maintains that GMOs are safe until proved otherwise, countries in Europe have taken the opposite position: that genetic modification has not been proved safe, so they will not accept genetically modified food from the United States or any other country. The World Trade Organization has determined that not allowing GMO food into a country creates an unnecessary obstacle to international trade.

GMOs represent perhaps the most highly technological way to date in which nature and society come together in the global food system. At present, so little is known about the wider impacts of GMOs on human health, the environment, or even the wider global economic system that it is difficult to sort the costs from the benefits of their increasing incorporation into global food production. What is clear is that genetic modification is no passing fad and the debate cannot be reduced to a simple "good" or "bad." While GMOs are neither entirely evil nor entirely good, certain applications may be widely beneficial, while others may not. Regulatory structures are crucial to protecting human health and the environment, as well as spreading whatever benefits may accrue from GMOs beyond the core and into the periphery, where food-security issues are at their most critical. But regulatory structures are not so easily accomplished.

Protests against GMO regulatory structures have been most effective in Europe and parts of Asia, Africa, and Latin America as well as in Canada and Mexico. In those regions, national governments have begun to devise regulations to control or publicize the entry of GMO commodities into the food system or are requiring more research in order to better understand the long-term effects of consuming GMOs on humans as well as the impact of GMOs on the food chain. While widespread protests against GMO foods have also been organized in the United States, the government has not responded with strong support for these movements. Although the U.S. govern-

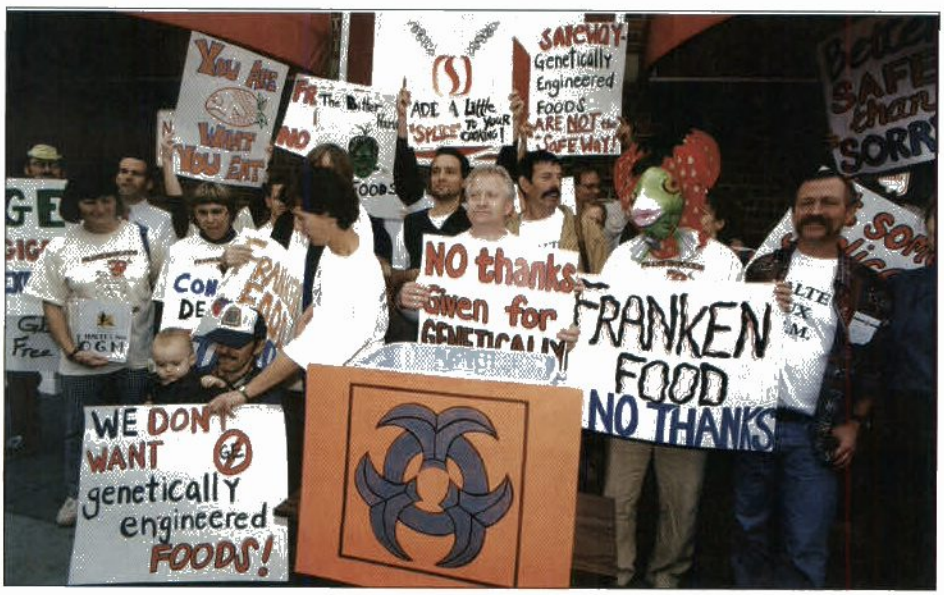


Figure 8.29 Protest over GMOs in Seattle Protesters at the World Trade Organization meeting in Seattle, Washington in 1999, expressed their concern that genetically modified organisms may not be safe for humans or the environment.

ment has passed domestic legislation making the labeling of GMOs voluntary, at the international level it has threatened action against countries who are arguing for the mandatory labeling of GMO foods traded in the global marketplace. It is important to be aware that the position taken by the United States is a pro-trade one, rather than a strictly pro-GMO food one. In short, the U.S. government is mostly concerned with the economic impact GMO labeling is likely to have on trade and is reluctant to put the trade of U.S. agricultural products at risk. This strategy occurs because the United States is the largest exporter of agricultural goods in the world as well as the largest producer of GMO foods. If GMO labeling were mandated by the World Trade Organization, it is likely that many U.S. trading partners—both large and small—would be legally bound either to refuse GMO commodities or the commodities would be seen as less valuable to potential buyers. At present, there is no sign that the WTO is likely to take such a step. In fact, its current regulations specify that if a country imposes additional restrictions and safety concerns on products that are thought to be unsafe, the WTO can overrule that country. Issues such as this one threaten the independence of individual nations and create governance problems for the WTO. Table 8.3 provides some insight into the national variation in response to GMO crops.

Global debate and activism—both popular and governmental—over GMOs is still in its early stages. Some of the most vocal opponents of GMOs are concerned that engineered food is destined for consumption by poor people in the periphery, while "real" food, produced by artisans and organic growers will only be available to rich people in the core with no attention paid to the importance of food to reducing world hunger or to ensuring a safe diet as a global human right.

Urban Agriculture

Although most people think of agriculture as a rural activity, urban agriculture made possible the emergence of the world's first cities. Until recently, however, urban agriculture was largely ignored in the development of urban economic policies, apparently because produce generated from it was seen to belong to the informal sector of the local economy and not significant in terms of income-generating potential. Most definitions of **urban agriculture** take it to mean the establishment or performance of agricultural practices in or near an urban or citylike setting. In countries like China, official policies have long recognized and even fostered urban agricultural practices. In many core countries, however, particularly since the Industrial Revolution, urban agriculture has been officially discouraged or made difficult as arable land has been taken for real estate development or seriously degraded through industrial processes.

Whether encouraged or discouraged by official policy, urban residents across the globe are increasing their participation in growing crops and raising livestock, for reasons ranging from food security to income production to taste and health concerns. Up to 30 percent of agricultural production occurs within metropolitan areas in the United States, for example, and up to 15 percent globally. Throughout the core, urban agriculture is largely a leisure activity that helps to supplement the routine purchase of commercial foodstuffs. In the periphery, however, it can often be the sole means of economic and personal survival. As wage cuts, inflation, job loss, civil strife, and natural disasters become more frequent, urban agriculture in the periphery has become a way to address greater food insecurity.

As we discuss in Chapter 10, urban populations throughout the world are growing more than twice as fast as rural populations. By the year 2015, according to the U.N. Center for Human Settlements, more than half of humanity will live in cities. And as development experts look to sustainable development as a way of maintaining economic growth without destroying the environment, urban agriculture has increasingly drawn their attention as a way of making cities sustainable. Proponents of urban agriculture contend that it should not be understood as an alternative to conventional agriculture but rather as a supplementary branch of modern agricultural systems. For most development experts, an ideal urban agricultural system would incorporate various elements of modern sustainable agriculture based on reusable, self-contained waste and nutrient cycles through resource conservation and management based on nonchemical fertilizers and pest-management techniques.

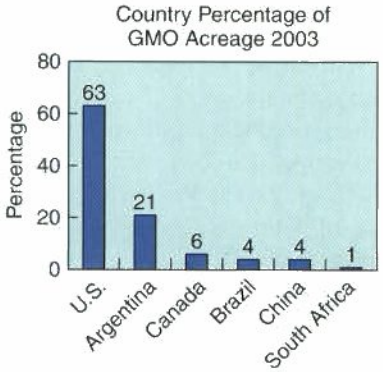
It is important to recognize that urban agriculture cannot solve the world's food-security problems. For example, small urban gardens will not replace agribusiness as the primary players in the global food system. Moreover, there are legitimate health concerns surrounding urban agriculture, particularly in terms of recycling urban wastes into agricultural inputs. In arid parts of the world, where water is scarce, the use of wastewater from domestic or commercial uses seems an obvious solution to the irrigation needs of urban agriculture. Yet while in some parts of the world wastewater is effectively treated and used for secondary applications, in others it is not treated and can easily carry disease, which can then be spread into the food system when applied to crops. Clearly, policies and practices need to be developed that very carefully address the health implications of urban agriculture in the very different settings in which it is being practiced.

Currently, urban agriculture is practiced in a variety of ways, including rooftop, hydroponic, and community gardens; roadside urban fringe agriculture; field-to-direct-sale farmers' markets; and livestock grazing in parks and feedlots (Figure 8.30). As a growing practice worldwide, urban agriculture may help establish sustainable food systems in predominately urban areas. While health concerns about urban agricultural practices should not be taken lightly, there is evidence that they are far outweighed by the current and potential benefits of urban agriculture. Particularly in developing countries and poorer inner city

TABLE 8.3 National regulatory responses to GMOs

	GMOs Banned with Few Exceptions	Strict Labeling Requirements	Cultivation of GMO Crops Allowed	Some Test Fields of GMO Cultivation Allowed	Some Varieties of GMO Banned	Significant Public Resistance to GMOs	Regions or Cities within Countries Where GMOs are Banned
Algeria	X			X			
Argentina			X	X			
Australia		X	X			X	
Austria					X		
Brazil	X	X	X			X	
Canada			X			X	
China		X	X		X		
Denmark		X					
Egypt					X		
E.U.		X	X	X	X	X	
France		X		X	X	X	
Germany		X			X	X	
Greece	X	X			X		
India			X		X	X	
Italy		X		X	X		X
Japan		X			X	X	
Korea		X					
Luxembourg		X			X		
Mexico		X					
Netherlands		X		X		X	
N. Zealand		X					
Norway					X		
Paraguay		X					
Philippines			X				X
Portugal				X		X	
Russia					X		
Saudi Arabia					X		
South Africa		X	X				
Spain				X		X	X
Sri Lanka	X						
Thailand	X	X				X	
U.K.				X		X	X
U.S.			X	X		X	
Vietnam		X					
Zimbabwe						X	

These bar graphs are from: http://pewagbiotech.org/resources/issuebriefs/feedtheworld.pdf



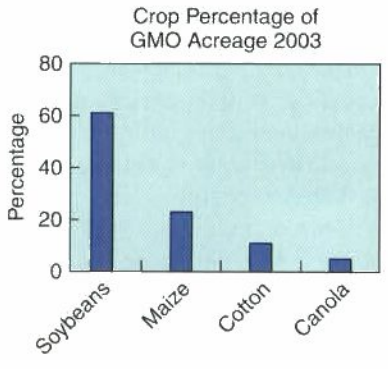


Figure 8.30 Urban garden, Hong Kong One of the most densely populated urban areas in the world, Hong Kong is also home to hundreds of urban gardens where residents of apartment blocks use the gardens to supplement market purchases. Throughout the world, in both the core and the periphery, private as well as communal gardens are becoming a more familiar feature of the urban landscape.

neighborhoods throughout the world, urban agriculture can be a crucial element in a family's survival. This ability of urban agriculture to enhance household food security seems to be currently drawing the most attention. Urban agriculture can also play a very important role in the absorption of labor—particularly women and youth—so that urban households are better able to take full advantage of their own human resources. It may even be a way of turning urban waste into a resource when incorporated safely into the food system.

CONCLUSION

Agriculture has become a highly complex, globally integrated system. While traditional forms of agricultural practices, such as subsistence farming, continue to exist, they have been overshadowed by the global industrialization of agriculture. This industrialization has included not only mechanization and chemical applications but also the linking of the agricultural sector to the manufacturing, service, and finance sectors of the economy. In addition, states have become important players in the regulation and support of agriculture at all levels, from the local to the global.

The dramatic changes that have occurred in agriculture have affected different places and different social groups. Households in both the core and the periphery have strained to adjust to these changes, often disrupting existing patterns of authority and access to resources. Just as people have been affected by the transformations in global agriculture, so have the land, air, and water.

The geography of agriculture at the turn of the twentieth century is a far cry from what it was 100 or even 50 years ago. As the globalization of the economy has accelerated in the last few decades, so has the globalization of agriculture. The changes in global agriculture do not necessarily mean increased prosperity in the core, nor are the implications of these changes simple. For example, the production of oranges in Florida is directly

influenced by the newer Brazilian orange industry. Both industries, in turn, affect the prices of oranges in the marketplaces of Europe and Asia. Additionally, the European unease with genetically engineered foods will affect U.S. producers, agricultural research, trade, and a host of other factors that have repercussions throughout the world system.

MAIN POINTS REVISITED

- **Agriculture has been transformed into a globally integrated system; the changes producing this result have occurred at many scales and have had many sources.**

  In addition to the restructuring of entire national farming systems, farming households have been transformed as well in core, periphery, and semiperiphery regions.

- **Agriculture has proceeded through three revolutionary phases, from the domestication of plants and animals to the latest developments in biotechnology and industrial innovation.**

  These three revolutionary phases have not occurred simultaneously throughout the globe but have been adopted and adapted to differing degrees, based on levels of development, culture, and physical geography.

- **The introduction of new technologies, political concerns about food security and self-sufficiency, and changing opportunities for investment and employment are among the many forces that have dramatically shaped agriculture as we know it today.**

  Two of the most important forces behind these transformations in agriculture have been multinational and transnational corporations and states. The World Trade Organization is another important influence.

- **The industrialized agricultural system of today's world has developed from—and largely displaced—older agricultural practices, including shifting cultivation, subsistence agriculture, and pastoralism.**

  Although these systems no longer dominate agricultural practices on a global scale, they are still practiced in many areas of the world, in some cases alongside more mechanized forms.

- **The contemporary agro-commodity system is organized around a chain of agribusiness components that begins at the farm and ends at the retail outlet. Different economic sectors, as well as *different corporate* forms, have been involved in the globalization process.**

  The farm is no longer the central piece in this chain of agricultural organization, but one of several important components that includes seed and fertilizer manufacturers, food processors, food distributors, and consumers.

- **Transformations in agriculture have had dramatic impacts on the environment, including soil erosion, desertification, deforestation, and soil and water pollution, as well as the elimination of some plant and animal species.**

  While most of the core countries have instituted legislation to address some of the problems associated with environmental degradation, these problems exist throughout the global agricultural system to greater and lesser degrees. In peripheral countries, where governments are often too poor to monitor and enforce such legislation, they are being encouraged by international agencies and environmental organizations to limit their degradational practices through relief of part of their national debt.

- **The biggest issues food-policy experts, national governments, consumers, and agriculturalists face revolve around the availability and quality of food in a world where access to safe, healthy, and nutritious foodstuffs is unevenly distributed.**

  Genetic modification is one way of improving productivity, though it does not address issues of access to food. Increasing opportunities for the world's poor—who are increasingly residing in urban settings—to grow their own food is another way.

KEY TERMS

agrarian (p. 302)
agribusiness (p. 325)
agricultural industrialization (p. 316)
agriculture (p. 302)
aquaculture (p. 313)
biotechnology (p. 328)
blue revolution (p. 313)
chemical farming (p. 311)
commercial agriculture (p. 304)
crop rotation (p. 304)
double cropping (p. 308)
ejidos (p. 324)
famine (p. 335)
farm crisis (p. 328)
food chain (p. 325)
food manufacturing (p. 311)
food regime (p. 325)
food security (p. 335)
globalized agriculture (p. 317)
GMO (genetically modified organism) (p. 336)
green revolution (p. 317)
hunting and gathering (p. 303)
intensive subsistence agriculture (p. 307)
intertillage (p. 306)
land reform (p. 324)
mechanization (p. 311)
nontraditional agricultural exports (NTAEs) (p. 324)
pastoralism (p. 308)
shifting cultivation (p. 304)
subsistence agriculture (p. 303)
swidden (p. 305)
transhumance (p. 309)
undernutrition (p. 335)
urban agriculture (p. 337)

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EXERCISES

On the Internet

The Internet exercises for this chapter focus on the impact of agriculture on the environment. We look at water policies and their affect on agriculture, especially irrigation policies. Using a GIS on sustainable development, we survey chronic undernutrition, dietary patterns, food production growth, and the role of agricultural trade. Exploring the *World Agricultural Information Center* Web site, we appraise human-induced soil degradation, and we provide international time-series data sets for production, trade, chemicals, aid shipments, land use, and more. We also take a backward look (via the Internet) at the successes and failures of the Green Revolution. Finally, we examine biotechnology in agriculture and the public's changing attitude about the genetic engineering of our agricultural producers.

Unplugged

1. Your neighborhood grocery store is a perfect location to begin to identify the "global" in the globalization of agriculture. Go to the produce section there, and document the source of at least 10 fruits and vegetables you find. You may need to ask the produce manager where they come from; once you have established that, illustrate those sources on a world map.
2. The Food and Agriculture Organization (FAO) has been publishing a range of yearbooks containing statistical data on many aspects of global food production since the mid-1950s. Using the *State of Food and Agricultural Production* yearbooks, compare the changes that have occurred in agricultural production between the core and the periphery since midcentury. You can use just two yearbooks for this exercise, or you may want to use several to get a better sense of when and where the most significant changes have occurred. Once you have identified where the changes have been most significant, try to explain why these changes may have occurred.
3. The U.S. Department of Agriculture (USDA) also provides statistics on food and agricultural production, though, of course, limited to the United States. Contained in volumes simply called Agricultural Statistics, a range of important variables are included, from what is being grown where, to who is working on farms, and what kinds of subsidies the government is providing. Using the USDA's annual publication *Agricultural Statistics*, examine the changing patterns of federal subsidies to agriculture over time. Using a map of the United States, show which states since the 1940s (just following the Great Depression) have received subsidies for the decades 1945, 1965, 1985, and the present. Have subsidies increased for some parts of the country and not others? If so or if not, why? Have subsidies increased or decreased overall for the entire country? Which farm sectors and, therefore, which regions have most heavily benefited from federal agricultural subsidies? Why?
4. Your breakfast is the result of the activities of a whole chain of producers, processors, distributors, and retailers whose interactions provide insights into both the globalization of food production and the industrialization of agriculture. Consider the various foods you consume in a typical breakfast and describe not only where (and by whom) they were produced—grown and processed—how they were transported (by whom) from the processing site—but also where and by whom they were retailed. Summarize how the various components of your breakfast illustrate the two concepts of globalization and the industrialization of agriculture.