

## INCREASING PRODUCTIVITY

### Learning Outcome 10.4.6

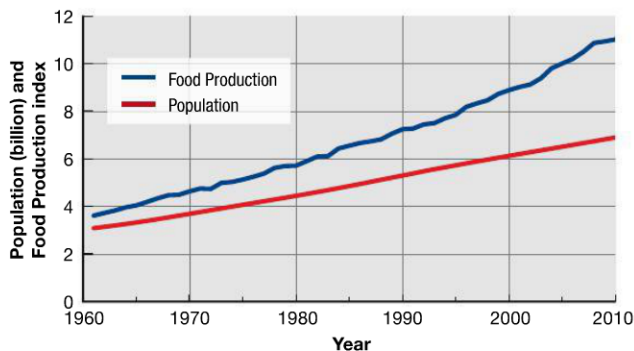
Describe the contribution of higher productivity to world food supply.

Population grew at the fastest rate in human history during the second half of the twentieth century, as discussed in Chapter 2. Many experts forecast massive global famine, but these dire predictions did not come true. Instead, new agricultural practices have permitted farmers worldwide to achieve much greater yields from the same amount of land. Worldwide, obtaining more food from the same amount of land has been the leading source of increasing the food supply.

**THE GREEN REVOLUTION.** 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 (Figure 10-62).

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 (Figure 10-63). During the 1960s, their scientists introduced a hybrid of Indonesian rice and Taiwan dwarf rice that was hardier and that increased yields. More recently, scientists have developed new high-yield maize (corn).

▼ **FIGURE 10-62 POPULATION AND FOOD PRODUCTION** World population has increased less rapidly than food production.



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▲ **FIGURE 10-63 INTERNATIONAL RICE RESEARCH INSTITUTE, HOME OF THE GREEN REVOLUTION** “Miracle” high-yield seeds have been produced through laboratory experiments at the International Rice Research Institute (IRRI). The IRRI is testing rice varieties in the Philippines.

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

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 improve fertility. Today these three elements form the basis for fertilizers—products that farmers apply to their fields to enrich the soil by restoring lost nutrients.

Nitrogen, the most important fertilizer, is a ubiquitous substance. China is the leading producer of nitrogen fertilizer. 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. 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 developing countries. 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.

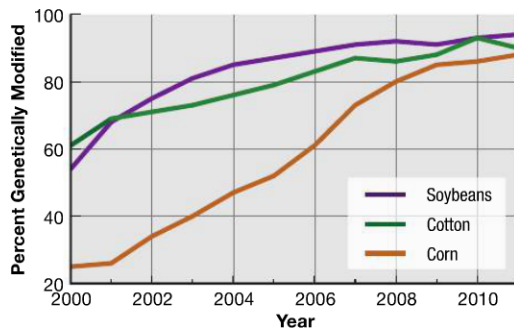
Farmers need tractors, irrigation pumps, and other machinery to make the most effective use of the new miracle seeds. In developing countries, farmers cannot afford such equipment and cannot, in view of high energy costs, buy fuel to operate the equipment. To maintain the green revolution, governments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

**GENETICALLY MODIFIED FOODS.** Farmers have been manipulating crops and livestock for thousands of years. The very nature of agriculture is to deliberately manipulate nature. Humans control selective reproduction of plants and animals in order to produce a larger number of stronger, hardier survivors. Beginning in the nineteenth century, the science of genetics expanded understanding of how to manipulate plants and animals to secure dominance of the most favorable traits. However, genetic modification (GM), which became widespread in the late twentieth century, marks a sharp break with the agricultural practices of the past several thousand years. Under GM, the genetic composition of an organism is not merely studied, it is actually altered; GM involves mixing genetic material of two or more species that would not otherwise mix in nature.

Worldwide, 160 million hectares—10 percent of all farmland—were devoted to genetically modified crops in 2010; 77 percent of the world's soybeans, 49 percent of cotton, and 26 percent of maize were genetically modified in 2010. GM is especially widespread in the United States: 94 percent of soybeans, 90 percent of cotton, and 88 percent of maize; usage increased rapidly during the first decade of the twenty-first century (Figure 10-64). Three-fourths of the processed food that Americans consume has at least one GM ingredient. North America was responsible for one-half of the world's genetically modified foods, and developing countries—especially in Latin America—were responsible for the other one-half.

The United States has urged sub-Saharan African countries to increase their food supply in part through increased use of GM of crops and livestock. Africans are divided on whether to accept genetically modified organisms. The

▼ **FIGURE 10-64 GENETICALLY MODIFIED CROPS IN THE UNITED STATES** Approximately 90 percent of major crops in the United States are genetically modified.



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positives of GM are higher yields, increased nutrition, and more resistance to pests. Genetically modified foods are also better tasting, at least to some palates. Despite these benefits, opposition to GM is strong in Africa for several reasons:

- **Health problems.** Consuming large quantities of genetically modified foods may reduce the effectiveness of antibiotics and could destroy long-standing ecological balances in local agriculture.
- **Export problems.** European countries, the main markets for Africa's agricultural exports, require genetically modified foods to be labeled. Europeans are especially strongly opposed to GM because they believe genetically modified food is not as nutritious as food from traditionally bred crops and livestock. Because European consumers shun genetically modified food, African farmers fear that if they are no longer able to certify their exports as being not genetically modified, European customers will stop buying them (Figure 10-65).
- **Increased dependence on the United States.** U.S.-based transnational corporations, such as Monsanto, manufacture most of the GM seeds. 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.

“We don't want to create a habit of using genetically modified maize that the country cannot maintain,” explained Mozambique's prime minister. 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 developed countries.

#### Pause and Reflect 10.4.6

What are the benefits and drawbacks for sub-Saharan Africa to plant more genetically modified crops?

▼ **FIGURE 10-65 GENETICALLY MODIFIED FOOD** Genetically modified food is widespread in the United States but shunned by most consumers in Europe.





## Sustainable Agriculture

### Learning Outcome 10.4.7

Describe the role of sustainable agriculture in world food supply.

Some commercial farmers are converting their operations to **sustainable agriculture**, agricultural practices that preserve and enhance 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. Worldwide, the UN classified 37 million hectares (75 million acres), or 0.6 percent of farmland, as organic in 2009. Australia was the leader, with 12 million of the hectares, or 32 percent of the worldwide total (Figure 10-66). Argentina accounted for 12 percent of the worldwide total, and the United States, China, and Brazil for 5 percent each. 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. Crops are planted on 10- to 20-centimeter (4- to 8-inch) ridges that are formed during cultivation or after harvest. A 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 a 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 spacers 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.

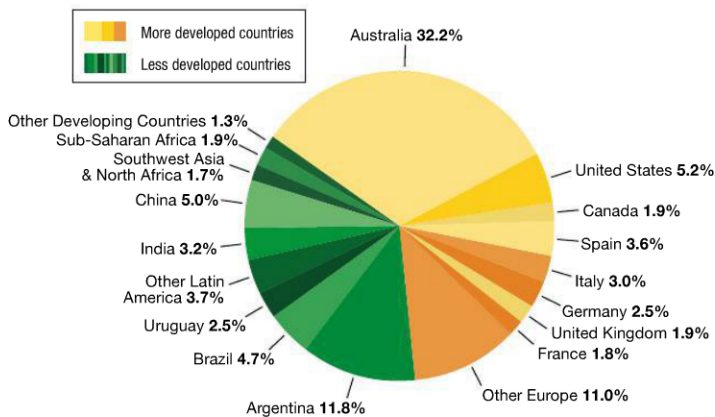
### LIMITED USE OF CHEMICALS

In conventional agriculture, seeds are often genetically modified to survive when herbicides and insecticides are sprayed on fields to kill weeds and insects. These are known as “Roundup Ready” seeds because their creator, Monsanto, sells its weed killers under the brand name Roundup. Roundup Ready seeds were planted in 90 percent of all soybean fields and 70 percent of all cotton and maize (corn) fields in the United States in 2010. In addition to the adverse impacts of herbicides on soil and water quality, widespread use of Roundup Ready seeds is causing some weeds to become resistant to herbicides.

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 doing so 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 tillage 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.

▼ FIGURE 10-66 DISTRIBUTION OF ORGANIC FARMING Australia accounts for nearly one-third of the world's organic farming.



## INTEGRATED CROP AND LIVESTOCK

Mixed crop and livestock is a common form of farming in the United States, as discussed earlier in the chapter. But many farmers in the mixed crop and livestock region actually choose to only grow crops or raise more animals than the crops they grow can feed. They sell their crops off the farm or purchase feed for their animals from outside suppliers. 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.

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:

- Number of livestock.** The correct number, as well as the distribution, of livestock for an area is determined based on the landscape and forage sources. Prolonged concentration of livestock in a specific location can result in permanent loss of vegetative cover, so a farmer needs to move the animals to reduce overuse in some areas. 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 some loss of vegetation in specific locations.
- Animal confinement.** The moral and ethical debate over animal welfare is particularly intense regarding confined livestock production systems (Figure 10-67). Confining livestock leads to surface and ground water pollution, 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.
- Management of extreme weather conditions.** Herd size may need to be reduced during periods of short- and long-term drought. 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 California's, properly managed grazing significantly reduces fire hazards by reducing fuel buildup in grasslands and brushlands.
- Flexible feeding and marketing.** Flexibility in feeding livestock and sending livestock to market 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. Most of the feed



**▲ FIGURE 10-67 (TOP) CONVENTIONAL VERSUS (BOTTOM) ORGANIC FARMING** Chickens are not penned up in cages on an organic farm.

may come from other enterprises on a ranch, though some is usually purchased 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.

### Pause and Reflect 10.4.7

Are you willing to pay more for food that is organically produced? Why or why not?

### CHECK-IN: KEY ISSUE 4

#### Why Do Farmers Face Economic Difficulties?

- ✓ Farmers in developing countries face challenges of meeting the needs of rapid population growth and growing food for export.
- ✓ Farmers in developed countries face challenges of overproduction and access to markets.
- ✓ Four strategies for increasing the world's food supplies include increasing exports, expanding agricultural land, expanding fishing, and increasing productivity of land.
- ✓ Sustainable agriculture involves sensitive land management, limited use of chemicals, and better integration of crops and livestock.



## Summary

### KEY ISSUE 1

#### Where Did Agriculture Originate?

Prior to the development of agriculture, people survived by hunting animals, gathering wild vegetation, and fishing. Current agricultural practices vary between developed and developing countries.

**LEARNING OUTCOME 10.1.1:** Identify the major crop and livestock hearths.

- Agriculture was invented approximately 10,000 years ago in multiple hearths of crops and livestock.

**LEARNING OUTCOME 10.1.2:** Describe the major differences between subsistence and commercial agriculture.

- Subsistence agriculture, practiced in developing countries, is characterized by a high percentage of farmers in the labor force, limited use of machinery, and small average farm size.
- Commercial agriculture, practiced in developed countries, is characterized by a small percentage of farmers in the labor force, heavy use of machinery, and large average farm size.

**THINKING GEOGRAPHICALLY 10.1:** Compare agricultural hearths with the origin of Indo-European (Figures 5-18 and 5-19). What similarities appear between the diffusion of language and of agriculture?

**GOOGLE EARTH 10.1:** Little Andaman Island is home to approximately 100 Onge people, who traditionally live by hunting and gathering. More than 90 percent of the land area of the island appears to be dense forests. Why is this type of land cover especially suitable habitat for animals being hunted?



## Key Terms

**Agribusiness** (p. 366) Commercial agriculture characterized by the integration of different steps in the food-processing industry, usually through ownership by large corporations.

**Agricultural revolution** (p. 348) The time when human beings first domesticated plants and animals and no longer relied entirely on hunting and gathering.

**Agriculture** (p. 347) The deliberate effort to modify a portion of Earth's surface through the cultivation of crops and the raising of livestock for sustenance or economic gain.

**Aquaculture (or aquafarming)** (p. 382) The cultivation of seafood under controlled conditions.

**Cereal grain (or cereal)** (p. 352) A grass that yields grain for food.

**Chaff** (p. 363) Husks of grain separated from the seed by threshing.

**Combine** (p. 370) A machine that reaps, threshes, and cleans grain while moving over a field.

**Commercial agriculture** (p. 350) Agriculture undertaken primarily to generate products for sale off the farm.

**Crop** (p. 347) Any plant gathered from a field as a harvest during a particular season.

**Crop rotation** (p. 364) The practice of rotating use of different fields from crop to crop each year to avoid exhausting the soil.

**Desertification** (p. 381) Degradation of land, especially in semiarid areas, primarily because of human actions such as excessive crop planting,

animal grazing, and tree cutting. Also known as semiarid land degradation.

**Dietary energy consumption** (p. 352) The amount of food that an individual consumes, measured in kilocalories (Calories in the United States).

**Double cropping** (p. 363) Harvesting twice a year from the same field.

**Food security** (p. 354) Physical, social, and economic access at all times to safe and nutritious food sufficient to meet dietary needs and food preferences for an active and healthy life.

**Grain** (p. 352) Seed of a cereal grass.

**Green revolution** (p. 384) Rapid diffusion of new agricultural technology, especially new high-yield seeds and fertilizers.

**Horticulture** (p. 371) The growing of fruits, vegetables, and flowers.

**Hull** (p. 363) The outer covering of a seed.

**Intensive subsistence agriculture** (p. 362) A form of subsistence agriculture in which farmers must expend a relatively large amount of effort to produce the maximum feasible yield from a parcel of land.

**Milkshed** (p. 368) The area surrounding a city from which milk is supplied.

**Paddy** (p. 363) The Malay word for wet rice, commonly but incorrectly used to describe a sawah.

**Pastoral nomadism** (p. 358) A form of subsistence agriculture based on herding domesticated animals.

## KEY ISSUE 2

### Why Do People Consume Different Foods?

Everyone needs food to survive. The amount of food and the dietary composition of the food vary between developed and developing countries.

**LEARNING OUTCOME 10.2.1:** Explain differences between developed and developing countries in food consumption.

- Most humans derive most of their dietary energy through cereal grains, especially wheat, rice, and maize.
- The primary source of protein is meat products in developed countries and grain in developing countries.

**LEARNING OUTCOME 10.2.2:** Explain the global distribution of undernourishment.

- The average individual consumes 50 percent more calories than the recommended minimum, but many in sub-Saharan Africa are getting less than the recommended minimum.
- Worldwide, an estimated 850 million people are undernourished, nearly all of them in developing countries.

**THINKING GEOGRAPHICALLY 10.2:** Compare world distributions of wheat, rice, and maize production. To what extent do differences derive from environmental conditions and to what extent from food preferences and other social customs?

**GOOGLE EARTH 10.2:** Fly to Jungle Jim's in Fairfield, Ohio, at 30,000 square meters, possibly the largest supermarket in the United States. Under Find Businesses, type Kroger. Move to the nearest Kroger to the west of Jungle Jim's. How many square meters is it?



**Pasture** (p. 359) Grass or other plants grown for feeding grazing animals, as well as land used for grazing.

**Plantation** (p. 364) A large farm in tropical and subtropical climates that specializes in the production of one or two crops for sale, usually to a more developed country.

**Prime agricultural land** (p. 381) The most productive farmland.

**Ranching** (p. 372) A form of commercial agriculture in which livestock graze over an extensive area.

**Reaper** (p. 370) A machine that cuts cereal grain standing in a field.

**Ridge tillage** (p. 386) A system of planting crops on ridge tops in order to reduce farm production costs and promote greater soil conservation.

**Sawah** (p. 363) A flooded field for growing rice.

**Shifting cultivation** (p. 360) A form of subsistence agriculture in which people shift activity from one field to another; each field is used for crops for a relatively few years and left fallow for a relatively long period.

**Slash-and-burn agriculture** (p. 360) Another name for shifting cultivation, so named because fields are cleared by slashing the vegetation and burning the debris.

**Spring wheat** (p. 370) Wheat planted in the spring and harvested in the late summer.

**Subsistence agriculture** (p. 350) Agriculture designed primarily to provide food for direct consumption by the farmer and the farmer's family.

**Sustainable agriculture** (p. 386) Farming methods that preserve long-term productivity of land and minimize pollution, typically by rotating soil-restoring crops with cash crops and reducing inputs of fertilizer and pesticides.

**Swidden** (p. 360) A patch of land cleared for planting through slashing and burning.

**Thresh** (p. 363) To beat out grain from stalks.

**Transhumance** (p. 359) The seasonal migration of livestock between mountains and lowland pastures.

**Truck farming** (p. 367) Commercial gardening and fruit farming, so named because *truck* was a Middle English word meaning "bartering" or "exchange of commodities."

**Undernourishment** (p. 354) Dietary energy consumption that is continuously below the minimum requirement for maintaining a healthy life and carrying out light physical activity.

**Wet rice** (p. 362) Rice planted on dry land in a nursery and then moved to a deliberately flooded field to promote growth.

**Winnow** (p. 363) To remove chaff by allowing it to be blown away by the wind.

**Winter wheat** (p. 370) Wheat planted in the autumn and harvested in the early summer.



### Where Is Agriculture Distributed?

Most people in developing countries are subsistence farmers, growing crops primarily to feed themselves. Important types of subsistence agriculture include shifting cultivation, pastoral nomadism, and intensive farming. The most common type of farm in developed countries is mixed crop and livestock. Where mixed crop and livestock farming is not suitable, commercial farmers practice other types of agriculture, including dairy farming, commercial gardening, grain, Mediterranean, and ranching.

**LEARNING OUTCOME 10.3.1:** Identify the 11 major agricultural regions.

- The most widely used map of agriculture divides the world into 11 major regions, including 5 in developing countries and 6 in developed countries.

**LEARNING OUTCOME 10.3.2:** Explain how pastoral nomadism works in the dry lands of developing regions.

- Pastoral nomadism, which is the herding of animals, is the principal form of agriculture adapted to the dry lands of developing countries.

**LEARNING OUTCOME 10.3.3:** Explain how shifting cultivation works in the tropics of developing regions.

- Distinctive features of shifting cultivation include the clearing of land through slashing and burning and the use of fields for only a few years.

**LEARNING OUTCOME 10.3.4:** Explain how intensive subsistence farming works in the high population concentrations of developing regions.

- The principal crop in the intensive subsistence region is wet rice.
- Growing rice is an intensive operation that depends primarily on abundant labor.

**LEARNING OUTCOME 10.3.5:** Describe reasons for growing crops other than wet rice in intensive subsistence regions.

- In intensive subsistence areas where the climate is unsuitable for rice, hardier crops are grown, such as wheat and barley.
- Plantation farming is a form of commercial agriculture conducted in developing regions. Plantations grow crops primarily for export to developed countries.

**LEARNING OUTCOME 10.3.6:** Describe how mixed crop and livestock farming works.

- Mixed crop and livestock is the most common form of agriculture in the center of the United States.
- Crops, especially maize and soybeans, are grown primarily to feed animals.

**LEARNING OUTCOME 10.3.7:** Describe how dairy farming and commercial gardening work.

- Dairy farming is especially important near major population concentrations in developed countries.
- Commercial gardening is the predominant form of agriculture in the southeastern United States. These farms specialize in fruits and vegetables preferred by relatively wealthy consumers in developed countries.

**LEARNING OUTCOME 10.3.8:** Describe how grain and Mediterranean farming work.

- Grain, especially wheat, is grown in areas that are too dry for mixed crop and livestock farming.
- Mediterranean agriculture specializes in crops such as grapes and olives.

**LEARNING OUTCOME 10.3.9:** Describe how livestock ranching works.

- Livestock is raised on land that is too dry for growing crops.

**THINKING GEOGRAPHICALLY 10.3:** Review the concept of overpopulation (the number of people in an area exceeding 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?

**GOOGLE EARTH 10.3:** Terraces for planting rice are carved into the hillsides surrounding the village of Banaue, Philippines. What step in growing rice, as described in Learning Outcome 10.3.4, makes it necessary to terrace the hillsides?



## KEY ISSUE 4

### Why Do Farmers Face Economic Difficulties?

Agriculture in developing countries faces distinctive economic problems resulting from rapid population growth and pressure to adopt international trade strategies to promote development. Agriculture in developed nations faces problems resulting from access to markets and overproduction.

**LEARNING OUTCOME 10.4.1:** Describe the impact of population growth and trade on farming in developing countries.

- Due to rapid population growth, subsistence farmers must feed more people.
- Pressure to contribute to international trade means that subsistence farmers increasingly grow crops to export rather than to consume at home.

**LEARNING OUTCOME 10.4.2** Understand distinctive challenges for developing countries to increase food supply.

- Africa faces the greatest challenge in providing enough food for a growing population.
- Export crops such as drugs are increasingly being grown in some developing countries.

**LEARNING OUTCOME 10.4.3:** Explain the impact of overproduction and market access on farming in developed countries.

- Because of their efficiency, commercial farmers produce more food than can be consumed in developed countries.

**LEARNING OUTCOME 10.4.4:** Explain the contribution of expanding exports and farmland to world food supply.

- Export of food has increased rapidly, although only a handful of countries produce enough to be major exporters.
- Historically, agricultural output was increased by expanding the amount of land that is farmed, but expansion of farmland has slowed in recent decades.



**LEARNING OUTCOME 10.4.5:** Describe the contribution of fishing to world food supply.

- Fish consumption is increasing but accounts for a small percentage of the average human's diet.
- Fish production has increased primarily through aquaculture rather than catching of wild fish.

**LEARNING OUTCOME 10.4.6:** Describe the contribution of higher productivity to world food supply.

- Agricultural productivity has increased sharply, especially through the invention of higher-yield seeds and expanded use of fertilizers.
- Despite advances, food prices in the early twenty-first century have been at a record high.

**LEARNING OUTCOME 10.4.7:** Describe the role of sustainable agriculture in world food supply.

- Sustainable agriculture involves sensitive land management, limited use of chemicals, and better integration of crops and livestock.
- Sustainable agriculture accounts for a small but increasing share of world agriculture.

**THINKING GEOGRAPHICALLY 10.4:** 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?

**GOOGLE EARTH 10.4:** The eastern end of the Chicago Sanitary and Ship Canal joins with the Chicago River near the center of Chicago. The canal was constructed to provide the only water link between the Great Lakes and the Mississippi River. If Asian carp now migrating up the Mississippi River are to be prevented from reaching Lake Michigan, the canal will have to be blocked. What is the approximate distance between the end of the canal at the Chicago River and Lake Michigan?

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# Chapter

# 11 Industry and Manufacturing



Why are most potato chips manufactured near their consumers? Page 401



Why are most fabrics made in Asia? Page 411

## KEY ISSUE 1

### Where Is Industry Distributed?



### Factories Past and Present p. 395

Much of the world's industry is clustered in three regions.

## KEY ISSUE 2

### Why Are Situation and Site Factors Important?



### Factors of Production p. 398

Geographers can explain reasons for the location of factories.