Crops such as tobacco, cotton, and sugarcane, which can be planted only once a year, are less likely to be grown on large plantations today than in the past. Crops are normally processed at the plantation before shipping, because processed goods are less bulky and are therefore cheaper to ship long distances to the North American and European markets.

Until the Civil War, plantations were important in the U.S. South, where the principal crop was cotton, followed by tobacco and sugarcane. Demand for cotton increased dramatically after the establishment of textile factories in England at the start of the Industrial Revolution in the late eighteenth century. Cotton production was stimulated by the improvement of the cotton gin by Eli Whitney in 1793 and the development of new varieties of cotton that were harder and easier to pick. Slaves brought from Africa performed most of the labor until the abolition of slavery and the defeat of the South in the Civil War. Thereafter, plantations declined in the United States; they were subdivided and either sold to individual farmers or worked by tenant farmers.

**KEY ISSUE 3**

Where Are Agricultural Regions in More Developed Countries?

- Mixed crop and livestock farming
- Dairy farming
- Grain farming
- Livestock ranching
- Mediterranean agriculture
- Commercial gardening and fruit farming
- Importance of access to markets

Commercial agriculture in MDCs can be divided into six main types—mixed crops and livestock, dairying, grain farming, livestock ranching, Mediterranean agriculture, and gardening and fruit culture. Each type is predominant in distinctive regions within MDCs, depending largely on climate.

**Mixed Crop and Livestock Farming**

Mixed crop and livestock farming is the most common form of commercial agriculture in the United States west of the Appalachians and east of 98° west longitude and in much of Europe from France to Russia (refer to Figure 10–5).

**Characteristics of Mixed Crop and Livestock Farming**

The most distinctive characteristic of mixed crop and livestock farming is its integration of crops and livestock. Most of the crops are fed to animals rather than consumed directly by humans. In turn, the livestock supply manure to improve soil fertility to grow more crops. A typical mixed commercial farm devotes nearly all land area to growing crops but derives more than three-fourths of its income from the sale of animal products, such as beef, milk, and eggs. In the United States pigs are often bred directly on the farms, whereas cattle may be brought in to be fattened on corn.

Mixed crop and livestock farming permits farmers to distribute the workload more evenly through the year. Fields require less attention in the winter than in the spring, when crops are planted, and in the fall, when they are harvested. Livestock, on the other hand, require year-long attention. A mix of crops and livestock also reduces seasonal variations in income; most income from crops comes during the harvest season, but livestock products can be sold throughout the year.

**CROP ROTATION SYSTEMS.** Mixed crop and livestock farming typically involves crop rotation. The farm is divided into a number of fields, and each field is planted on a planned cycle, often of several years. The crop planted changes from one year to the next, typically going through a cycle of two or more crops and a year of fallow before the cycle is repeated. Crop rotation helps maintain the fertility of a field, because various crops deplete the soil of certain nutrients but restore others. Crop rotation contrasts with shifting cultivation, in which nutrients depleted from a field are restored only by leaving the field fallow (uncropped) for many years. In any given year, crops cannot be planted in most of an area’s fields, so overall production in shifting cultivation is much lower than in mixed commercial farming.

A two-field crop-rotation system was developed in Northwestern Europe as early as the fifth century. A cereal grain, such as oats, wheat, rye, or barley, was planted in Field A one year, while Field B was left fallow. The following year Field B was planted but A left fallow, and so forth. Beginning in the eighth century, a three-field system was introduced. The first field was planted with a winter cereal, the second with a spring cereal, and the third was left fallow. As a result, each field yielded four harvests every 6 years, compared to three every 6 years under the two-field system.

A four-field system was used in Northwest Europe by the eighteenth century. The first year, the farmer could plant a root crop (such as turnips) in Field A, a cereal in Field B, a "rest" crop (such as clover, which helps restore the field) in Field C, and a cereal in Field D. The second year, the farmer might select a cereal for Field A, a rest crop for Field B, a cereal for Field C, and a root for Field D. The rotation would continue for two more years before the cycle would start again. Each field thus passed through a cycle of four crops—root, cereal, rest crop, and another cereal.

Cereals such as wheat and barley were sold for flour and beer production, and straw (the stalks remaining after the heads of wheat are threshed) was retained for animal bedding. Root crops such as turnips were fed to the animals during the winter. Clover and other "rest" crops were used for cattle grazing and restoration of nitrogen to the soil.

**Choice of Crops**

In the United States, mixed crop and livestock farmers select corn most frequently because of higher yields per acre than other crops. Some of the corn is consumed by people either
directly or as oil, margarine, and other food products, but most is fed to pigs and cattle (Figure 10–7). The most important mixed crop and livestock farming region in the United States—extending from Ohio to the Dakotas, with its center in Iowa—is frequently called the Corn Belt, because approximately half of the crop land is planted in corn (maize).

Soybeans have become the second most important crop in the U.S. mixed commercial farming region. Like corn, soybeans are sometimes used to make products consumed directly by people, but mostly to make animal feed. Tofu (made from soybean milk) is a major food source, especially for people in China and Japan. Soybean oil is widely used in U.S. foods but as a hidden ingredient.

Why Dairy Farms Locate Near Urban Areas

In MDCs, dairying is the most important type of commercial agriculture in the first ring outside large cities because of transportation factors. Dairy farms must be closer to their market than other products because milk is highly perishable. The ring surrounding a city from which milk can be supplied without spoiling is known as the milkshed.

Improvements in transportation have permitted dairying to be undertaken farther from the market. Until the 1840s, when railroads were first used for transporting dairy products, milksheds rarely had a radius beyond 50 kilometers (30 miles). Today refrigerated railcars and trucks enable farmers to ship milk more than 500 kilometers (300 miles). As a result, nearly every farm in the U.S. Northeast and Northwest Europe is within the milkshed of at least one urban area.

Some dairy farms specialize in products other than milk. Originally, butter and cheese were made directly on the farm, primarily from the excess milk produced in the summer, before modern agricultural methods evened the flow of milk through the year. In the twentieth century, dairy farmers have generally chosen to specialize either in fresh milk production or other products, such as butter and cheese.

Regional Differences in Dairy Products

The choice of product varies within the U.S. dairy region, depending on whether the farms are within the milkshed of a large urban area. In general, the farther the farm is from large urban concentrations, the smaller is the percentage of output devoted to fresh milk. Farms located farther from consumers are more likely to sell their output to processors who make butter, cheese, or dried, evaporated,
and condensed milk. The reason is that these products keep fresh longer than milk does and therefore can be safely shipped from remote farms.

In the East, virtually all milk is sold to consumers living in New York, Philadelphia, Boston, and the other large urban areas. Farther west, most milk is processed into cheese and butter. Most of the milk in Wisconsin is processed, for example, compared to only 5 percent in Pennsylvania. The proximity of northeastern farmers to several large markets accounts for these regional differences (Figure 10–9).

Countries likewise tend to specialize in certain products. New Zealand, the world’s largest per capita producer of dairy products, devotes about 5 percent to liquid milk, compared to more than 50 percent in the United Kingdom. New Zealand farmers do not sell much liquid milk, because the country is too far from North America and Northwest Europe, the two largest relatively wealthy population concentrations.

Dairy farmers, like other commercial farmers, usually do not sell their products directly to consumers. Instead, they generally sell milk to wholesalers, who distribute it in turn to retailers. Retailers then sell milk to consumers in shops or at home. Farmers also sell milk to butter and cheese manufacturers.

**Challenges for Dairy Farmers**

Like other commercial farmers, dairy farmers face economic difficulties because of declining revenues and rising costs. Distinctive features of dairy farming have exacerbated the economic difficulties. First, dairy farming is labor intensive, because the cows must be milked twice a day, every day. Although the actual milking can be done by machines, dairy farming nonetheless requires constant attention throughout the year.

Dairy farmers also face the expense of feeding the cows in the winter, when they may be unable to graze on grass. In Northwest Europe and in the Northeastern United States, farmers generally purchase hay or grain for winter feed. In the western part of the U.S. dairy region, crops are more likely to be grown in the summer and stored for winter feed on the same farm.

The number of farms with milk cows declined in the United States by two-thirds between 1980 and 2000. Departing dairy
The most important crop grown is wheat, used to make bread flour. Wheat generally can be sold for a higher price than other grains, such as rye, oats, and barley, and it has more uses as human food. It can be stored relatively easily without spoiling and can be transported a long distance. Because wheat has a relatively high value per unit weight, it can be shipped profitably from remote farms to markets.

Wheat's significance extends beyond the amount of land or number of people involved in growing it. Unlike other agricultural products, wheat is grown to a considerable extent for international trade and is the world's leading export crop. As the United States and Canada account for about half of the world's wheat exports, the North American prairies are accurately labeled the world's "breadbasket." The ability to provide food for many people elsewhere in the world is a major source of economic and political strength for the United States and Canada.

The United States is by far the largest commercial producer of grain. Large-scale commercial grain production is found in only a few other countries, including Canada, Argentina, Australia, France, and the United Kingdom. Commercial grain farms are generally located in regions that are too dry for mixed crop and livestock agriculture (Figure 10–10).

Within North America, large-scale grain production is concentrated in three areas. The first is the winter-wheat belt that extends through Kansas, Colorado, and Oklahoma. In the winter wheat area, the crop is planted in the autumn and develops a strong root system before growth stops for the winter. The wheat survives the winter, especially if it is insulated beneath a snow blanket, and is ripe by the beginning of summer.

The second important grain-producing region in North America is the spring-wheat belt of the Dakotas, Montana, and southern Saskatchewan in Canada. Because winters are usually too severe for winter wheat in this region, spring wheat is planted in the spring and harvested in the late summer. Approximately two-thirds of the wheat grown in the United States comes either from the winter- or the spring-wheat belt. A third important grain-growing region is the Palouse region of Washington State.

Large-scale grain production, like other commercial farming ventures in MDCs, is heavily mechanized, conducted on large farms, and oriented to consumer preferences. The McCormick reaper (a machine that cuts grain standing in the field), invented in the 1830s, first permitted large-scale wheat production. Today the combine machine performs in one operation the three tasks of reaping, threshing, and cleaning.

Unlike work on a mixed crop and livestock farm, the effort required to grow wheat is not uniform throughout the year. Some individuals or firms may therefore have two sets of fields—one in the spring-wheat belt and one in the winter-wheat belt. Because the planting and harvesting in the two regions occur at different times of the year, the workload can be distributed throughout the year. In addition, the same machinery can be used in the two regions, thus spreading the cost of the expensive equipment. Combine companies start working in Oklahoma in early summer and work their way northward.
Livestock Ranching

Ranching is the commercial grazing of livestock over an extensive area. This form of agriculture is adapted to semiarid or arid land. It is practiced in MDCs, where the vegetation is too sparse and the soil too poor to support crops.

Cattle Ranching in U.S. Popular Culture

The importance of ranching in the United States extends beyond the people who choose this form of commercial farming. Its prominence in popular culture, especially in Hollywood films and television, has not only helped to draw attention to this form of commercial farming but has also served to illustrate, albeit in sometimes romanticized ways, the crucial role that ranching played in the history and settlement of areas of the United States. Cattle ranching in Texas, as glamorized in popular culture, did actually dominate commercial agriculture, but only for a short period—from 1867 to 1885.

BEGINNING OF U.S. CATTLE RANCHING. Cattle were first brought to the Americas by Columbus on his second voyage, because they were sufficiently hardy to survive the ocean crossing. Living in the wild, the cattle multiplied and thrived on abundant grazing lands on the frontiers of North and South America. Immigrants from Spain and Portugal—the only European countries with a tradition of cattle ranching—began ranching in the Americas. They taught the practice to settlers from Northern Europe and the Eastern United States who moved to Texas and other frontier territories in the nineteenth century.

Cattle ranching in the United States expanded because of demand for beef in the East Coast cities during the 1860s. The challenge for ranchers was to transport the cattle from Texas to eastern markets. Ranchers who could get their cattle to Chicago were paid $30 to $40 per head, compared to only $3 or $4 per head in Texas. Once in Chicago, the cattle could be slaughtered and processed by meat-packing companies and sold to consumers in the East.

TRANSPORTING CATTLE TO MARKET. To reach Chicago, cattle were driven on hoof by cowboys over trails from Texas to the nearest railhead. Distances were several hundred kilometers. There they were driven into cattle cars for the rest of their
journey. The western terminus of the rail line reached Abilene, Kansas, in 1867. That year, a man named Joseph G. McCoy (on whom the expression “the real McCoy” was based) launched a massive construction effort to provide Abilene with homes, shops, and stockyards. As a result, the number of cattle brought into Abilene increased from 1,000 in 1867 to 35,000 in 1868 and 150,000 in 1869. McCoy became the first mayor of the city of Abilene.

Like other frontier towns, Abilene became a haven where cowboys let off steam. Gunfights, prostitution, gambling, and alcoholism were rampant until McCoy hired James B. “Wild Bill” Hickock as sheriff to clean up the town. After a few years the terminus of the railroad moved farther west. Wichita, Caldwell, Dodge City, and other towns in Kansas took their turns as the main destination for cattle driven north on trails from Texas. Abilene became a ghost town for a while. Eventually, though, use of the surrounding land changed from cattle grazing to crop growing, and Abilene became a prosperous market center.

The most famous route from Texas northward to the rail line was the Chisholm Trail, which began near Brownsville at the Mexican border and extended northward through Texas, Indian Territory (now the state of Oklahoma), and Kansas. The trail had many branches, but the main line extended through Austin, Waco, Fort Worth, and Caldwell (Figure 10–11). The Western Trail became more important in the 1870s when the railroad terminus moved farther west. Today U.S. Route 81 roughly follows the course of the Chisholm Trail.

### Fixed Location Ranching

Cattle ranching declined in importance during the 1880s after it came in conflict with sedentary agriculture. Most early U.S. ranchers adhered to “The Code of the West,” although the system had no official legal status. Under the code, ranchers had range rights—that is, their cattle could graze on any open land and had access to scarce water sources and grasslands. The early cattle ranchers in the West owned little land, only cattle.

**RANGE WARS.** The U.S. government, which owned most of the land used for open grazing, began to sell it to farmers to grow crops, leaving cattle ranchers with no legal claim to it. For a few years the ranchers tried to drive out the farmers by cutting fences and then illegally erecting their own fences on public land, and “range wars” flared.

The farmers’ most potent weapon proved to be barbed wire, first commercially produced in 1873. The farmers eventually won the battle, and ranchers were compelled to buy or lease land to accommodate their cattle. Large cattle ranches were established, primarily on land that was too dry to support crops. Ironically, 60 percent of cattle grazing today takes place on land leased from the U.S. government.

**CHANGES IN CATTLE BREEDING.** Ranchers were also induced to switch from cattle drives to fixed-location ranching by a change in the predominant breed of cattle. Longhorns, the first cattle used by ranchers, were hardy animals, able to survive the long-distance drive...
along the trails with little weight loss. But longhorns were susceptible to cattle ticks, parasitic insects that carried a fever and were difficult to remove, and the meat of longhorns was of poor quality.

New cattle breeds introduced from Europe, such as the Hereford, offered superior meat but were not adapted to the old ranching system. The new breeds could not survive the winter by open grazing, as could the longhorns. Instead, crops had to be grown or feed purchased for them. The cattle could not be driven long distances, and they required more water. However, these breeds thrived once open grazing was replaced by fixed ranching, and long-distance trail drives and rail journeys to Chicago gave way to short rail or truck trips to nearby meat packers.

With the spread of irrigation techniques and hardier crops, land in the United States has been converted from ranching to crop growing. Ranching generates lower income per area of land, although it has lower operating costs. Cattle are still raised on ranches but are frequently sent for fattening to farms or to local feed lots along major railroad and highway routes rather than directly to meat processors. The average size of a ranch is large, because the capacity of the land to support cattle is low in much of the semiarid West. Large ranches may be owned by meat-processing companies rather than individuals.

Ranching Outside the United States

Commercial ranching is conducted in other more developed regions of the world (Figure 10-12). Ranching is rare in Europe, except in Spain and Portugal. In South America, a large portion of the pampas of Argentina, southern Brazil, and Uruguay are devoted to grazing cattle and sheep. The cattle industry grew rapidly in Argentina in part because the land devoted to ranching was relatively accessible to the ocean, and meat could be transported to overseas markets.

The relatively humid climate on the pampas provides more shoots and shrubs on a given area of land than in the U.S. West. This growth of ranching in South America was stimulated because more cattle could graze on a given area of land in the pampas than in the U.S. West. Land was divided into large holdings in the nineteenth century, in contrast to the U.S. practice of permitting common grazing on public land. Ranching has declined in Argentina, as in the United States, because growing crops is more profitable except on very dry lands.

The interior of Australia was opened for grazing in the nineteenth century, although sheep are more common than cattle. Ranches in the Middle East, New Zealand, and South Africa are also more likely to have sheep. Like the U.S. West, Australia’s drylands went through several land-use changes. Until the 1860s, shepherding was practiced on the open range. Then large ranches with fixed boundaries were established, stock was improved, and water facilities were expanded. Eventually, ranching was confined to drier lands, and wheat—which yielded greater profits per hectare than ranching—was planted where precipitation levels permitted.

Ranching has followed similar stages around the world. First was the herding of animals over open ranges, in a seminomadic style. Then ranching was transformed into fixed farming by dividing the open land into ranches. Many of the farms converted to growing crops, and ranching was confined to the drier lands. To survive, the remaining ranches experimented with new methods of breeding and sources of water and feed. Ranching became part of the meat-processing industry rather than an

![Figure 10-12](image-url)  
**Figure 10-12** Meat production. Cattle, sheep, and goats are the three animals most commonly found on ranches. Cattle on ranches in the Western Hemisphere, sheep in Australia, and goats in Central Asia.
Mediterranean Agriculture

Mediterranean agriculture exists primarily on the lands that border the Mediterranean Sea in Southern Europe, North Africa, and western Asia. Farmers in California, central Chile, the southwestern part of South Africa, and southwestern Australia practice Mediterranean agriculture as well.

These Mediterranean areas share a similar physical environment (refer to Figure 10–5). Every Mediterranean area borders a sea. Mediterranean areas are on west coasts of continents (except for some lands surrounding the Mediterranean Sea). Prevailing sea winds provide moisture and moderate the winter temperatures. Summers are hot and dry, but sea breezes provide some relief. The land is very hilly, and mountains frequently plunge directly to the sea, leaving very narrow strips of flat land along the coast.

Farmers derive a smaller percentage of income from animal products in the Mediterranean region than in the mixed crop and livestock region. Livestock production is hindered during the summer by the lack of water and good grazing land. Some farmers living along the Mediterranean Sea traditionally used transhumance to raise animals, although the practice is now less common. Under transhumance, animals—primarily sheep and goats—are kept on the coastal plains in the winter and transferred to the hills in the summer.

Most crops in Mediterranean lands are grown for human consumption rather than for animal feed. Horticulture—which is the growing of fruits, vegetables, and flowers—and tree crops form the commercial base of Mediterranean farming. Most of the world’s olives, grapes, fruits, and vegetables are grown in Mediterranean agriculture areas. A combination of local physical and cultural characteristics determines which crops are grown in each area. The hilly landscape encourages farmers to plant a variety of crops within one farming area.

In the lands bordering the Mediterranean Sea, the two most important cash crops are olives and grapes. Two-thirds of the world’s wine is produced in countries that border the Mediterranean Sea, especially Italy, France, and Spain. Mediterranean agricultural regions elsewhere in the world produce most of the remaining one-third. The lands near the Mediterranean Sea are also responsible for a large percentage of the world’s supply of olives, an important source of cooking oil.

Despite the importance of olives and grapes to commercial farms bordering the Mediterranean Sea, approximately half of the land is devoted to growing cereals, especially wheat for pasta and bread. As in the U.S. winter-wheat belt, the seeds are sown in the fall and harvested in early summer. After cultivation, cash crops are planted on some of the land, whereas the remainder is left fallow for a year or two to conserve moisture in the soil.

Cereals occupy a much lower percentage of the cultivated land in California than in other Mediterranean climates. Instead, much of California farmland is devoted to fruit and vegetable horticulture. California supplies much of the citrus fruits, tree nuts, and deciduous fruits consumed in the United States. Horticulture is practiced in other Mediterranean climates, but not to the extent found in California.

The rapid growth of urban areas in California, especially Los Angeles, has converted high-quality agricultural land into housing developments. Thus far, the loss of farmland has been offset by the expansion of agriculture into arid lands. However, farming in drylands requires massive irrigation to provide water. In the future, agriculture may face stiffer competition to divert the Southwest’s increasingly scarce water supply.

Commercial Gardening and Fruit Farming

Commercial gardening and fruit farming is the predominant type of agriculture in the U.S. Southeast. The region has a long growing season and humid climate and is accessible to the large markets of New York, Philadelphia, Washington, and other eastern U.S. urban areas. The type of agriculture practiced in this region is frequently called truck farming, because “truck” was a Middle English word meaning bartering or the exchange of commodities.

Truck farms grow many of the fruits and vegetables that consumers demand in more developed societies, such as apples, asparagus, cherries, lettuce, mushrooms, and tomatoes. Some of these fruits and vegetables are sold fresh to consumers, but most are sold to large processors for canning or freezing.

Truck farms are highly efficient large-scale operations that take full advantage of machines at every stage of the growing process. Truck farmers are willing to experiment with new varieties, seeds, fertilizers, and other inputs to maximize efficiency. Labor costs are kept down by hiring migrant farm workers, some of whom are undocumented immigrants from Mexico who work for very low wages. Farms tend to specialize in a few crops, and a handful of farms may dominate national output of some fruits and vegetables.

A form of truck farming called specialty farming has spread to New England. Farmers are profitably growing crops that have limited but increasing demand among affluent consumers, such as asparagus, peppers, mushrooms, strawberries, and nursery
plants. Specialty farming represents a profitable alternative for New England farmers, at a time when dairy farming is declining because of relatively high operating costs and low milk prices.

**Importance of Access to Markets**

Because the purpose of commercial farming is to sell produce off the farm, the distance from the farm to the market influences the farmer's choice of crop to plant. The clearest example of the importance of proximity to the market is dairy farming, because milk spoils quickly. Crops that can be shipped long distances without spoiling are grown farther from the market.

**Von Thünen Model**

Geographers use the von Thünen model to help explain the importance of proximity to market in the choice of crops on commercial farms. The von Thünen model was first proposed in 1826 by Johann Heinrich von Thünen, a farmer in northern Germany, in a book titled *The Isolated State*. According to the model, which was later modified by geographers, a commercial farmer initially considers which crops to cultivate and which animals to raise based on market location.

In choosing an enterprise, a commercial farmer compares two costs—the cost of the land versus the cost of transporting products to market. First, a farmer identifies a crop that can be sold for more than the land cost. Assume that a farmer's land costs $100 per hectare per year. The farmer would consider planting wheat if the output from 1 hectare could be marketed for more than $100 that year. Another crop, such as corn, will also be considered if the yield from 1 hectare can sell for more than $100.

A farmer will not necessarily plant the crop that sells for the highest price per hectare. The choice further depends on the distance of the farmer's land from the central market city. Distance to market is critical because the cost of transporting each product is different. The following example illustrates the influence of transportation cost on the profitability of growing wheat:

1. **Gross profit from sale of wheat grown on 1 hectare of land not including transportation costs:**
   - Wheat can be grown for $0.25 per kilogram.
   - Yield per hectare of wheat is 1,000 kilograms.
   - Gross profit is $250 per hectare ($0.25 per kilogram \( \times \) 1,000 kilograms per hectare).

2. **Net profit from sale of wheat grown on 1 hectare of land including transportation costs:**
   - Cost of transporting 1,000 kilograms of wheat to the market is $62.50 per kilometer.
   - Net profit from the sale of 1,000 kilograms of wheat grown on a farm located 1 kilometer from the market is $187.50 ($250 gross profit – $62.50 per kilometer transport costs).
   - Net profit from sale of 1,000 kilograms of wheat grown on a farm located 4 kilometers from the market is $0 ($250 gross profit – $62.50 per kilometer \( \times \) 4 kilometers).

The example shows that a farmer would make a profit growing wheat on land located less than 4 kilometers from the market. Beyond 4 kilometers, wheat is not profitable, because the cost of transporting it exceeds the gross profit.

The von Thünen model shows that a commercial farmer must combine two sets of monetary values to determine the most profitable crop:

- The value of the yield per hectare
- The cost of transporting the yield per hectare

These calculations demonstrate that farms located closer to the market tend to select crops with higher transportation costs per hectare of output, whereas more distant farms are more likely to select crops that can be transported less expensively.

**Application of Von Thünen Model**

Von Thünen based his general model of the spatial arrangement of different crops on his experiences as owner of a large estate in northern Germany during the early nineteenth century (Figure 10-13). He found that specific crops were grown in different rings around the cities in the area. Market-oriented gardens and milk producers were located in the first
ring out from the cities. These products are expensive to deliver and must reach the market quickly because they are perishable.

The next ring out from the cities contained wood lots, where timber was cut for construction and fuel; closeness to market is important for this commodity because of its weight. The next rings were used for various crops and for pasture; the specific commodity was rotated from one year to the next. The outermost ring was devoted exclusively to animal grazing, which requires lots of space.

Von Thünen did not consider site or human factors in his model. The model assumed that all land in a study area had similar site characteristics and was of uniform quality, although he recognized that the model could vary according to topography and other distinctive physical conditions. For example, a river might modify the shape of the rings because transportation costs change when products are shipped by water routes rather than over roads. The model also failed to consider that social customs and government policies influence the attractiveness of plants and animals for a commercial farmer.

Although von Thünen developed the model for a small region with a single market center, it is also applicable on a national or global scale. Farmers in relatively remote locations who wish to sell their output in the major markets of Western Europe and North America, for example, are less likely to grow highly perishable and bulky products.

**KEY ISSUE 4**

Why Do Farmers Face Economic Difficulties?

- Challenges for commercial farmers
- Challenges for subsistence farmers
- Strategies to increase food supply

Commercial and subsistence farmers face similar challenges. In both regions, farmers have difficulty generating enough income to continue farming. The underlying reasons, though, are different. Commercial farmers are producing a surplus of food, whereas many subsistence farmers are barely able to produce enough food to survive.

**Challenges for Commercial Farmers**

Commercial farmers are in some ways victims of their own success. Having figured out how to produce large quantities of food, commercial farmers face low prices for their output. Government subsidies help prop up farm income. Many believe that the future health of commercial farming rests with embracing more sustainable practices.

**Overproduction in Commercial Farming**

Commercial farmers suffer from low incomes because they are capable of producing much more food than is demanded by consumers in MDCs. A surplus of food can be produced because of widespread adoption of efficient agricultural practices. New seeds, fertilizers, pesticides, mechanical equipment, and management practices have enabled farmers to obtain greatly increased yields per area of land.

The experience of dairy farming in the United States demonstrates the growth in productivity. The United States had 20 million dairy cows producing 57 million metric tons (63 million tons) of milk a year during the 1960s. The number of dairy cows in the United States declined to 9 million in 2005, but production increased to 80 million metric tons (90 million tons). In other words, yield per cow has tripled over the past several decades.

Although the food supply has increased in MDCs, demand has remained constant, because the market for most products is already saturated. In MDCs, consumption of a particular commodity may not change significantly if the price changes. Americans, for example, do not switch from wheat to corn products if the price of corn falls more rapidly than wheat. Demand is also stagnant for most agricultural products in MDCs because of low population growth.

The U.S. government has three policies that are supposed to address the problem of excess productive capacity. First, farmers are encouraged to avoid producing crops that are in excess supply. Because soil erosion is a constant threat, the government encourages planting fallow crops, such as clover, to restore nutrients to the soil and to help hold the soil in place. These crops can be used for hay, forage for pigs, or to produce seeds for sale.

Second, the government pays farmers when certain commodity prices are low. The government sets a target price for the commodity and pays farmers the difference between the price they receive in the market and a target price set by the government as a fair level for the commodity. The target prices are calculated to give farmers the same price for the commodity today as in the past, when compared to other consumer goods and services.

Third, the government buys surplus production and sells or donates it to foreign governments. In addition, low-income Americans receive food stamps in part to stimulate their purchase of additional food.

The United States spent about $25 billion a year on farm subsidies in 2005. Annual spending varies considerably from one year to the next: subsidy payments are lower in years when market prices rise and production is down, typically as a result of poor weather conditions in the United States or political problems in other countries.

Farming in Europe is subsidized even more than in the United States. More farmers receive subsidies in Europe, and they receive more than American farmers. The high subsidies are a legacy of a long-standing commitment by the European Union to maintain agriculture in its member states, especially in France. Supporters point to the preservation of rural village life in parts of Europe, while critics charge that Europeans pay needlessly high prices for food as a result of the subsidies.
Government policies in MDCs point out a fundamental irony in worldwide agricultural patterns. In an MDC such as the United States, farmers are encouraged to grow less food, whereas LDCs struggle to increase food production to match the rate of growth in the population.

**Sustainable Agriculture**

Some commercial farmers are converting their operations to sustainable agriculture, an agricultural practice that preserves and enhances environmental quality. Farmers practicing sustainable agriculture typically generate lower revenues than do conventional farmers, but they also have lower costs.

An increasingly popular form of sustainable agriculture is organic farming. However, some organic farms, especially the larger ones, may rely in part on unsustainable practices, such as use of fossil fuels to operate tractors.

In the United States, the Department of Agriculture sets national standards for what constitutes organic. Several dozen state and private agencies have been empowered to certify that a farm complies with the organic standards. About 0.2 percent of U.S. farmland was certified organic in 2003, including 4 percent of apple orchards and 4 percent of lettuce fields. Percentages have been lower for the leading field crops: only 0.4 percent of wheat fields, 0.2 percent of soybean fields, and 0.1 percent of corn fields were certified organic in 2003.

Worldwide, 0.23 percent of farmland was classified as organic in 2006, including 0.4 percent in MDCs and 0.2 percent in LDCs. Australia was the leader, with organic farming practiced on 2.7 percent of its farmland.

Three principal practices distinguish sustainable agriculture (and at its best, organic farming) from conventional agriculture:

- Sensitive land management
- Limited use of chemicals
- Better integration of crops and livestock

**SENSITIVE LAND MANAGEMENT.** Sustainable agriculture protects soil in part through ridge tillage, which is a system of planting crops on ridge tops. Croops are planted on 10- to 20-centimeter (4- to 8-inch) ridges that are formed during cultivation or after harvest. The crop is planted on the same ridges, in the same rows, year after year. Ridge tillage is attractive for two main reasons—lower production costs and greater soil conservation.

Production costs are lower with ridge tillage in part because it requires less investment in tractors and other machinery than conventional planting. An area that would be prepared for planting under conventional farming with three to five tractors can be prepared for ridge tillage with only one or two tractors. The primary tillage tool is a row-crop cultivator that can form ridges. There is no need for a plow, or field cultivator, or a 300-horsepower four-wheel-drive tractor.

With ridge tillage, the space between rows needs to match the distance between wheels of the machinery. If 75 centimeters (30 inches) are left between rows, tractor tires will typically be on 150-centimeter (60-inch) centers and combine wheels on 300-centimeter (120-inch) centers. Wheel spaces are available from most manufacturers to fit the required spacing.

Ridge tillage features a minimum of soil disturbance from harvest to the next planting. A compaction-free zone is created under each ridge and in some row middles. Keeping the trafficked area separate from the crop-growing area improves soil properties. Over several years the soil will tend to have increased organic matter, greater water holding capacity and more earthworms. The channels left by earthworms and decaying roots enhance drainage.

Ridge tillage compares favorably with conventional farming for yields while lowering the cost of production. Although more labor intensive than other systems, it is profitable on a per-acre basis. In Iowa, for example, ridge tillage has gained favor for production of organic and herbicide-free soybeans, which sell for more than regular soybeans.

**LIMITED USE OF CHEMICALS.** In conventional agriculture, seeds are often genetically modified to survive when herbicides and insecticides are sprayed on the fields to kill weeds and insects. These are known as “Roundup-Ready” seeds, because its creator Monsanto Corp. sells it under the brand name “Roundup.” “Roundup-Ready” seeds were planted in 80 percent of all soybean acreage, 54 percent of all cotton acreage, and 12 percent of all corn acreage in the United States in 2003. Aside from adverse impacts on soil and water quality, widespread use of “Roundup-Ready” seeds is causing some weeds to become resistant to the herbicide.

Sustainable agriculture, on the other hand, involves application of limited if any herbicides to control weeds. In principle, farmers can control weeds without chemicals, although it requires additional time and expense that few farmers can afford. Researchers have found that combining mechanical weed control with some chemicals yields higher returns per acre than relying solely on one of the two methods.

Ridge tilling also promotes decreased use of chemicals, which can be applied only to the ridges and not the entire field.
Combining herbicide banding—which applies chemicals in narrow bands over crop rows—with cultivating may be the best option for many farmers.

**INTEGRATED CROP AND LIVESTOCK.** Sustainable agriculture attempts to integrate the growing of crops and the raising of livestock as much as possible at the level of the individual farm. Animals consume crops grown on the farm and are not confined to small pens. As discussed earlier in the chapter, mixed crop and livestock is the predominant form of farming in many developed countries, including the Corn Belt of the United States. In conventional farming, integration between crops and livestock generally takes place through intermediaries rather than inside an individual farm. That is, many farmers in the mixed crop and livestock region actually choose to only grow crops or only raise animals. They sell their crops off the farm or purchase feed for their animals from outside suppliers.

Integration of crops and livestock reflects a return to the historical practice of mixed crop and livestock farming, in which growing crops and raising animals were regarded as complementary activities on the farm. This was the common practice for centuries until the mid-1900s when technology, government policy, and economics encouraged farmers to become more specialized.

Sustainable agriculture is sensitive to the complexities of biological and economic interdependencies between crops and livestock. The first complexity is finding the correct number and distribution of livestock for the area based on the landscape and forage sources. Prolonged concentration of livestock in a specific location can result in permanent loss of vegetative cover, so the farmer needs to move the animals to reduce overuse in some areas. However, growing row crops on the more level land while confining pastures to steeper slopes will reduce soil erosion, so it may be necessary to tolerate loss of vegetation in specific locations. The farmer may need to balance the need to secure livestock inside fences with the convenience of tilling large unfenced fields through the use of temporary fencing.

The second complexity in integrating crops and livestock for sustainable agriculture is animal confinement. The moral and ethical debate regarding animal welfare is particularly intense for confined livestock production systems. Confined livestock are a source of surface and ground water pollutants, particularly where the density of animals is high. Expensive waste management facilities are a necessary cost of confined production systems. If animals are not confined, manure can contribute to soil fertility. However, quality of life in nearby communities may be adversely affected by the smell.

The third complexity in sustainable integration of crops and livestock is management of extreme weather conditions. Herd size may need to be reduced during periods of short- and long-term droughts. On the other hand, livestock can buffer the negative impacts of low rainfall periods by consuming crops that in conventional farming would be left as failures. Especially in Mediterranean climates such as in California, properly managed grazing significantly reduces fire hazards by reducing fuel build-up in grasslands and brushlands.

Finally, feeding and marketing are flexible in animal production systems. This can help cushion farmers against trade and price fluctuations and, in conjunction with cropping operations, make more efficient use of farm labor. Feed costs are the largest single variable cost in any livestock operation. While most of the feed may come from other enterprises on the ranch, some purchased feed is usually imported from off the farm. Feed costs can be kept to a minimum by monitoring animal condition and performance and understanding seasonal variations in feed and forage quality on the farm.

**Challenges for Subsistence Farmers**

Two issues discussed in earlier chapters influence the choice of crops planted by subsistence farmers. First, because of rapid population growth in LDCs (discussed in Chapter 2), subsistence farmers must feed an increasing number of people. Second, because of adopting the international trade approach to development (discussed in Chapter 9), subsistence farmers must grow food for export instead of for direct consumption.

**Subsistence Farming and Population Growth**

Ester Boserup, an economist, has offered an explanation for why population growth influences the distribution of types of subsistence farming. According to the Boserup thesis, population growth compels subsistence farmers to consider new farming approaches that produce enough food to take care of the additional people.

For hundreds if not thousands of years, subsistence farming in LDCs yielded enough food for people living in rural villages to survive, assuming no drought, flood, or other natural disaster occurs. Suddenly in the late twentieth century, the LDCs needed to provide enough food for a rapidly increasing population, as well as for the growing number of urban residents who cannot grow their own food.

According to the Boserup thesis, subsistence farmers increase the supply of food through intensification of production, achieved in two ways. First, land is left fallow for shorter periods, resulting in an expansion in the amount of land area devoted to growing crops at any given time. Boserup identified five basic stages in the intensification of farmland:

- **Forest Fallow.** Fields are cleared and utilized for up to 2 years and left fallow for more than 20 years, long enough for the forest to grow back.
- **Bush Fallow.** Fields are cleared and utilized for up to 8 years and left fallow for up to 10 years, long enough for small trees and bushes to grow back.
- **Short Fallow.** Fields are cleared and utilized for perhaps 2 years (Boserup was uncertain) and left fallow for up to 2 years, long enough for wild grasses to grow back.
- **Annual Cropping.** Fields are used every year and left fallow for a few months by planting legumes and roots.
- **Multicropping.** Fields are used several times a year and never left fallow.
Sub-Saharan African countries have been urged by the United States to increase their food supply in part through increased use of genetic modification (GM) of crops and livestock. Africans are divided on whether to accept GM organisms.

Farmers have been manipulating crops and livestock for thousands of years: the very nature of agriculture is to deliberately manipulate nature. Humans have controlled selective reproduction of plants and animals in order to produce a larger number of stronger, harder survivors. The science of genetics beginning in the nineteenth century expanded understanding of how to manipulate plants and animals to secure dominance of the most favorable traits.

GM, which became widespread in the late twentieth century, marks a sharp break with the agricultural practices of the past several thousand years. Whereas traditional selective breeding of plants and animals has involved increasing understanding of genetic traits, GM for the first time has involved the modification of those traits. Under GM the genetic composition of an organism is not merely studied, it is actually altered. GM involves mixing genetic material among two or more species that would not otherwise mix in nature.

GM is widespread in the United States, especially in the processed food that Americans consume in restaurants and at home heated in microwave ovens. The United States was responsible for 63 percent of the world’s GM crops in 2003, and Canada another 6 percent. Argentina was second to the United States, accounting for 21 percent of the world’s GM crops.

Africans must weigh arguments both for and against adoption of GM. The positives of GM are higher yields, increased nutrition, and more resistance to pests. GM foods are better tasting, at least to some palates.

Despite these benefits, opposition to GM is strong in Africa for several reasons. GM may cause safety problems, such as lowered resistance to antibiotics, and could destroy long-standing ecological balances in local agriculture. Europeans are especially strongly opposed to GM, because they believe the food is not as nutritious as that from traditionally bred crops and livestock.

In Africa, opposition to GM stems in part from practical economics. European countries, the main markets for Africa’s agricultural exports, require GM foods to be labeled. Because European consumers shun GM food, African farmers fear that if they are no longer able to certify their exports as GM-free, European customers will stop buying them.

Africans are especially uneasy with GM primarily because it would increase dependence on the U.S.-based transnational corporations responsible for manufacturing most of the GM seeds. Every country in Africa except South Africa rejected an offer of GM seeds made by Monsanto and other U.S.-based biotech corporations at a 1998 UN meeting. After the 1998 UN meeting, African countries released this statement: “We strongly object that the image of the poor and hungry from our countries is being used by giant multinational corporations to push a technology that is neither safe, environmentally friendly, nor economically beneficial to us.”

Africans fear that the biotech companies could—and would—introduce a so-called “terminator” gene in the GM seeds, to prevent farmers from replanting them after harvest and require them to continue to purchase seeds year after year from the transnational corporations. Mozambique’s Prime Minister said, “We don’t want to create a habit of using genetically modified maize that the country cannot maintain.” If agriculture is regarded as a way of life, not just a food production business, GM represents for many Africans an unhealthy level of dependency on MDCs.

When a drought threatened millions in southern Africa with starvation in 2006, the United States offered one-half million tons of GM grain, but most countries rejected the offer. Zambia’s president called GM food “poison.” Ultimately, some countries accepted the offer, but only after the United States agreed to several safeguards, such as milling the grain before delivery rather than sending seeds that risked cross-breeding with local strains.
Contrast shifting cultivation, practiced in regions of low population density, such as central Africa, with intensive subsistence agriculture, practiced in regions of high population density, such as East Asia. Under shifting cultivation, cleared fields are utilized for a couple of years, then left fallow for 20 years or more. This type of agriculture supports a small population living at low density. As the number of people living in an area increases, more food must be grown, fields will be left fallow for shorter periods of time. Eventually, farmers achieve the very intensive use of farmland characteristic of areas of high population density.

The second way that subsistence farmers intensify production, according to the Boserup thesis, is through adopting new farming methods. Ploughs replace axes and sticks. More weeding is done, more manure applied, more terraces carved out of hillsides, and more irrigation ditches dug. The additional labor needed to perform these operations comes from the population growth. The farmland yields more food per area of land, but with the growing population, output per person remains about the same.

**Subsistence Farming and International Trade**

To expand production, subsistence farmers need higher-yield seeds, fertilizer, pesticides, and machinery. Some needed supplies can be secured by trading food with urban dwellers. For many African and Asian countries, though, the main way to obtain agricultural supplies is to import them from other countries. These countries lack the money to buy agricultural equipment and materials from MDCs.

To generate the funds they need to buy agricultural supplies, LDCs must produce something they can sell in MDCs. The LDCs sell some manufactured goods (see Chapter 11), but most raise funds through the sale of crops in MDCs. Consumers in MDCs are willing to pay high prices for fruits and vegetables that would otherwise be out of season, or for crops such as coffee and tea that cannot be grown there because of the climate.

In an LDC such as Kenya, families may divide by gender between traditional subsistence agriculture and contributing to international trade. Women practice most of the subsistence agriculture—that is, growing food for their families to consume—in addition to the tasks of cooking, cleaning, and carrying water from wells. Men may work for wages, either growing crops for export or at jobs in distant cities. Because men in Kenya frequently do not share the wages with their families, many women try to generate income for the household by making clothes, jewelry, baked goods, and other objects for sale in local markets.

The sale of export crops brings an LDC foreign currency, a portion of which can be used to buy agricultural supplies. But governments in LDCs face a dilemma: the more land that is devoted to growing export crops, the less that is available to grow crops for domestic consumption. Rather than helping to increase productivity, the funds generated through the sale of export crops may be needed to feed the people who switched from subsistence farming to growing export crops.

**DRUG CROPS.** The export crops chosen in some LDCs, especially in Latin America and Asia, are those that can be converted to drugs. Marijuana, the leading drug, is estimated to be used by 140 million worldwide. Cocaine and heroin, the two leading especially dangerous drugs, are abused by 13 million and 8 million people, respectively, worldwide. The United Nations estimated in 1998 that the incomes of 4 million people, primarily in Asia and Latin America, were dependent on cultivation of the opium poppy or coca leaf.

Heroin is derived from raw opium gum, which is produced by the opium poppy plant. The source of 60 percent of the world's opium is the so-called Golden Triangle of Southeast Asia, centered on Myanmar (Burma) and extending into Laos, Thailand, and Vietnam. Most of the remainder is grown in the so-called Golden Crescent of Southwest Asia, centered on Afghanistan and extending into Pakistan. Thailand serves as the transportation hub for distribution to MDCs.

Coca leaf is principally grown in southwestern South America, especially in Bolivia, Colombia, and Peru, which together account for 98 percent of world supply. Most of the processing of cocaine, as well as its distribution to the United States and other MDCs, is based in Colombia.

Marijuana, produced from the Cannabis sativa plant, is cultivated widely around the world. The overwhelming majority of the marijuana that reaches the United States is grown in Mexico. Cultivation of *C. sativa* is not thought to be expanding worldwide, whereas opium poppies and coca leaf are.

**Strategies to Increase Food Supply**

The implementation of four strategies can increase the food supply:

- Expand the land area used for agriculture.
- Increase the productivity of land now used for agriculture.
- Identify new food sources.
- Increase exports from other countries.

Challenges underlie each of these strategies.

**INCREASE FOOD SUPPLY BY EXPANDING LAND AREA FOR AGRICULTURAL USE**

Historically, world food production increased primarily by expanding the amount of land devoted to agriculture. When the world's population began to increase more rapidly in the late eighteenth and early nineteenth centuries, during the Industrial Revolution, pioneers could migrate to uninhabited territory and cultivate the land. Sparsely inhabited land suitable for agriculture was available in western North America, central Russia, and Argentina's pampas.

Two centuries ago people believed that good agricultural land would always be available for willing pioneers. Today few scientists believe that further expansion of agricultural land can feed the growing world population. Beginning about 1950, the human population has increased faster than the expansion of agricultural land.

At first glance, new agricultural land appears to be available, because only 11 percent of the world's land area is currently cultivated. In fact, cultivated land has expanded in Africa from
130 million hectares (330 million acres) in 1960 to 147 million hectares (380 million acres) in 1980 and 189 million hectares (490 million acres) in 2000. Growth is theoretically possible in North America, where some land is not cultivated for economic reasons, although in reality the amount has declined slightly since 1960.

In some regions, farmland is abandoned for lack of water. Especially in semiarid regions, human actions are causing land to deteriorate to a desertlike condition, a process called desertification (more precisely, semiarid land degradation). Semiarid lands that can support only a handful of pastoral nomads are overused because of rapid population growth. Excessive crop planting, animal grazing, and tree cutting exhaust the soil’s nutrients and preclude agriculture. Earth Policy Institute estimates that 2 billion hectares (5 million acres) of land have been degraded around the world. Overgrazing is thought to be responsible for 34 percent of the total, deforestation for 30 percent, and agricultural use for 28 percent (Figure 10–14). The United Nations estimates that desertification removes 27 million hectares (70 million acres) of land from agricultural production each year, an area roughly equivalent to Colorado.

Excessive water threatens other agricultural areas, especially drier lands that receive water from human-built irrigation systems. If the irrigated land has inadequate drainage, the underground water level rises to the point where roots become waterlogged. The United Nations estimates that 10 percent of all irrigated land is waterlogged, mostly in Asia and South America. If the water is salty, it can damage plants. The ancient civilization of Mesopotamia may have collapsed in part because of waterlogging and excessive salinity in their agricultural lands near the Tigris and Euphrates rivers.

Urbanization can also contribute to reducing agricultural land. As urban areas grow in population and land area, farms on the periphery are replaced by homes, roads, shops, and other urban land uses. In North America, farms outside urban areas are left idle until the speculators who own them can sell them at a profit to builders and developers, who convert the land to urban uses.

**INCREASE FOOD SUPPLY THROUGH HIGHER PRODUCTIVITY**

Population began to grow faster than agricultural land expanded during the 1960s, especially in LDCs. At the time, many experts forecast massive global famine within a decade. However, these dire predictions did not come true, because new agricultural practices have permitted farmers worldwide to achieve much greater yields from the same amount of land.

The invention and rapid diffusion of more productive agricultural techniques during the 1970s and 1980s is called the green revolution. The green revolution involves two main practices—the introduction of new higher-yield seeds and the expanded use of fertilizers. Because of the green revolution, agricultural productivity at a global scale has increased faster than population growth.

Scientists began an intensive series of experiments during the 1950s to develop a higher-yield form of wheat. A decade later, the “miracle wheat seed” was ready. Shorter and stiffer than traditional breeds, the new wheat was less sensitive to variation in day length, responded better to fertilizers, and matured faster. The Rockefeller and Ford foundations sponsored many of the studies, and the program’s director, Dr. Norman Borlaug, won the Nobel Peace Prize in 1970.

The International Rice Research Institute, established in the Philippines by the Rockefeller and Ford foundations,
worked to create a miracle rice seed. During the 1960s, their scientists introduced a hybrid of Indonesian rice and Taiwan dwarf rice that was harder and that increased yields. More recently, scientists have developed new high-yield maize (corn).

The new miracle seeds were diffused rapidly around the world. India's wheat production, for example, more than doubled in 5 years. After importing 10 million tons of wheat annually in the mid-1960s, India by 1971 had a surplus of several million tons. Other Asian and Latin American countries recorded similar productivity increases.

To take full advantage of the new miracle seeds, farmers must use more fertilizer and machinery. Farmers have known for thousands of years that application of manure, bones, and ashes somehow increases, or at least maintains, the fertility of the land. Not until the nineteenth century did scientists identify nitrogen, phosphorus, and potassium (potash) as the critical elements in these substances that improved fertility. Today these three elements form the basis for fertilizers—products that farmers apply on their fields to enrich the soil by restoring lost nutrients.

Nitrogen, the most important fertilizer, is a ubiquitous substance. Europeans most commonly produce a fertilizer known as urea, which contains 46 percent nitrogen. In North America, nitrogen is available as ammonia gas, which is 82 percent nitrogen but more awkward than urea to transport and store. China is the leading producer of nitrogen.

Both urea and ammonia gas combine nitrogen and hydrogen. The problem is that the cheapest way to produce both types of nitrogen-based fertilizers is to obtain hydrogen from natural gas or petroleum. As fossil-fuel prices increase, so do the prices for nitrogen-based fertilizers, which then become too expensive for many farmers in LDCs.

In contrast to nitrogen, phosphorus and potash reserves are not distributed uniformly across Earth's surface. Phosphate rock reserves are clustered in China, Morocco, and the United States. Proven potash reserves are concentrated in Canada, Russia, and Ukraine.

Farmers need tractors, irrigation pumps, and other machinery to make the most effective use of the new miracle seeds. In LDCs, farmers cannot afford such equipment and cannot, in view of high energy costs, buy fuel to operate the equipment. To maintain the green revolution, governments in LDCs must allocate scarce funds to subsidize the cost of seeds, fertilizers, and machinery.

The green revolution did not stop with miracle seeds. Scientists have continued to create higher-yield hybrids that are adapted to environmental conditions in specific regions.

Thanks to the green revolution, Dutch scientists calculate that the maximum annual crop yield currently has reached 6,000 kilograms of grain per hectare (5,000 pounds per acre) in parts of Asia and Latin America. This, however, still is far lower than the maximum possible yields of 15,000 kilograms per hectare (13,000 pounds per acre) in Asia and 20,000 kilograms per hectare (18,000 pounds per acre) in Latin America. The green revolution was largely responsible for preventing a food crisis in these regions during the 1970s and 1980s, but will these scientific breakthroughs continue in the twenty-first century?

INCREASE FOOD SUPPLY BY IDENTIFYING NEW FOOD SOURCES

A third alternative for increasing the world's food supply is to develop new food sources. Three strategies being considered are to cultivate the oceans, to develop higher-protein cereals, and to improve palatability of rarely consumed foods.

Cultivate Oceans. At first glance, increased use of food from the sea is attractive. Oceans are vast, covering nearly three-fourths of Earth's surface and lying near most population concentrations. But historically the sea has provided only a small percentage of world food supply. About two-thirds of the fish caught from the ocean is consumed directly, whereas the remainder is converted to fish meal and fed to poultry and hogs.

Hope grew during the 1950s and 1960s that increased fish consumption could meet the needs of a rapidly growing global population. Indeed, the world's annual fish catch increased from 22 million tons in 1954 to 100 million tons in 1991. However, the population of some fish species declined because they have been harvested faster than they can reproduce. The population of large predatory fish, such as tuna and swordfish, has declined by 90 percent in the past half-century because of overfishing. Overfishing has been particularly acute in the North Atlantic and Pacific oceans.

The United Nations estimates that one-quarter of fish stocks have been overfished and one-half fully exploited, leaving only one-fourth underfished. Consequently, the total world fish catch has remained relatively constant since the 1980s despite population growth.

To protect fishing areas, many countries have claimed control of the oceans within 200 nautical miles of the coast. These countries have the right to seize foreign fishing vessels that venture into the so-called exclusive economic zone.

Peru has been especially sensitive to the overfishing problem after the country's catch of anchovies, its most important fish, declined by more than 75 percent between 1970 and 1973. To
prevent further overfishing, the government nationalized its fish meal production industry, but the Peruvian experience demonstrates that the ocean is not a limitless source of fish.

**Develop Higher-Protein Cereals.** A second possible new food source is higher-protein cereal grains. People in MDCs obtain protein by consuming meat, but people in LDCs generally rely on wheat, corn, and rice, which lack certain proteins. Scientists are experimenting with hybrids of the world's major cereals that have higher protein content.

People can also obtain needed nutrition by consuming foods that are fortified during processing with vitamins, minerals, and protein-carrying amino acids. This approach achieves better nutrition without changing food-consumption habits. However, fortification has limited application in LDCs, where most people grow their own food rather than buy processed food.

**Improve Palatability of Rarely Consumed Foods.** To fulfill basic nutritional needs, people consume types of food adapted to their community’s climate, soil, and other physical characteristics. People also select foods on the basis of religious values, taboos, and other social customs that are unrelated to nutritional or environmental factors. A third way to make more effective use of existing global resources is to encourage consumption of foods that are avoided for social reasons.

A prominent example of an underused food resource in North America is the soybean. Although the soybean is one of the region’s leading crops, most of the output is processed into animal feed, in part because many North Americans avoid consuming tofut, sprouts, and other recognizable soybean products. However, burgers, franks, oils, and other products that do not look like soybeans are more widely accepted in North America. New food products have been created in LDCs as well. In Asia, for example, high-protein beverages made from seeds resemble popular soft drinks.

Krill (a term for a group of small crustaceans) could be an important source of food from the oceans. The krill population has increased rapidly in recent years, because overhunting has reduced the number of whales that eat krill. The Soviet Union was a major harvester of krill, used primarily to feed chickens and livestock. Since the breakup of the Soviet Union in the early 1990s, the world krill harvest has declined substantially.

The harvest could be substantially increased for human food with new processing methods, because krill deteriorates rapidly. But krill does not taste very good.

**INCREASE FOOD SUPPLY BY INCREASING EXPORTS FROM OTHER COUNTRIES** A fourth alternative for increasing the world’s food supply is to export more food from countries that produce surpluses (Figure 10–15). The three top export grains are wheat, maize (corn), and rice. Few countries are major exporters of food, but increased production in these countries could cover the gap elsewhere.

Before World War II, Western Europe was the only major grain-importing region. Prior to their independence, colonies of Western European countries supplied food to their parent states. Asia became a net grain importer in the 1950s, Africa and Eastern Europe in the 1960s, and Latin America in the 1970s. Population increases in these regions largely accounted for the need to import grain. By 1980 North America was the only major exporting region in the world.

In response to the increasing global demand for food imports, the United States passed Public Law 480, the Agricultural, Trade, and Assistance Act of 1954 (frequently referred to as “P.L. 480”).

**FIGURE 10–15** Grain imports and exports. Most countries must import more food than they export. The United States has by far the largest excess of food exports compared to imports. Western European countries are also leading food exporters, though they are also leading food importers.
Title I of the act provided for the sale of grain at low interest rates, and Title II gave grants to needy groups of people.

The United States remains the world's leading exporter of grain by a wide margin, accounting for one-third of the total exports of the three leading grains, including more than one-half of all maize exports and more than one-fourth of all wheat exports.

Elsewhere in the world the picture has changed in the twenty-first century. From net importers of grain, South Asia and Southeast Asia have now become net exporters. Thailand has replaced the United States as the leading exporter of rice, accounting for one-third of the world total, followed by India in second place with one-sixth. Vietnam and Pakistan ranked fourth and fifth, respectively, in rice exports in 2004, behind the United States in third place.

Japan is by far the world's leading grain importing country, followed by China. Japan is the leading importer of maize, and China of wheat, and both rank among leading rice importers. On a regional scale, the Middle East has become the leading net importer of all three major grains, and Saudi Arabia was the world's leading importer of rice in 2004. Sub-Saharan Africa also ranks among the leaders in net imports of all three grains.

**Africa's Food-Supply Crisis**

Some countries that previously depended on imported grain have become self-sufficient in recent years. Higher productivity generated by the green revolution is primarily responsible for reducing dependency on imports in Asia. As long as population growth continues to decline and agricultural productivity continues to increase, the large population concentrations of Asia can maintain the delicate balance between population and resources.

In contrast, sub-Saharan Africa is losing the race to keep food production ahead of population growth (Figure 10–16). Production of the three main grains tripled in Africa between 1961 and 2003, from 40 million tons to 130 million tons, whereas population increased more than sixfold, from 130 million to 850 million people.

Forty million Africans face famine, according to the World Food Program, including 14 million in Ethiopia, 7 million in Zimbabwe, and at least 1 million in eight other countries. The UN Food and Agricultural Organization estimates that one-third of Africans are undernourished (Figure 10–17).

The problem is particularly severe in the Horn of Africa, including Somalia, Ethiopia, and Sudan. Also facing severe food shortages are countries in the Sahel region, a 400- to 550-kilometer (250- to 350-mile) belt in West Africa that marks the southern border of the Sahara (Figure 10–18). The most severely affected countries in the Sahel are Gambia, Senegal, Mali, Mauritania, Burkina Faso, Niger, and Chad.

Traditionally, this region supported limited agriculture. Pastoral nomads moved their herds frequently, permitting vegetation to regenerate. Farmers grew groundnuts for export and used the receipts to import rice. With rapid population growth, herd size increased beyond the capacity of the

---

**FIGURE 10–16** Change in population and food production in Africa. The levels of population and food production in 1961 were set at 1 in the chart. Food production increased more rapidly than population in Africa until the late 1970s, when food production fell behind population growth. Compare with Malthus's theory from more than 200 years ago that population would increase more rapidly than food production, shown in Figure 2–20.

**FIGURE 10–17** Percent of population undernourished. One-third of Africans and one-sixth of all people living in less developed countries (LDCs) are considered undernourished. Progress in reducing undernourishment has been substantial in Asia but not in other LDCs.

**FIGURE 10–18** The Sahel. The Sahel, which lies south of the drylands of the Sahara, faces severe food-supply problems, as does the Horn of Africa.
land to support the animals. Animals overgrazed the limited vegetation and clustered at scarce water sources. Many died of hunger.

Farmers overplanted, exhausting soil nutrients, and reduced fallow time, during which unplanted fields can recover. Soil erosion increased after most of the remaining trees were cut for wood and charcoal, used for urban cooking and heating. Productivity declined further, following several unusual drought years in the 1970s, 1980s, and 1990s.

Government policies have aggravated the food-shortage crisis. To make food affordable for urban residents, governments keep agricultural prices low. Constrained by price controls, farmers are unable to sell their commodities at a profit and therefore have little incentive to increase productivity.

**SUMMARY**

A country's agricultural system remains one of the best measures of its level of development and standard of material comfort. Despite major changes, agriculture in LDCs still employs the majority of the population, and producing food for local survival is still paramount.

Farming in MDCs directly employs few people, but when manufacturers of food products, supermarkets, restaurants, and other businesses that handle food are considered, then the food industry is actually the largest employer. The production and distribution of food are not primary-sector or agricultural activities, though; they are part of the industrial and service sectors of the economies in MDCs.

Even farming may one day no longer be considered a distinct primary-sector activity in MDCs. True, farmers still deliberately modify the land by planting seeds or grazing animals, but they spend more time sitting at computers, operating sophisticated machinery, and reviewing finances and devising marketing strategies.

Here again are the key questions concerning agricultural geography:

1. **Where did agriculture originate?** Prior to the development of agriculture, people survived by hunting animals, gathering wild vegetation, or fishing. Agriculture was not simply invented but was the product of thousands of years of experiments and accidents. Current agricultural practices vary between more developed and less developed countries.

2. **Where are agricultural regions in less developed countries?** Most people in the world, especially those in LDCs, are subsistence farmers, growing crops primarily to feed themselves. Important types of subsistence agriculture include shifting cultivation, pastoral nomadism, and intensive farming. Regions where subsistence agriculture is practiced are characterized by a large percentage of the labor force engaged in agriculture, with few mechanical aids.

3. **Where are agricultural regions in more developed countries?** The most common type of farm found in MDCs is mixed crop and livestock. Where mixed crop and livestock farming is not suitable, commercial farmers practice a variety of other types of agriculture, including dairying, commercial grain, and ranching.

4. **Why do farmers face economic difficulties?** Agriculture in LDCs faces distinctive economic problems resulting from rapid population growth and pressure to adopt international trade strategies to promote development. Agriculture in MDCs faces problems resulting from access to markets and overproduction.

**CASE STUDY REVISITED**

**Uncertain Future for Farming**

The future is uncertain for both subsistence farmers in LDCs such as Pakistan and commercial farmers in MDCs such as the United States. In one respect, the uncertainty stems from a similar problem: farming in neither location produces sufficient income to support the standard of living farm families desire. However, the underlying cause of low incomes differs significantly between more developed and less developed countries.

In LDCs people migrate from the farms to the cities in search of higher-paying jobs and a better life. Given the high natural increase rate and pressure to produce more for international trade, the migrants are not missed on the farms. The need for more food will not be met by adding more workers on the farms, but from more intensive use of existing farms and purchase of food from abroad.

In MDCs people also migrate from the farms to the cities in search of higher-paying jobs. However, these migrants are missed. Small farming communities in the United States are dying, and their death causes a loss of rural-based culture and values.

In many ways, the current migration from the farms in MDCs is simply the continuation of long-term trends. With farms becoming ever larger and more mechanized, the number of farmworkers continually declines. Farm communities are suffering because most of the emigrants are young. But this has always been the case, as well: nearly a century ago, World War I veterans returning to the United States from Europe sang, "How ya gonna keep 'em down on the farm after they've seen Paree (Paris)."

The current decline in the farm population in MDCs has an especially strong impact on the rural landscape because, with so few farmers left, each further loss registers a large decline in percentage terms. Farming is the backbone of many small-town economies. Without farmers, banks and shops lose their main sources of income. For every five people that give up farming, one business closes in a small town. People still live on farms but work in factories, offices, or businesses in the nearest big city. And they shop at the big-city Wal-Mart instead of the small-town Main Street.
KEY TERMS

Agribusiness (p. 333)
Agriculture (p. 329)
Cereal grain (p. 342)
Chaff (p. 341)
Combine (p. 345)
Commercial agriculture (p. 330)
Crop (p. 329)
Crop rotation (p. 341)
Desertification (p. 356)
Double cropping (p. 341)
Grain (p. 345)
Green revolution (p. 356)
Horticulture (p. 349)
Hull (p. 341)
Intensive subsistence agriculture (p. 339)
Milkshed (p. 343)
Paddy (p. 340)
Pastoral nomadism (p. 338)
Pasture (p. 339)
Plantation (p. 341)
Prime agricultural land (p. 333)
Ranching (p. 346)
Reaper (p. 345)
Ridge tillage (p. 352)
Sawah (p. 340)
Seed agriculture (p. 329)
Shifting cultivation (p. 335)
Slash-and-burn agriculture (p. 335)
Spring wheat (p. 345)
Subsistence agriculture (p. 330)
Sustainable agriculture (p. 352)
Swidden (p. 335)
Thresh (p. 341)
Transhumance (p. 339)
Truck farming (p. 349)
Vegetative planting (p. 329)
Wet rice (p. 340)
Winnow (p. 341)
Winter wheat (p. 345)

THINKING GEOGRAPHICALLY

1. Assume that the United States constitutes one agricultural market centered around New York City, the largest metropolitan area. To what extent can the major agricultural regions of the United States be viewed as irregularly shaped rings around the market center, as von Thünen applied to southern Germany?

2. New Zealand once sold nearly all its dairy products to the British, but since the United Kingdom joined the European Union in 1973, New Zealand has been forced to find other markets. What are some other examples of countries that have restructured their agricultural production in the face of increased global interdependence and regional cooperation?

3. Review the concept of overpopulation (the number of people in an area exceeds the capacity of the environment to support life at a decent standard of living). What agricultural regions have relatively limited capacities to support intensive food production? Which of these regions face rapid population growth?

4. Compare world distributions of corn, wheat, and rice production. To what extent do differences derive from environmental conditions and to what extent from food preferences and other social customs?

5. How might the loss of farmland on the edge of rapidly growing cities alter the choice of crops that other farmers make in a commercial agricultural society?

FURTHER READINGS


Also consult this journal: *Journal of Rural Studies*. 