

9

Food and Agriculture

All humans need food to survive. We have two choices in obtaining our food: Buy it or produce it ourselves. In developed countries people purchase nearly all of their food, which is produced primarily through commercial agriculture. In developing countries people produce much of their food themselves through subsistence agriculture.

Fair trade coffee farmer harvesting her crop in Uganda.



LOCATIONS IN THIS CHAPTER



KEY ISSUES

1

Where Did Agriculture Originate?

Agriculture was invented around 10,000 years ago in multiple **places**. Prior to the agricultural revolution, people survived by hunting and gathering food.





2



Why Do People Consume Different Foods?

Humans display a distinctive distribution across **space** of food consumption. People vary in the quantity of food they consume and the variety.

3



Where Is Agriculture Distributed?

Farming practices vary around the world depending on cultural and environmental factors. Distinctive **regions** can be identified in **developing** countries and in **developed** countries.

4



Why Do Farmers Face Sustainability Challenges?

Agriculture is a global business with many **connections** between farms and other industries, as well as connections through international trade. At the same time, the local **scale** is increasingly important in farming practices and obtaining food.

Where Did Agriculture Originate?

- **Introducing Food and Agriculture**
- **Subsistence and Commercial Agriculture**

LEARNING OUTCOME 9.1.1

Understand the origin of agriculture.

Agriculture is deliberate modification of Earth's surface through cultivation of plants and rearing of animals to obtain sustenance or economic gain (Figure 9-1). Agriculture originated when humans domesticated plants and animals for their use. The word *cultivate* means "to care for," and a **crop** is any plant cultivated by people.

Introducing Food and Agriculture

The origin of agriculture cannot be documented with certainty because it began before recorded history. Scholars try to reconstruct a logical sequence of events based on fragments of information about ancient agricultural practices and historical environmental conditions. Improvements in cultivating plants and domesticating animals evolved over thousands of years. This section offers an explanation for the origin and diffusion of agriculture.

INVENTION OF AGRICULTURE

The **agricultural revolution** was the time when human beings first domesticated plants and animals and no longer relied entirely on hunting and gathering. Geographers and other scientists believe that the agricultural revolution occurred around the year 8000 B.C. because the world's population began to grow at a more rapid rate than it had in the past. By growing plants and raising animals, human beings created larger and more stable sources of food, so more people could survive.

Scientists do not agree on whether the agricultural revolution originated primarily because of environmental factors or cultural factors. Probably a combination of both factors contributed:

- **Environmental factors.** The first domestication of crops and animals coincided with climate change. This marked the end of the last ice age, when permanent ice cover receded from Earth's mid-latitudes to the polar regions, resulting in a massive redistribution of humans, other animals, and plants at that time.
- **Cultural factors.** A preference for living in a fixed place rather than as nomads may have led hunters and gatherers to build permanent settlements and to store surplus vegetation there. In gathering wild vegetation, people inevitably cut plants and dropped berries, fruits, and seeds. These hunters probably observed that, over time, damaged or discarded food produced new plants. They may have deliberately cut plants or dropped berries on the ground to see if they would produce new plants. Subsequent generations learned to pour water over the site and to introduce manure and other soil improvements. Over thousands of years, plant cultivation apparently evolved from a combination of accident and deliberate experiment.

▼ **FIGURE 9-1 AGRICULTURE** Agriculture involves the deliberate modification of Earth's surface.



AGRICULTURE HEARTHTHS

Scientists also do not agree on how agriculture diffused or why most nomadic groups converted from hunting, gathering, and fishing to agriculture. Scientists agree that planting of crops originated in multiple hearths around the world (Figure 9-2). Animals were also domesticated in multiple hearths at various dates. Important hearths include:

- **Southwest Asia.** The earliest crops domesticated in Southwest Asia around 10,000 years ago are thought to have been barley, wheat, lentil, and olive. Southwest Asia is also thought to have been the hearth for the domestication of the largest number of animals that would prove to be most important for agriculture, including cattle, goats, pigs, and sheep, between 8,000 and 9,000 years ago. Domestication of the dog is thought to date even earlier, around 12,000 years ago. From this hearth, cultivation diffused west to Europe and east to Central Asia.
- **East Asia.** Rice is thought to have been domesticated in East Asia more than 10,000 years ago, along the Yangtze River in eastern China. Millet was cultivated at an early date along the Yellow River.
- **Central and South Asia.** Chickens are thought to have diffused from South Asia around 4,000 years ago. The horse is considered to have been domesticated in Central Asia. Diffusion of the domesticated horse is thought to be associated with the diffusion of the Indo-European language, as discussed in Chapter 5.
- **Sub-Saharan Africa.** Sorghum was domesticated in central Africa around 8,000 years ago. Yams may have been domesticated even earlier. Millet and rice may have been domesticated in sub-Saharan Africa independently of the hearth in East Asia. From central

Africa, domestication of crops probably diffused further south in Africa.

- **Latin America.** Two important hearths of crop domestication are thought to have emerged in Mexico and Peru around 4,000 to 5,000 years ago. Mexico is considered a hearth for beans and cotton, and Peru for potato. The most important contribution of the Americas to crop domestication, maize (corn), may have emerged in the two hearths independently around the same time. From these two hearths, cultivation of maize and other crops diffused northward into North America and southward into tropical South America. Some researchers place the origin of squash in the southeastern portion of present-day United States.

PAUSE & REFLECT 9.1.1

Which crops appear to have reached the present-day United States first, according to Figure 9-2?

That agriculture had multiple origins means that, from earliest times, people have produced food in distinctive ways in different regions. This diversity derives from a unique legacy of wild plants, climatic conditions, and cultural preferences in each region. Improved communications in recent centuries have encouraged the diffusion of some plants to varied locations around the world. Many plants and animals thrive across a wide portion of Earth's surface, not just in their place of original domestication. Only after 1500, for example, were wheat, oats, and barley introduced to the Western Hemisphere and maize to the Eastern Hemisphere.

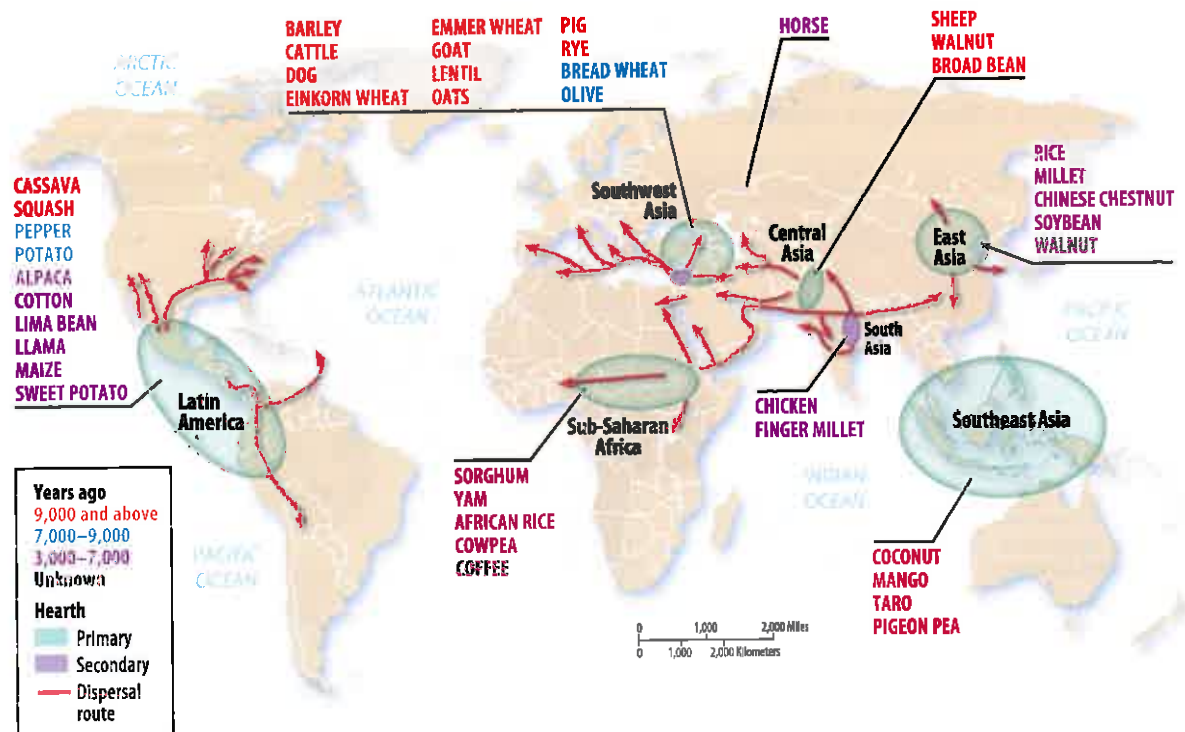


FIGURE 9-2
AGRICULTURE HEARTHTHS Planting of crops and domestication of animals originated in multiple hearths.

Subsistence and Commercial Agriculture

LEARNING OUTCOME 9.1.2

Describe the principal differences between subsistence and commercial agriculture.

The most fundamental differences in agricultural practices are between those in developing countries and those in developed countries. Farmers in developing countries generally practice subsistence agriculture, whereas farmers in developed countries practice commercial agriculture. **Subsistence agriculture**, found in developing countries, is the production of food primarily for consumption by the farmer's family. **Commercial agriculture**, found in developed countries, is the production of food primarily for sale off the farm. The main features that distinguish commercial agriculture from subsistence agriculture include the percentage of farmers in the labor force, the use of machinery, and farm size.

PERCENTAGE OF FARMERS

In developed countries, around 3 percent of workers are engaged directly in farming, compared to around 42 percent in developing countries (Figure 9-3). A priority for all people is to secure the food needed to survive. In developing countries a large percentage of people are subsistence farmers who work in agriculture to produce the food they and their families require. In developed countries the relatively few people engaged in farming are commercial farmers, and most people buy food with money earned by working in factories or offices or by performing other services.

The percentage of farmers is even lower in North America—only around 2 percent. Yet the small percentage of farmers in the United States and Canada produces not only enough food for themselves and the rest of the region but also a surplus to feed people elsewhere.

The number of farmers declined dramatically in developed countries during the twentieth century. The United States had about 60 percent fewer farms and 85 percent fewer farmers in 2000 than in 1900. The number of farms in the United States declined from about 6 million in 1940 to 4 million in 1960 and 2 million in 1980. Both push and pull migration factors have been responsible for the decline: People were pushed away from farms by lack of opportunity to earn a decent income, and at the same time they were pulled to higher-paying jobs in urban areas. The number of U.S. farmers has stabilized since 1980, at around 2 million.

ROLE OF MACHINERY, SCIENCE, AND TECHNOLOGY

In developed countries, a small number of commercial farmers can feed many people because they rely on machinery to perform work rather than on people or animals (Figure 9-4). In developing countries, subsistence farmers do much of the work with hand tools and animal power.

Traditionally, the farmer or local craftspeople made equipment from wood, but beginning in the late eighteenth century, factories produced farm machinery. The first all-iron plow was made in the 1770s and was followed in the nineteenth and twentieth centuries by inventions that made farming less dependent on human or animal power. Today, farmers use tractors, combines, corn pickers, planters, and other factory-made farm machines to increase productivity.

Experiments conducted in university laboratories, industry, and research organizations generate new fertilizers, herbicides, hybrid plants, animal breeds, and farming practices, which lead to higher crop yields and healthier animals. Access to other scientific information has enabled farmers to make more intelligent decisions concerning proper agricultural practices. Some farmers conduct their own on-farm research.

Electronics also help commercial farmers. Farmers use Global Positioning System (GPS) devices to determine the precise coordinates for planting seeds and for spreading different types and amounts of fertilizers. On large ranches, they also use GPS devices to monitor the locations of cattle and tractors. They use satellite imagery to measure crop progress and yield monitors attached to combines to determine the precise number of bushels being harvested.

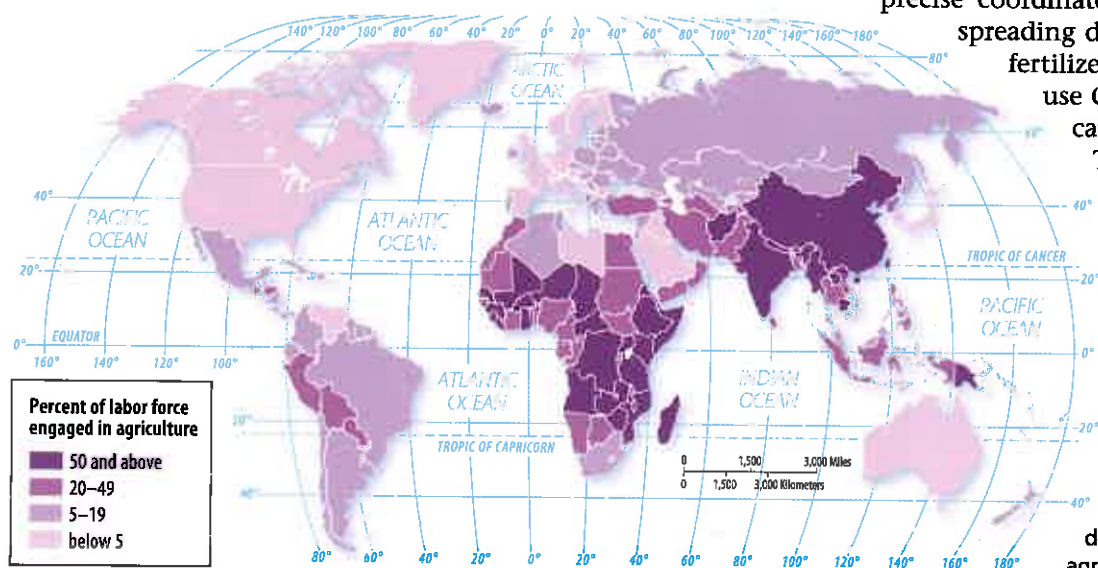
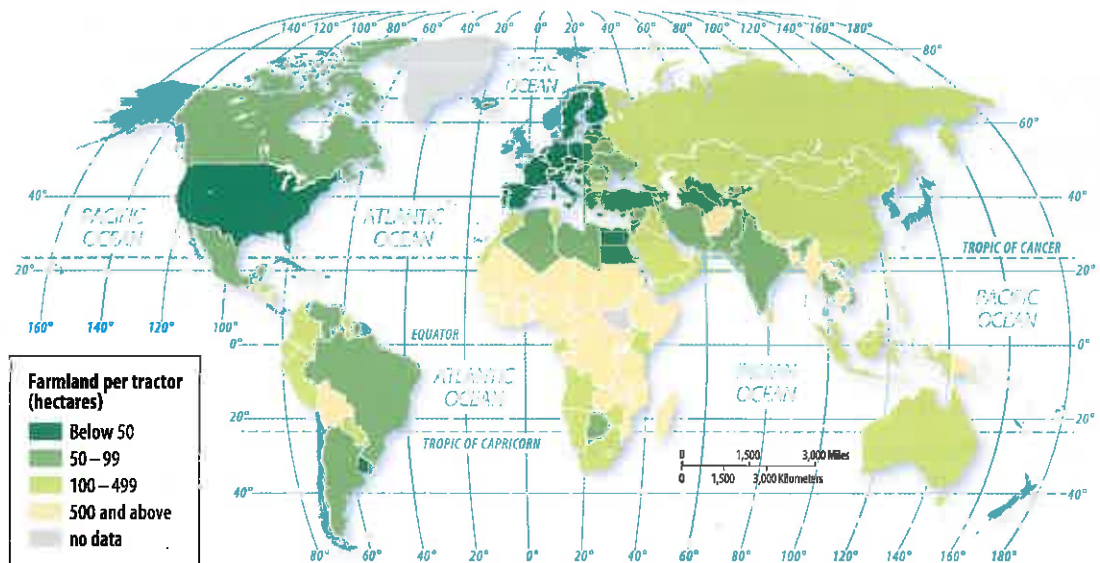


FIGURE 9-3 AGRICULTURAL WORKERS The percentage of the workforce engaged in agriculture is much higher in developing countries with subsistence agriculture than in developed countries with commercial agriculture.

► **FIGURE 9-4 AREA OF FARMLAND PER TRACTOR** Farmers practicing commercial agriculture in developed countries have more hectares or acres of land per tractor than do farmers practicing subsistence agriculture in developing countries. The machinery makes it possible for commercial farmers to farm extensive areas, a practice necessary to pay for the expensive machinery.



FARM SIZE

The average farm is relatively large in commercial agriculture. Farms average 178 hectares (441 acres) in the United States, compared to about 1 hectare (2.5 acres) in China (Figure 9-5). Farm size partly depends on mechanization. Combines, pickers, and other machinery perform most efficiently at very large scales, and their considerable expense cannot be justified on a small farm. As a result of the large size and the high level of mechanization, commercial agriculture is an expensive business. Farmers spend hundreds of thousands of dollars to buy or rent land and machinery before beginning operations. This money is frequently borrowed from a bank and repaid after output is sold.

▼ **FIGURE 9-5 SMALL CHINA FARM WITH HAND TOOLS** Digging up sweet potato vines, Pengzhou, China.



Commercial agriculture is increasingly dominated by a handful of large farms. In the United States, the largest 5 percent of farms produce 75 percent of the country's total agriculture. Despite their size, most commercial farms in developed countries—90 percent in the United States—are family owned and operated. Commercial farmers frequently expand their holdings by renting nearby fields.

Although the United States had fewer farms and farmers in 2000 than in 1900, the amount of land devoted to agriculture increased by 13 percent, primarily due to irrigation and reclamation. However, in the twenty-first century, the United States has been losing 1.2 million hectares (3 million acres) per year of its 400 million hectares (1 billion acres) of farmland, primarily because of the expansion of urban areas.

PAUSE & REFLECT 9.1.2

What other electronics, in addition to GPS devices, might help a farmer on a very large farm?

CHECK-IN KEY ISSUE 1

Where Did Agriculture Originate?

- ✓ Before the invention of agriculture, most humans were hunters and gatherers.
- ✓ Agriculture was invented in multiple hearths beginning approximately 10,000 years ago.
- ✓ Modern agriculture is divided between subsistence agriculture in developing countries and commercial agriculture in developed countries. They differ according to the percentage of farmers, use of machinery, and farm size.

KEY ISSUE 2

Why Do People Consume Different Foods?

- **Diet and Nutrition**
- **Source of Nutrients**

LEARNING OUTCOME 9.2.1

Explain differences between developed and developing countries in food consumption.

When you buy food in a supermarket, are you reminded of a farm? Not likely. The meat is carved into pieces that no longer resemble an animal and is wrapped in paper or plastic film. Often the vegetables are canned or frozen. The milk and eggs are in cartons.

The food industry in the United States and Canada is vast, but only a few people are full-time farmers, and they may be more familiar with the operation of computers and advanced machinery than the typical factory or office worker. The mechanized, highly productive American or Canadian farm contrasts with the subsistence farm found in much of the world. The most “typical” human—if there is such a person—is an Asian farmer who grows enough food to survive, with little surplus. This sharp contrast in agricultural practices constitutes one of the most fundamental differences between the more developed and less developed countries of the world.

Diet and Nutrition

Everyone needs food to survive. Consumption of food varies around the world, both in total amount and source of nutrients. The variation results from a combination of:

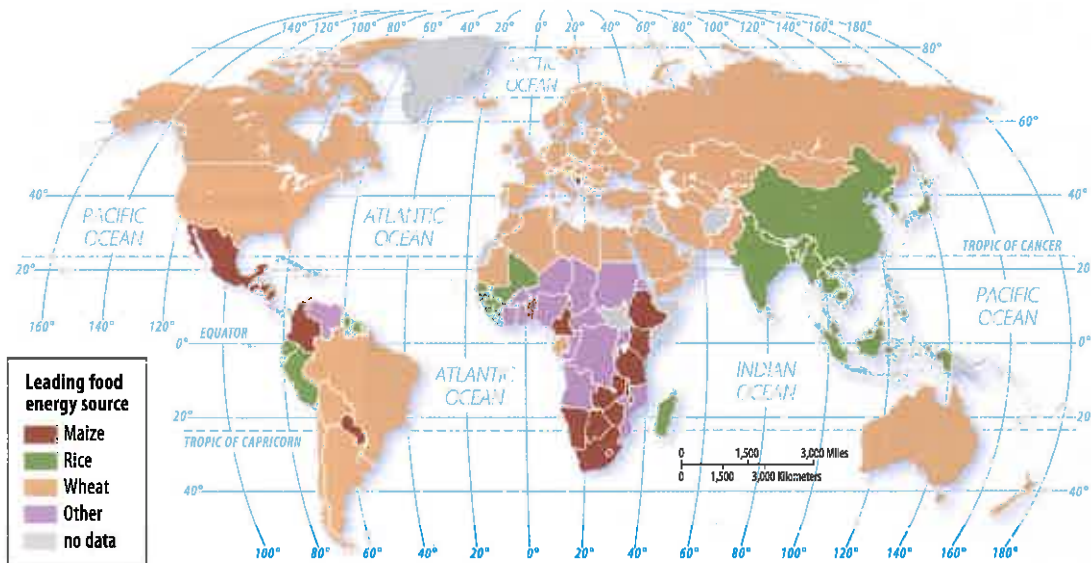
- **Level of development.** People in developed countries tend to consume more food and from different sources than do people in developing countries.
- **Physical conditions.** Climate is important in influencing what can be most easily grown and therefore consumed in developing countries. In developed countries, though, food is shipped long distances to locations with different climates.
- **Cultural preferences.** Some food preferences and avoidances are expressed without regard for physical and economic factors, as discussed in Chapter 4.

TOTAL CONSUMPTION OF FOOD

Dietary energy consumption is the amount of food that an individual consumes. The unit of measurement of dietary energy is the kilocalorie (kcal), or Calorie in the United States. One gram (or ounce) of each food source delivers a kilocalorie level that nutritionists can measure.

Most humans derive most of their kilocalories through consumption of **cereal grain**, or simply cereal, which is a grass that yields grain for food. **Grain** is the seed from a cereal grass. The three leading cereal grains—wheat, rice, and maize (corn in North America)—together account for nearly 90 percent of all grain production and more than 40 percent of all dietary energy consumed worldwide (Figure 9-6):

- **Wheat.** The principal cereal grain consumed in the developed regions of Europe and North America is wheat, which is consumed in bread, pasta, cake, and many other forms. It is also the most consumed grain in the developing regions of Central and Southwest Asia, where relatively dry conditions are more suitable for growing wheat than other grains.
- **Rice.** The principal cereal grain consumed in the developing regions of East, South, and Southeast Asia is rice. It is the most suitable crop for production in tropical climates.



► **FIGURE 9-6 DIETARY ENERGY BY SOURCE** Wheat, rice, and maize are the three main sources of kilocalories.

- **Maize.** The leading crop in the world is maize (called corn in North America), though much of it is grown for purposes other than direct human consumption, especially as animal feed. It is the leading crop in some countries of sub-Saharan Africa.
- **Other crops.** A handful of countries obtain the largest share of dietary energy from other crops, especially in sub-Saharan Africa. These include cassava, sorghum, millet, plantains, sweet potatoes, and yams. Sugar is the leading source of dietary energy in Venezuela.

DIETARY ENERGY NEEDS

To maintain a moderate level of physical activity, according to the U.N. Food and Agricultural Organization, an average individual needs to consume on a daily basis at least 1,844 kcal. Average consumption worldwide is 2,902 kcal per day, well above the recommended minimum. Thus, most people get enough food to survive (Figure 9-7).

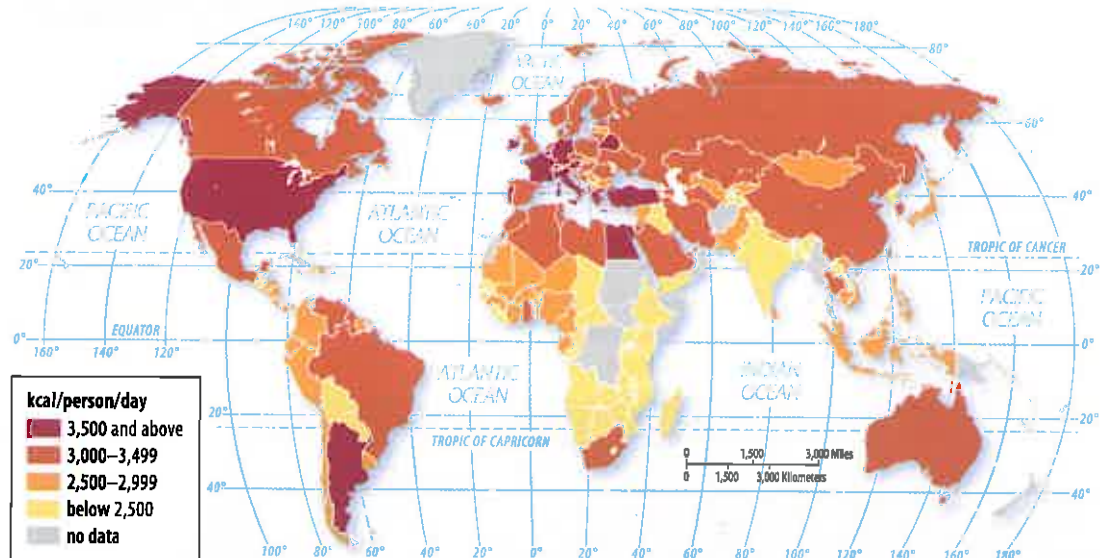
People in developed countries are consuming on average nearly twice the recommended minimum, 3,400 kcal per day. The United States has the world's highest consumption, 3,800 kcal per day per person. The consumption of so much food is one reason that obesity is more prevalent than hunger in the United States, as well as in other developed countries.

In developing regions, average daily consumption is 2,800 kcal, still above the recommended minimum. However, the average in sub-Saharan Africa is only 2,400, an indication that a large percentage of Africans are not getting enough to eat. Diets are more likely to be deficient in countries where people have to spend a high percentage of their income to obtain food (Figure 9-8).

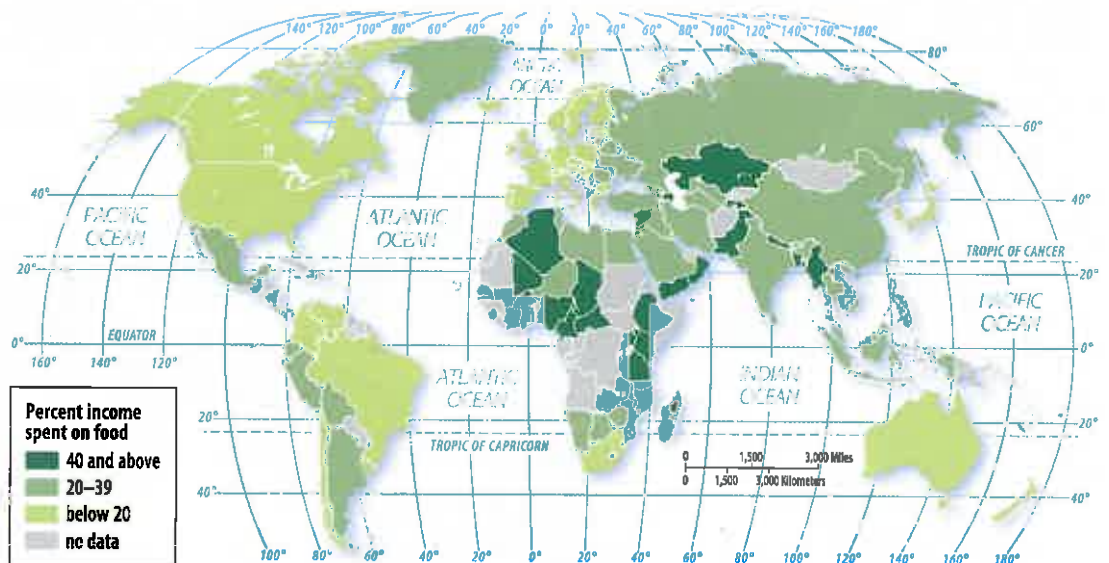
PAUSE & REFLECT 9.2.1

Many restaurants now tell you how many Calories (kilocalories) are in their meals. Does this information influence your choice of meal? Why or why not?

► **FIGURE 9-7** DIETARY ENERGY CONSUMPTION



► **FIGURE 9-8** INCOME SPENT ON FOOD



Source of Nutrients

LEARNING OUTCOME 9.2.2

Explain differences between developed and developing countries in source of nutrients.

The United Nations defines **food security** as 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. By this definition, around 10 percent of the world's inhabitants do not have food security.

PROTEIN

Protein is a nutrient needed for growth and maintenance of the human body. Many food sources provide protein of varying quantity and quality. One of the most fundamental differences between developed and developing regions is the primary source of protein (Figure 9-9).

In developed countries, the leading source of protein is meat products, including beef, pork, and poultry (Figure 9-10). Meat accounts for approximately one-third of all protein intake in developed countries, compared to approximately one-tenth in developing ones (Figure 9-11). In most developing countries, cereal grains provide the largest share of protein (Figure 9-12).

▼ **FIGURE 9-9 AFRICAN FOOD** This group in Mozambique is preparing cassavas. At home, these roots will be pounded to break up the fibrous texture and cooked into a porridge.



▲ **FIGURE 9-10 WORLD'S LARGEST CATTLE FEEDLOT** Cattle are fattened in Broken Bow, Nebraska, before being processed into cuts of beef.

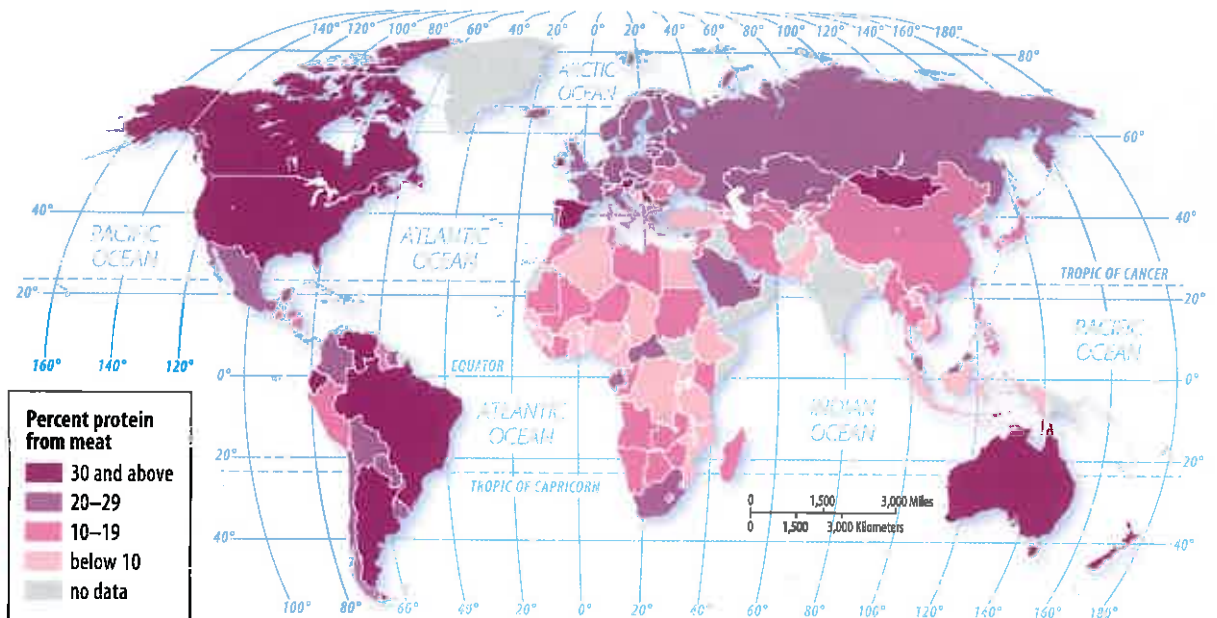
PAUSE & REFLECT 9.2.2

What is your main source of protein?

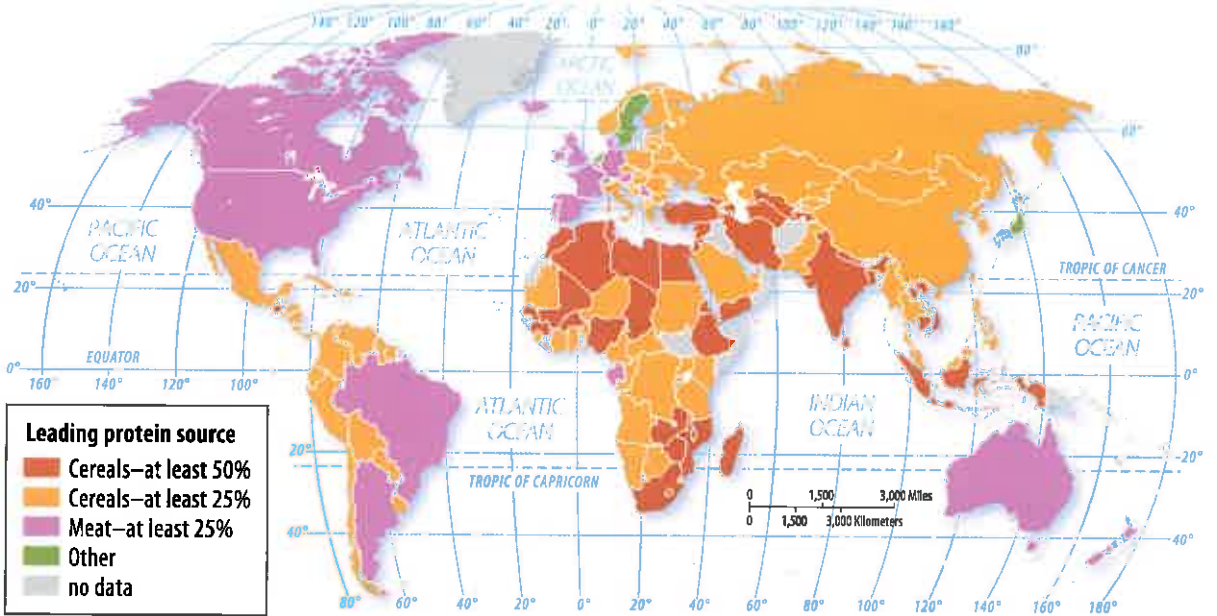


► **FIGURE 9-11****PROTEIN FROM**

MEAT The percentage of protein from meat is much higher for people in developed countries than for those in developing countries.

► **FIGURE 9-12****PROTEIN BY**

SOURCE People get most of their protein from meat in developed countries and from cereals in developing countries.

**CHECK-IN KEY ISSUE 2****Why Do People Consume Different Foods?**

- ✓ Most food is consumed in the form of cereal grains, especially wheat, rice, and maize.
- ✓ People in developed countries consume more total calories and a higher percentage through animal products.
- ✓ Most humans consume more than the recommended minimum calories, and the number who are undernourished is declining, but undernourishment is still common in Asia and sub-Saharan Africa.

Where Is Agriculture Distributed?

- **Agricultural Regions and Climate**
- **Subsistence Agriculture in Dry Regions**
- **Subsistence Agriculture in Tropical Regions**
- **Subsistence Agriculture in Population Concentrations**
- **Fishing**
- **Commercial Agriculture: Crop-based**
- **Commercial Agriculture: Mixed Crop and Livestock**
- **Commercial Agriculture: Animal-based**

LEARNING OUTCOME 9.3.1

Recognize relationships between maps of agriculture and of climate.

People have been able to practice agriculture in a wide variety of places. The most widely used map of world agricultural regions is based on work done by geographer Derwent Whittlesey in 1936 (Figure 9-13). Much has changed in the world since Whittlesey's work, but his broad division of the world into agriculture regions is still used.

Agricultural Regions and Climate

Similarities between the agriculture and climate maps are striking (Figure 9-14). For example, pastoral nomadism is the predominant type of agriculture in Southwest Asia & North Africa, which has a dry climate, whereas shifting cultivation is the predominant type of agriculture in sub-Saharan Africa, which has a tropical climate. Note the division between southeastern China (warm mid-latitude climate, intensive subsistence agriculture with wet-rice dominant) and north-eastern China (cold mid-latitude climate, intensive subsistence agriculture with wet rice not dominant).

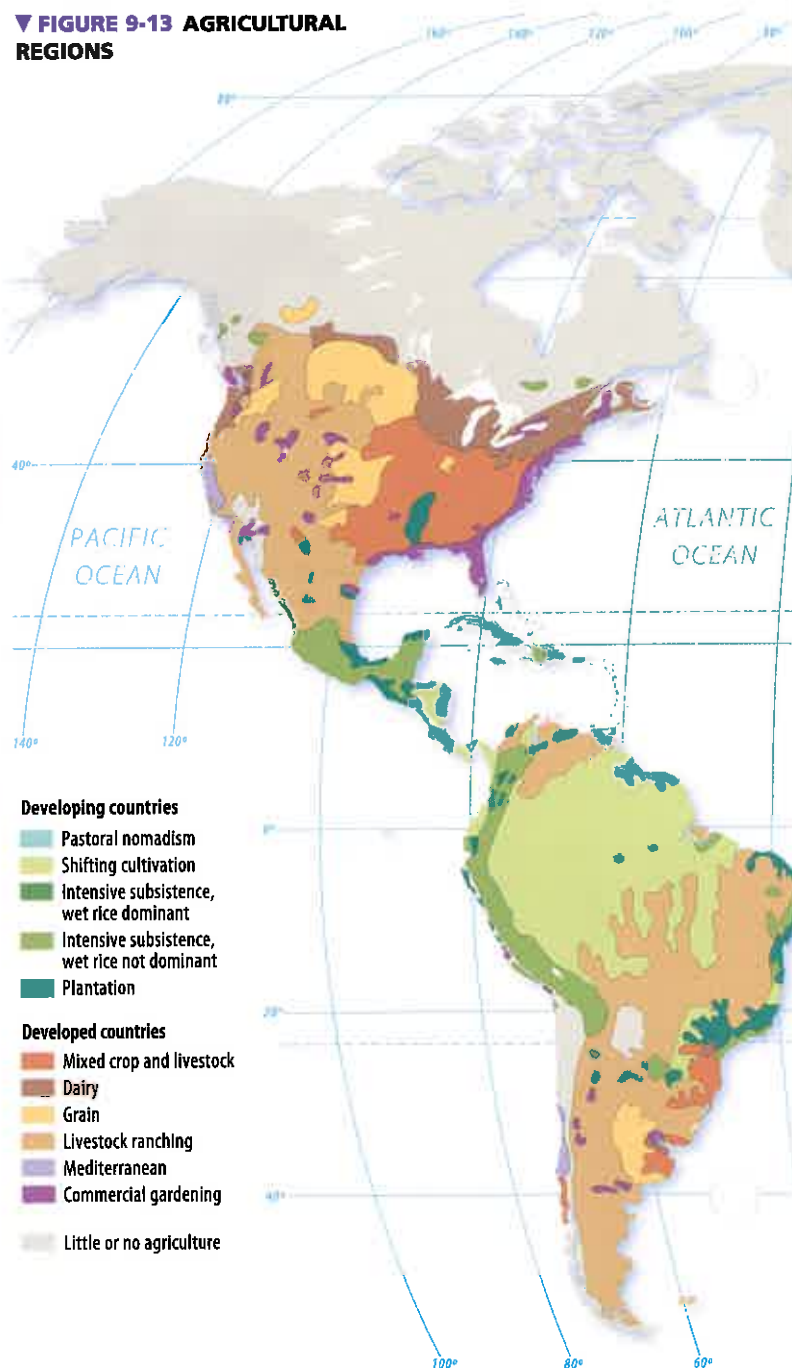
In the United States, much of the West is distinguished from the rest of the country according to climate (dry) and agriculture (livestock ranching). Thus, agriculture varies between the drylands and the tropics within developing countries—as well as between the drylands of developing and developed countries.

Because of the problems involved with the concept of environmental determinism, discussed in Chapter 1, geographers are wary of placing too much emphasis on the role of climate. Differences in cultural preferences and levels of development also explain agricultural differences in areas of similar climate.

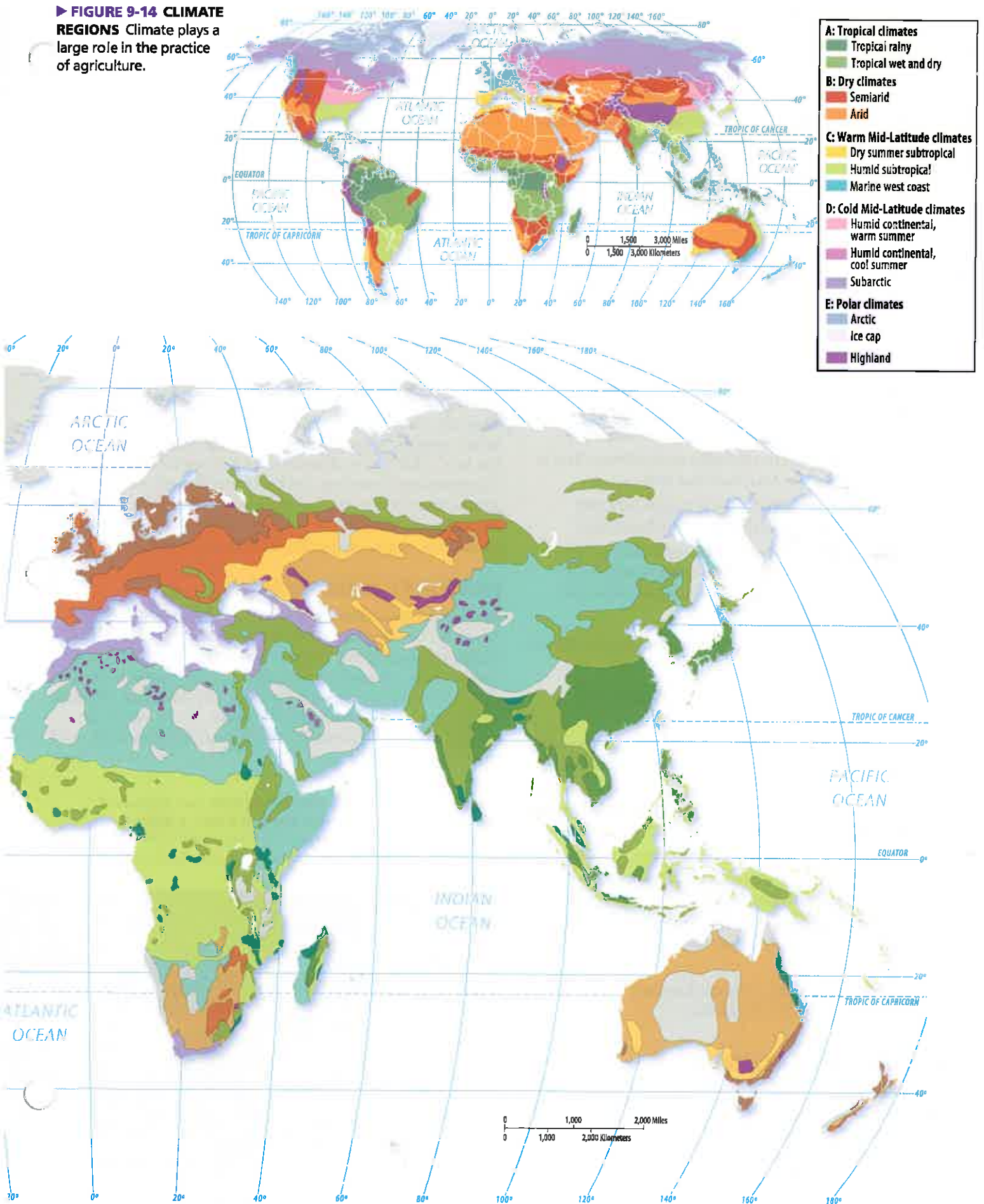
PAUSE & REFLECT 9.3.1

In Figures 9-13 and 9-14, do the agricultural regions match the climate regions more closely in the developed regions of North America and Europe or in the developing regions of Latin America, Africa, and Asia?

▼ **FIGURE 9-13 AGRICULTURAL REGIONS**



► **FIGURE 9-14 CLIMATE REGIONS** Climate plays a large role in the practice of agriculture.



Subsistence Agriculture in Dry Regions

LEARNING OUTCOME 9.3.2

Explain the principal forms of subsistence agriculture in lower-density dry regions.

Whittlesey identified 11 main agricultural regions, plus areas where agriculture was nonexistent. Whittlesey's 11 regions are divided between 5 that are important forms of agriculture in developing countries and 6 that are forms of commercial agriculture important in developed countries.

The five agricultural regions that predominate in developing countries are:

- **Intensive subsistence, wet-rice dominant.** The large population concentrations of East Asia and South Asia.
- **Intensive subsistence, crops other than rice dominant.** The large population concentrations of East Asia and South Asia, where growing rice is difficult.
- **Pastoral nomadism.** The drylands of Southwest Asia & North Africa, Central Asia, and East Asia.
- **Shifting cultivation.** The tropical regions of Latin America, sub-Saharan Africa, and Southeast Asia.
- **Plantation.** A form of commercial agriculture found in tropical and subtropical developing countries of Latin America, sub-Saharan Africa, South Asia, and Southeast Asia.

The six agricultural regions that predominate in developed countries are:

- **Mixed crop and livestock.** The U.S. Midwest and central Europe.
- **Dairying.** Near population clusters in the northeastern United States, southeastern Canada, and northwestern Europe.
- **Grain.** The north-central United States, south-central Canada, and Eastern Europe.
- **Ranching.** The drylands of western North America, southeastern Latin America, Central Asia, sub-Saharan Africa, and the South Pacific.
- **Mediterranean.** Lands surrounding the Mediterranean Sea, the western United States, the southern tip of Africa, and Chile.
- **Commercial gardening.** The southeastern United States and southeastern Australia.

HUNTERS AND GATHERERS

Before the invention of agriculture, all humans probably obtained the food they needed for survival through hunting for animals, fishing, or gathering plants (including berries, nuts, fruits, and roots). Hunters and gatherers lived in small groups of usually fewer than 50 persons because

a larger number would quickly exhaust the available resources within walking distance.

The group traveled frequently, establishing new home bases or camps. The direction and frequency of migration depended on the movement of game and the seasonal growth of plants at various locations. We can assume that groups communicated with each other concerning hunting rights, intermarriage, and other specific subjects. For the most part, they kept the peace by steering clear of each other's territory.

The men hunted game or fished, and the women collected berries, nuts, and roots. This division of labor sounds like a stereotype but is based on evidence from archaeology and anthropology. They collected food often, perhaps daily. The food search might have taken only a short time or much of the day, depending on local conditions.

Today, perhaps a quarter-million people, or less than 0.005 percent of the world's population, still survive by hunting and gathering rather than by agriculture. Examples include the Spinifex (also known as Pila Nguru) people, who live in Australia's Great Victorian Desert; the Sentinelese people, who live in India's Andaman Islands; and the San, who live in Botswana and Namibia (Figure 9-15). Contemporary hunting and gathering societies are isolated groups that live on the periphery of world settlement, but they provide insight into human customs that prevailed in prehistoric times, before the invention of agriculture.

PASTORAL NOMADISM

Pastoral nomadism is a form of subsistence agriculture based on the herding of domesticated animals in dry climates, where planting crops is impossible. Pastoral nomads, unlike other subsistence farmers, depend primarily on animals rather than crops for survival. The Bedouins of Saudi Arabia and North Africa and the Masai of East Africa are examples of pastoral nomads. The animals provide milk, and their skins and hair are used for clothing and tents. Their

FIGURE 9-15 HUNTING AND GATHERING Two members of Namibia's San People hunt with bow and arrow. 1. Before the invention of agriculture, 8,000 years ago, why would a bow and arrow be used rather than ammunition? 2. Why might a bow and arrow be used by hunters today, rather than a rifle?



animals are usually not slaughtered, although dead ones may be consumed. To nomads, the size of their herd is both an important measure of power and prestige and their main security during adverse environmental conditions.

Like other subsistence farmers, though, pastoral nomads consume mostly grain rather than meat. To obtain grain, many present-day nomads do raise crops or obtain them by trading animal products.

Nomads select the type and number of animals for the herd according to local cultural and physical characteristics. The choice depends on the relative prestige of animals and the ability of species to adapt to a particular climate and vegetation:

- Camels are well suited to arid climates because they can go long periods without water, carry heavy baggage, and move rapidly, but they are particularly bothered by flies and sleeping sickness and have a relatively long gestation period—12 months from conception to birth.
- Goats need more water than do camels but are tough and agile and can survive on virtually any vegetation, no matter how poor (Figure 9-16).
- Sheep are relatively slow moving and affected by climatic changes; they require more water than camels and goats and are more selective about which plants they will eat.

Pastoral nomads do not wander randomly across the landscape but have a strong sense of territoriality. Every group controls a piece of territory and will invade another group's territory only in an emergency or if war is declared. The goal of each group is to control a territory large enough to contain the forage and water needed for survival. The actual amount of land a group controls depends on its wealth and power. The precise migration patterns evolve from intimate knowledge of the area's physical and cultural characteristics.

Some pastoral nomads practice **transhumance**, which is seasonal migration of livestock between mountains and lowland pasture areas. Pasture is grass or other plants grown for feeding grazing animals, as well as land used for grazing. Sheep or other animals may pasture in alpine meadows in the summer and be herded back down into valleys for winter pasture.

Agricultural experts once regarded pastoral nomadism as a stage in the evolution of agriculture—between the hunters and gatherers who migrated across Earth's surface in search of food and sedentary farmers who cultivated grain in one place. Because they had domesticated animals but not plants, pastoral nomads were considered more advanced than hunters and gatherers but less advanced than settled farmers.

Pastoral nomadism is now generally recognized as an offshoot of sedentary agriculture, not as a primitive precursor of it. It is simply a practical way of surviving on land that receives too little rain for cultivation of crops.

Today, pastoral nomadism is a declining form of agriculture, partly a victim of modern technology. Before recent transportation and communications inventions, pastoral nomads played an important role as carriers of goods and information across the sparsely inhabited drylands. They used to be the most powerful inhabitants of the drylands, but now, with modern weapons, national governments can control nomadic population more effectively.

Governments force groups to give up pastoral nomadism because they want the land for other uses. Land that can be irrigated is converted from nomadic to sedentary agriculture. In some instances, the mining and petroleum industries now operate in drylands formerly occupied by pastoral nomads. Some nomads are encouraged to try sedentary agriculture or to work for mining or petroleum companies. Others are still allowed to move about, but only within ranches of fixed boundaries. In the future, pastoral nomadism will be increasingly confined to areas that cannot be irrigated or that lack valuable raw materials.

► **FIGURE 9-16**
PASTORAL NOMADISM
Milking goats, Gobi
Desert, Mongolia.



Subsistence Agriculture in Tropical Regions

LEARNING OUTCOME 9.3.3

Explain the principal forms of subsistence agriculture in lower-density tropical regions.

Shifting cultivation is practiced in much of the world's tropical, or A, climate regions, which have relatively high temperatures and abundant rainfall. It is practiced by roughly 250 million people across 36 million square kilometers (14 million square miles), especially in the tropical rain forests of Latin America, sub-Saharan Africa, and Southeast Asia. **Plantation** farming is also found.

SHIFTING CULTIVATION

Two distinctive features of shifting cultivation are:

- Farmers clear land for planting by slashing vegetation and burning the debris; shifting cultivation is sometimes called **slash-and-burn agriculture**.
- Farmers grow crops on a cleared field for only a few years, until soil nutrients are depleted, and then leave it fallow (with nothing planted) for many years so the soil can recover.

People who practice shifting cultivation generally live in small villages and grow food on the surrounding land, which the village controls. Each year villagers designate for planting an area surrounding the settlement. Before planting, they must remove the dense vegetation that typically covers tropical land. Using axes, they cut down most of the trees, sparing only those that are economically useful. The undergrowth is cleared away with a machete or other long knife. On a windless day the debris is burned under carefully

controlled conditions. The rains wash the fresh ashes into the soil, providing needed nutrients (Figure 9-17).

Before planting, the cleared area, known by a variety of names in different regions, including **swidden**, lading, milpa, chena, and kaingin, is prepared by hand, perhaps with the help of a simple implement such as a hoe; plows and animals are rarely used (Figure 9-18). The only fertilizer generally available is potash (potassium) from burning the debris when the site is cleared. Little weeding is done the first year that a cleared patch of land is farmed; weeds may be cleared with a hoe in subsequent years.

The cleared land can support crops only briefly, usually three years or less. In many regions, the most productive harvest comes in the second year after burning. Thereafter, soil nutrients are rapidly depleted and the land becomes too infertile to nourish crops. Rapid weed growth also contributes to the abandonment of a swidden after a few years. When the swidden is no longer fertile, villagers identify a new site and begin clearing it. They leave the old site uncropped for many years, allowing it to become overrun again by natural vegetation. The field is not actually abandoned; the villagers will return to the site someday, perhaps as few as 6 years or as many as 20 years later, to begin the process of clearing the land again. In the meantime, they may still care for fruit-bearing trees on the site.

If a cleared area outside a village is too small to provide food for the population, then some of the people may establish a new village and practice shifting cultivation there. Some farmers may move temporarily to another settlement if the field they are clearing that year is distant.

CROPS OF SHIFTING CULTIVATION. The crops grown by each village vary by local custom and taste. The predominant crops include upland rice in Southeast Asia, maize (corn) and manioc (cassava) in South America, and millet and sorghum in Africa. Yams, sugarcane, plantain, and vegetables are also grown in some regions. These crops have originated in one region of shifting cultivation and have diffused to other areas in recent years.

The Kayapo people of Brazil's Amazon tropical rain forest do not arrange crops in the rectangular fields and rows that are familiar to us. They plant in concentric rings. At first they plant sweet potatoes and yams in the inner area. In successive rings go corn and rice, manioc, and more yams. In subsequent years the inner area of potatoes and yams expands to replace corn and rice. The outermost ring contains plants that require more nutrients, including papaya, banana, pineapple, mango, cotton, and beans. It is here that the leafy crowns of cut trees fall when the field is cleared, and their rotting releases more nutrients into the soil.

Most families grow only for their own needs, so one swidden may contain a large variety of intermingled crops, which are harvested individually at the best time. In shifting cultivation a "farm field" appears much more chaotic than do fields in developed countries, where a single crop such as corn or wheat may grow over an extensive area. In some cases, families may specialize in a few crops and trade with villagers who have a surplus of others.



▲ **FIGURE 9-17 SHIFTING CULTIVATION: SLASH AND BURN** A field is burned prior to planting in Mozambique.

OWNERSHIP AND USE OF LAND IN SHIFTING CULTIVATION. Traditionally, land was owned by the village as a whole rather than separately by each resident. The chief or ruling council allocated a patch of land to each family and allowed it to retain the output. Individuals may also have had the right to own or protect specific trees surrounding the village. Today, private individuals now own the land in some communities, especially in Latin America.

Shifting cultivation occupies approximately one-fourth of the world's land area, a higher percentage than any other type of agriculture. However, less than 5 percent of the world's people engage in shifting cultivation. The gap between the percentage of people and land area is not surprising, because the practice of moving from one field to another every couple of years requires more land per person than do other types of agriculture.

FUTURE OF SHIFTING CULTIVATION. Land devoted to shifting cultivation is declining in the tropics at the rate of about 75,000 square kilometers (30,000 square miles), or 0.2 percent, per year according to the United Nations (Figure 10-25). The amount of Earth's surface allocated to tropical rain forests has already been reduced to less than half of its original area, for until recent years the World Bank supported deforestation with loans to finance development schemes that required clearing forests. Shifting cultivation is being replaced by logging, cattle ranching, and the cultivation of cash crops. Selling timber to builders or raising beef cattle for fast-food restaurants are more effective development strategies than maintaining shifting cultivation. Developing countries also see shifting cultivation as an inefficient way to grow food in a hungry world. Indeed, compared to other forms of agriculture, shifting cultivation can support only a small population in an area without causing environmental damage.

To its critics, shifting cultivation is at best a preliminary step in economic development. Pioneers use shifting cultivation to clear forests in the tropics and to open land for development where permanent agriculture never existed. People unable to find agricultural land elsewhere can migrate to the tropical forests and initially practice shifting cultivation. Critics say it then should be replaced by more sophisticated agricultural techniques that yield more per land area. Defenders of shifting cultivation consider it the most environmentally sound approach for the tropics. Practices used in other forms of agriculture, such as fertilizers and pesticides and permanently clearing fields, may damage the soil, cause severe erosion, and upset balanced ecosystems.

Large-scale destruction of the rain forests also may contribute to global warming. When large numbers of trees are cut, their burning and decay release large volumes of carbon dioxide. This gas can build up in the atmosphere, acting like the window glass in a greenhouse to trap solar energy in the atmosphere, resulting in the "greenhouse effect," discussed in Chapter 11. Elimination of shifting cultivation could also upset the traditional local diversity of cultures in the tropics. The activities of shifting cultivation are intertwined with other social, religious, political, and

various folk customs. A drastic change in the agricultural economy could disrupt other activities of daily life.

As the importance of tropical rain forests to the global environment has become recognized, developing countries have been pressured to restrict further destruction of them. In one innovative strategy, Bolivia agreed to set aside 1.5 million hectares (3.7 million acres) in a forest reserve in exchange for cancellation of \$650,000,000 of its debt to developed countries. Meanwhile, in Brazil's Amazon rain forest, deforestation has increased from 2.7 million hectares (7 million acres) per year during the 1990s to 3.1 million hectares (8 million acres) since 2000.

PAUSE & REFLECT 9.3.3

How would rapid population growth make it difficult to practice shifting cultivation?

PLANTATION FARMING

Most plantations are located in the tropics and subtropics, especially in Latin America, Africa, and Asia. Although generally situated in developing countries, plantations are often owned or operated by Europeans or North Americans, and they grow crops for sale primarily to developed countries. Among the most important crops grown on plantations are cotton, sugarcane, coffee, rubber, and tobacco. Also produced in large quantities are cocoa, jute, bananas, tea, coconuts, and palm oil.

Until the Civil War, plantations were important in the U.S. South, where the principal crop was cotton, followed by tobacco and sugarcane. 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.

▼ **FIGURE 9-18 SHIFTING CULTIVATION: PREPARING THE LAND** This field in Côte d'Ivoire is being prepared for planting.



Subsistence Agriculture in Population Concentrations

LEARNING OUTCOME 9.3.4

Explain the principal forms of agriculture in higher-density developing regions.

Three-fourths of the world's people live in developing countries, and the form of subsistence agriculture that feeds most of them is **intensive subsistence agriculture**. The term intensive implies that farmers must work intensively to subsist on a parcel of land.

CHARACTERISTICS OF INTENSIVE SUBSISTENCE FARMING

In developing countries, most people produce food for their own consumption. This is especially true in intensive subsistence agriculture, the most widely practiced form of agriculture in densely populated East, South, and Southeast Asia.

Intensive subsistence agriculture involves careful agricultural practices refined over thousands of years in response to local environmental and cultural patterns. Because the agricultural density—the ratio of farmers to arable land—is so high in parts of East and South Asia, families must produce enough food for their survival from a very small area of land. Most of the work is done by hand or with animals rather than with machines, in part due to abundant labor but largely from lack of funds to buy equipment.

The typical farm in Asia's intensive subsistence agriculture regions is much smaller than farms elsewhere in the world. Many Asian farmers own several fragmented plots, frequently a result of dividing individual holdings among several children over several centuries. To maximize food production, intensive subsistence farmers waste virtually no land. Corners of fields and irregularly shaped pieces of land are planted rather than left idle. Paths and roads are kept as narrow as possible to minimize the loss of arable land. Livestock are rarely permitted

to graze on land that could be used to plant crops, and little grain is grown to feed the animals.

Land is used even more intensively in parts of Asia by obtaining two harvests per year from one field, a process known as **double cropping**. Double cropping is common in places that have warm winters, such as southern China and Taiwan, but is relatively rare in India, where most areas have dry winters. Normally, double cropping involves alternating between wet rice, grown in the summer when precipitation is higher, and wheat, barley, or another dry crop, grown in the drier winter season. Crops other than rice may be grown in the wet-rice region in the summer on nonirrigated land.

WET-RICE DOMINANT

The intensive agriculture region of Asia can be divided between areas where wet rice dominates and areas where it does not (refer to Figure 9-13). The term **wet rice** refers to rice planted on dry land in a nursery and then moved as seedlings to a flooded field to promote growth. Wet rice occupies a relatively small percentage of Asia's agricultural land but is the region's most important source of food.

Intensive wet-rice farming is the dominant type of agriculture in southeastern China, East India, and much of Southeast Asia. China and India account for nearly 50 percent of the world's rice production, and more than 90 percent is produced in East, South, and Southeast Asia (Figure 9-19).

Successful production of large yields of rice is an elaborate process that is time-consuming and done mostly by hand. The consumers of the rice also perform the work, and all family members, including children, contribute to the effort. Growing rice involves four principal steps. As the name implies, all four steps are intensive:

1. The field is prepared, typically using animal power (Figure 9-20). Flat land is needed to grow rice, so hillsides are terraced.
2. The field is flooded with water (Figure 9-21). The flooded field is called a **sawah** in Indonesia and is

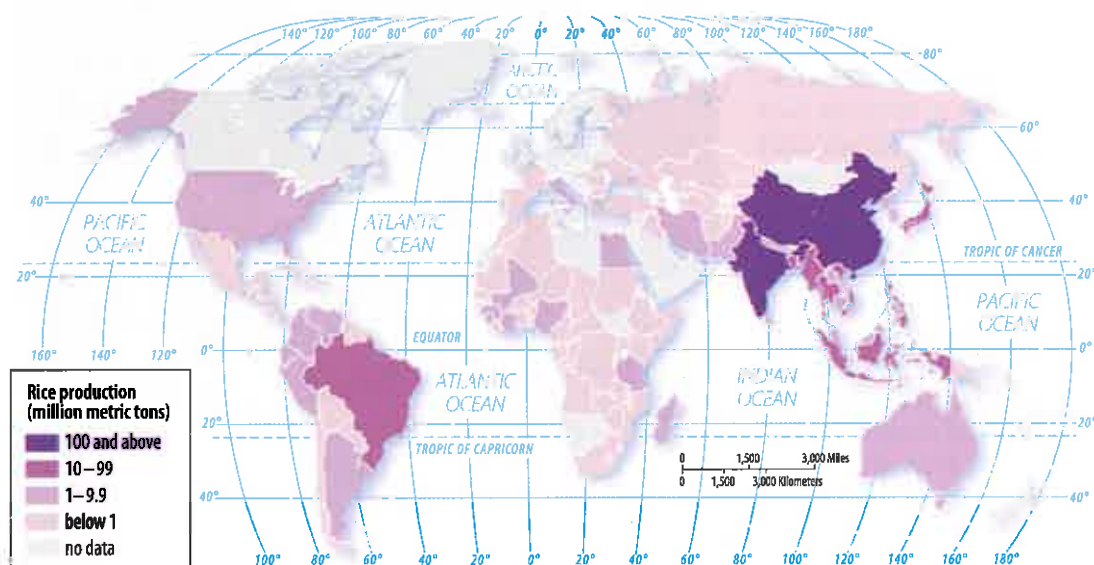


FIGURE 9-19 RICE PRODUCTION China and India produce one-half of the world's rice.



▲ **FIGURE 9-20 GROWING RICE: PREPARING THE FIELD** Cows pull a level in India.



▲ **FIGURE 9-21 GROWING RICE: FLOODING THE FIELD** Flooded fields in Indonesia.

increasingly referred to a **paddy**, which is actually the Malay word for wet rice.

3. Rice seedlings grown for the first month in a nursery are transplanted into the flooded field (Figure 9-22).
4. Rice plants are harvested with knives (Figure 9-23). The chaff (husks) is separated from the seeds by threshing (beating) the husks on the ground. The threshed rice is placed in a tray for winnowing, in which the lighter chaff is allowed to be blown away by the wind.



▲ **FIGURE 9-22 GROWING RICE: TRANSPLANTING PLANTS** Rice plants are transplanted by hand in India.

WET RICE NOT DOMINANT

Climate discourages farmers from growing wet rice in portions of Asia, especially where summer precipitation levels are too low and winters are too harsh (refer to Figure 9-13). Agriculture in much of the interior of India and northeastern China is devoted to crops other than wet rice. Wheat is the most important crop, followed by barley. Other grains and legumes are grown for household consumption, including millet, oats, corn, sorghum, and soybeans. In addition, some crops are grown in order to be sold for cash, such as cotton, flax, hemp, and tobacco.

Aside from what is grown, this region shares most of the features of the wet-rice region. Land is used intensively and worked primarily by human power, with the assistance of some hand implements and animals. In milder parts of the region where wet rice does not dominate, more than one harvest can be obtained some years through skilled use of **crop rotation**, which is the practice of rotating use of different fields from crop to crop each year to avoid exhausting the soil. In colder climates, wheat or another crop is planted in the spring and harvested in the fall, but no crops can be sown through the winter.

PAUSE & REFLECT 9.3.4

What challenges might farmers in East and South Asia face if they wish to adopt farming practices that are less labor intensive than growing wet rice?



◀ **FIGURE 9-23 GROWING RICE: HARVESTING** Harvesting and threshing rice by hand in Myanmar.

Fishing

LEARNING OUTCOME 9.3.5

Describe the contribution of fishing to the world food supply.

Food acquired from Earth's waters includes fish, crustaceans (such as shrimp and crabs), mollusks (such as clams and oysters), and aquatic plants (such as watercress). Water-based food is acquired in two ways:

- **Fishing**, which is the capture of wild fish and other seafood living in the waters.
- **Aquaculture**, or **aquafarming**, which is the cultivation of seafood under controlled conditions.

Fishing and aquaculture are practiced in both subsistence and commercial agriculture.

Oceans are vast, covering nearly three-fourths of Earth's surface and lying near most population concentrations. Historically the sea has provided only a small percentage of the world food supply. So at first glance, increased use of food from the sea is attractive. However, overfishing has reduced fish supplies in many regions.

FISH PRODUCTION

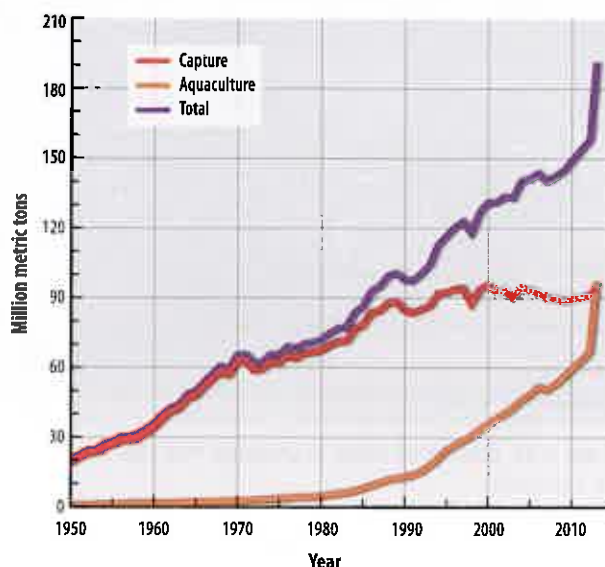
The world's oceans are divided into 18 major fishing regions, including seven each in the Atlantic and Pacific oceans, three in the Indian Ocean, and one the Mediterranean (Figure 9-24). Fishing is also conducted in inland waterways, such as lakes and rivers. The areas with the largest yields are the Pacific Northwest and Asia's inland waterways.

During the past half-century, global fish production has increased from approximately 36 to 158 million metric tons. The growth has resulted entirely from expansion of aquaculture (Figure 9-25). The capture of wild fish in the oceans and lakes has stagnated since the 1990s, despite population

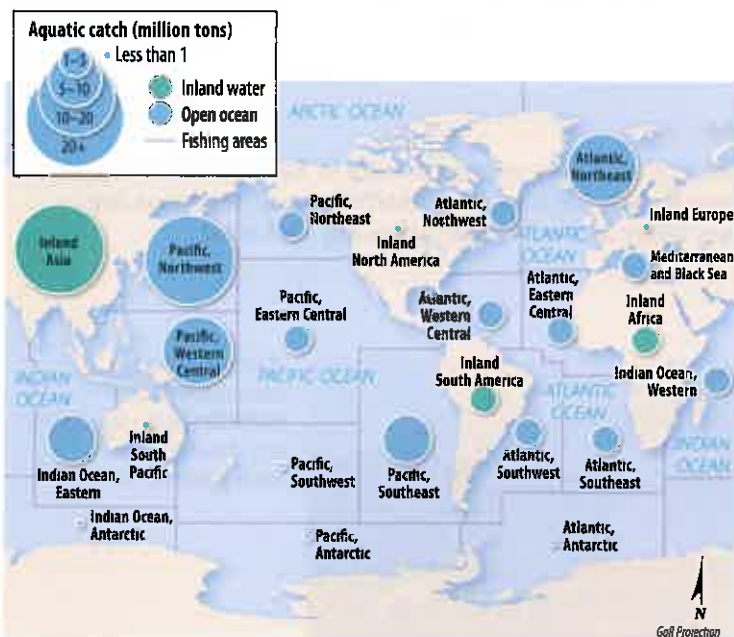


▲ **FIGURE 9-25 AQUACULTURE** Fish are raised inside the containers at this fish farm in Kassiope, Corfu, Greece.

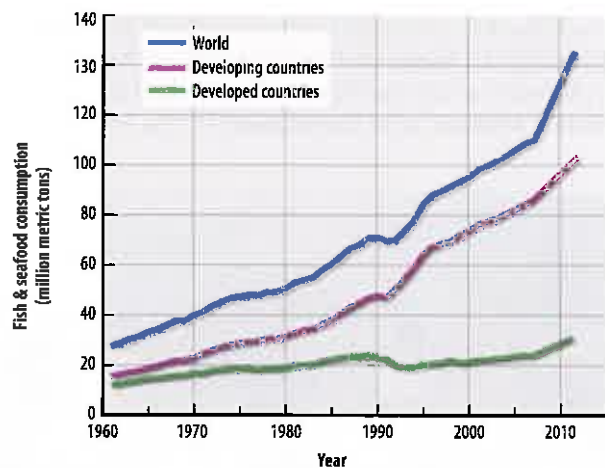
growth and increased demand to consume fish. The reason that production is higher than human consumption is that a large portion of the fish that is caught is converted to fish meal and fed to poultry and hogs. Only two-thirds of the fish caught from the ocean is consumed directly by humans (see Sustainability & Our Environment feature).



▲ **FIGURE 9-26 GROWTH IN FISH PRODUCTION**



▲ **FIGURE 9-24 MAJOR FISHING REGIONS**



▲ **FIGURE 9-27 GROWTH IN HUMAN CONSUMPTION OF FISH**

SUSTAINABILITY & OUR ENVIRONMENT

Asian Carp and Chicago's Economy

The growth of aquaculture has led to the farming of nonnative species. One example is the Asian carp, which were imported to the United States in the 1970s to stock a fish farm in Arkansas. Flooding allowed the carp to escape the farm and enter U.S. waterways. Fast-growing and voracious eaters, Asian carp can grow to over 45 kilograms (100 pounds) (Figure 9-28). Once in the waterways, the extremely aggressive Asian carp compete successfully with native fish for food and habitat threatening the sustainability of native species. They have even attacked people fishing in small boats.

Asian carp have traveled up the Mississippi and Illinois rivers, and they now constitute 97 percent of the fish in these rivers. Now the Asian carp threaten to reach the Great Lakes. The most likely point of entry into the Great Lakes for the Asian carp is through Chicago-area waterways. The U.S. Army Corps of Engineers has installed electric barriers to try to keep the Asian carp from traveling through the canals to Lake Michigan.

In the long run, the only effective way to keep the carp out of the Great Lakes is to shut the canals. But the canals play a major role, in



▲ FIGURE 9-28 **ASIAN CARP** in the Illinois River.

sustaining Chicago's economy, so shutting them could devastate the city's economy.

FISH CONSUMPTION

Human consumption of fish and seafood increased from 27 million metric tons in 1960 to 132 million metric tons in 2012. Developing countries are responsible for five-sixths of the increase.

Fish consumption has increased more rapidly than population growth. During the past half-century, per capita consumption of fish has nearly doubled in both developed and developing countries. Still, fish and seafood account for only 1 percent of all calories consumed by humans.

A comparison of Figures 9-26 and 9-27 shows that production of fish is considerably higher than human consumption of it. Around 85 percent of the fish is consumed directly by humans. The remainder is converted to fish meal and fed to poultry and hogs.

OVERFISHING

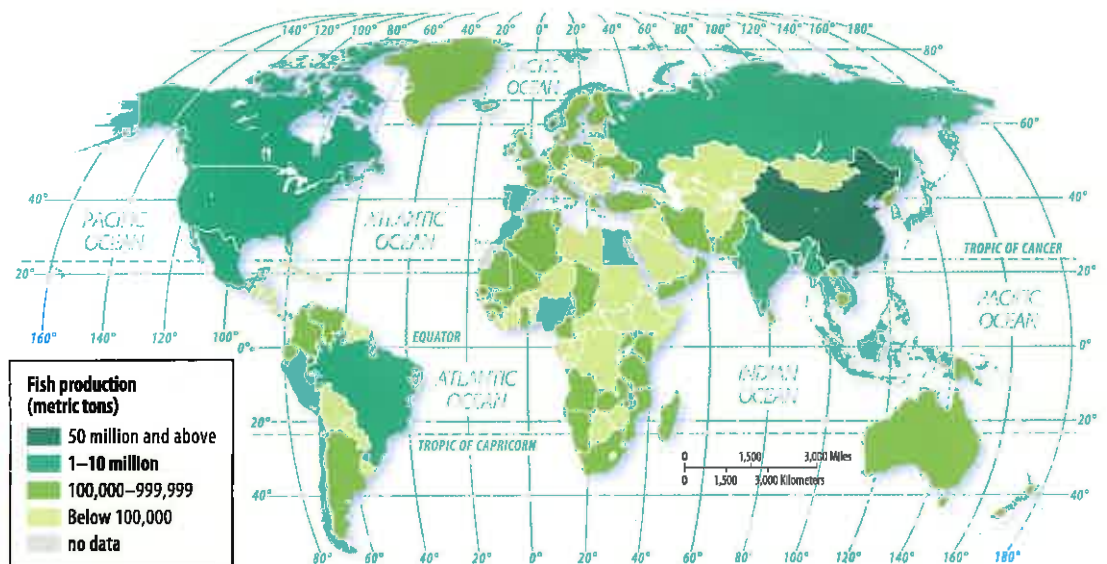
China is responsible for one-third of the world's yield of fish (Figure 9-29). The other leading countries are naturally those with extensive ocean boundaries, such as Chile, Indonesia, and Peru.

The populations of some fish species in the oceans and lakes have declined because of **overfishing**, which is capturing fish faster than they can reproduce. Hope grew during the mid-twentieth century that increased fish consumption could meet the needs of a rapidly growing global population. However, the populations of some fish species declined because of overfishing. The U.N. estimates that one-quarter of fish stocks have been overfished and one-half fully exploited, leaving only one-fourth underfished.

PAUSE & REFLECT

9.3.5

The average resident in a developed country consumes around 6 ounces (170 grams) of fish per week. Why might your consumption be higher or lower than the average?



► FIGURE 9-29 **FISH PRODUCTION**

Commercial Agriculture: Crop Based

LEARNING OUTCOME 9.3.6

Describe the basic principles of several forms of crop-based commercial agriculture.

The system of commercial farming found in developed countries is called **agribusiness** because farming is integrated into a large food-production industry. Farmers account for less than 2 percent of the U.S. labor force, but around 20 percent of U.S. laborers work in food production and services related to agribusiness—food processing, packaging, storage, distribution, and retailing. Agribusiness also encompasses such diverse enterprises as tractor manufacturing, fertilizer production, and seed distribution.

Most farms are owned by individual families, but most other aspects of agribusiness are controlled by large corporations. Agricultural products are not sold directly to consumers but to food-processing companies. Large processors, such as General Mills and Kraft, typically sign contracts with commercial farmers to buy their crops and animals.

Commercial agriculture in developed countries can be divided into six main types: grain, Mediterranean, commercial gardening and fruit, mixed crop and livestock, dairy, and ranching. The first three derive most of their income from the sale of crops and the second three from the sale of animal products.

GRAIN FARMING

The major crop on most farms is grain, such as wheat, corn, oats, barley, rice, and millet. Commercial grain agriculture is distinguished from mixed crop and livestock farming because crops on a grain farm are grown primarily for consumption by humans rather than by livestock. Large-scale grain production, like other commercial farming ventures

in developed countries, is heavily mechanized, conducted on large farms, and oriented to consumer preferences.

Commercial grain farms sell their output to manufacturers of food products, such as breakfast cereal and bread. 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.

As has been the case with milk production, the share of world production of wheat in developing countries has increased rapidly. Much of this increased production results from growth in large-scale commercial agriculture. Developing countries accounted for more than one-half of world wheat production in 2013, compared to only one-fourth in 1960. The United States is by far the largest producer of wheat among developed countries, but it now ranks third among all countries, behind China and India (Figure 9-30). China has been the world leader since 1983, and India has been second since 1999.

Commercial grain farms are generally located in regions that are too dry for mixed crop and livestock agriculture. Within North America, large-scale grain production is concentrated in three areas:

- The winter wheat belt through Kansas, Colorado, and Oklahoma, where planting is in the autumn and harvesting in the early summer.
- The spring wheat belt through the Dakotas, Montana, and southern Saskatchewan in Canada, where planting is in the spring and harvesting in the late summer.
- The Palouse region of Washington State.

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 it is the world's

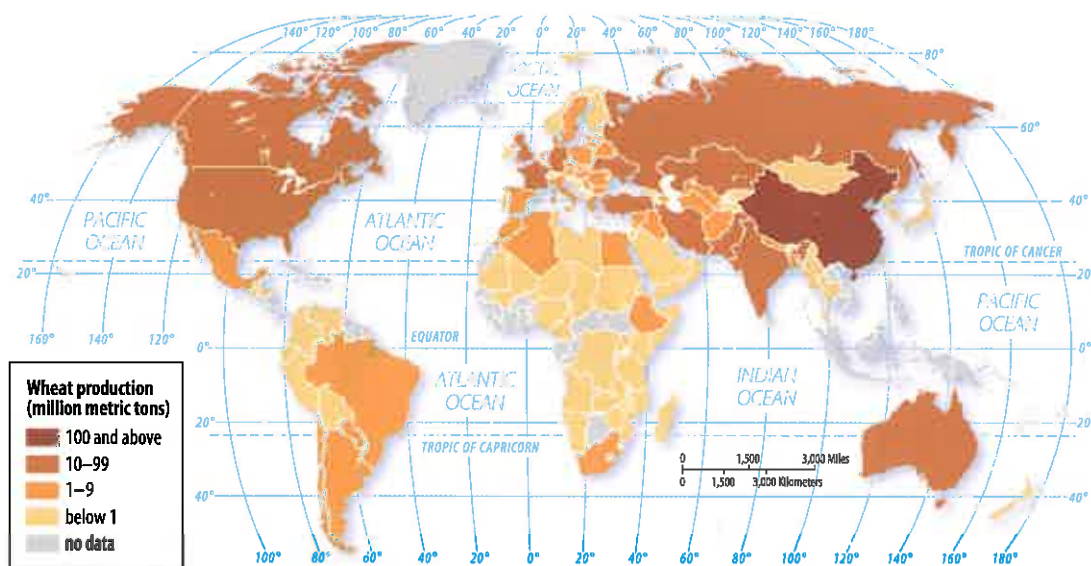


FIGURE 9-30 WHEAT PRODUCTION China and India are the leading wheat producers, followed by the United States.



▲ **FIGURE 9-31 MEDITERRANEAN AGRICULTURE** Vineyard on a hillside overlooking the Mediterranean Sea, Vernazza, Italy.

leading export crop. The United States and Canada account for about one-fourth of the world's wheat exports. The ability to provide food for many people elsewhere in the world is a major source of economic and political strength for these two countries.

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 9-13). Every Mediterranean area borders a sea (Figure 9-31). 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.

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. In the lands bordering the Mediterranean Sea, the two most important cash crops are olives and grapes (refer to Figure 4-16). A large portion of California farmland is devoted to fruit and vegetable horticulture, which supplies a large portion of the citrus fruits, tree nuts, and deciduous fruits consumed in the United States.

COMMERCIAL GARDENING AND FRUIT FARMING

Commercial gardening and fruit farming is the predominant type of agriculture in the southeastern United States. The region has a long growing season and humid climate, and it is accessible to the large number of consumers in the northeast United States. This type of agriculture is frequently called **truck farming**, from the Middle

English word *truck*, meaning “barter” or “exchange of commodities.”

Truck farms grow many of the fruits and vegetables that consumers in developed countries demand, such as apples, asparagus, cherries, lettuce, mushrooms, and tomatoes (Figure 9-32). Some of these fruits and vegetables are sold fresh to consumers, but most are sold to large processors for canning or freezing. 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, among other places. 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.

PAUSE & REFLECT 9.3.6

Why might wheat be easier to export than produce from truck farming?

▼ **FIGURE 9-32 TRUCK FARMING** Harvesting peanuts, Georgia.



Commercial Agriculture: Mixed Crop and Livestock

LEARNING OUTCOME 9.3.7

Describe the basic principles of several forms of mixed crop and livestock agriculture.

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.

MIXED CROP AND LIVESTOCK

The most distinctive characteristic of **mixed crop and livestock farming** is the 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 crop and livestock 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.

Mixing crops and livestock 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. Meanwhile, livestock require year-round 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.

In the United States, corn (maize) is the crop most frequently planted in the mixed crop and livestock region



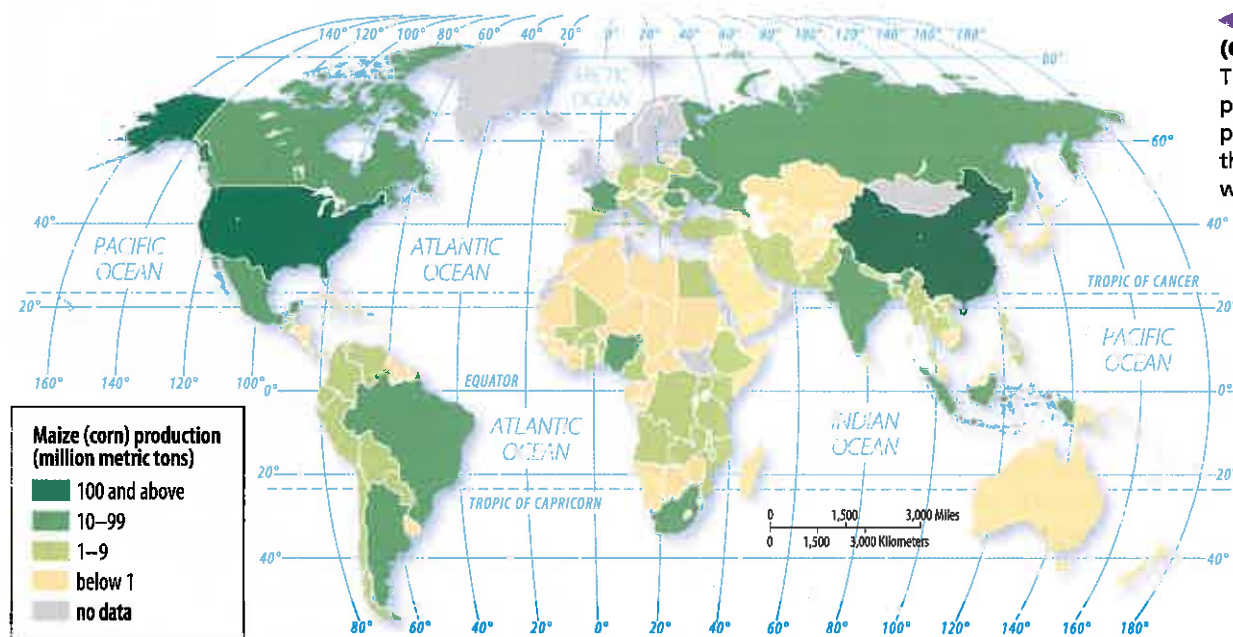
▲ **FIGURE 9-34 MIXED CROP AND LIVESTOCK** Harvesting corn in Iowa.

because it generates higher yields per area than do other crops (Figure 9-33). Some of the corn is consumed by people as oil, margarine, and other food products, but most is fed to pigs and cattle. 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 around half of the cropland is planted in corn (Figure 9-34).

Soybeans have become the second-most-important crop in the U.S. mixed commercial farming region. Like corn, soybeans are mostly used 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, as a hidden ingredient.

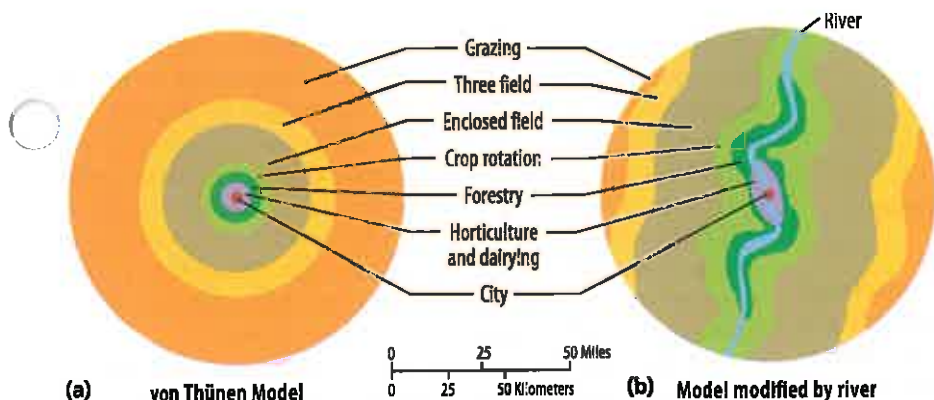
IMPORTANCE OF ACCESS TO MARKETS

The use of land in developed countries is determined primarily by market forces of supply and demand. The value of the land affects the form of commercial agriculture practiced



▲ **FIGURE 9-33 MAIZE (CORN) PRODUCTION**

The United States produces nearly 40 percent and China more than 20 percent of the world's maize.



◀ **FIGURE 9-35 VON THÜNEN MODEL (a)**

According to the von Thünen model, in the absence of topographic factors, different types of farming are conducted at different distances from a city, depending on the cost of transportation and the value of the product. (b) von Thünen recognized that his model would be modified by site factors, such as a river in this sketch, which changes the accessibility of different land parcels to the market center. Agricultural uses that seek highly accessible locations need to locate nearer the river.

on it. Agricultural land is lost altogether to some other use if someone is willing to pay to use it for another purpose.

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. Geographers use the von Thünen model to help explain the importance of proximity to market in the choice of crops on commercial farms. Johann Heinrich von Thünen, an estate owner in northern Germany, first proposed the model in 1826, in a book titled *The Isolated State*. According to this model, which geographers later modified, a commercial farmer initially considers which crops to cultivate and which animals to raise based on market location. In choosing an enterprise, the farmer compares two costs: the cost of the land and the cost of transporting products to market.

Von Thünen based his general model of the spatial arrangement of different crops on his experience as the owner of a large estate in northern Germany during the early nineteenth century. He found that specific crops were grown in different rings around the cities in the area (Figure 9-35):

- **First ring.** 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.
- **Second ring.** 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.
- **Third ring.** The next ring was used for various crops and for pasture; the specific commodity was rotated from one year to the next.
- **Fourth ring.** The outermost ring was devoted exclusively to animal grazing, which requires lots of space.

The model assumed that all land in a study area had similar site characteristics and was of uniform quality, although von Thünen recognized that the model could vary according to topography and other distinctive physical conditions. For example, a river might modify the shape of

TABLE 9-1 Transportation in the von Thünen Model

The influence of transportation cost on the profitability of growing wheat, according to the von Thünen model:

- Gross profit from sale of wheat grown on 1 hectare of land not including transportation costs:
 - a. Wheat can be sold for \$250 per metric ton.
 - b. Yield per hectare of wheat is 4 tons.
 - c. Gross profit is \$1,000 per hectare (\$250 per ton × 4 tons).
- Net profit from sale of wheat grown on 1 hectare of land including transportation costs:
 - a. Cost of transporting 4 tons of wheat to market is \$0.10 per kilometer.
 - b. Net profit from the sale of 4 tons of wheat grown on a farm located 1,000 kilometers from the market is \$900 (\$1,000 gross profit – \$100 for 1,000 kilometers of transport costs).
 - c. Net profit from sale of 1,000 kilograms of wheat grown on a farm located 10,000 kilometers from the market is \$0 (\$1,000 gross profit – \$1,000 for 10,000 kilometers of transport costs).

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.

Table 9-1 illustrates the influence of transportation cost on the profitability of growing wheat. The example in Table 9-1 shows that a farmer would make a profit by growing wheat on land located less than 10,000 kilometers from the market. Beyond 10,000 kilometers, wheat is not profitable because the cost of transporting it exceeds the gross profit. These calculations demonstrate that farms located closer to 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.

PAUSE & REFLECT 9.3.7

If the price of wheat dropped to \$200 per ton, what would be the maximum distance that the wheat could be profitably shipped?

Commercial Agriculture: Animal-based

LEARNING OUTCOME 9.3.8

Describe dairy and ranching commercial agriculture.

Dairy farming is the most important agriculture practiced near large urban areas in developed countries. Ranching is adapted to semiarid or arid land and is practiced in developed countries where the vegetation is too sparse and soil too poor to support crops.

DAIRY

A **dairy farm** specializes in the production of milk and other dairy products. Because milk is highly perishable, dairy farms must be closer to their markets than other products. The ring surrounding a city from which milk can be supplied without spoiling is known as the **milkshed**.

Dairy farms located farther from consumers are more likely to sell their output to processors that 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.

Traditionally most milk was produced and consumed in developed countries (Figure 9-36). However, the share of the world's dairy farming conducted in developing countries has risen dramatically in recent years, and it now surpasses the total in developed countries (Figure 9-37). Rising incomes permit urban residents to buy more milk products.

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

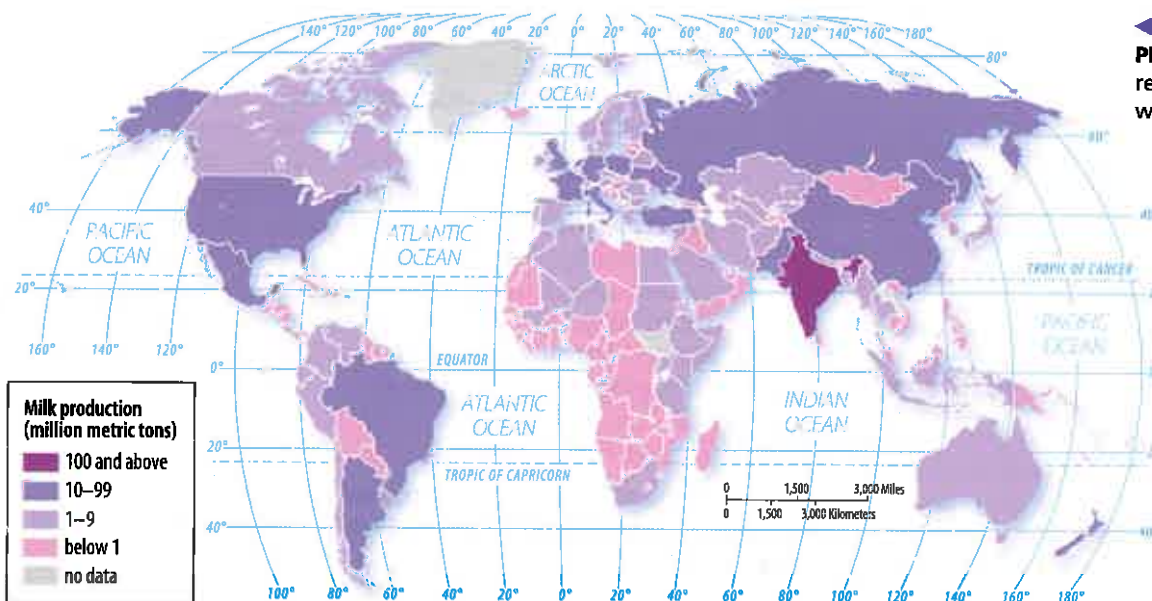
cheese manufacturers. The choice of product varies within the U.S. dairy region, depending on whether the farms are within the milkshed of a large urban area. In general, the farther the farm is from large urban concentrations, the smaller is the percentage of output devoted to fresh milk. Farms located 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.

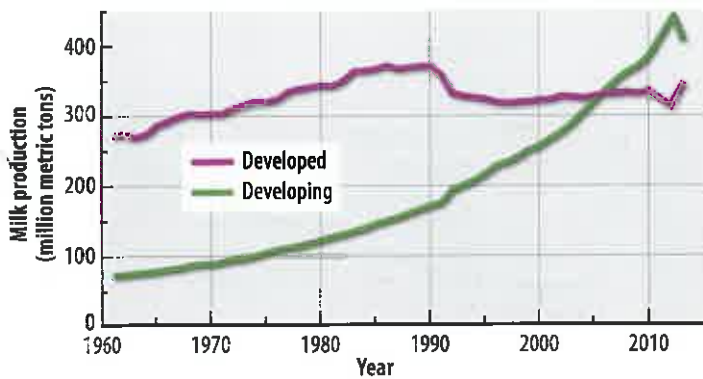
Countries likewise tend to specialize in certain products. New Zealand, the world's largest per capita producer of dairy products, devotes about 5 percent to liquid milk, compared to more than 50 percent in the United Kingdom. New Zealand farmers do not sell much liquid milk, because the country is too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

Like other commercial farmers, dairy farmers face economic difficulties because of declining revenues and rising costs. Dairy farmers who have quit most often cite lack of profitability and excessive workload as reasons for getting out of the business. Distinctive features of dairy farming have exacerbated the economic difficulties:

- **Labor-intensive.** 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.



◀ **FIGURE 9-36 MILK PRODUCTION** India has replaced the United States as the world's leading milk producer.



▲ FIGURE 9-37 CHANGING MILK PRODUCTION Developing countries now produce more milk than developed countries.

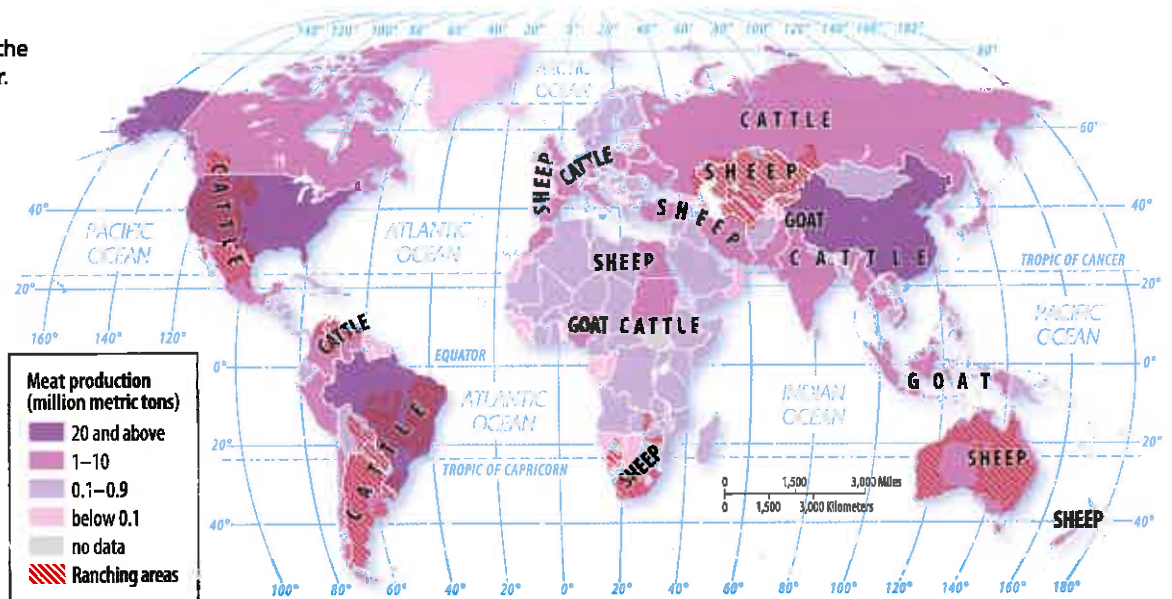
- **Winter Feed.** Dairy farmers face the expense of feeding the cows in the winter, when they may be unable to graze on grass. In Northwest Europe and in the Northeastern United States, farmers generally purchase hay or grain for winter feed. In the western part of the U.S. dairy region, crops are more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

LIVESTOCK RANCHING

Ranching is the commercial grazing of livestock over an extensive area. Commercial ranching is conducted in several developed countries besides the United States and, increasingly, in developing countries. For example, the interior of Australia was opened for grazing in the nineteenth century, although sheep are more common there than cattle.

The United States is the leading producer of chicken and beef, but as with other forms of commercial agriculture, the growth in ranching has been in developing countries. Developed countries were responsible for only one-third of world meat production in 2013, compared to two-thirds in 1980. China is the leading producer of meat, ahead of the United States, and Brazil is third (Figure 9-38). China passed the

► FIGURE 9-38 MEAT PRODUCTION China is now the world's largest meat producer.



United States as the world's leading meat producer in 1990 and now produces twice as much. In South America, a large portion of the pampas of Argentina, southern Brazil, and Uruguay is 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, making it possible for meat to be transported to overseas markets.

Meanwhile, due to the spread of irrigation techniques and harder 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.

PAUSE & REFLECT 9.3.8

What are the two most important ranched animals, according to Figure 9-38?

CHECK-IN KEY ISSUE 3

Where Is Agriculture Distributed?

- ✓ Agriculture can be divided into 11 major regions, including 5 subsistence and 6 commercial regions.
- ✓ In subsistence regions, pastoral nomadism is prevalent in drylands, shifting cultivation in tropical forests, and intensive subsistence in regions with high population concentrations.
- ✓ In commercial regions, mixed crop and livestock is the most common form of agriculture. Dairy, commercial gardening, grain, Mediterranean, and livestock ranching are also important.

Why Do Farmers Face Sustainability Challenges?

- ▶ **Losing Agricultural Land**
- ▶ **Improving Agricultural Productivity**
- ▶ **Conserving Agricultural Resources**
- ▶ **Applying Biotechnology to Agriculture**
- ▶ **Global Food Trade**
- ▶ **Global Agriculture and Undernourishment**
- ▶ **Sustainable Agriculture**

LEARNING OUTCOME 9.4.1

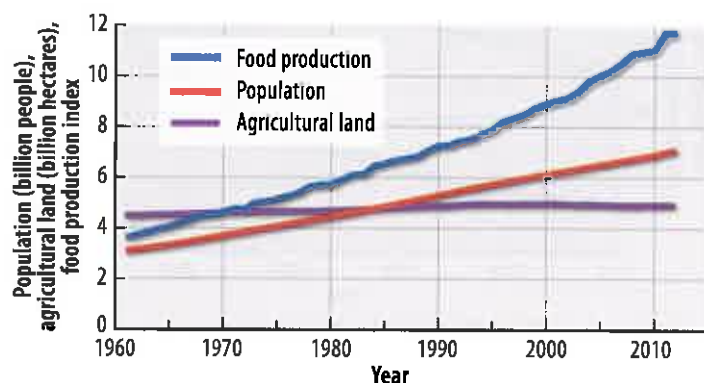
Explain reasons for loss of farmland.

Both subsistence and commercial agriculture faces several challenges to produce more food for a growing and hungry world in ways that preserve and protect Earth's agricultural resources for the future. This key issue considers seven challenges for agriculture:

- Losing agricultural land to competing uses.
- Improving the productivity of existing farmland.
- Conserving scarce resources, such as water and top soil.
- Identifying the appropriate role in agriculture for biotechnology.
- Balancing production of food for international trade rather than for consumption at home.
- Meeting the needs of people who are undernourished.
- Making greater use of organic farming.

Losing Agricultural Land

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.



▲ **FIGURE 9-39 WORLD POPULATION GROWTH, AGRICULTURAL LAND, AND FOOD PRODUCTION** The food production index is set at 10 in the year 2005.

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. At first glance, new agricultural land appears to be available because only 11 percent of the world's land area is currently cultivated. However, in recent decades, population has increased much more rapidly than agricultural land (Figure 9-39).

LOSS OF FARMLAND TO URBANIZATION

The von Thünen model shows the influence of proximity to urban markets in the form of agriculture practiced on a piece of land. The expansion of urban areas has contributed to reducing agricultural land.

Loss of farmland to urban growth is especially severe at the edge of the string of large metropolitan areas along the East Coast of the United States. As urban areas grow in population and land area, farms on the periphery are replaced by urban land uses. A serious problem in the United States has been the loss of 200,000 hectares (500,000 acres) of the most productive farmland, known as **prime agricultural land**, as urban areas sprawl into the surrounding countryside.

Some of the most threatened agricultural land lies in Maryland, a small state where two major cities—Washington and Baltimore—have coalesced into a continuous built-up area (see Chapter 13). In Maryland, a geographic information system (GIS) was used to identify which farms should be preserved. Maps generated through GIS were essential in identifying agricultural land to protect because the most appropriate farms to preserve were not necessarily those with the highest-quality soil. Why should the state and nonprofit organizations spend scarce funds to preserve “prime” farmland that is nowhere near the path of urban sprawl? Conversely, why purchase an expensive, isolated farm already totally surrounded by residential developments, when the same amount of money could buy several large contiguous farms that effectively blocked urban sprawl elsewhere?

To identify the “best” lands to protect, GIS consultants produced a series of soil quality, environmental, and economic maps that were combined into a single composite

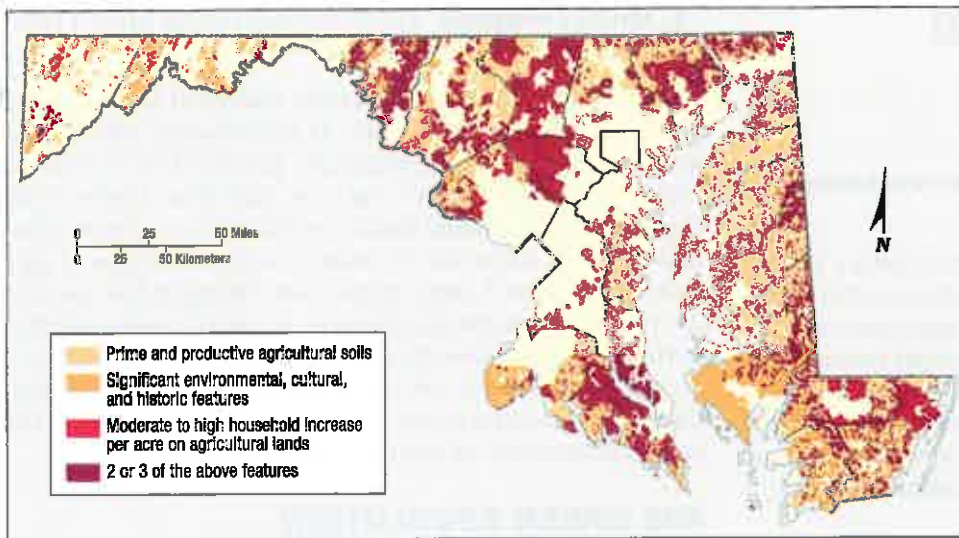


FIGURE 9-40 PROTECTING FARMLAND IN MARYLAND Prime farmland is typically flat and well drained. Significant environmental features include water quality, flood control, species habitats, historic sites, and especially attractive scenery.

map (Figure 9-40). The map shows that 4 percent of the state's farmland had prime soils, significant environmental features, and high projected population growth, and 25 percent had two of the three factors.

DESERTIFICATION

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** (or, 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.

The Earth Policy Institute estimates that 2 billion hectares (5 million acres) of land have been degraded around the world (Figure 9-41). Overgrazing is thought to be responsible for 34 percent of the total, deforestation for 30 percent, and agricultural use for 28 percent. The U.N.

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 U.N. 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 its agricultural lands near the Tigris and Euphrates rivers.

PAUSE & REFLECT 9.4.1

Have you seen loss of farmland near where you live? For what new purpose is the land used?

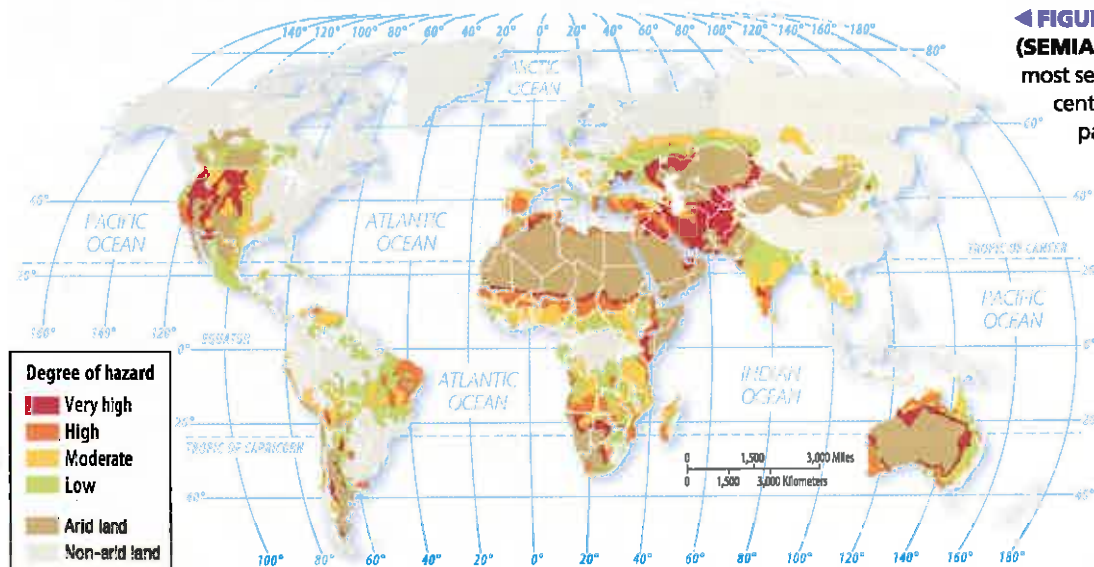


FIGURE 9-41 DESERTIFICATION (SEMIARID LAND DEGRADATION) The most severe problems are in northern Africa, central Australia, and the southwestern parts of Africa, Asia, North America, and South America.

Improving Agricultural Productivity

LEARNING OUTCOME 9.4.2

Understand the importance of the green revolution.

Population grew at the fastest rate in human history during the second half of the twentieth century, as discussed in Chapter 2. With the amount of land devoted to agriculture not increasing, many experts forecast massive global famine. But these dire predictions did not come true. Instead, increased productivity has resulted in an expansion of food supply. New agricultural practices have permitted farmers worldwide to achieve much greater yields from the same amount of land.

INTENSIFICATION BY SUBSISTENCE FARMERS

For hundreds if not thousands of years, subsistence farming in developing countries yielded enough food for people living in rural villages to survive, assuming that no drought, flood, or other natural disaster occurred. Suddenly in the late twentieth century, subsistence farming practices 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.

Population growth influences the distribution of types of subsistence farming, according to economist Ester Boserup. It compels subsistence farmers to consider new farming approaches that produce enough food to take care of the additional people. According to Boserup, subsistence farmers increase the supply of food through intensification of production, achieved in two ways. First, new farming methods are adopted. Plows replace axes and sticks. More weeding is done, more manure is applied, more terraces are carved out of hillsides, and more irrigation ditches are dug (Figure 9-42). 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.

Second, land is left fallow for shorter periods. This expands the amount of land area devoted to growing crops at any given time. Boserup identified five basic stages in the reduction of fallow farmland:

- 1. 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.
- 2. 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.
- 3. 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.
- 4. Annual cropping.** Fields are used every year and rotated between legumes and roots.

- 5. Multi-cropping.** Fields are used several times a year and never left fallow.

Contrast shifting cultivation, practiced in regions of low population density, such as sub-Saharan 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 years and 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 (that is, as the population density increases) and 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 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.

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.

▼ **FIGURE 9-42 INTENSIVE FARMING** Hillsides in Radi, Bhutan, are terraced into fields for intensive planting of rice.





▲ FIGURE 9-43 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 International Rice Research Institute, established in the Philippines by the Rockefeller and Ford foundations, worked to create a miracle rice seed (Figure 9-43). 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).

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. When 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.

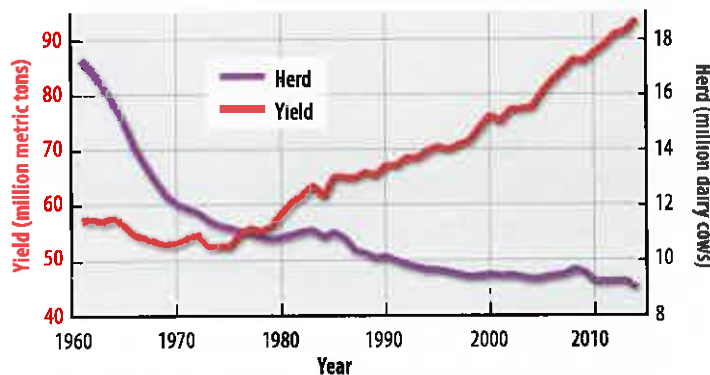
PAUSE & REFLECT 8.4.2

What would be the impact on the green revolution of a decline in energy prices?

INCREASED PRODUCTIVITY: COMMERCIAL FARMERS

Productivity has also increased among commercial farmers in recent years. New seeds, fertilizers, pesticides, mechanical equipment, and management practices have enabled commercial 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 number of dairy cows in the United States decreased from 10.8 million to 9.3 million between 1980 and 2014. But milk production increased from 58 to 93 million metric tons. Thus, yield per cow increased 78 percent during this 34-year period, from 5.4 to 10.1 metric tons per cow (Figure 9-44).



▲ FIGURE 9-44 U.S. DAIRY PRODUCTIVITY The amount of milk produced per cow has increased rapidly in the United States, especially since the 1980s.

Conserving Agricultural Resources

LEARNING OUTCOME 9.4.3

Understand the importance of water in agriculture.

Plants and animals need water to survive and thrive. Lack of water is causing stress on agriculture in many regions. Too much water can cause soil erosion.

AGRICULTURE AND WATER IN CALIFORNIA

California's limited water supply comes from two main sources:

- Surface water, which is water that travels or gathers on the ground, like rivers, streams, and lakes.

- Groundwater, which is water that is pumped out from the ground.

After several years of drought, the volume of water in California's rivers, streams, and lakes has been severely reduced. In normal years 70 percent of California's water comes from surface water, but after several years of drought the share dropped to 40 percent.

The distribution of water in California does not match the distribution of demand. Most of California's water is in the north, whereas most of the demand is in the central and southern parts of the state. Urban areas use around 20 percent of the water that California distributes, and most of the demand is in Los Angeles and adjacent smaller metropolitan areas in the south. Agriculture uses around 80 percent of California's distributed water, and the bulk of that demand is in the center of the state (Figure 9-45).

DOING GEOGRAPHY California Agriculture and Water

California's extended extreme drought is stressing agriculture, which uses 80 percent of the state's distributed water. Homeowners and businesses in California have been required to make substantial cuts in their water usage. California farmers produce one-third of U.S. vegetables and two-thirds of fruits and nuts. It takes a lot of water to grow these fruits and vegetables. So if you are living in any of the 50 U.S. states, you are consuming California water indirectly through consuming produce. In fact, the average American consumes around 40 gallons of California water per day. Table 9-2 has examples of the amounts of California water that go into growing some fruits and vegetables.

TABLE 9-2 Amount of Water Needed to Grow Selected Fruits and Vegetables in California

Fruits and nuts	Gallons	Your produce consumption	Your water consumption
1 apple, peach, pear, or plum, ¼ melon	7.0		
5 strawberries	3.0		
1 almond	1.0		
1 walnut	5.0		
3 grapes	1.0		
1 lemon, orange, grapefruit, or clementine	20		
1 avocado	40		
Vegetables			
1 broccoli or cauliflower floret	0.5		
Lettuce, cabbage, spinach [salad portion]	1.0		
1 carrot or celery stalk	0.5		
1 slice tomato, onion, or potato	0.5		

What's Your Food and Agriculture Geography?

Your California Water Consumption

How much California water did you consume today in your fruits and vegetables?

1. Determine from Table 9-2 the quantities of the listed fruits and vegetables that you have consumed today (or another day specified for your class).
2. What was your total consumption of California water from eating produce?
3. How does your total consumption compare to the national average of 40 gallons?
4. What factors might account for having consumption that is higher or lower than the national average?

◀ **FIGURE 9-45 AGRICULTURE AND DROUGHT IN CALIFORNIA** The contrast between agricultural land being irrigated and the dry land not irrigated.



SUSTAINABLE LAND MANAGEMENT

In the U.S. Midwest, farm fields are more likely to be damaged by too much precipitation than by drought. Heavy rains can wash away the protective layer of high-quality top soil and deposit it in bodies of water. After harvesting, conventional farming clears away crop residue, such as corn stalks. The soil is churned up or tilled before the next year's seeds are planted. This practice loosens the soil particles, making them susceptible to being washed away by rain or blown away by wind.

Conservation tillage is a method of soil cultivation that reduces soil erosion and runoff. Under conservation tillage, some or all of the previous harvest is left on the

fields through the winter. **No tillage**, as the name implies, leaves all of the soil undisturbed, and the entire residue of the previous year's harvest is left untouched on the fields (Figure 9-46). **Ridge tillage** 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.

PAUSE & REFLECT 9.4.3

According to Figure 9-13, what is the predominant form of agriculture in California?

▶ **FIGURE 9-46 NO-TILL AGRICULTURE** Soybeans are growing in a field on top of stubble from last year's corn harvest.



Applying Biotechnology to Agriculture

LEARNING OUTCOME 9.4.4

Understand the debate over the planting of GMO seeds.

One of the most challenging issues in contemporary agriculture is the extent to which genetically modified seeds should be planted. 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.

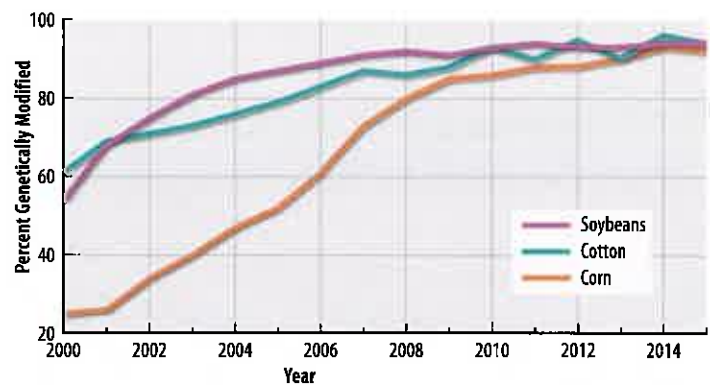
Beginning in the nineteenth century, the science of genetics expanded understanding of how to manipulate plants and animals to secure dominance of the most favorable traits. However, genetic modification, which became widespread in the late twentieth century, marks a sharp break with the agricultural practices of the past several thousand years. The genetic composition of an organism is not merely studied, it is actually altered.

GENETICALLY MODIFIED ORGANISMS

A **genetically modified organism (GMO)** is a living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology. GMO seeds are 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. A GMO mixes genetic material of two or more species that would not otherwise mix in nature.

Worldwide, 160 million hectares—10 percent of all farmland—was 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. Genetic modification 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 9-47). Three-fourths of the processed food that Americans consume has at least one genetically modified 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 developing countries, especially in sub-Saharan Africa, to increase their food supply in part through increased use of GMOs. Africans are divided on whether to accept GMOs. The positives of genetic modification are higher yields, increased nutrition, and more resistance to pests. Genetically modified foods are also better tasting to some palates. Despite these benefits, opposition to GMOs is strong in Africa for several reasons:



▲ FIGURE 9-47 GENETICALLY MODIFIED CROPS IN THE UNITED STATES Approximately 90 percent of major crops in the United States are grown from GMO seeds.

- **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 GMOs 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.
- **Increased dependence on the United States.** U.S.-based transnational corporations, such as Monsanto, manufacture most of the GMO seeds. Africans fear that the biotech companies could—and would—introduce a so-called “terminator” gene in the GMO seeds to prevent farmers from replanting them after harvest and require them to continue to purchase seeds year after year from the transnational corporations.

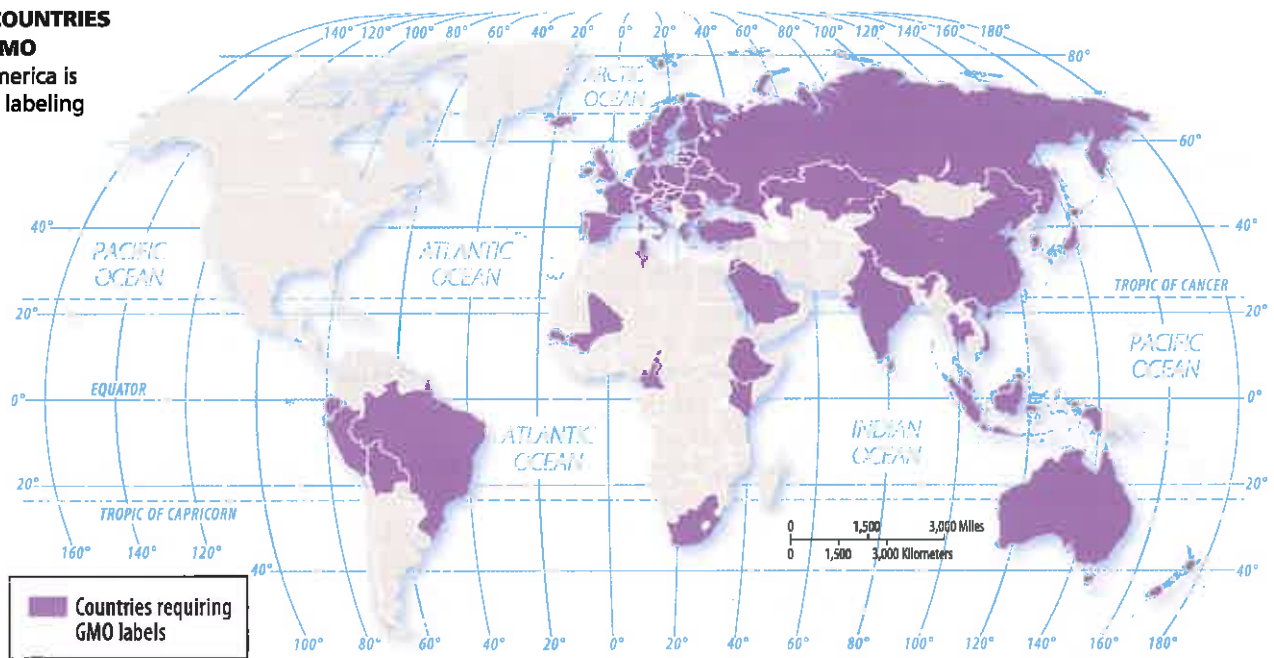
“We don’t want to create a habit of using genetically modified maize that the country cannot maintain,” explained Mozambique’s prime minister. If agriculture is regarded as a way of life, not just a food production business, GMO represents for many Africans an unhealthy level of dependency on developed countries.

Many countries, including most European countries, China, and India, require GMO labeling (Figure 9-48). The debate in the United States has been especially fierce concerning whether GMO food should be labeled (see Debate It feature and Figures 9-49 and 9-50).

PAUSE & REFLECT 9.4.4

Does your family avoid foods made with GMO seeds? Why or why not?

► **FIGURE 9-48 COUNTRIES THAT REQUIRE GMO LABELS** North America is a holdout in GMO labeling laws.



DEBATE IT! Should GMOs be labeled?

Labeling is required for most GMOs in Europe (Figures 9-49 and 9-50). In the United States, the food industry opposes GMO labeling, and voters are divided.

GMOs SHOULD BE LABELED

- Mandatory labeling of GMO products would give consumers the information necessary to choose whether or not to consume GMOs.
- Most countries other than the United States have signed agreements to regulate GMOs, including labels.
- U.S. consumers may wish to cut back on their consumption of GMOs until more is learned about their long-term effects on ecosystems and health.



▲ **FIGURE 9-49 GMO LABEL IN EUROPE**

GMOs SHOULD NOT BE LABELED

- Labeling would unnecessarily spook consumers because labeling is for health and safety, not type of seed. GMOs have comparable nutrition content to GMO-free food.
- Mandatory labeling would severely disrupt U.S. agriculture because GMO products are already widespread in the food system.
- The private sector is increasingly labeling GMO-free products, so requiring GMO labeling is unnecessary.



▲ **FIGURE 9-50 GMO-FREE LABEL**

Global Food Trade

LEARNING OUTCOME 9.4.5

Explain the contribution of expanding exports to world food supply.

Trade in food has increased rapidly in the twenty-first century. Total agricultural exports from all countries have increased from \$0.4 trillion in 2000 to \$1.3 trillion in 2012 (Figure 9-51). Exporting countries benefit from the revenues, and importing countries meet the food needs of their people. However, increased food trade is generating challenges for both exporting and importing countries.

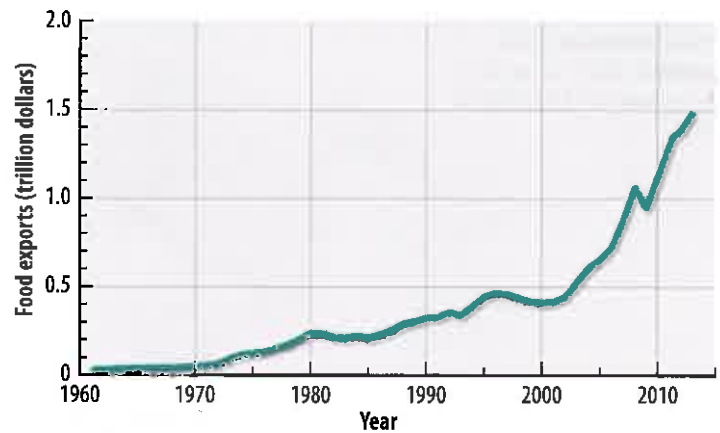
Europe was the only major food importing region prior to World War II. Historically, European countries used their colonies as suppliers of food; after they became independent countries, the former colonies sold food to Europe. East Asia and the former Soviet Union became net food importers in the 1950s, Southwest Asia & North Africa during the 1970s, South Asia and sub-Saharan Africa during the 1980s, and Central Asia in 2008. Food production was unable to keep up with rapid population growth in these regions, and as they embraced the international trade path of development, agriculture was increasingly devoted to growing export crops for sale in developed countries. Japan is by far the leading importer of food, followed by the United Kingdom, China, and Russia.

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 (referred to as P.L.-480). 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, including nearly one-half of the world's maize exports.

GLOBAL TRADE PATTERNS

On a global scale, agricultural products are moving primarily from the Western Hemisphere to the Eastern Hemisphere. Latin America, led by Brazil and Argentina, is the by far the leading region for export of agricultural products; North America, Southeast Asia, and the South Pacific are the other major exporting regions (Figure 9-52). The overall share of exports accounted for by the United States has declined rapidly, from 18 to 19 percent of the world total in the 1970s to 10 to 11 percent in the twenty-first century. Agricultural exports from the United States have continued to increase rapidly, but developing regions—especially Latin America and Southeast Asia—have had more rapid increases.

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. However, subsistence



▲ FIGURE 9-51 AGRICULTURAL EXPORTS Agricultural trade increased from \$400 billion in 2000 to \$1.3 trillion in 2012.

farmers lack the money to buy agricultural equipment and materials from developed countries. To generate the funds they need to buy agricultural supplies, developing countries must produce something they can sell in developed countries. The developing countries sell some manufactured goods (see Chapter 11), but most raise funds through the sale of crops in developed countries. Consumers in developed countries 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 in developed countries because of the climate.

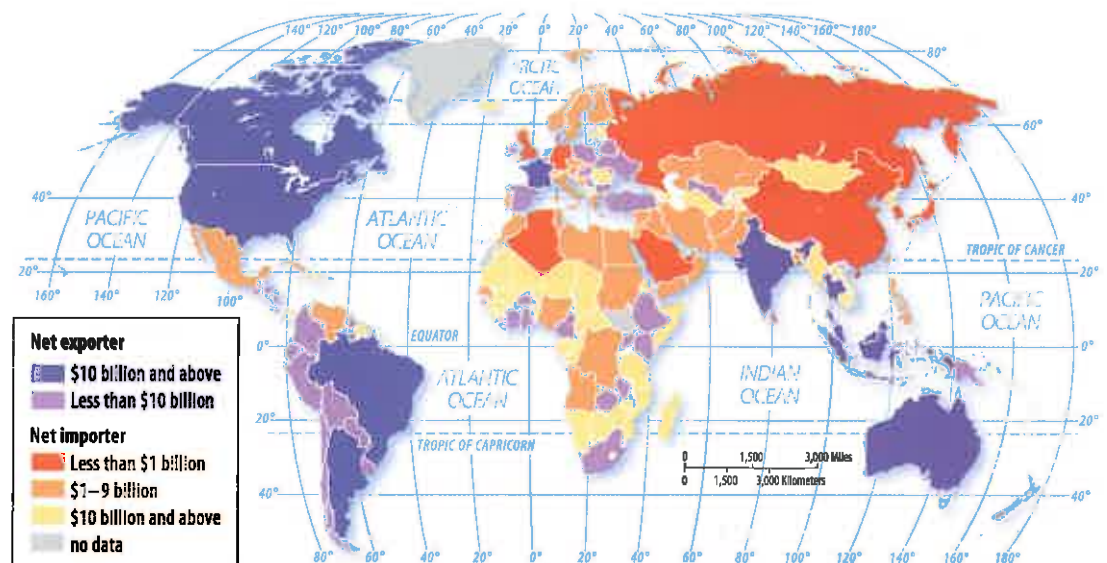
In a developing country such as Kenya, families may divide by gender between traditional subsistence agriculture and contributing to international trade. Women practice most of the subsistence agriculture—that is, growing food for their families to consume—in addition to the tasks of cooking, cleaning, 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 a developing country foreign currency, a portion of which can be used to buy agricultural supplies. But governments in developing countries 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 help 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 TRADE

The export crops grown in some developing countries, especially in Latin America and Asia, are those that can be converted to drugs. Cocaine and heroin, the two leading, especially dangerous drugs, are abused by 16 to 17 million people each, and marijuana, the most popular drug, is estimated to be used by 140 million worldwide:

► **FIGURE 9-52 TRADE IN AGRICULTURE** The principal flow of agriculture in the world is from the Western Hemisphere to Europe and Asia.



- Cocaine is derived from coca leaf, most of which is grown in Colombia or the neighboring countries Peru and Bolivia. Most consumers are located in developed countries, especially in North America. The principal shipping route is from Colombia by sea to Mexico or other Central American countries and then by land through Mexico to the United States (Figure 9-53).
- Heroin is derived from raw opium gum, which is produced by the opium poppy plant. Afghanistan is the source of nearly 90 percent of the world's opium; most of the remainder is grown in Myanmar (Burma) and Laos. Most traffic flows from Afghanistan through Iran, Turkey, and the Balkans to Western Europe, where the largest numbers of the world's

users live. A second route goes through Central Asia to Russia.

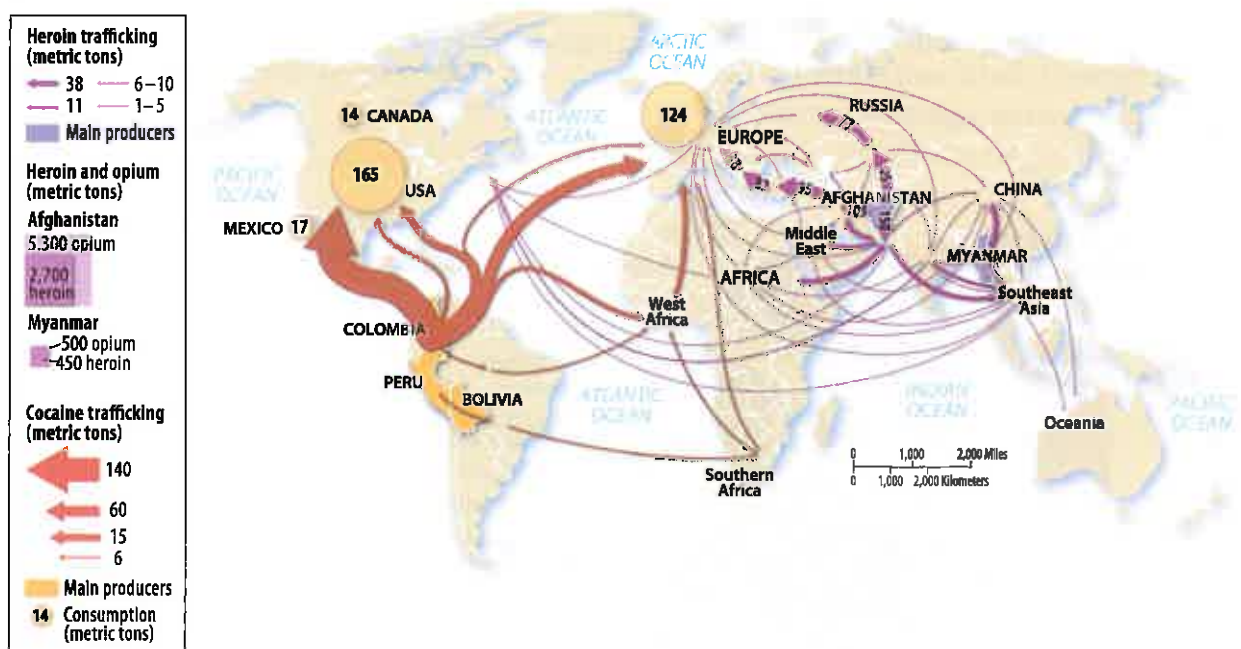
- Marijuana, produced from the *Cannabis sativa* plant, is cultivated widely around the world. The overwhelming majority of the marijuana that reaches the United States is grown in Mexico. Cultivation of *C. sativa* is not thought to be expanding worldwide, whereas cultivation of opium poppies and coca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

PAUSE & REFLECT 9.4.5

Why does most consumption of cocaine and heroin occur in developed countries?

► **FIGURE 9-53 INTERNATIONAL DRUG TRAFFICKING**

The main routes for heroin are from Afghanistan through Southwest Asia to Europe and through Central Asia to Russia. The main routes for cocaine are from Colombia to North America through Mexico and to Europe by sea.



Global Agriculture and Undernourishment

LEARNING OUTCOME 9.4.6

Understand the distribution of undernourishment.

The future of food and agriculture is being pulled in global and local directions. On the one hand, an increasingly integrated global agricultural system is devoted to producing the most food at the lowest cost for the world's 7+ billion humans. And in the twenty-first century, food production is higher and undernourishment is lower.

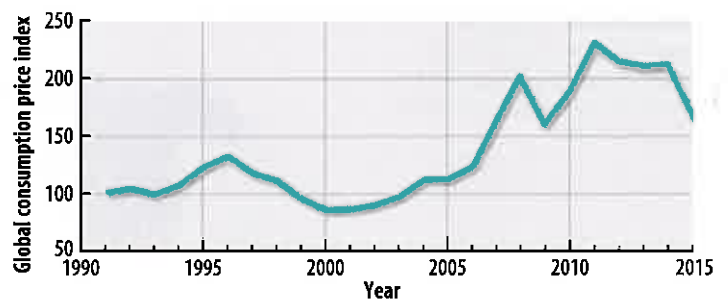
But critics charge that the global agriculture system is causing major long-run damage to the environment and to local ecosystems for the sake of short-term production. They say that Roundup-ready seeds, international trade, deforestation, and other practices documented in this chapter are not sustainable ways to meet humanity's need for food.

Meanwhile, the biggest increase in demand in developed countries is for locally grown food produced through sustainable farming methods. But criticism of the local and organic food movements is also fierce. Critics charge that the local and organic movements are not capable of providing affordable food for the world's 7+ billion humans

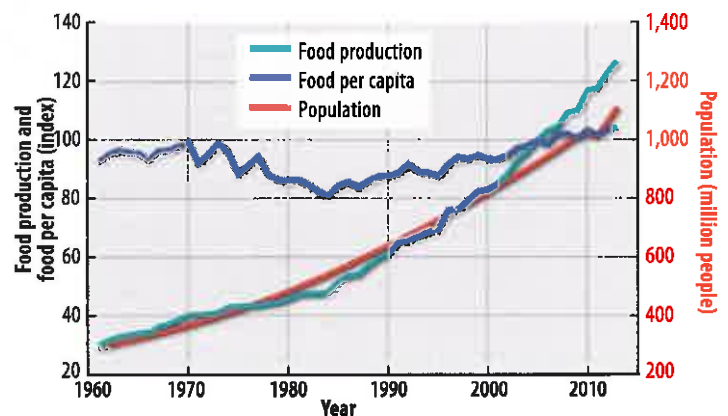
GLOBAL SCALE: SUPPLY AND DEMAND

The greatest challenge to world food supply in the twenty-first century has been food prices rather than food supply. Food prices more than doubled between 2006 and 2008, remained at record high levels through 2014, and declined sharply in 2015 (Figure 9-54). The U.N. attributes the record high food prices through 2014 to four factors:

- Poor weather, especially in major crop-growing regions of the South Pacific and North America.
- Higher demand, especially in China and India.



▲ FIGURE 9-54 FOOD PRICES Worldwide food prices rose rapidly between 2006 and 2008, remained high through 2014, and declined rapidly in 2015.

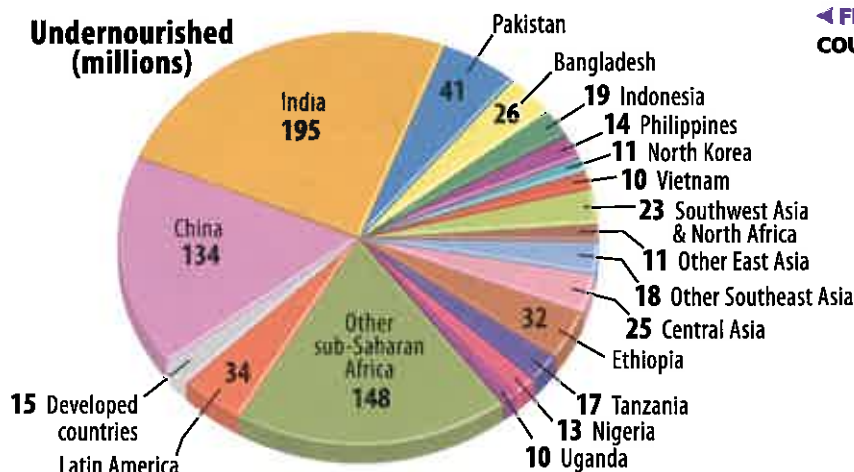


▲ FIGURE 9-55 POPULATION AND FOOD IN AFRICA Food production and food per capita indexes are set at 100 in the year 2005. Food production is increasing at about the same rate as population in Africa. As a result, food production per capita is staying about the same.

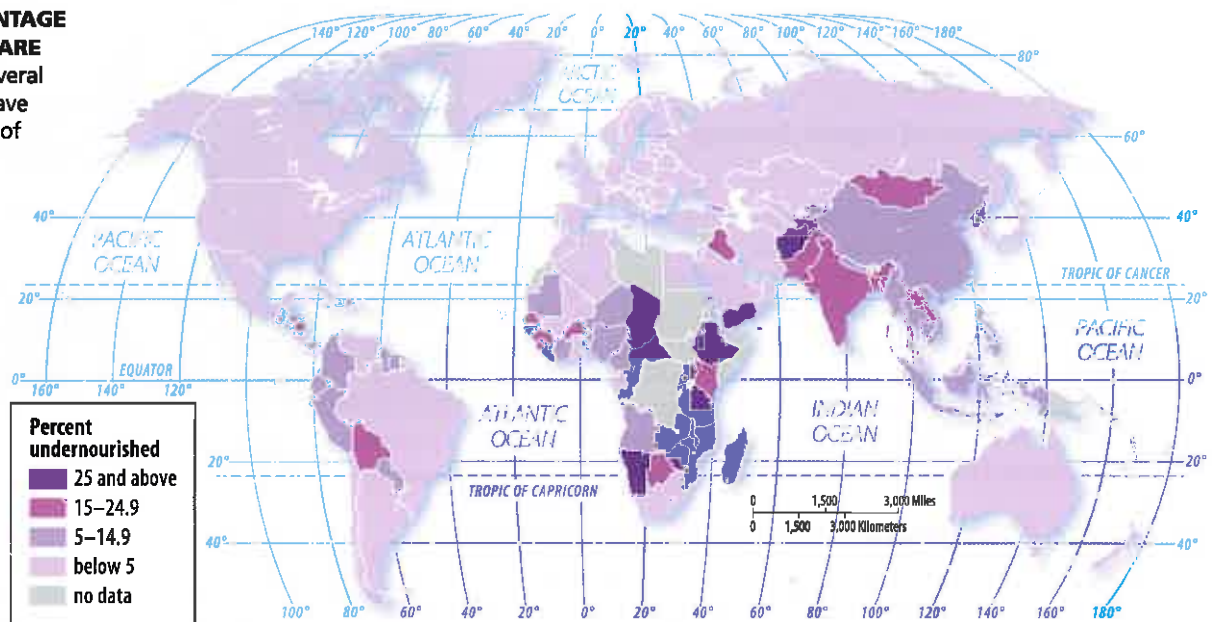
- Smaller growth in productivity, especially without major new “miracle” breakthroughs.
- Use of crops as biofuels instead of food, especially in Latin America.

The sharp decline in 2015 was attributed to increased supplies.

◀ FIGURE 9-56 DISTRIBUTION OF UNDERNOURISHMENT BY COUNTRY



► **FIGURE 9-57 PERCENTAGE OF POPULATION WHO ARE UNDERNOURISHED** Several sub-Saharan countries have the highest percentages of undernourished people.



On the other side of the coin, record-high food prices have stimulated record-high prices for prime agricultural land. Adjusting for inflation, the price of farmland in Iowa doubled from around \$2,500 per acre in 2000 to \$5,000 in 2010.

Sub-Saharan Africa is struggling to keep food production ahead of population growth. Since 1961, food production has increased substantially in sub-Saharan Africa, but so has population (Figure 9-55). As a result, food production per capita has changed little in a half-century.

The threat of famine is particularly severe in the Horn of Africa and the Sahel. Traditionally, this region supported limited agriculture. With rapid population growth, farmers overplanted, and herd size increased beyond the capacity of the land to support the animals. Animals overgrazed the limited vegetation and clustered at scarce water sources.

UNDERNOURISHMENT

Undernourishment is dietary energy consumption that is continuously below that needed for healthy life and carrying out light physical activity. The U.N. estimates that 795 million people in the world are undernourished, one-half of them in South Asia and East Asia. The largest numbers are in India and China, the world's two most populous countries. India has one-fourth of the world's undernourished people (Figure 9-56). Overall, all but 2 percent of the world's undernourished people are in developing countries.

As a percentage of a country's population, undernourishment is most prevalent in sub-Saharan Africa and South Asia. One-fourth of the population in sub-Saharan Africa and one-fifth in South Asia are undernourished (Figure 9-57).

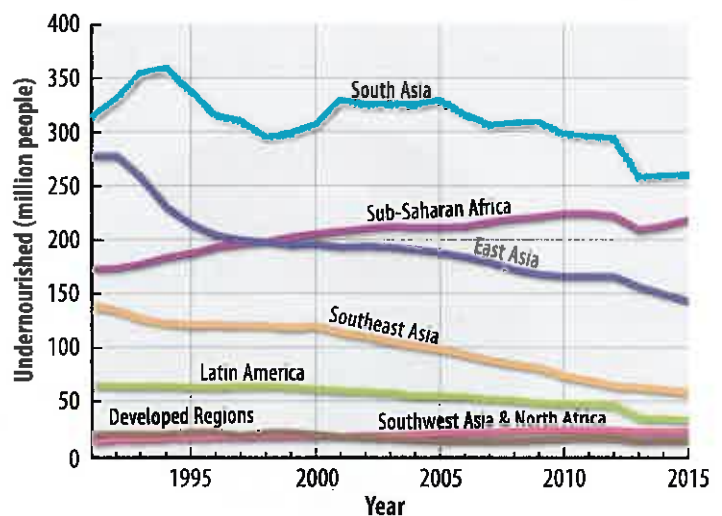
The world as a whole has made progress in reducing hunger during the twenty-first century. Between 2000

and 2015, the number of undernourished people declined from 924 million to 795 million, and the percentage of people who are undernourished declined from 15 percent in 2000 to 11 percent (Figure 9-58). East Asia, led by China, has had by far the largest decrease in the number and percentage undernourished, followed by South-east Asia. Sub-Saharan Africa has had an increase in the number undernourished and a modest decrease in the percentage.

PAUSE & REFLECT 9.4.6

Why does China appear as a leader in undernourishment in Figure 9-56 but not in Figures 9-57 and 9-58?

▼ **FIGURE 9-58 CHANGE IN UNDERNOURISHMENT**



Sustainable Agriculture

LEARNING OUTCOME 9.4.7

Understand principles of organic farming.

As the world as a whole is experiencing an increase in food production, overall demand for food has remained constant in developed countries because of low population growth and saturation of the market for most products. The most rapid growth in demand has been for organic food, including non-GMO food. Some consumers in developed countries are questioning the health risks in consuming biotech food produced through heavy application of chemicals, as well as the long-term adverse environmental impacts for agriculture.

ORGANIC FARMING

Worldwide, the U.N. classified 43 million hectares (75 million acres), or 1 percent of farmland, as organic in 2013. Australia was the leader, with 17 million hectares, or 40 percent of the worldwide total (Figure 9-59). Argentina accounted for 8 percent of the worldwide total, and the United States and China for 5 percent each. USDA economists reported that organic food sales spiked from \$3.4 billion in 1997 to an estimated \$35.9 billion in 2014. Organic food accounted for 5 percent of food purchases in the United States in 2014, compared with less than 1 percent in 1997.

Organic farming is sensitive to the complexities of biological and economic interdependencies between crops and livestock. Growing crops and raising livestock is integrated as much as possible at the level of the individual farm. This integration 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.

In organic farming, crops are grown without application of herbicides and pesticides to control weeds. GMO seeds are not used.

In organic farming, animals consume crops grown on the farm and are not confined to small pens. The moral



▲ **FIGURE 9-60 ORGANIC FARM** Free-range chickens, Hampshire, United Kingdom.

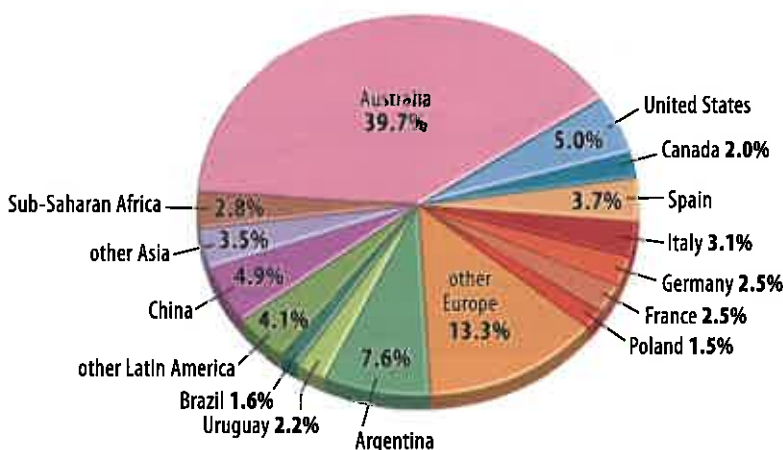
and ethical debate over animal welfare is particularly intense regarding confined livestock production systems (Figure 9-60). Confining livestock leads to surface water and groundwater pollution, particularly where the density of animals is high. If animals are not confined, manure can contribute to soil fertility.

In organic farming, antibiotics are administered to animals only for therapeutic purposes. Many conventional livestock farms have fed animals antibiotics to foster weight gain. The European Union has banned the use of antibiotics in livestock for reasons other than medical. The United States has permitted the practice, but the U.S. Food & Drug Administration has ordered the practice to be phased out.

HOW CLEAN IS OUR PRODUCE?

The U.S. Department of Agriculture tests samples of fruits and vegetables for pesticides. Nearly two-thirds of the 3,015 produce samples tested by the USDA in 2013 contained residues of at least one of 165 different pesticides. These pesticides linger on produce even if washed or peeled.

The five most pesticide-ridden fruits are apples, peaches, nectarines, strawberries, and grapes. The USDA found pesticide residue in 99 percent of apples, 98 percent of peaches, and 97 percent of nectarines. Leafy greens (kale and collards) and hot peppers have especially high concentrations of highly toxic insecticides. The five cleanest of the 50 types of produce



◀ **FIGURE 9-59 DISTRIBUTION OF ORGANIC FARMING** Australia has the largest share of the world's organic farms.

tested are avocados, corn, pineapples, cabbage, and frozen sweet peas. Relatively few pesticides were detected on these foods; pesticides were detected on only 1 percent of avocados.

What features differentiate the five cleanest from the five dirtiest? Think about the outermost portion. How protected from the environment is the edible portion of the fruit or vegetable?

The Environmental Working Group publishes the findings annually at ewg.org. The 12 most infected are called “the dirty dozen,” and the 15 least infected are called “the clean fifteen.” The Environmental Working Group urges consumers to consider organic versions of the dirty dozen (Table 9-3).

GOVERNMENT POLICIES

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 production.

The U.S. government has three agriculture policies designed to improve the financial position of farmers:

- 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 or forage for pigs, or to produce seeds for sale.
- The government pays farmers when certain commodity prices are low. The government sets a target price for a commodity and pays farmers the difference between the price they receive in the market and the 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.
- 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 has averaged about \$20 billion a year on farm subsidies in recent years. 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.

TABLE 9-3 The Dirty Dozen and Clean Fifteen, 2015

Dirty Dozen	Clean Fifteen
Apples	Avocados
Peaches	Sweet corn
Nectarines	Pineapples
Strawberries	Cabbage
Grapes	Frozen sweet peas
Celery	Onions
Spinach	Asparagus
Sweet bell peppers	Mangoes
Cucumbers	Papayas
Cherry tomatoes	Kiwi
Imported snap peas	Eggplant
Potatoes	Grapefruit
	Cantaloupe
* Kale	Cauliflower
* Collard greens	Sweet potatoes

*Not ranked but buy organic because nonorganic versions have trace levels of highly toxic chemicals.

Government policies in developed countries point out a fundamental irony in worldwide agricultural patterns: In developed regions such as North America and Europe, farmers are encouraged to grow less food, whereas developing countries struggle to increase food production to match the rate of growth in the population.

PAUSE & REFLECT 9.4.7

Does your family go out of its way to get local or organic food? Why or why not?

CHECK-IN KEY ISSUE 4

Why Do Farmers Face Sustainability Challenges?

- ✓ **Agricultural land is being lost to competing uses, such as urbanization.**
- ✓ **The green revolution has improved the productivity of farming in some countries.**
- ✓ **Some agricultural regions face a severe shortage of water.**
- ✓ **GMO crops are increasingly planted in some countries, especially in the United States.**
- ✓ **International trade in food is increasing, but in some places at the expense of producing food for domestic consumption.**

Summary & Review

KEY ISSUE 1

Where did agriculture originate?

Before the invention of agriculture, humans were hunters and gatherers. Agriculture originated in multiple hearths and diffused to numerous places independently. Subsistence agriculture is the production of food primarily for consumption by the farmer's family. Commercial agriculture is the production of food primarily for sale off the farm. Commercial agriculture involves larger farms, fewer farmers, and more mechanization than does subsistence agriculture.

THINKING GEOGRAPHICALLY



1. Several large sculptures honoring the horse are erected in the center of Kazakhstan's capital Astana. Why might the horse be specially honored there?

▲ FIGURE 9-61 HORSE SCULPTURE, ASTANA KAZAKHSTAN

KEY ISSUE 2

Why do people consume different foods?

What people eat is influenced by a combination of level of development, cultural preferences, and environmental constraints. Most humans derive most of their dietary energy from grains, but the amount consumed varies widely. People in developed countries consume more protein through animal products. One in 10 humans is undernourished. The percentage of undernourished people has been declining.

THINKING GEOGRAPHICALLY



2. Review what you have eaten today. How conscious were you of where the food was grown or raised?
3. Why or why are you not paying attention to the origin of your food?
4. Do you have access to a farmers' market or an organic grocery store? If so, do you go to it? Why or why not?

▲ FIGURE 9-62 FARMERS MARKET Union Square Greenmarket, New York City.

KEY ISSUE 3

Where is agriculture distributed?

The distribution of major agricultural regions is closely related to the distribution of climate regions. The principal forms of subsistence agriculture are intensive subsistence, pastoral nomadism, and shifting cultivation. Commercial agriculture in developed countries includes three principal crop-based forms (grain, Mediterranean, and commercial gardening and fruit farming) and three principal animal-based forms (mixed crop and livestock, dairy, and ranching).

THINKING GEOGRAPHICALLY



5. Although one of the world's wealthiest countries, Japan is shown in Figure 9-13 as specializing intensive subsistence farming with wet rice dominant. The rice farming is done primarily by elderly people. Why might Japan be retaining traditional rice production despite its wealthy status?

▲ FIGURE 9-63 Elderly Japanese man works in rice field.

KEY ISSUE 4

Why do farmers face sustainability challenges?

Subsistence and commercial farmers are challenged to produce food in sustainable ways. The global food production system is expanding and feeding more people. The green revolution has increased production in subsistence agriculture through higher-yield seeds and expanded use of fertilizers. At the same time, demand is increasing for local and organic foods.

THINKING GEOGRAPHICALLY



6. The food services at a number of schools and universities now offer some healthy, local, and organic food choices. If yours does, why do you or don't you select these healthy and local choices? If yours does not, have you asked your school to provide healthier choices? Why have you or have you not asked?

▲ FIGURE 9-64 SCHOOL CAFETERIA Napa High School serves California-grown food.

KEY TERMS

Agribusiness (p. 326) Commercial agriculture characterized by the integration of different steps in the food-processing industry, usually through ownership by large corporations.

Agricultural revolution (p. 308) The time when human beings first domesticated plants and animals and no longer relied entirely on hunting and gathering.

Agriculture (p. 308) 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. 324) The cultivation of seafood under controlled conditions.

Cereal grain (p. 312) A grass that yields grain for food.

Commercial agriculture (p. 310) Agriculture undertaken primarily to generate products for sale off the farm.

Crop (p. 308) Any plant gathered from a field as a harvest during a particular season.

Crop rotation (p. 323) The practice of rotating use of different fields from crop to crop each year to avoid exhausting the soil.

Dairy farm (p. 330) A form of commercial agriculture that specializes in the production of milk and other dairy products.

Desertification (p. 333) 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. 312) The amount of food that an individual consumes, measured in kilocalories (Calories in the United States).

Double cropping (p. 322) Harvesting twice a year from the same field.

Fishing (p. 324) The capture of wild fish and other seafood living in the waters.

Food security (p. 314) 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.

Genetically modified organism (GMO) (p. 338) A living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology.

Grain (p. 312) Seed of a cereal grass.

Green revolution (p. 324) Rapid diffusion of new agricultural technology, especially new high-yield seeds and fertilizers.

Horticulture (p. 327) The growing of fruits, vegetables, and flowers.

Intensive subsistence agriculture (p. 322) A form of subsistence agriculture characteristics of Asia's major population concentrations in which farmers must expend a relatively large amount of effort to produce the maximum feasible yield from a parcel of land.

Milkshed (p. 330) The area surrounding a city from which milk is supplied.

Mixed crop and livestock farming (p. 328) Commercial farming characterized by integration of crops and livestock; most of the crops are fed to animals rather than consumed directly by humans.

No tillage (p. 337) A farming practice that leaves all of the soil undisturbed and the entire residue of the previous year's harvest left untouched on the fields.

Overfishing (p. 325) Capturing fish faster than they can reproduce.

Paddy (p. 323) The Malay word for wet rice, increasingly used to describe a flooded field.

Pastoral nomadism (p. 318) A form of subsistence agriculture based on herding domesticated animals.

Plantation (p. 320) 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. 332) The most productive farmland.

Ranching (p. 331) A form of commercial agriculture in which livestock graze over an extensive area.

Ridge tillage (p. 337) A system of planting crops on ridge tops in order to reduce farm production costs and promote greater soil conservation.

Sawah (p. 322) A flooded field for growing rice.

Shifting cultivation (p. 320) 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. 320) Another name for shifting cultivation, so named because fields are cleared by slashing the vegetation and burning the debris.

Subsistence agriculture (p. 310) Agriculture designed primarily to provide food for direct consumption by the farmer and the farmer's family.

Swidden (p. 320) A patch of land cleared for planting through slashing and burning.

Transhumance (p. 319) The seasonal migration of livestock between mountains and lowland pastures.

Truck farming (p. 327) Commercial gardening and fruit farming, so named for the Middle English word *truck*, meaning "barter" or "exchange of commodities."

Undernourishment (p. 343) Dietary energy consumption that is continuously below the minimum requirement for maintaining a healthy life and carrying out light physical activity.

Wet rice (p. 322) Rice planted on dry land in a nursery and then moved to a deliberately flooded field to promote growth.

EXPLORE



Growing Rice

Use Google Earth to see rice growing outside a village in Asia.

Fly to *Banaue, Philippines*.

Drag to *Street View* on the balloon marking the location of the village of Banaue.

1. Describe the landscape around the village.
2. According to Figure 9-17, what is the principal form of agriculture in the Philippines? Exit ground level view. Zoom in immediately to the north of balloon marking the village. A series of parallel strips can be seen immediately north of the village.
3. Why would the villagers have created these terraces?

MG

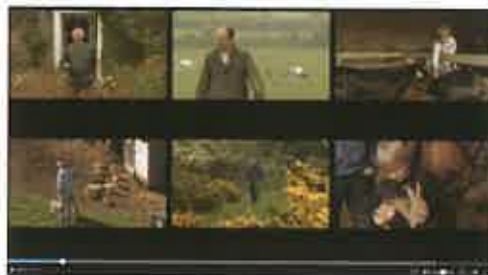
GeoVideo

Log in to the MasteringGeography Study Area to view this video

Organic Farming in the U.K.

Organic farming is increasing in many countries. Farmers feel better about organic practices and they are responding to growing consumer demand.

1. What were some of the things the farmer needed to do to convert the farm to organic?
2. What are some of the environmental and economic benefits of organic farming?
3. What are some of the challenges in converting to organic farming?



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