UNIT 5

Agriculture and Rural Land-Use Patterns and Processes

Unit Overview

About 12,000 years ago, people living in Southwest Asia began to intentionally grow crops and raise animals. From the beginning of agriculture in that region, and later in other regions, agriculture diffused throughout the world. The evolution of agriculture has been punctuated by four revolutions that have pushed agriculture and societies forward. Since 1750, mechanization, the use of chemicals, and research have dramatically increased agricultural productivity. Additional advancements have increased productivity and allowed more people to work outside of agriculture, but these advancements have increased stress on the environment.

Physical Geography, Economics, and Settlement Patterns

What people have grown and raised has always been shaped by the climate, soils, and landforms of a place. In addition, the types of agricultural goods that farmers produce, whether dairy or vegetables or grain, are heavily influenced by the nearness of the market. Farmers have also shaped the landscape by cutting down trees, draining wetlands, etc. Improvements in technology have shifted agriculture toward larger enterprises and greater interdependence.

Changes and Opportunities

Changes in technology and society influence how people produce and consume food. Historically, women have often been responsible for cooking, but as more women entered the workforce, more food has been prepared outside the home.

ENDURING UNDERSTANDINGS

1. Availability of resources and cultural practices influence agricultural practices and land-use patterns. (PSO-5)
2. Agriculture has changed over time because of cultural diffusion and advances in technology. (SPS-5)
3. Agricultural production and consumption patterns vary in different locations, presenting different environmental, social, economic, and cultural opportunities and challenges. (IMP-5)

Source: *AP® Human Geography Course and Exam Description.* Effective Fall 2020 (College Board).

CHAPTER 11

Origins, Patterns, and Settlements of Agriculture

Topics 5.1–5.3

Topic 5.1 Introduction to Agriculture

Learning Objective: Explain the connection between physical geography and agricultural practices. (PSO-5.A)

Topic 5.2 Settlement Patterns and Survey Methods

Learning Objective: Identify different rural settlement patterns and methods of surveying rural settlements. (PSO-5.B)

Topic 5.3 Agricultural Origins and Diffusions

Learning Objectives: Identify major centers of domestication of plants and animals. (SPS-5.A)

Explain how plants and animals diffuse globally (SPS-5.B)

To most people, this is just dirt. To a farmer, it is potential.

—Anonymous

Source: Getty Images

An aerial view of rectangular plots of land in Kansas showing the Public Land Survey System used in the United States. The circular shapes are created by using center-pivot irrigation systems. (See Topic 5.2 for more about survey patterns and Topic 5.10 for more on irrigation systems.)

5.1

Introduction to Agriculture

Essential Question: What is the connection between physical geography and agricultural practices?

Two physical elements have always shaped **agriculture**, the process by which humans alter the landscape in order to raise crops and livestock for consumption and trade. One is physical geography, such as soil types and landforms. The other is **climate**, the long-term weather patterns in a region. For example, coffee grows best on hillsides in warm climates, such as in Kenya or Colombia. Olives, grapes, and figs do well in the soil and climate near the Mediterranean Sea. Those foods became dietary staples for people in the region.

Economic factors also impact agriculture. For example, whether consumers want to purchase peaches or plums influences what farmers will grow.

Physical Geography and Agriculture

Agriculture is affected by physical geography in numerous ways. Animals and crops need water. Even cattle herders in the Sahel, a dry region on the southern edge of the Sahara, must have access to water. Nutrient levels in the soil influence what people can grow. For example, cotton needs nutrient-rich soil, while sorghum can grow in nutrient-poor soils, such as those in tropical rainforests.

Landforms also shape agricultural activity. Flat land in large, expansive valleys provides excellent landscapes for agriculture. In contrast, rugged land requires more human labor in order to make the land useful for agriculture.

Humans have altered the physical environment to increase agricultural production. They have used techniques such as irrigation, terrace farming, deforestation, desertification, and the drainage of wetlands. (See Topic 5.10.)

Source: Wikimedia Commons, Raoul Rives

Agricultural activities are dictated by physical constraints as well as the level of economic development of a region. Pictured above are examples of agricultural products and activity in Morocco

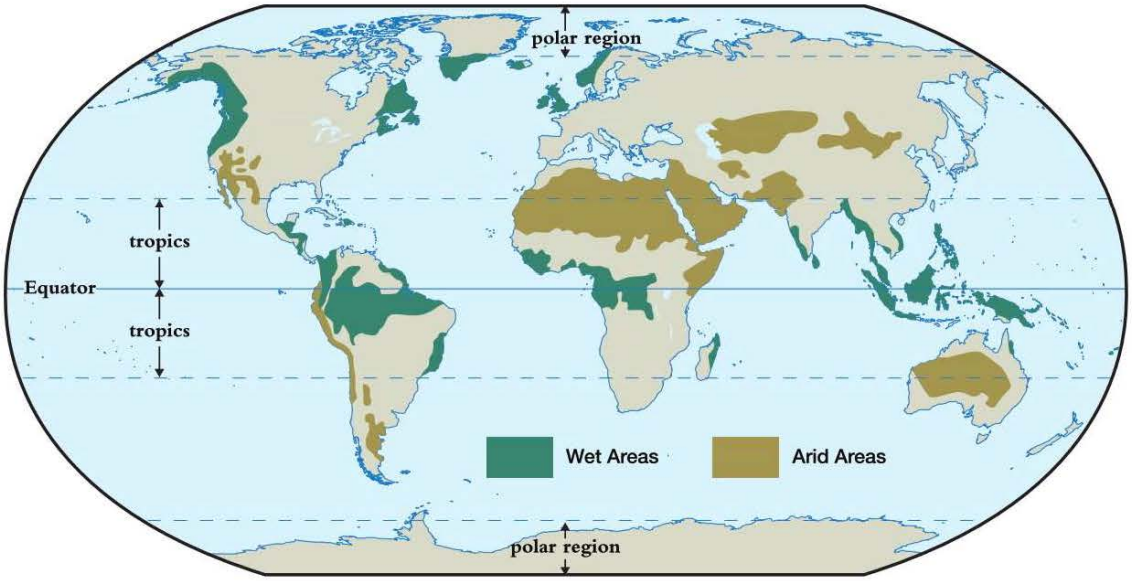
Climate and Agriculture

Despite human intervention, environmental and economic factors are often the most important influence on agriculture. They will determine what types of crops will be grown and what types of animals will be raised by farmers in many cases.

Climate Conditions and Agricultural Production

Climate always has and will continue to play a major role in determining what types of agriculture will take place throughout the world. Most of the earth's land surface supports some type of agricultural activity. The few exceptions are those that are considered to be physically extreme. These include land at highest latitudes or highest elevations, and areas with the highest or lowest precipitation. In these areas, population density for most of human history has been low

WET AND ARID AREAS OF THE WORLD



The level of development of a country and its access to modern technology can have a significant influence overcoming climatic obstacles. In the cold climates of Iceland and Greenland, farmers can grow crops in greenhouses. The tomato market, once dominated by sunny and warm U.S. states such as Florida and California, now includes the products of large Canadian indoor growing facilities.

The relationship between climate and cultural traits, such as food preferences, also shapes agricultural activity. The climate of Southwest Asia is fine for raising hogs. However, in a region dominated by Muslims and Jews, most people have religious objections to eating hogs, so farmers choose to raise other animals.

Economic Factors and Agriculture

Climate has a significant influence on agriculture, but economic factors also influence production. Many people across the world are involved in food production, but a significant difference is who consumes the food they produce.

Subsistence Agriculture The primary goal of subsistence agriculture is to grow enough food or raise enough livestock to meet the immediate needs of the farmer and his or her family. A secondary goal is to sell or trade any surplus for income or goods. Most subsistent farmers live in less-developed regions of the world and have small farms of fewer than two acres. Limited land and the expense of advanced agricultural technologies have made it difficult for subsistent farmers to grow excess food to sell or trade.

Commercial Agriculture The primary goal of the commercial farmer is to grow enough crops or raise enough livestock to sell for profit. It exists in all countries but is more common in developed countries. However, it has become increasingly common in semiperiphery countries, such as China, Mexico, and Brazil. To increase yields further, commercial farmers often use the profit from the sale of their products to purchase more land, equipment, and technology, or to pay for training in the newest farming techniques.

The interaction of economic factors and climate influences agricultural activities in many locations. For example, animal herding takes place in drier climates such as North Africa and parts of the United States and Canada. Animal herding practiced by pastoral nomads in North Africa is an example of subsistence agriculture. Their herds are generally smaller in size, and the milk, meat, and hides are used by the farmers and their families, rather than sold for profit. By contrast, cattle raising in the United States and Canada is commercial agriculture. Cattle roam the western prairies and feed on natural vegetation prior to being sold and slaughtered.

Intensive and Extensive Farming Practices

Another factor that influences agriculture is the amount and type of resources used to grow crops or raise animals. **Intensive agricultural** practices are those in which farmers or ranchers use large amounts of inputs, such as energy, fertilizers, labor, or machines, to maximize yields. **Extensive agricultural** practices use fewer amounts of the inputs and typically result in less yields. Every type of agriculture involves labor, resources, and capital. Consider these ideas as part of a continuum, or line, in which each agricultural activity uses resources more or less intensely than the others. (See Topic 5.6.)

Intensive Commercial Agriculture Heavy investments in labor and capital are used in this type of agriculture which often results in high yields and profits. **Capital** is the money invested in land, equipment, and machines. Intensive commercial agriculture is almost always capital intensive but can also be labor intensive. Examples include market gardening, plantations, and large-scale mixed crop and livestock systems.

Intensive Subsistent Agriculture This form of agriculture is often labor and animal intensive. For example, in rice paddies in Southeast Asia, most of the farming is performed using low-paid human labor rather than machines. The seedlings are planted by hand and during the harvesting process, laborers cut the crops and take the outer husks off to expose the grains of rice.

Extensive Commercial Agriculture This type of farming uses low inputs of resources but has the goal of selling the product for profit. Ranching is the most common example and can be found in the western regions of the United States and Canada, Argentina, New Zealand, and Australia. Typically, the human labor required for this type of agricultural activity is extremely low.

Extensive Subsistent Agriculture Few inputs are used in this type of agricultural activity. It is often practiced in areas that have climatic extremes such as tropical, semi-arid, or arid regions. Two examples include nomadic herding and shifting cultivation.

TYPES OF AGRICULTURE				
	Intensive Commercial	**Intensive Subsistent**	**Extensive Commercial**	**Extensive Subsistent**
Location	▪ Global: core, semiperiphery, and periphery ▪ Regional: near transportation access to urban and global markets	▪ Global: primarily periphery and semiperiphery ▪ Regional: usually near towns and cities with access to local markets	▪ Global: core, semiperiphery, and periphery ▪ Regional: transportation access to processing and local, regional, and global markets	▪ Global: primarily periphery and semiperiphery ▪ Regional: usually in sparsely populated areas with limited access to local markets
Inputs	▪ Labor: intensive ▪ Capital: intensive	▪ Labor: intensive ▪ Capital: not intensive	▪ Labor: not intensive ▪ Capital: intensive	▪ Labor: intensive ▪ Capital: not intensive
Yield	▪ Crop productivity: high ▪ Livestock productivity: high	▪ Crop productivity: low ▪ Livestock productivity: low	▪ Crop productivity: high ▪ Livestock productivity: low	▪ Crop productivity: low ▪ Livestock productivity: low

Agricultural Practices and Regions

There are a variety of agricultural practice classifications, and the regions in which they occur are strongly influenced by level of development, climate, and the purpose of the product. American geographer Derwent Whittlesey identified the eleven main agricultural regions in 1936. The following chart summarizes the types of agriculture commonly found in each climate region.

AGRICULTURAL REGIONS		
Agricultural Practice	**Climate**	**Locations**
Pastoral Nomadism	Drylands	▪ Southwest, Central, and East Asia ▪ North Africa
Shifting Cultivation	Tropical	▪ Latin America ▪ Sub-Saharan Africa ▪ Southeast Asia
Plantation	Tropical/Sub-Tropical	▪ Latin America ▪ Sub-Saharan Africa ▪ South and Southeast Asia
Mixed Crop and Livestock	Cold and Warm Mid-Latitude	▪ Midwest United States and Canada ▪ Central Europe
Grain	Cold Mid-Latitude	▪ North Central United States ▪ South Central Canada ▪ East Europe
Commercial Gardening	Warm Mid-Latitude	▪ Southeast United States ▪ Southeast Australia
Dairy	Cold and Warm Mid-Latitude	▪ Northeast United States ▪ Southeast Canada ▪ Northwest Europe
Mediterranean	Warm Mid-Latitude	▪ Southern coast of Europe ▪ Northern coast of Africa ▪ Pacific coast of the United States
Livestock Ranching	Drylands	▪ Western North America ▪ Southeast South America ▪ Central Asia ▪ Southern Africa
Intensive Subsistence	Warm Mid-Latitude	▪ South, Southeast, and East Asia ▪ Near large populations

Pastoral Nomadism This type of subsistent extensive agriculture is practiced in arid and semi-arid climates throughout the world. Nomads rely on the animals for survival. Animals such as cattle, camels, reindeer, goats, yaks, sheep, and horses provide meat for food and hides for clothing and shelter. Pastoral nomads move their herds to different pastures within their territory and often trade meat for crops with nearby subsistence farmers. Nomads in different regions rely upon different animals, depending on their culture and the climate in which they live:

- In South Central Asia and East Africa, people rely on cattle because they adapt to the hot climate.
- In desert regions of the Middle East, people rely on camels because they can survive without water for long periods.
- In Siberia, people rely on reindeer because they thrive in cold weather.

Shifting Cultivation In this type of subsistent extensive farming, farmers grow crops on a piece of land for a year or two. When the soil loses fertility, they move to another field. Unlike crop rotation, in which farmers change the crops that are grown within a field, shifting cultivation involves using new fields.

A specific type of shifting cultivation used in tropical climate regions is known as slash-and-burn agriculture, or swidden agriculture, because farmers sometimes clear the land by burning vegetation. This process enriches nutrient-poor soil by adding nitrogen to it. On the cleared land, farmers plant and harvest crops for a few growing seasons until the soil becomes less fertile. Then, they move to another area of dense, wild vegetation and repeat the process.

Examples of shifting cultivation including growing rice in Southeast Asia, maize (corn) in South America, and millet and sorghum in Sub-Saharan Africa. Most families grow various food crops in one field for their own consumption. The community or village often owns the land used for shifting cultivation. As population increases and land becomes scarce, this practice is not sustainable.

Shifting cultivation practices are often not sustainable and have negative influences on land, including depletion of nutrients in the soil.

Plantation Agriculture Under colonialism, commerical agriculture often replaced subsistence farming. A **plantation** is a large commercial farm that specializes in one crop. Most plantations are found in the low latitudes with hot, humid climates and substantial rainfall. They are typically labor intensive and often exploit the low-wage labor available in nearby villages and towns.

To reduce the cost of moving bulky crops, some processing occurs near the plantation. The valuable portion of the crop is transported. Common plantation crops include coffee, cocoa, rubber, sugarcane, bananas, tobacco, tea, and cotton. As labor costs rise, plantations become more capital intensive.

Mixed Crop and Livestock Farming Large-scale mixed crop and livestock farming is an intensive commercial integrated system that demonstrates an interdependence between crops and animals. In some cases, one person owns the land on which the crops are grown and the cattle are raised. In other cases, the adjacent parcels of land are owned by different people—one raises crops and the other raises livestock. On these farms, the majority of the crops are grains that are eaten by the livestock—to fatten cattle for slaughter or to feed dairy cows. The animals' manure is, in turn, used to help fertilize the crops.

Mixed crop and livestock farming is common in developed regions, such as Canada, the Midwestern United States, and northern Europe, but it has diffused to parts of the developing world. U.S. farmers often grow corn and soybeans. These crops can be used as animal feed or made into various products.

Grain Farming In regions too dry for mixed crop agriculture, farmers often raise wheat. Consumed mostly by people, wheat is produced in the prairies and plains. China, India, Russia, and the United States are the world's top wheat producers. The type of wheat grown reflects the climate:

- *Spring wheat* is planted in early spring and harvested in early autumn. It is grown in colder regions such as Canada, Montana, and the Dakotas.
- *Winter wheat* is planted in the fall and harvested in early summer. It is grown in warmer regions such as Kansas, Oklahoma, and Europe.

Commercial Gardening Typical fruits and vegetables grown in the United States include lettuce, broccoli, apples, oranges, and tomatoes. Large-scale commercial vegetable gardens and fruit farms are found mostly in California, Arizona, and states of the Southeast. In the winter, the United States imports these types of products from Mexico and Chile. This type of intensive farming is also referred to as truck farming because the products were traditionally driven to local urban markets and sold. Today, however, most trucks are refrigerated which allows farmers to sell their products to distant markets.

The concept of small-scale market gardening is making a resurgence near cities with buy-local food movements. **Market gardening** is when fruits and vegetables are grown near an urban market and sold to local suppliers, stores, restaurants. Today's market gardening in the United States is intensive and usually requires capital investments of greenhouses and fertilizers.

Dairy Farming Traditionally, dairies were local farms that supplied products to customers in a small geographic area. This pattern still exists in many less-developed regions of the world. However, during later 20th century, improvements in refrigeration and transportation expanded the **milk shed**, the geographic distance that milk is delivered. Large corporate dairy operations replaced smaller family-owned farms, which resulted in fewer farms but more

production. Most commercial dairy farms in the United States, Canada, and other developed countries are near urban centers and transportation corridors.

In a few countries, such as Argentina and Brazil, demand for dairy products increased faster than the pressure for consolidation. With economic growth and higher incomes, the number of dairy farms increased.

Mediterranean Agriculture Mediterranean agriculture is practiced in regions with hot, dry summers, mild winters, narrow valleys, and often some irrigation. Some of these regions are southern Europe, northern Africa, southwestern Africa, southwestern Asia, southwestern Australia, California, and central Chile. Common crops grown in Mediterranean agriculture include figs, dates, olives, and grapes. Herders in these regions often practice **transhumance**, the seasonal herding of animals from higher elevations in the summer to lower elevations and valleys in the winter. (See Topic 2.11.) Goats and sheep are the principal livestock because of the region's rugged terrain.

Livestock Ranching Livestock ranching is the commercial grazing of animals confined to a specific area. Similar to pastoral nomadism, livestock ranching is found in areas that are too dry to grow crops in large quantities. Ranching is common in the western United States; the pampas of Argentina, Brazil, and Uruguay; parts of Spain and Portugal; China; and central Australia.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What is the connection between physical geography and agricultural practices?*

Elements That Influence Agriculture	Effects on Agriculture

KEY TERMS

agriculture
climate
subsistence agriculture
commercial agriculture
intensive agriculture
extensive agriculture
intensive commercial agriculture
intensive subsistent agriculture
extensive commercial agriculture
capital
extensive subsistent agriculture
pastoral nomadism
shifting cultivation
plantation
mixed crop and livestock farming
grain farming
commercial gardening
market gardening
dairy farming
milk shed
Mediterranean agriculture
transhumance
livestock ranching

5.2

Settlement Patterns and Survey Methods

Essential Question: What are rural settlement patterns and methods of surveying rural settlements?

The study of geography emphasizes a spatial perspective. Learning how people organized themselves spatially in the rural, or agricultural, environment has the same spatial perspective. Population density is less in rural regions compared to urban regions, but how and why humans interact with their environment in rural areas is just as significant. As technology has changed how people interact with the physical environment and the patterns of settlements.

Rural Settlement Patterns

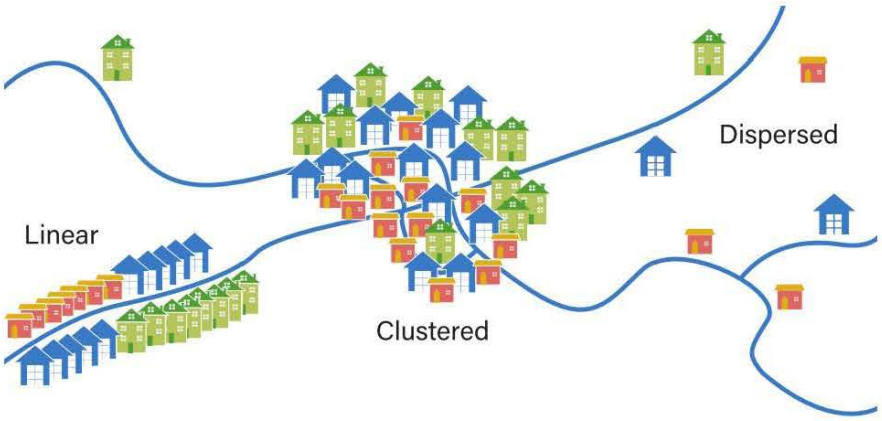
Throughout history, rural residents commonly lived in **clustered,** or **nucleated settlements**. These settlements had groups of homes located near each other in a village and fostered a strong sense of place and often shared of services, such as schools. Villagers raised crops and animals in the fields and pastures around their settlements. Soil types, climate, and labor force influenced the types of crops grown by residents of rural settlements and sold in local markets.

In contrast to many parts of the world, North American farmers usually created **dispersed settlements**, patterns in which farmers lived in homes spread throughout the countryside. In Canada and the United States, the governments promoted westward expansion by giving farmers land—usually 160 acres—if they agreed to reside on it for several years. Settlers moving westward also utilized the wide-open land to raise cattle. Fertile land in the expansive Ohio Valley allowed farmers to grow crops on large farms. As a result, most farmers in North America lived near their fields, and agricultural villages were rare.

Dispersed settlements do occur in other locations, particularly areas that have rugged or challenging environments, such as with limited water or poor soil. Dispersed settlements encourage individual self-sufficiency but make shared services such as schools or defense difficult.

Another rural settlement pattern is a **linear settlement**, in which buildings and human activities are organized close to a body of water or along a transportation route. Linear settlements along a river were common before industrialization because of the need for fresh water to irrigate crops. Today, the desire to be close to a transportation route is even more important. Small communities will sprawl along a railroad track or a metropolitan city will have multiple entry and exit points from an interstate highway.

RURAL SETTLEMENT PATTERNS



Agricultural Practices Impact Land-Use Patterns

Rural land use evolved as agricultural practices changed, often due to new technology. For example, Cyrus McCormick's invention of the mechanical reaper in 1831 reduced need for human labor since the machine cut and harvested crops. New technology made it easier for more agricultural products to be grown on more land with fewer laborers. Farming techniques, like crop rotation, also improved crop yields and produced a greater variety of foods.

Since new technology allowed more land to be farmed, changes in land ownership followed. The British enclosure movement divided up common land that had been shared by farmers into individual plots. Other European countries did the same, and farm size and production grew across the continent.

Rural land use was further altered by the Green Revolution (see Topic 5.5), which allowed agriculture to be practiced in regions of Mexico, India, and Indonesia, which were previously thought to be incapable of producing food. As agriculture became more commercialized, family farms struggled to compete with large corporate farms and many failed. Each of these changes impacted the size, scope, and organization of land-use patterns.

Source: goegraph.org.uk

Irregularly shaped plots of land created by the metes and bounds system in the United Kingdom.

Establishing Property Boundaries

In England, fields often had irregular shapes that reflected the location of physical features and traditional patterns of use. Plot boundaries were described using the **metes and bounds** system. Metes were used for short distances and often referred to features of specific points, such as "from the oak tree, 100 yards north, to the corner of the barn." Bounds covered larger areas and were based on larger features, such as streams or roads.

The English colonists in America also used metes and bounds. However, beginning in 1785, the United States switched to a system based on surveying rather than landscape features. Surveying involves measuring and recording the distance, elevation, and size of features on the earth's surface. The **Public Land Survey System,** or **township and range system,** created rectangular plots of consistent size. The government organized land into **townships**, areas six miles long and six miles wide. Each square mile, or **section**, consisted of 640 acres, and it could be divided into smaller lots, such as half sections or quarter sections. Because of this system, property boundaries in most of the land the west of the Appalachian Mountains often contain squares or rectangles.

French settlers in North America emphasized the value of access to a river for water and trade. So many farmers could have some river frontage, they developed the **French long-lot system**, in which farms were long, thin sections of land that ran perpendicular to a river. The best examples of this system in North America occur in Quebec and Louisiana.

A positive aspect of the long-lot system is that each landowner had access to water. What are some negative aspects of this system?

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are rural settlement patterns and methods of surveying rural settlements?*

Rural Land-Use Patterns	Rural Land Surveying Methods

KEY TERMS

clustered (nucleated) settlements
dispersed settlements
linear settlement
metes and bounds
Public Land Survey System (township and range system)
townships
section
French long-lot system

5.3

Agricultural Origins and Diffusions

Essential Question: What are major centers of domestication of plants and animals and how have plants and animals diffused globally?

Until humans learned to produce a regular, predictable food source, searching for food consumed their time. But as people learned to grow crops, they eventually had time to develop new nonagricultural technologies. The development of agriculture was a gateway to other advances.

Centers of Plant and Animal Domestication

The **First (Neolithic) Agricultural Revolution** was the origin of farming. It was marked by the domestication of plants and animals. Much of the farming that took place during this time was subsistence farming, when farmers consumed the crops that they raised using simple tools and manual labor. The First Agricultural Revolution began in five centers, or hearths. The first hearths were in Southwest Asia, East Asia, South Asia, Africa, and the Americas.

Agricultural Hearths

In the mid-20th century, geographer Carl Sauer was among the first to argue that people in various times and locations developed agricultural hearths independently. He claimed the first hearths were in areas with high biodiversity on the edge of forests. Additional common characteristics of hearths include available fresh water, fertile soils, moderate climates, and skilled residents.

Before humans developed agriculture, they had existed as hunters and gatherers for tens of thousands of years. They lived in small, mobile groups—approximately 30 to 50 people—who could move easily in search of food. Larger groups would have surpassed the carrying capacity of their respective regions. People survived by living in low population density regions.

Animal Domestication Hunters in Central Asia were probably the first people to domesticate animals. They raised dogs and horses for protection, work, transportation, or as a food source. Later, agriculturalists in Southwest Asia kept goats, pigs, sheep, and cattle. People then domesticated cats, horses, camels, donkeys, and llamas, among other animals.

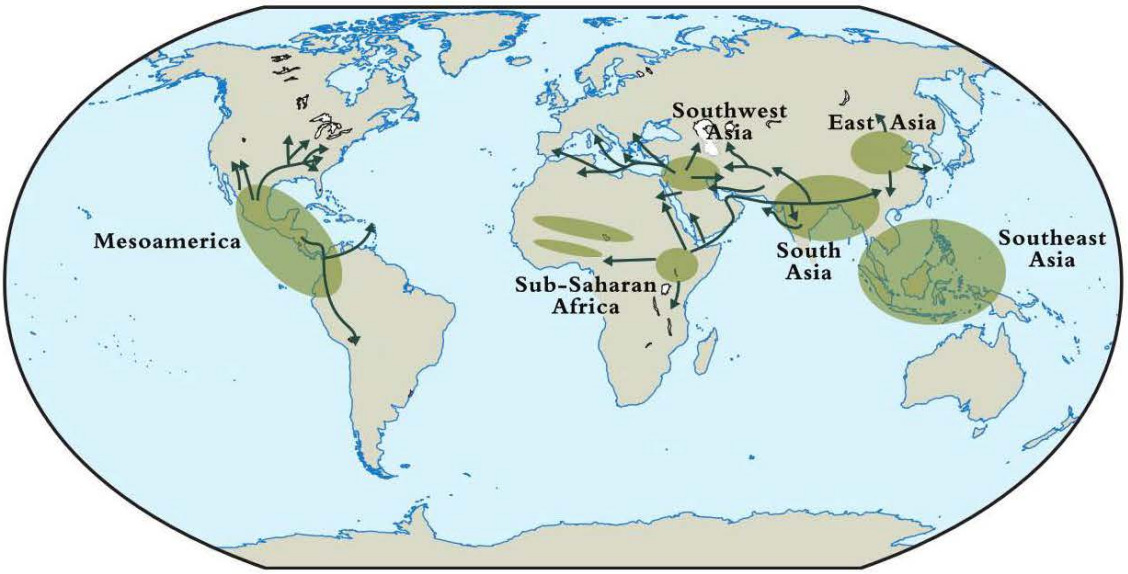
Plant Domestication Growing crops probably began after domestication of animals. People first used vegetative planting, or using parts of the stems or roots of existing plants to grow others. Planting seeds came later. Eventually, people in separate hearths began to trade of crops, animals, and innovations.

MAJOR HEARTHS OF CROP AGRICULTURE			
Time Period	**Location**	**Crops**	**Early Diffusion Pattern**
10,000 to 12,000 years ago	Southwest Asia (Fertile Crescent)	▪ Barley ▪ Wheat ▪ Lentils ▪ Olives	▪ North Africa ▪ Southern Europe ▪ Central Asia
10,000 years ago	Southeast Asia	▪ Mangos ▪ Taro ▪ Coconuts	▪ Southeastern Asia
9,500 to 7,500 years ago	South Asia (Indus Valley)	▪ Barley ▪ Cotton ▪ Wheat ▪ Peas	▪ Indian subcontinent ▪ Southwest Asia
9,500 years ago	East Asia	▪ Rice ▪ Soybeans ▪ Walnuts	▪ North Central Asia ▪ Korean peninsula
7,000 years ago	Sub-Saharan Africa	▪ Yams ▪ Sorghum ▪ Cowpeas ▪ Coffee ▪ African rice	▪ Western Africa ▪ North Africa
5,500 years ago	Mesoamerica	▪ Squash ▪ Peppers ▪ Maize (corn) ▪ Potatos ▪ Cassava	▪ North America ▪ South America

The development of agriculture allowed people to live in permanent, higher-density communities. These communities were usually along rivers, which provided a source of water for people to drink. Rivers also provided a source of food (fish), a means of transporation for trade with other people, and, at times, defense from other groups.

But rivers such as the Nile, the Chang Jiang, and the Indus had another benefit. They flooded regularly, which spread nutrients across the land that contributed to soil fertility. Since this made agriculture more productive, farmers could support denser settlements, and it freed more people to specialize in tasks other than growing food. People could dedicate themselves to building stronger structures in which to live and store products, providing protection from predators and enemies (military), and developing new ideas and products. Increases in agricultural productivity spurrred creativity and advances in all areas of human life.

THE FIRST AGRICULTURAL HEARTHS



Diffusion of the First Agricultural Revolution

The first major hearth of agriculture is the **Fertile Crescent** in Southwest Asia. The area extends from the eastern coast of the Mediterranean Sea and continues in an arc along the Tigris and Euphrates rivers to the Persian Gulf. Other major hearths existed along large river valleys such as the Chang Jiang (Yangtze) and Huang He (Yellow) valleys in East Asia, the Ganges valley in South Asia, and the Nile valley in northeastern Africa. In each location, people raised a variety of domesticated crops and animals.

In some cases, crops and animals were domesticated in multiple regions with seemingly no interaction among the people. This is called an **independent innovation**. For example, wheat was domesticated independently in Southwest Asia, East Asia, and South Asia. Pigs were domesticated in Southwest Asia, Southeast Asia, and South Asia.

Unique to the hearth of the Americas was the domestication of maize (corn), sweet and white potatoes, and tomatoes. Through diffusion, these products are now important parts of diets throughout most of the world.

Impacts of Hearths and Agriculture

The major hearths of agriculture led to the first urban centers. These first settlements grew into the first civilizations—large societies with cities and powerful states. Civilization brought increased trade, larger empires, and conquest. As societies continued to develop, people had time to specialize in their work and develop new occupations and technologies. This led to the advent of full-time metalworkers, artists, soldiers, weavers, and other specialized jobs.

Over thousands of years, agriculture spread widely and led to increased trade. The diffusion paths in the ancient world were expansive considering the transportation technology of the time. For example, the Roman Empire, which reached its geographic peak around 200 C.E., carried on extensive trade in

wheat and other agricultural products with present-day England, Africa, and Southwest Asia. On the Silk Roads, the land and sea routes connecting East Asia to the Middle East and Rome, people traded silk, rice, and other goods.

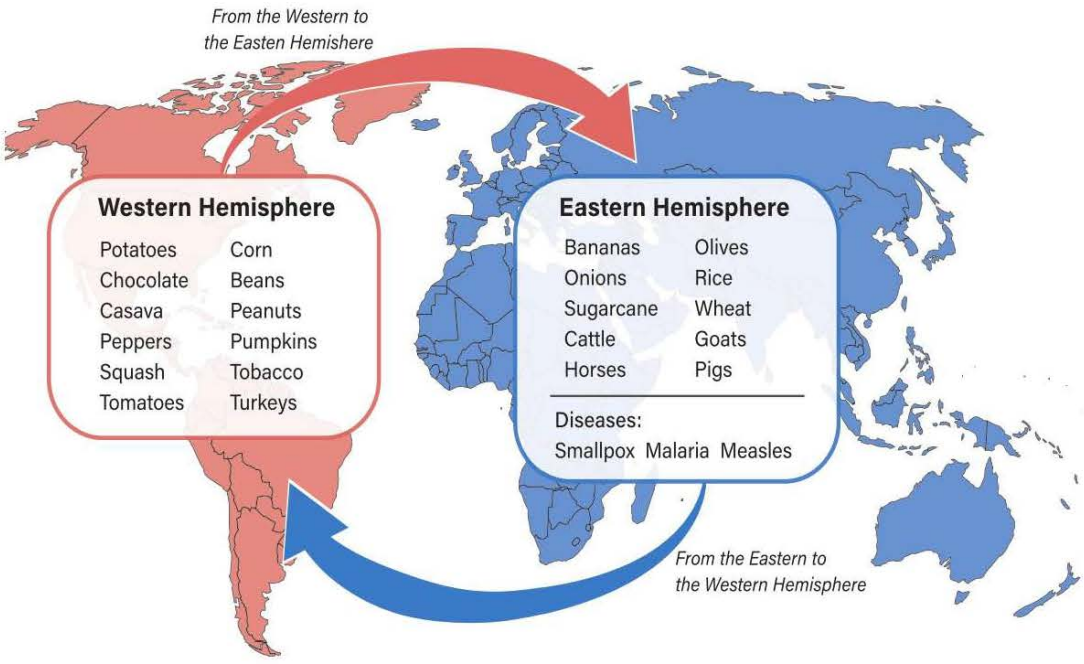
The Columbian Exchange

One of the most dramatic shifts in agriculture came after the voyage of Christopher Columbus in 1492. The **Columbian Exchange** was the global movement of plants and animals between Afro-Eurasia and the Americas. Europeans brought hundreds of plants and animals west across the Atlantic Ocean to the Americas and took hundreds of plants and animals back east. Crops such as coffee (originally from eastern Africa) and bananas and sugarcane (originally from New Guinea) continue to thrive today in the tropical climates of the Americas. Temperate climate crops such as potatoes (originally from northwest South America) and maize (originally from southern Mexico) are still extensively grown in Europe, Asia, Africa, and the Americas.

Domesticated animals from the Eastern Hemisphere, such as cattle, goats, and horses, were also brought to the Western Hemisphere. The turkey was originally found in the Americas and taken by Europeans back to their respective countries.

In addition to the agricultural exchange, there were many diseases that were also diffused across the Atlantic Ocean to the Americas, including smallpox, influenza, malaria, and measles. All of these had a devastating impact on indigenous populations. Tens of millions of people died, with the total population decreasing as much as 90 percent within a few generations of contact with European diseases.

COLUMBIAN EXCHANGE



Modern Diffusion

Diffusion of agricultural products, techniques, and technologies continued as civilizations became more advanced. The impact of the Industrial Revolution, which started in Great Britain in the mid-18th century, marked the Second Agricultural Revolution. (See Topic 5.4.) New machines, coupled with scientific discoveries to better preserve food, increased the food supply exponentially. Industrialization diffused across Europe about the same time as it reached the Americas, and ever since, most of Europe, the United States, and Canada have continued to be global leaders in food production and distribution.

By the mid-20th century, Green Revolution (see Topic 5.5) scientists created new crossbred or hybrid seedlings in a laboratory. These seedlings are used in more climatically restrictive regions and allowed people to produce food for themselves. This has helped to support growing populations in the semiperiphery countries of Mexico, India, and Indonesia.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are major centers of domestication of plants and animals and how have plants and animals diffused globally?*

Agricultural Hearths	Diffusion Patterns from Hearth

KEY TERMS

First (Neolithic) Agricultural Revolution
animal domestication
plant domestication
Fertile Crescent
independent innovation
Columbian Exchange

GEOGRAPHIC PERSPECTIVES: *DIFFUSION OF GOODS*

A modern diet is often rich in food from around the world. Geographers have traced the diffusion of these crops from their hearths and the networks created through trade.

Crops and Locations

Florida oranges, Irish potatoes, Colombian coffee, Swiss chocolate, and Italian tomato sauces are closely associated with specific geographic locations. But each of these items originated in hearths distant from where they are produced today. Similarly, black pepper from India, cinnamon from Sri Lanka, and nutmeg from the Moluccas are among the many non-native luxuries that diffused to the European mainland. The goal of reducing the friction of distance between Europe and these faraway lands in order to improve the variety of peoples' diets was a significant factor in the diffusion of crops from one location to another.

Rate of Adoption

But people are creatures of habit, so it can take centuries for the new crops to be accepted by another culture. For example, when Europeans brought tomatoes from the Americas back to Europe, they became popular in Italy—but only for ornamental purposes. Initially believed to be poisonous, tomatoes did not find their way into conventional Italian cuisine until the 19th century.

Impact of Land and Climate

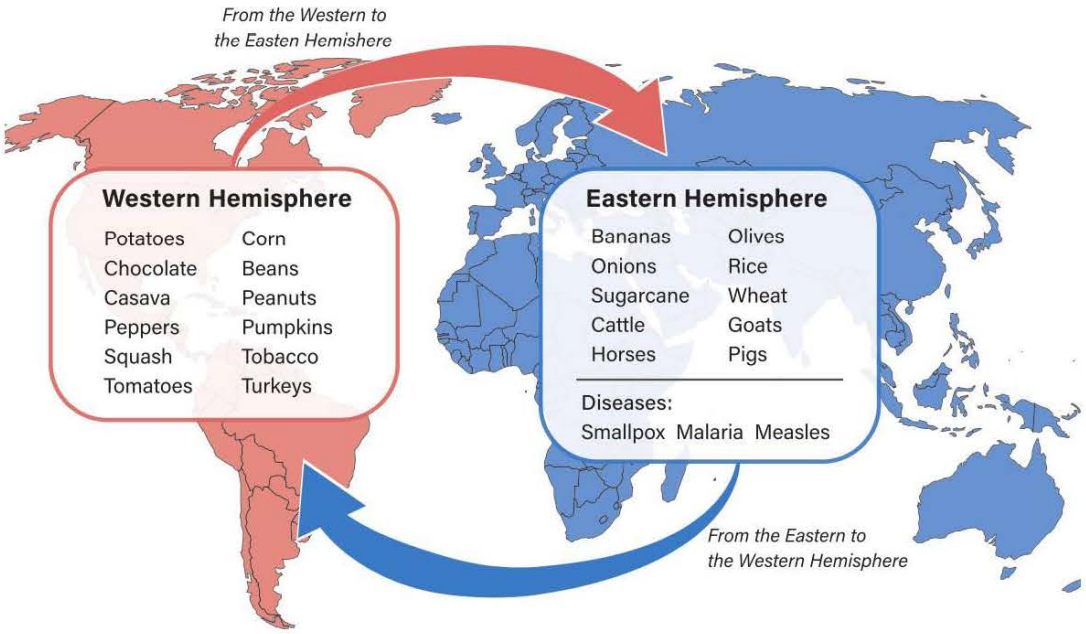
Successful diffusion depends on more than what people want. Crops are notoriously fickle with respect to the conditions in which they grow best. A slight change in soil conditions, average temperature, growing season, moisture, and latitudinal position can severely hinder the production of a crop.

For instance, natural latex, extracted from rubber trees originating in South America, was first introduced to France in the 18th century. French and British companies then started to plant rubber trees in their colonies in South and Southeast Asia. Today, over 90 percent of its production is concentrated in Southeast Asian countries such as Thailand, Indonesia, and Malaysia. This primarily has to do with the availability of abundant low-paid labor in those regions, as opposed to the Americas. However, this has occurred only because both regions' distances from the equator and relative climates are very similar.

1. Describe a benefit of having access to food from a variety of places around the world.
2. Describe a cultural or social reason why the adoption of food from another location is a slow process.
3. Describe an environmental barrier that slows the spread of new crops growing in different regions.

THINK AS A GEOGRAPHER: *ANALYZING RURAL NETWORKS*

Global trade has been significantly different ever since Columbus sailed across the Atlantic Ocean in search of India. Even though he did not achieve his goal, lives were changed forever because of the migrations of people, the diffusion of ideas, the introduction of new foods, and the spread of diseases.



1. Define the Columbian Exchange.
2. Explain ONE positive and ONE negative social consequence of the Columbian Exchange on the Americas.
3. Using the graphic, explain the degree to which you have benefited from the diffusion of foods from Afro-Eurasia to the Americas.
4. Using the graphic, explain to what extent the Columbian Exchange changed the way human beings eat.

CHAPTER 11 REVIEW:
Origins, Patterns, and Settlements of Agriculture

Topics 5.1–5.3

MULTIPLE-CHOICE QUESTIONS

1. As a result of the Columbian Exchange, which crop was transferred from the Americas to Europe and later spread through the world?

(A) Coffee
(B) Maize (corn)
(C) Rice
(D) Olives
(E) Wheat

2. An agricultural hearth is a location where

(A) linear settlements are commonly found
(B) the Second Agricultural Revolution began
(C) widespread terracing is used
(D) plants and animals were first domesticated
(E) where the Third Agricultural Revolution failed

3. In which state or province is the long-lot land division most common?

(A) Montana
(B) Quebec
(C) Texas
(D) Iowa
(E) British Columbia

4. Mediterranean agricultural products are most commonly grown in

(A) Southern Spain and California
(B) the American Midwest and the European Highlands
(C) Northern Italy and the Nordic countries
(D) Australia and Central Asia
(E) the Middle East and the Andean Highlands

5. A meal that includes olives, pita bread, cheese, figs, lamb, and wine is most associated with which of the following?
   (A) Mexico
   (B) United Kingdom
   (C) Greece
   (D) China
   (E) Russia

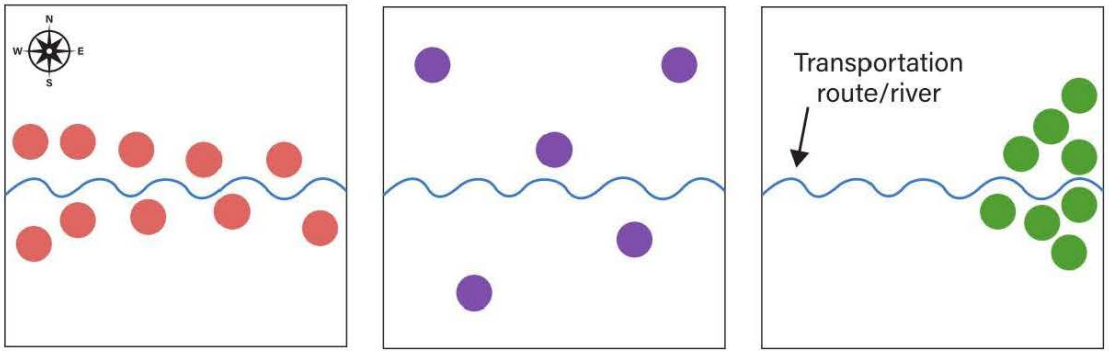
Question 6 refers to the following image.

6. Using the image above, which of the following is the most important identifier of the Public Land Survey System?
   (A) Circular fields
   (B) Alternating crops shown with different colors in the fields
   (C) Storage structures shown in the top half of image
   (D) Square and rectangular fields
   (E) Darker fields showing the flow of water

7. Rice and beans are very common ingredients used in Latin American food today. Which of the following scenarios best explains this?
   (A) Beans diffused from Europe and were added to meals using rice
   (B) Rice and beans diffused from Europe and added to the diets of local people in the Americas
   (C) Rice and beans are indigenous foods of the Americas
   (D) Rice diffused from China and beans from Spain
   (E) Rice diffused from Europe and was added to meals using beans.

FREE-RESPONSE QUESTION

Different types of rural settlement patterns developed for specific reasons.



Settlement A Settlement B Settlement C

(A) Identify the type of rural settlement of A, B, and C.

(B) Describe ONE reason why people settled in permanent rural settlements.

(C) Explain ONE economic reason why people would settle in a pattern that reflects Settlement A.

(D) Describe ONE environmental reason for the settlement pattern on Settlement C.

(E) Using ONE world region explain how technology encouraged the settlement pattern such as in Settlement B.

(F) Explain ONE negative social aspect of the settlement pattern in Settlement B.

(G) Describe ONE limitation of analyzing settlement patterns by using a hypothetical diagram.

CHAPTER 12

The Second and Third Agricultural Revolutions

Topics 5.4–5.5

Topic 5.4 The Second Agricultural Revolution

Learning Objective: Explain the advances and impacts of the Second Agricultural Revolution. (SPS-5.C)

Topic 5.5 The Green Revolution

Learning Objective: Explain the consequences of the Green Revolution on food supply and the environment in the developing world. (SPS-5.D)

Yet food is something that is taken for granted by most world leaders despite the fact that more than half of the population of the world is hungry.

—Norman Borlaug, **Nobel lecture, 1970**

Source: Getty Images

Advanced agricultural techniques and irrigations systems have diffused around the world. This image shows a center-pivot irrigation system in Botswana, Africa. (See Topics 5.4 and 5.5 for irrigation changes during agricultural revolutions.)

5.4

The Second Agricultural Revolution

Essential Question: What are the advances and impacts of the Second Agricultural Revolution?

Agriculture underwent a wide-ranging overhaul beginning in the mid-18th century, and the changes have not slowed since. Technological advances of the Industrial Revolution benefited farmers with dramatically better yields and productivity. As a result, the world moved out of the First Agricultural Revolution and into a series of new agricultural revolutions based on innovation and science to meet an increased global demand for food:

- The **Second Agricultural Revolution**, which began in the 1700s, used the advances of the Industrial Revolution to increase food supplies and support population growth. Agriculture benefited from mechanization and improved knowledge of fertilizers, soils, and selective breeding practices for plants and animals.
- The Third Agricultural Revolution (see Topic 5.5), which began in the 1960s, included the Green Revolution and an agribusiness model that controlled the development, planting, processing, and selling of food products.

Impact of the Second Agricultural Revolution

The Second Agricultural Revolution involved the mechanization of agricultural production, advances in transportation, development of large-scale irrigation, and changes to consumption patterns of agricultural goods. Innovations, such as the steel plow and mechanized harvesting, greatly increased food production, particularly in Europe and the United States. The impact of the Second Agricultural Revolution, coupled with discoveries to better preserve food, increased the food supply, especially to countries that participated in global trade networks. The net result was that more people had access to a greater variety of food, which increased life expectancies.

Property Rights and Farming Advances

Paralleling changes in technology were changes in the law. The **Enclosure Acts** were a series of laws enacted by the British government that enabled landowners to purchase and enclose land for their own use. This land had previously been common land shared by peasant farmers. Similar enclosure movements occurred throughout Europe that allowed for larger farms, more efficient production, and crops sold for profit rather than personal consumption.

However, the enclosures came at a high cost. Many farmers were forced off their land and lost their traditional way of life.

Advances in food production technology—in the mid-19th century through the early half of the 20th century—led to better diets, longer life expectancies, and increased population. These factors, combined with many displaced farmers due to the Enclosure Acts, led to a larger potential workforce for growing factories.

Mechanized agricultural technology created a shift in employment as fewer farmers and farm laborers were needed to produce more food. With fewer jobs in farming, workers looked to jobs created in the industrial or manufacturing sector of the economy. Since most of these industrial jobs existed in cities and new factory towns, rural-to-urban migration increased dramatically, which changed the cultural landscape and worldwide population distributions.

Agricultural advancements in sowing (planting) and reaping (harvesting), storage, irrigation, and transportation were made during the 19th century.

EARLY ADVANCES IN MODERN AGRICULTURE

Advancement	Date	Effect
Iron/Steel Plow	1819	▪ Reduced human labor ▪ Increased strength to break through harder soils ▪ Increased amounts of crops grown per acre ▪ Increased size of farms
Mechanized Seed Drilling	18th century	▪ Planted and covered each seed quickly ▪ Resulted in increased yield per acre
McCormick Reaper/ Harvester	1831	▪ Increased harvest ▪ Reduced human labor ▪ Reduced amount of crops that perished in the field before harvest
Grain Elevator	1849	▪ Increased storage space and food supply ▪ Protected harvested food from animals and the elements
Barbed Wire	1870s	▪ Provided inexpensive fencing to keep livestock in grazing areas ▪ Demarcated property
Mixed Nitrogen and Nitric Acid Fertilizer	1903	▪ Increased crop yields per acre

Farming techniques, like crop rotation and irrigation, increased yields and allowed farmers to produce a greater variety of food products. **Crop rotation** is the technique of planting different crops in a specific sequence on the same plot of land in order to restore nutrients back into the soil. Grains usually extract nitrogen from the soil, while alfalfa puts nitrogen into the soil. A fallow period

(ground left unseeded) that allows the land to rest, is also a common technique. Farmers significantly develped their understand of proper soil management during the Second Agricultural Revolution.

Improved irrigation systems provided a stable and controlled water supply thus increasing yields. **Irrigation** is the process of applying controlled amounts of water to crops using canals, pipes, sprinkler systems, or other human-made devices, rather than to rely on just rainfall.

During the same time period as the Second Agricultural Revolution, transportation infrastructure in Europe, the United States, and core regions improved dramatically with the greater use of roads, canals, ships, steamboats, and railroads. Additional improvements in refrigeration of train cars and trucks further increased the distance goods could be transported, while reducing the time that it took agricultural products to get to domestic urban markets. These transportation infrastructure improvements laid the foundation of a global trade explosion of the Third Agricultural Revolution. (See Topic 5.5.)

Agricultural Changes and Shifting Demographics

The Second Agricultural Revolution resulted in fewer, yet larger and much more productive farms. This change caused a decrease in the number of farm owners and an even greater drop-off in the need for agricultural laborers. By the late 19th century, a large number of displaced farm laborers migrated to U.S. urban centers. The 1920 U.S. Census showed, for the first time in the country's history, that more people lived in urban areas than in rural areas. Only 30 percent of the labor force worked in agriculture, less than half what it was in 1840. Today, only 3.6 percent of the U.S. workforce is involved with farming or related industries.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are the advances and impacts of the Second Agricultural Revolution?*

Agricultural Advances	Impact on Farming

KEY TERMS

Second Agricultural Revolution
Enclosure Acts
crop rotation
irrigation

5.5

The Green Revolution

Essential Question: What are the consequences of the Green Revolution on food supply and the environment in the developing world?

M.S. Swaminatha, an Indian geneticist and a prominent leader in the Green Revolution, once said, "We should look upon agriculture not just as a food-producing machine for the urban population, but as the major source of skilled and remunerative employment and a hub for global outsourcing." Throughout much of human history, farms in rural regions have provided the food necessary for people to survive. However, the Green Revolution introduced a wave of advancement in agricultural technology and its effects on food security, jobs, and the environment are still being realized.

The Third Agricultural Revolution

In the mid-20th century, the **Third Agricultural Revolution** was born out of science, research, and technology, and it continues today. This revolution expanded mechanization of farming, developed new global agricultural systems, and used scientific and information technologies to further previous advances in agricultural production.

Researchers in core countries are responsibile for most of the technological developments of the third revolution, but the benefits and impacts were global. This is most evident in vastly improved varieties of grain facilitated by crossbreeding seedlings in laboratories. These advances are at the heart of the Green Revolution, which is considered the most important aspect of the Third Agricultural Revolution.

The Green Revolution

The advances in plant biology of the mid-20th century are known as the **Green Revolution**. Dr. Norman Borlaug, considered the "Father of the Green Revolution," laid the foundation for scientifically increasing the food supply to meet the demands of an ever-increasing global population. Borlaug's development of higher-yield, more disease-resistant, and faster-growing varities of grain are his most important contribution to the revolution. His work set in motion an entire movement that created hybrid wheat, rice, and corn seedlings. Borlaug's research led to the modern method of plant breeding and eventually earned him a Nobel Peace Prize in 1970.

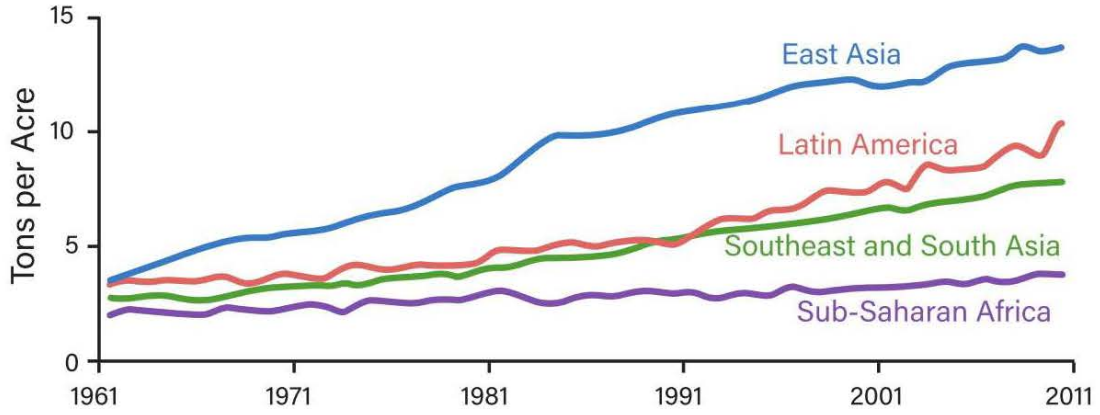
Borlaug worked specifically on developing a shorter grain of wheat that was both resistant to disease and capable of a growing in harsher climates in Mexico. His work was successful in turning Mexico from a wheat-importing

country to one that was self-sufficient and even had a wheat surplus. After his success in Mexico, Borlaug worked with governments in South Asia to deal with food shortages in the face of expanding populations.

Borlaug's work and the resulting transfer of agricultural technology from the United States to Mexico and South Asia would serve as a model for the Green Revolution. Green Revolution scientists also encouraged farmers to *double crop*, or grow more than one crop in a year in the same field (see Topic 5.6), while increasing the use of fertilizer and pesticides.

However, the benefits of increased food production were accompanied by concerns. The increased use of chemical fertilizers and pesticides led to fears about the unforeseen consequences of their use on farm products. Borlaug argued that the alternative of people dying from famine was not acceptable, and his research and methodology are credited with saving millions of lives.

INCREASE IN GRAIN PRODUCTION BY REGION



Source: "World Development Report 2013: Jobs," World Bank, 2013.

Based on the graph, which regions increased grain production the most? Why did production in Sub-Saharan Africa lag?

Hybrids Seed **hybridization** is the process of breeding two plants that have desirable characteristics to produce a single seed with both characteristics. For hundreds of years, humans created plant hybrids from local varieties available to them. However, Green Revolution scientists focused their attention on grains. Further, living in an increasingly globalized world, these scientists had a much wider range of plants from which to crossbreed than did local farmers.

Scientists used hybridization to create a new strain of rice in the 1960s. They used long-grain rice from Indonesia and dense-grain dwarf rice of Taiwan to produce a rice grain that was both longer and denser. The hybrid of these two strains was introduced to rice-growing countries in East and Southeast Asia.

Machinery In addition to using hybrids, chemical fertilizers, and pesticides, proponents of the Green Revolution encouraged the transfer of mechanical technology as well. Machinery such as tractors, tillers, broadcast seeders, and grain carts were introduced to countries of the developing world. The introduction of these agricultural technologies assisted in production and challenged traditional labor-intensive farming practices that had been in place for thousands of years.

GMOs Hybridization differs from the production of a **genetically modified organism** (GMO), a process by which humans use engineering techniques to change the DNA of a seed. They have been developed to increase yields, resist diseases, and withstand the chemicals used to kill weeds and pests. (See Topic 5.11 for more about GMOs.)

Source: Wikimedia Commons

A farmer in India uses a tractor to plow his field, while in the background, another farmer does the same with a pair of oxen. The process of accessing Green Revolution and Third Agricultural Revolution technologies is often unevenly distributed across the world and even within the same community.

Positive Impacts of the Green Revolution

During the Green Revolution, global food production increased dramatically. The introduction of new seed technology, mechanization, pesticides, chemical (human-made) fertilizers, and irrigation led to increased yields. More food led to reduced hunger, lower death rates, and growing populations in many parts of the developing world.

Higher Yields

Increased food production in the developing world has prevented millions from starvation. By the mid-1950s, crop yields had increased without cultivating more land. The increased yields have kept up with global population growth, but experts debate whether agricultural production increases or population increases will be greater in the future.

Similar to what occurred in Mexico, India went from being an importer of wheat to harvesting a surplus of wheat within a few decades after World War II. India's increased wheat output helped curb hunger in South Asia. The Green Revolution was also successful in Latin America, East Asia, and Southeast Asia.

The worldwide result of the Green Revolution was higher yields on the same amount of land. Despite rapid population growth in many regions during the mid- to late 20th century, the increased crop output helped to stave off hunger and famine. By the second decade of the 21st century, the World Bank estimated

that 80 percent of the developing world's population had an adequate diet. The UN Food and Agriculture Organization (FAO) in Rome, Italy, reported the following yield increases from 1960 to 2000:

- wheat: 208%
- corn: 157%
- rice: 109%
- potatoes: 78%

Money for Research and Business

The Green Revolution helped to create high rates of investment in both the public and private sectors. Research for seed hybridization, fertilizer, and pesticides was funded by governments and universities in developed countries, led by the United States. This research was then used by for-profit corporations to create and market the products farmers used. While the Green Revolution benefited people in poor regions, it also financially benefited universities and corporations in more prosperous regions.

Food Prices

Higher yields and increased production led to falling real food prices, or prices adjusted for inflation. The supply of certain crops, mainly wheat, corn, and rice, grew through the mid- to late 20th century and led to lower prices. More food at affordable prices helped to ease the economic stress of hunger and famine on governments and economic systems in the developing world. However, starting in 2005, global food prices began to rise which triggered large-scale protests in many countries and increased concerns about food insecurity. (See Topic 5.11.)

Negative Consequences of the Green Revolution

Like all large and rapid changes, the Green Revolution had some negative consequences. Some of these were environmental damages, gender inequalities, economic obstacles, and failures in Africa.

Much of the success of the Green Revolution hinged on human-manufactured products such as hybrid seeds, chemical fertilizers, pesticides, and fossil-fuel using equipment. While crop yields increased, they often did so at the expense of the natural environment. The intensive use of land and double or triple cropping, combined with more aggressive irrigation, led to soil erosion and increased environmental pollution. Critics of the Green Revolution argued that it was not a sustainable system.

Farming practices during the Green Revolution increasingly drained the soil of its natural nutrients, which led to more use of and dependecny on human-made fertilizers. The introduction of these chemicals to the environment resulted in potentially hazardous runoff into streams, rivers, and lakes, which posed serious consequences to the local ecosystems, habitats, and communities. Hazards included polluted drinking water, species extinction, and health issues for the population.

The transfer of technology from developed countries to developing countries included machinery such as tractors, tillers, and harvesters. These new technologies required vast amounts of fossil fuels, which increased air, water, and sound pollution. In order for the Green Revolution to succeed, it needed mechanization to keep up with crop production, thus resulting in further environmental stress.

The Green Revolution's Impact on Gender Roles

Many countries in the developing world that participated in the Green Revolution had traditional economies. In a traditional economy, subsistence farming is the cornerstone of economic activity. Even though much of the farming labor is performed by women, men usually dominate socially, politically, and economically based on many societies' traditional beliefs.

When the Green Revolution and its technologies were introduced to these countries, it was often men who benefited and were given decision-making powers. Men owned the land, had access to financial resources, and were educated on newer methods of farming, while women were often excluded from these opportunities. This further marginalized women and limited their role within many societies. (See Topic 5.12 for more about women and agriculture.)

Economic Changes

The initial successes of the Green Revolution were a mixture of private and public investments. The transfer of farming technology heavily relied on private investment by corporations and public support by governments. As the amount of research and production increased, so too did the cost. Machinery, seeds, fertilizers, and pesticides became more expensive and the cost was passed on to farmers in the developing world and the organizations that supported them. As profit margins decreased, many corporations began to curtail further investments in the Green Revolution. Without a clear financial incentive, the motivation to invest waned.

In addition, the labor markets of less-developed countries changed. As with the Second Agricultural Revolution, the Green Revolution allowed, or pushed, people from rural areas to move to urban areas in search of industrial and service sector jobs. Demographers predict that migration from rural to urban areas in the developing world will continue. In the future, the percentage of people living in cities will continue to increase.

People in the developing world had unequal access to Green Revolution technology. Income, accessibility, and government policies played a role in which people and regions of a country had access to or could afford the technologies. The wealthy and transportation-connected core areas have advantages over the outlying, isolated, and poor periphery areas of a country, and resulted in uneven development.

The Green Revolution's Struggles in Africa

Unlike Latin America and Asia, Africa benefited very little from successes of the Green Revolution. The reasons the Green Revolution failed throughout the continent of Africa are environmental, economic, and cultural.

- Africa has a greater diversity of climate and soils than other places. Hence, development of the right fertilizers proved to be very expensive.
- Africa has many regions with harsh environmental conditions. Insects, plants, and viral strains proved to be extremely challenging to the Green Revolution researchers and their technology.
- Africa is large and lacks a well-developed transportation infrastructure, so the costs of investment in research, development, and transportation were very high.
- Africa's staple crops such as sorghum, millet, cassava, yams, cowpeas, and peanuts were not always included in research for seed-hybridization programs.

During the Green Revolution, the world's population more than doubled. Most of this growth was in poor countries on the periphery of the global economy. From the mid-20th into the 21st centuries, Africa had the highest population growth rate of any continent. Since that is where the Green Revolution had the least impact, hunger remains a greater problem there than elsewhere. Today, nearly 30 percent of Africa's population has been affected by food insecurity.

In response to the ongoing food problems in Africa, private foundations and governments are working together. They hope to develop a new Green Revolution there, using updated technology.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are the consequences of the Green Revolution on food supply and the environment in the developing world?*

Green Revolution's Consequences on Food Supply	Green Revolution's Consequences on the Environment

KEY TERMS

Third Agricultural Revolution
Green Revolution
hybridization
genetically modified organism (GMO)

GEOGRAPHIC PERSPECTIVES: *AGRICULTURAL POLLUTION*

Dr. Norman Borlaug contributed to the advancement of humanity by researching and developing methods to expand the food supply, thereby reducing the possibility of famine around the world. His work, and the subsequent Green Revolution, had many positive impacts on the world, but there are also negative consequences.

The Food and Agricultural Organization (FAO), a specialized agency of the United Nations, believes that providing safe drinking water to people is among its most important functions. Because the Green Revolution occurred as rapidly as it did, it had the unintended consequence of pollution. Agricultural pollution can be defined as contamination of the environment because of the process of farming or raising livestock. One of the most obvious and critical concerns related to agricultural pollution is the contamination of the water supply by chemical pesticides and fertilizers.

The FAO believes that population growth has put undue pressures on countries to produce enough food that, in some cases, regulatory short cuts have been taken in order to achieve food production needs. Chemical contamination of surface and ground water not only endangers the marine life in the water, but also potentially pollutes the supply of drinking water for people. Contaminated water can cause immediate illnesses or long-term diseases, such as cancer or birth defects.

Another concern of the FAO is that surface water can be contaminated because of industrial waste or poor water treatment processes. If surface water reservoirs are used to help irrigate farmland, and there are pollutants in those sources of water, disease can spread from the water supply to the crops, and in some cases, even to the agricultural workers themselves.

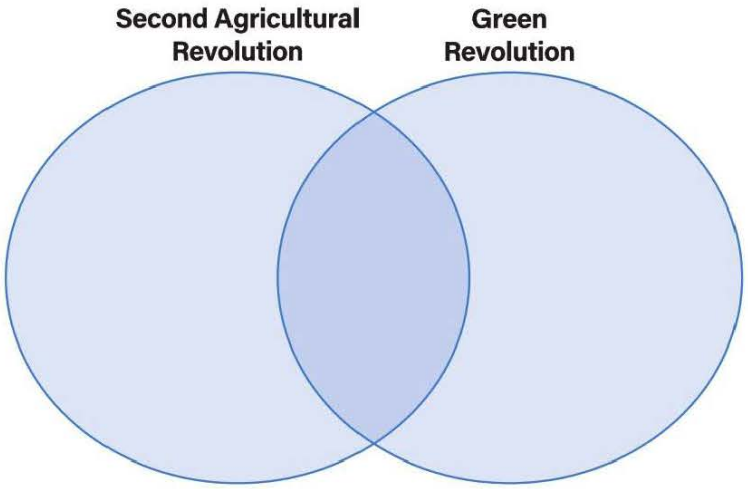
Human beings continue to try to understand the implications, both positive and negative, of their policies and actions regarding agriculture. Agricultural pollution was an unintended consequence of the Green Revolution and remains a concern in the 21st century.

1. What is the FAO's concern about water use and agriculture?
2. Describe two unintended negative consequences of the Green Revolution.
3. Explain the danger of water pollution to people and the environment.

THINK AS A GEOGRAPHER: *COMPARE THE SECOND AGRICULTURAL REVOLUTION TO THE GREEN REVOLUTION*

Understanding how to compare two ideas, concepts, images, or sets of data is critical for geographers. The skill of comparing requires looking for both similarities and differences. Similarities are things the two concepts have in common, while differences are what make each concept unique. When making a comparison, geographers must take into account that the experiences in one country or region may be different than another and even the experiences of people in the same community can be different. Looking for and describing these subtle distinctions with precision is an important skill for geographers to master.

1. On your own paper, create a Venn diagram like the one below. List characteristics that are individual to the Second Agricultural Revolution and the Green Revolution in the outside portion of each circle. List similarities shared by both revolutions in the center of the circles, where they overlap.
2. After you complete your list, circle or highlight those which you consider the most important similarities and differences.
3. Deepen your comparison. Using your most important similarity and difference, find facts, data, details, or examples to support your answers.
4. Explain how your answers could change if you use different regions, countries, or communities of the world to support your answers.



CHAPTER 12 REVIEW:
The Second and Third Agricultural Revolutions

Topics 5.4–5.5

MULTIPLE-CHOICE QUESTIONS

1. Which of the following is NOT considered to be a negative consequence of the Green Revolution?

(A) Air pollution from farm equipment that use fossil fuels increased.

(B) Overfertilization resulted in soil pollution.

(C) Gender income inequality worsened as women were frequently not allowed to operate or own farm equipment.

(D) Family farms disappeared because they could not compete with the corporate farms and the increased costs of farming.

(E) Agricultural yields increased and food prices dropped until 2005.

2. Which statement best explains a result of crop rotation?

(A) Maintains soil fertility by restoring nutrients

(B) Increases reliance on synthetic fertilizers

(C) Extracts nitrogen making fields more fertile

(D) Increases the need to mechanize farms and develop new seeds

(E) Increases migration of people to cities in search of jobs

3. Though the research and scientific discovery that fueled the Green Revolution occurred mostly in the United States, which of the following regions benefited the most from the Green Revolution?

(A) Western Europe

(B) Russia

(C) South Asia

(D) Sub-Saharan Africa

(E) North America

4. The greatest impact of the Second Agricultural Revolution was

(A) an increase in farm jobs

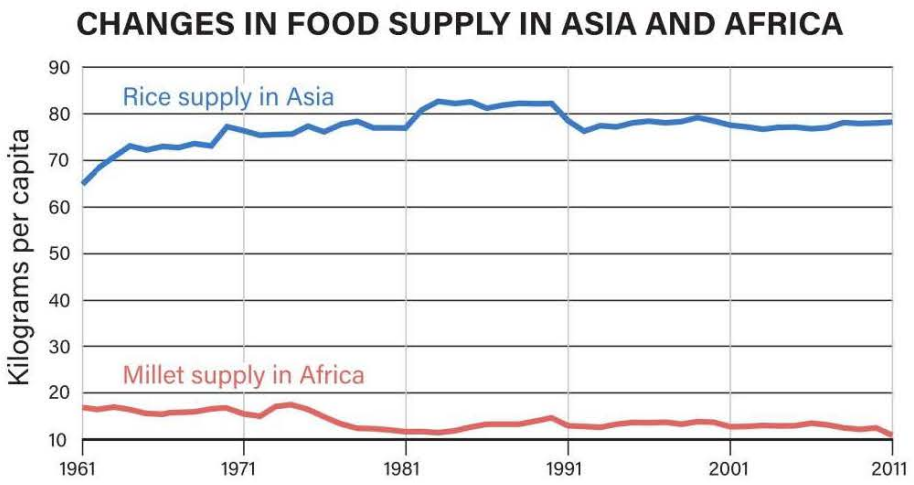
(B) an increase in available food supplies

(C) an increase in global conflicts over control of natural resources

(D) a decrease in life expectancy

(E) a decrease in factory jobs

Question 5 refers to the following graph.



Source: Food and Agricultural Organization

5. Which statement about 1961 to 2011 is best supported by the graph?

(A) Food security improved in both Asia and Africa.

(B) Green Revolution techniques worked better in Asia than in Africa.

(C) Population growth was higher in Africa than in Asia.

(D) Green Revolution techniques worked well in both regions but slowed down dramatically.

(E) Millet and rice are not very important food sources for either region, indicating that a conclusion about food security is invalid.

6. Which is a characteristic of the Second Agricultural Revolution?

(A) Domestication of wheat and rice

(B) Increased mechanization of farming

(C) Increased number of woman farmers as compared to men

(D) Rapid development of genetically modified crops (GMO)

(E) Higher percentage of farming jobs in a country's economy

7. Which of the following is most accurate about agriculture today?

(A) Agricultural resources are equally distributed among developed and developing countries.

(B) A higher percentage of the population is works in agriculture than the 1800's.

(C) Productivity of land is increasing as are concerns about sustainability.

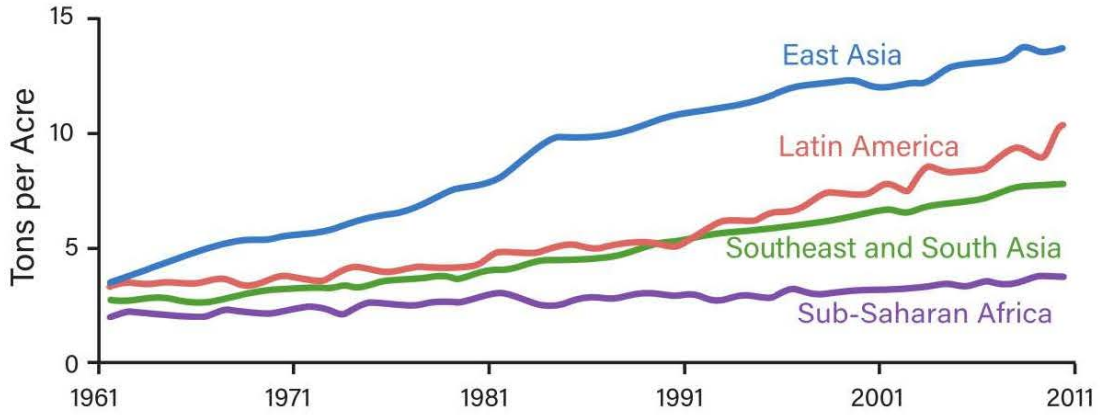
(D) Less land is used for farming and productivity is declining.

(E) A much smaller percentage of women are involved in farming compared to the 1900s.

FREE-RESPONSE QUESTION

1. The Second Agricultural Revolution (mid-1800s and early 1900s) benefitted mostly developed countries. The Green Revolution (1961 to 2011) dramatically changed agriculture in developing countries.

INCREASE IN GRAIN PRODUCTION BY REGION



Source: "World Development Report 2013: Jobs," World Bank, 2013.

(A) Using the graph, identify the region that had the largest increase in grain production between 1961 and 2011.

(B) Explain ONE environmental reason why Sub-Saharan Africa's grain production did not increase as much as other regions.

(C) Explain ONE economic reason why Sub-Saharan Africa's grain production did not increase as much as other regions.

(D) Describe ONE technological change that occurred in agriculture as a result of the Green Revolution.

(E) Describe ONE technological change that occurred in agriculture as a result of the Second Agricultural Revolution.

(F) Compare ONE demographic impact that occurred as a result of the Second Agricultural and Green Revolutions.

(G) Describe ONE environmental impact of the Second Agricultural Revolution.

CHAPTER 13

Spatial Arrangement of Agriculture

Topics 5.6–5.9

Topic 5.6 Agricultural Production Regions

Learning Objective: Explain how economic forces influence agricultural practices. (PSO-5.C)

Topic 5.7 Spatial Organization of Agriculture

Learning Objective: Explain how economic forces influence agricultural practices. (PSO-5.C)

Topic 5.8 Von Thünen Model

Learning Objective: Describe how the von Thünen model is used to explain patterns of agricultural production at various scales. (PSO-5.D)

Topic 5.9 The Global System of Agriculture

Learning Objective: Explain the interdependence among regions of agricultural production and consumption. (PSO-5.E)

Without agriculture it is not possible to have a city, stock market, banks, university, church, or army. Agriculture is the foundation of civilization and any stable economy.

—Allan Savory, biologist and farmer, Zimbabwe

Source: Getty Images

High-density cattle feedlots often contain a mill to produce feed which increases the efficiency of beef production. (See Topic 5.6 for how feedlots and other agricultural practices are shaped by economic factors.)

5.6

Agricultural Production Regions

Essential Question: How do economic forces influence agricultural practices?

Residents of every continent, except Antarctica, practice agriculture. There are differences in agricultural practices in various regions of the world, and even within individual continents. These differences include the crops or animals raised, level of technology, methods for production, percentage of the population working in agriculture, importance of agriculture to the economy, and gender roles in farming. These variables are important considerations in farmers' decisions about agricultural practices and land use.

Influence of Economic Forces

Among the many factors that influence farmers' decisions are available capital and the relative costs of land and labor. Because of these different costs, farmers balance the use of their resources differently. If land is plentiful and costs little, they use it extensively. If land is scarce and expensive, they use it intensely. In reality, not every farm fits perfectly into one of these two categories.

Geographers often refer to the **bid-rent theory** when discussing land costs for different types of agricultural activities. There is usually a distance-decay relationship between proximity to the urban market and the value of the land, meaning the closer the land is to an urban center, the more valuable it is. The farmer willing to pay the highest price will gain possession of the land. Consequently, the farmer must use intensive agricultural practices to turn a profit on the land closest to market. (See Topic 5.8 for more about bid-rent and von Thünen's model.)

Intensive land-use agriculture involves greater inputs of capital and paid labor relative to the space used. (See Topic 5.1 for more on intensive agriculture.) Intensive practices are used in various regions and conditions:

- Paddy rice farming in South Asia, Southeast Asia, and East Asia is very labor intensive. Commonly used terraced fields makes using machinery difficult.
- Truck farming in California, Texas, Florida, and near large cities is sometimes **capital intensive** because it uses expensive machinery and other inputs. In addition to being capital intensive, it is nearly always **labor intensive**. These large farms produce very large quantities of vegetables and fruit, often relying on many low-paid migrant workers, to tend and harvest crops.

- **Factory farming** is a capital-intensive livestock operation in which many animals are kept in close quarters, and bred and fed in a controlled environment. The term comes from these operations running like a factory. Instead of cars or computers moving along an assembly line, it is the animals that progress from one end of the "factory" to the other end, where they are eventually processed into meat products.
- **Aquaculture (aquafarming)** is a type of intensive farming. Rather than raising typical farm animals in close quarters with a controlled environment, fish, shellfish, or water plants are raised in netted areas in the sea, tanks, or other bodies of water. (See Topic 5.11.)

Extensive land-use agriculture uses fewer inputs of capital and paid labor relative to the amount of space used. Extensive practices, such as shifting cultivation, nomadic herding, and ranching (see Topic 5.1) can be found throughout the world and across the entire spectrum of economic development.

Increasing Intensity

Regions of the world that traditionally relied on extensive agricultural techniques are under pressure because of local increases in demand for food, regional population growth, and global competition to use land more intensely. These demographic and economic forces have placed more stress on the land because they have pushed farmers to use land continuously, rather than allowing land to lie fallow and recover. This shift increases demand for expensive inputs such as irrigation, chemicals fertilizers, and improved seeds.

Those who rely on shifting cultivation have found it more difficult to continue these methods as global demand for tropical cash crops, such as coffee, tea, and cacao, compete for more land use. The timber industry has also put an economic strain on shifting cultivation. For subsistence farmers, increasing population and competition—for space to grow timber, rubber, cotton, or products that are not eaten but used in industry—have resulted in food security issues, most noticeably in Africa.

Methods of Planting

Different methods of planting increase the intensity of land use. **Double** (or triple) **cropping** is planting and harvesting a crop two (or three) times per year on the same piece of land**.** Another technique, **intercropping**, also known as **multicropping**, is when farmers grow two or more crops simultaneously on the same field. For example, a farmer might plant a legume crop alongside a cereal crop to add nitrogen to the soil and guard against soil erosion.

The opposite of multicropping is **monoculture**, in which only one crop is grown or one type of animal is raised per season on a piece of land. **Monocropping,** or continuous monoculture, is only growing one type of crop or raising one type of animal year after year. As a result, these farmers purchase very specific equipment, irrigation systems, fertilizers, and pesticides designed for their one crop or animal to maximize efficiency.

Large scale monocropping farms can be thousands of acres of just wheat, corn, rice, coffee, cacao, etc. This can result in lower per-unit cost of production, higher yields, and more profits. Negative impacts include soil depletion, decreased yields over time, increased reliance on chemical fertilizers and pesticides, and increased risk since all of the farmer's resources are invested in one crop.

The Meat Industry

The economic structure of livestock raising has changed in the past few decades. Global consumption of meat increased over 50 percent between 1998 and 2018, mostly because of population growth. Growing demand accelerated the trend toward factory farms and centralized processing centers.

Today, cattle are less likely to graze on large expanses of land, but instead are raised in **feedlots**, which are confined spaces in which cattle and hogs have limited movement, also known as concentrated animal feeding operations (CAFOs). The animals grow bigger in a shorter period of time because of their reduced movement. This new practice maximizes the use of space and prepares the animal for slaughter quickly, thus maximizing profit.

The global expansion of fast-food operations and the increased demand for meat has led to larger ranching operations in the United States and South America. In the United States, the competition for space, desire for larger animals, and reduced raising time have led to an increased use of feedlots.

Some agricultural products combine extensive and intensive phases. Raising cattle in Wyoming is an example of extensive farming. The cattle roam and feed on grass in large ranches that average nearly six square miles in size. As the cattle reach maturity, the intensive phase begins. Farmers transport the cattle to feedlots in northern Colorado to fatten the animals quickly before being processed into meat for market.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *How do economic forces influence agricultural practices?*

Economic Factor	Influence of Economic Factor

KEY TERMS

bid-rent theory
capital intensive
labor intensive
factory farming
aquaculture (aquafarming)
double cropping
intercropping (multicropping)
monoculture
monocropping
feedlots

5.7

Spatial Organization of Agriculture

Essential Question: How do economic forces influence agricultural practices?

A number of agricultural trends have changed the agricultural landscape over the past several decades. The most obvious changes involve the decline in small family farms, the development of much larger corporate farms, and the expansion of farmland into what was previously forested or wetland areas. The agricultural landscape has also been altered by the reduction in the variety of crops and the introduction of new crops to a region. Reasons for the evolving agricultural landscape are the growth of **agribusiness**, farms run as corporations, and the globalization of agriculture.

Commercial Agriculture and Agribusiness

Agribusiness involves the integration of various steps of production in the food-processing industry such as research and development, processing and production, transportation, marketing, and retail of agricultural goods. Given the enormity of this system, the largest agribusinesses are owned by **transnational corporations,** or those that operate in many countries. These large-scale operations are commercial, highly mechanized, and often use chemicals and biotechnology in raising crops and animals. The following chart compares farming at the scale of a homeowner and an agribusiness.

VEGETABLE FARMING ON TWO SCALES

Activity	Homeowner Scale	Agribusiness Scale
Growing food	Raising vegetables in a backyard garden	Owning farms of thousands of acres that are worked by a large staff of employees
Processing food	Eating fresh, home-grown vegetables for dinner and preserving vegetables for future use	Canning and freezing products in factories that are often located near the fields
Selling food	Selling vegetables at a local market	Selling products to wholesale distributors who ship them regionally and globally
Financing the food industry	Giving some vegetables to a neighbor in exchange for using some of their land for a garden	Borrowing money from banks and selling stock to raise money for operating expenses
Researching food options	Growing different varieties of tomatoes to see which grow best	Investing in research and development of new seeds, fertilizers, and pesticides

Impact of Large-Scale Farms

Globalization has accelerated the growth of agribusiness and corporate farms during the latter half of the 20th century. Competition in agricultural products and services encouraged large-scale farms to operate more as a corporation than a family farm. Agribusinesses have often resulted from the consolidation of family farms, thus eliminating many small-scale farm operations. Many of the remaining family-owned farms have shifted to a corporate operating model.

Often, large corporate farms practice **vertical integration**, or the ownership of other businesses involved in the steps of producing a a particular good. Owning the contributing businesses gives the large farm more control of the variables and results in greater overall profits. Those businesses might include a research and development company that improves seeds, a trucking firm that transports farm products, a factory that processes the goods, and a wholesaler that distributes the food to stores.

Large-Scale Replacing Small-Scale Farms

Large-scale farms are usually specialized and practice monoculture. As farms become larger, more specialized, and vertically integrated, it becomes easier to take advantage of **economies of scale**, or an increase in efficiency to lower the per-unit production cost, resulting in greater profits. For example, consider a grain farmer who increases the size of his or her farm by purchasing an additional quarter section (160 acres). By using the existing machinery on the farm more efficiently, the farmer can successfully plant and harvest the additional acreage without the purchase of new equipment. This will increase the owner's revenues while the expenses will not increase proportionally. As a result, the cost per unit of grain will decrease and profits will increase.

Larger farms can afford the latest technology, such as better seeds or machinery, and are more likely to produce greater profits through economies of scale. Large corporate farms have made it increasingly difficult for family farms to survive since they cannot compete with the significantly cheaper costs per-unit production of large-scale farming operations.

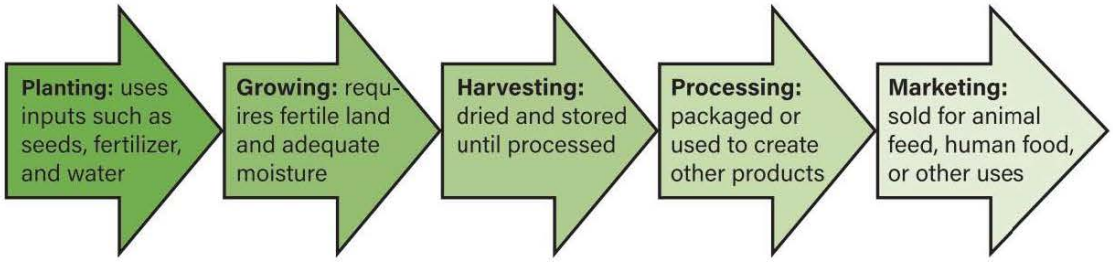
The success and efficiency of large farms has encouraged the World Bank to fund agribusiness ventures in the developing world, often at the expense of family and subsistence farmers. Also, many family farms in the periphery have disappeared because of the rising expenses associated with Green Revolution technology and the need to adopt this technology to survive and compete in an increasingly global market.

Commodity Chains and Consumption

The transformation of agriculture has resulted in a complex system that connected producers and consumers at a global scale. This complex and enormous system enabled someone who lives in a small American town to consume bananas from Ecuador, coffee from Ethiopia, chocolate from Switzerland, and cashews from Vietnam. This transformation may be attributed to advancements in biotechnology, mechanization, transportation, and food preservation.

A **commodity chain** is a process used by corporations to gather resources, transform them into goods, and then transport them to consumers.

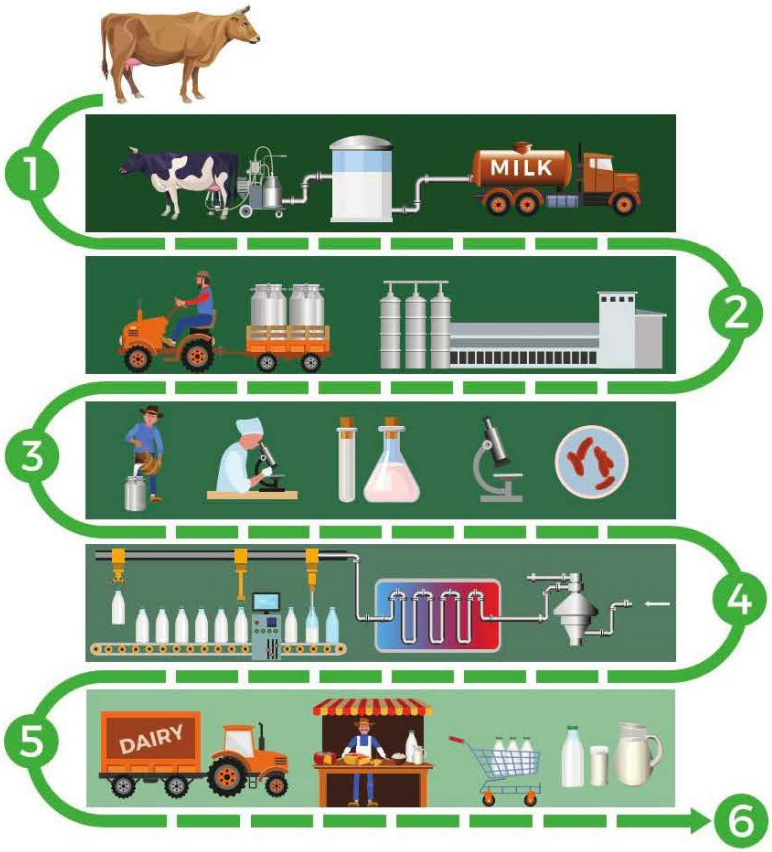
COMMODITY CHAIN FOR CORN



Improvements in agricultural technology, advances in transportation, and an increasingly globalized economy enables farmers to raise crops and animals far from their final market and allows consumers to still purchase the final products at low prices. Corn has numerous uses, such as livestock feed, sweetener, or fuel. Thus, the actual commodity chain of corn would be more specialized and complex than the one shown.

Additional elements of commodity chains that facilitate the process include financial institutions (banks), transportation companies, distributors, and governments. Each plays a key role in getting food from field to store. A detailed commodity chain shows the elements for milk production below.

COMMODITY CHAIN FOR MILK PRODUCTION



Source: Getty Images

Identify the six steps in the milk commodity chain.

Technological Improvements

The number of people that U.S. farmers can support given the available resources, or the **carrying capacity**, has risen tremendously over the past half century. In 1962, an average U.S. farmer fed an average of 26 people. Today, mostly due to technological advances, that figure has risen to 166 people. Farmers in the United States provide enough food to supply the needs of the nation, as well as many people in other parts of the world. Of course, there are other resources that are also necessary for life, such as clean air, water, and fuel.

Benefits Improvement in food production is attributed to technological advancements of the Second and Third Agricultural Revolutions. (See Topics 5.4 and 5.5.) Improvements in the quality and the use of fertilizers, pesticides, insecticides, herbicides, irrigation, soil management, and farming equipment have all resulted in higher yields. A deeper understanding of the science of plants and animals has led to efficient selective breeding programs, hybrid seeds developed through the Green Revolution, and genetically modified organisms (GMOs) created through biotechnology. These developments have had a tremendous impact on the agricultural output of farmers.

Transportation and storage advances have allowed for the more extensive use of **cool chains**, which are transportation networks that keep food cool throughout a trip. Fruits and vegetables from the tropics can be delivered fresh to the temperate climates of North America and Europe at relatively low prices for consumers.

Costs Technological advancements have created some environmental damage. The loss of wetlands and large tracts of rainforest cleared to increase farmable land have led to the loss of biodiversity and water resources. Petroleum-based fertilizers, pesticides, and herbicides have caused soil, water, and air pollution and threatened ecosystems. (See Topics 5.10 and 5.11 for more about environmental challenges due to agricultural practices.)

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *How do economic forces influence agricultural practices?*

Large-Scale Agricultural Practices	Impact of Practices

KEY TERMS

agribusiness
transnational corporations
vertical integration
economies of scale
commodity chain
carrying capacity
cool chains

5.8

Von Thünen Model

Essential Question: How is the von Thünen model used to explain patterns of agricultural production at various scales?

It is interesting that an almost 200-year-old economic location model, the von Thünen model, is still considered essential by geographers to explain the spatial pattern of agricultural land use. Over the past two centuries there have been many changes to agriculture, as well as transportation, a key component of von Thünen's model, yet it is still used by geographers today.

Location theory, a key component of economic geography, deals with why people choose certain locations for various types of economic activity—factories, stores, restaurants, or agriculture. The **von Thünen model**, an economic model that suggested a pattern for the types of products that farmers would produce at different positions relative to the market (community) where they sold their goods, is the start of location theory. Since his original work, numerous other geographers have built on his ideas and developed their own location theories and models.

Von Thünen's Land Use Model Zones

In 1826, Johann von Thünen, a farm owner in Germany, based his rural land use model, sometimes referred to as the Isolated State model, on numerous assumptions:

- farming was an economic activity
- farmers were in business to make a profit
- there was one market where farmers sold their products
- there was one transportation system
- farmers paid transportation costs, which varied with distance
- the market was situated in the center of an **isotropic plain**, which means flat and featureless with similar fertility and climate throughout
- the area beyond the market and farmland (the Isolated State) was wilderness

The von Thünen model is based on the concept that farmers' decisions regarding what to produce were based largely upon four factors: transportation costs, land costs, intensity of land use, and perishability of the product. Distance from the market impacts the cost of transportation and land. In essence, the land closest to the market is the most valuable and the land farther away decreases in value. Farmers will use land closer to the market more intensely

because it is more valuable. The farther goods are transported, the higher the cost. Perishability relates to how well a product can survive transport without spoiling or breaking.

Zones and the Von Thünen Model

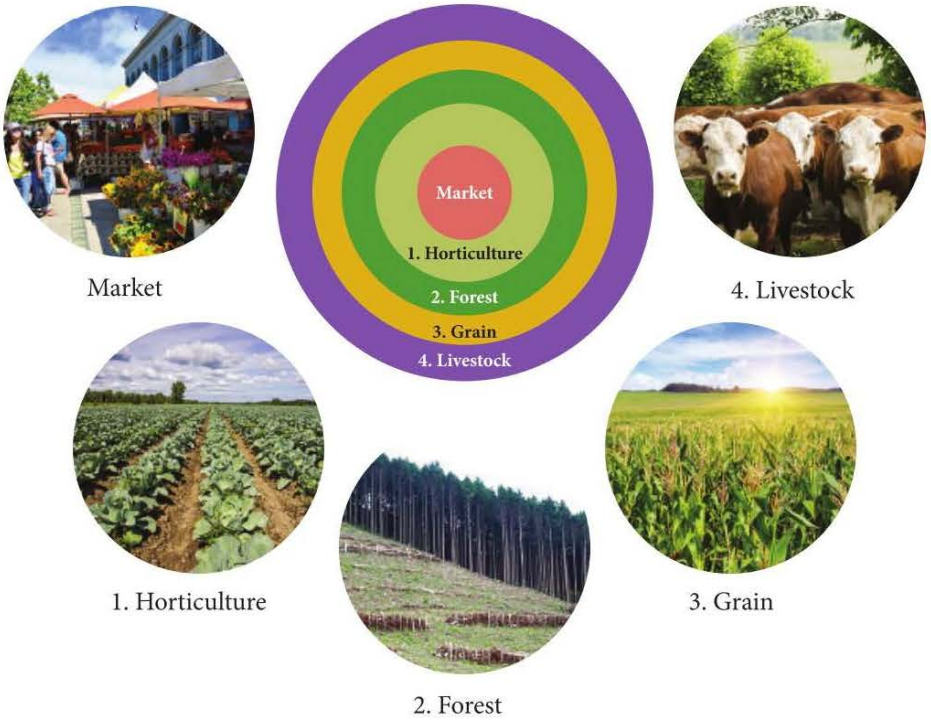
In the zone closest to the market, von Thünen suggested that **horticulture**, a type of agriculture that includes market gardening/truck farming and dairy farming, would occur. Horticulture produces perishable items, and farmers need to get them to market quickly, especially important before trucks and refrigeration. Growing highly perishable crops, such as tomatoes and strawberries, and dairy farming are considered to be intensive forms of agriculture.

Von Thünen's second zone included forests. Wood was an extremely important resource in 1826, both as building material and as a source of fuel. Von Thünen thought that wood products would be close to the market because they were not only important but heavy, costly, and difficult to transport.

Farther from the market, in the third ring, were crops such as wheat and corn. Though valuable, they did not perish as quickly as vegetables and milk and were not as difficult to transport as wood. In addition, corn can be used to feed live stock located in the second and fourth rings.

The final ring was used for grazing of livestock, such as beef cattle. Livestock could be located farther from the market since they have lower transportation costs because farmers can walk them to market.

The extensive nature of grain and livestock farming meant that the farms were larger than those located in the inner ring of the model. While there is more farmland available in the larger outer rings, that was not necessarily the reason for these crops to be located there. Grain and livestock farmers could find adequate space in the innermost ring if they were willing to pay enough to acquire the land.



Land Value

The value of land was influenced by its spatial relationship to the market. Because the land in the inner ring was closest to the market, it was more valuable. Therefore, few farmers could afford large amounts of it. Consequently, only farmers who could use a small amount of land intensely and make a profit from it could be successful in the inner ring. They needed to grow high-value crops there, such as fruits and vegetables, in order to make a living.

Grain and Livestock Land farther from the market was less valuable. Because grain and livestock are less perishable than the crops in the inner ring, the farmers could locate in the area of cheaper land farther from the market and still transport the product to market successfully. Meat is perishable after it is processed, so farmers could avoid spoilage if they walked their livestock to market and had them slaughtered there. This was the common practice when von Thünen developed his model two centuries ago.

Wheat Farms in North Dakota Recent studies have shown that the distance to the market still greatly influences land prices, even for farmers who raise the same crop. One example from the 21st century is value of land for North Dakota wheat farmers. For them, the market is often the nearest grain elevator. The elevator owner purchases the grain from many farmers and then resells it to companies in the food processing business. In one study reported by the United States Department of Agriculture, land within 5 miles of a grain elevator was worth double the amount of land approximately 25 miles away. That disparity in land value grew even larger farther than 25 miles away from a grain elevator.

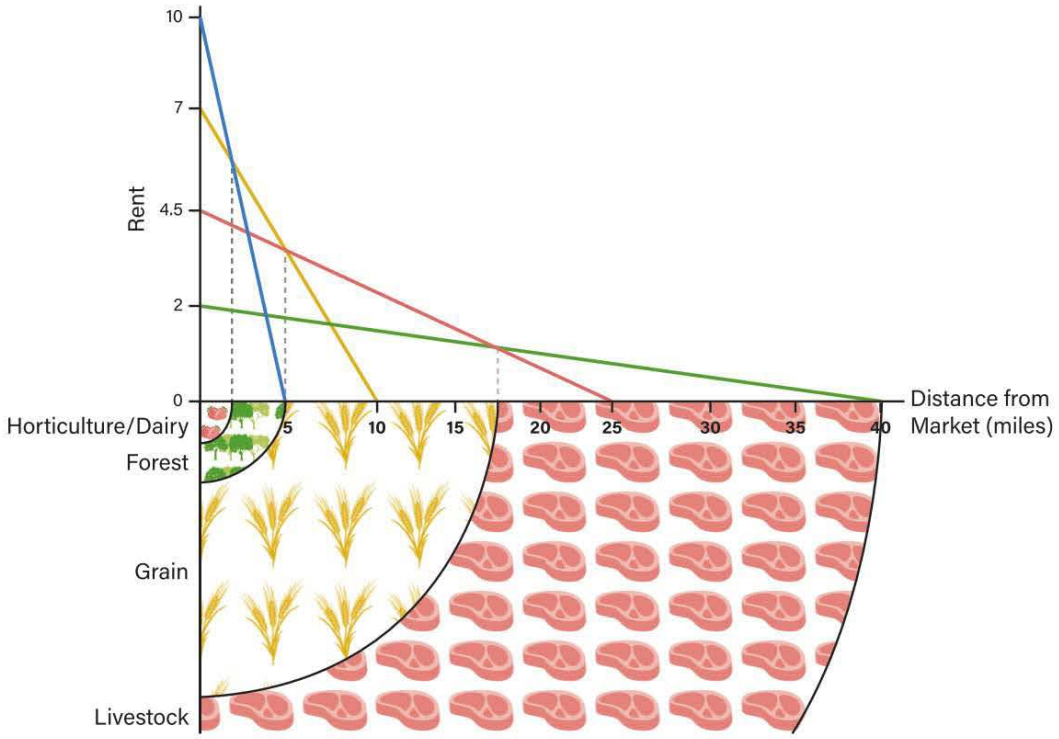
The Bid-Rent Curve

In the case of von Thünen's model, the bid-rent theory, which refers to the changing value and demand for land as the distance from the market increases, is used to determine what type of agriculture is located in each zone. A graph known as a **bid-price curve** or **bid-rent curve** can be used to determine the starting position for each land use relative to the market, as well as where each land use would end.

Each line on the graph reflects the farmers' willingness to pay for land at various distances from the market. Farmers are willing to pay more for land near the market than for land farther away. However, how much more varies with the types of activities. In a **free-market economy**—where supply and demand, not government policy, determine the outcome of competition for land—the farmer who will have the greatest profit will pay the most at each location to occupy the land. It is where the uppermost line on the graph intersects with the next uppermost line that represents the end of one zone and the start of another.

For example, where the strawberry line intersects the forest line indicates the end of where strawberries will be grown and the beginning of where forests will be found. Where the forest line intersects the wheat line indicates where the forest zone ends and the wheat zone begins.

BID-RENT CURVE AND VON THÜNEN'S MODEL



The bid-price curve is used to determine the borders of each land use. Determine the starting and ending distance for each of the four agricultural land uses shown in the graph.

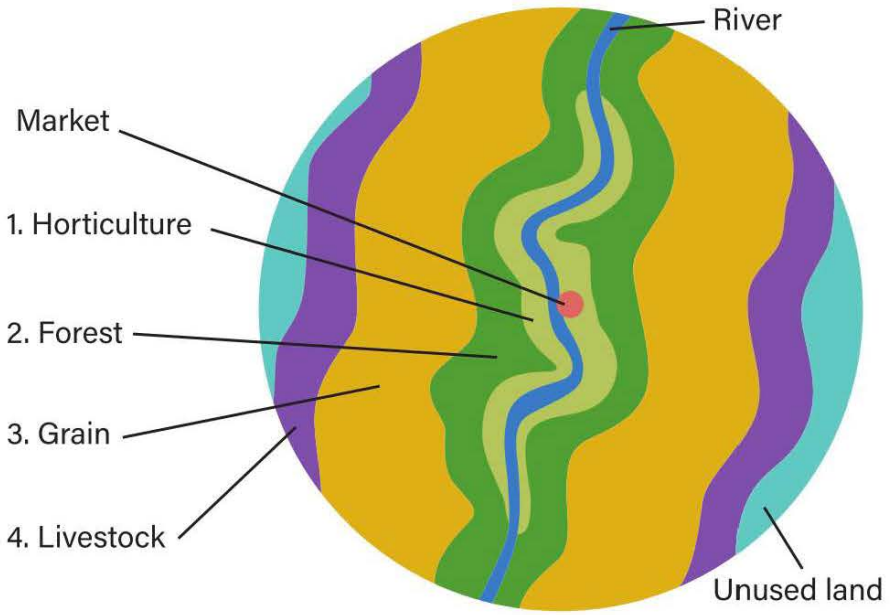
Application of Von Thünen's Model

Von Thünen's model has been valuable in many ways. It has had application far beyond the topic of agriculture. His recognition of the spatial pattern in how farmers made decisions about using resources was the first economic location model. It provided the basis for the industrial location models of Alfred Weber and others who followed.

In addition, even though von Thünen created his model nearly two centuries ago, it continues to be applicable today. The basic insight of the model is still valuable, but like all models, it needs to be adapted to actual conditions and changes in technology.

Non-Isotropic Plains Von Thünen's model assumed that land was an isotropic plain—but real land includes rivers, mountains, and other physical features that make it non-isotropic. Von Thünen considered how various landscape situations would alter the shape of each land-use ring and possible impacts on transportation. For example, if a river flowed through the plain, making transportation easier and cheaper, then the zones would stretch out along the river. In addition, some areas have better climates or soil conditions for certain crops. These areas have a **comparative advantage**, or naturally occurring beneficial conditions, that would prompt farmers to plant crops differently from those predicted by von Thünen's model.

AGRICULTURAL ZONES AROUND A RIVER



Multiple Markets Von Thünen assumed that a farmer had one primary market, but they often have secondary markets as well. A dairy farmer might primarily sell milk to a local dairy. But the farmer might also make and sell cheese, which does not spoil as quickly as milk, in a distant market.

Changes in Transportation The development of trains, cars, planes, and storage techniques, such as refrigeration, has allowed food to be transported much longer distances without spoiling compared to 1826. As a result, the rings in the model now are wider than originally created by von Thünen. For example, rapidly perishable goods, such as strawberries and milk, can be produced much farther away from the market than in von Thünen's time. Strawberries and milk are still produced closer to the market than are grains and livestock. It is the size of the rings that has changed, not necessarily the relative position of the rings.

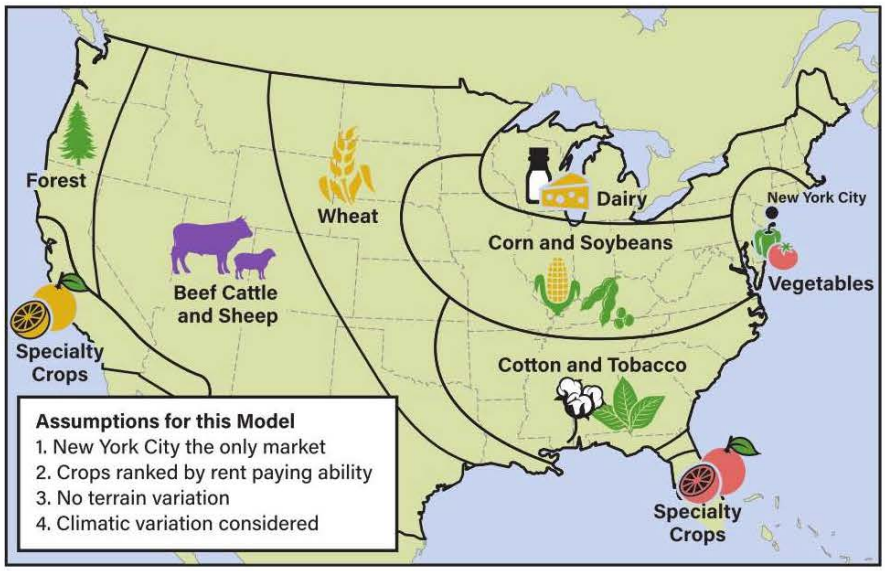
The cut flower market demonstrates the impact of transportation on the application of von Thünen's model. Cut flowers are very perishable and have to arrive at the market quickly, so they are similar to horticulture and dairy products that the model predicts will be produced nearby and trucked to market. However, many flowers sold in New York City are grown in the Caribbean and South America and flown to market. While air travel costs from these areas are far higher than truck transport from the outskirts of New York, other costs of flower production are much less. Land, labor, and energy costs are so much lower in the Caribbean and South America than in the outskirts of New York City that the savings outweigh the extra transportation costs. Therefore, producers can grow flowers for New York more profitably in the Caribbean than in nearby locations.

Other Changes in Technology Changes in technology have modified demand for products. Since 1826, wood has been mostly replaced by oil, natural gas, and electricity as fuel for heating homes, so forests as a source of fuel are not particulary important any longer. Forests were also important for producing lumber required for construction of homes and barns. Today, transport trucks can easily and efficiently bring the necessary lumber to the market from distant forests. As a result of both of these changes, forests are rarely located near communities today. Now, forested land at a city's edge is probably highly valued as a *greenbelt*, an area of recreational parks or other undeveloped land (see Topic 6.8), rather than a source of fuel or lumber.

Von Thünen Model at a National Scale

The improved transportation and storage methods have created changes in the use of the von Thünen model today. Since agricultural products are now transported much greater distances to markets, the model can be applied at a much larger scale than von Thünen allowed. The image below illustrates what the general pattern of agricultural land use in the continental United States would look like if the zones were positioned according to the farmer's rent-paying ability, as suggested by von Thünen. The model assumes that the New York City area is the market, and thus the rings radiate away from there. Also, the map recognizes that there are climatic variations across the country and therefore indicates some pockets of specialty crops as well as distorted rings.

AGRICULTURAL LAND USE IN THE UNITED STATES



What would be similarities between von Thünen's model and this agricultural land-use map for the United States? How might they differ?

Von Thünen's model was based upon southern Germany, a much smaller region than the United States. His assumption of an isotropic plain does not apply well to the diversity of physical features and climate of the United States. Also, von Thünen's assumption of a single market is true for virtually no farmers in the United States or anywhere in the world.

Special Circumstances No model accounts for every variation that occurs in practice. For example, von Thünen's model does not fit some areas of specialty farming, such as citrus farming in Florida or the variety of crops grown in the Central Valley of California. Nor does it explain the decisions by developers who speculatively purchase land close to a city and use it for less-intensive agriculture. These developers usually want to invest as little money as possible into the farmland while they wait for the optimal time to build homes, retail space, or commercial structures on it.

Criticisms of Von Thünen's Model

Many of the criticisms of the model involve the assumptions made by von Thünen.

VON THÜNEN MODEL	
Assumptions	**Limitations**
Farming was an economic activity	Government policies can interfere with a free-market economy and effect farmers' decisions.
Farmers were in business to make a profit	Simply to provide enough food for his or her family, not profit, is the goal for many farmers, especially in less-developed areas.
There was one market where farmers sold their products	Modern agriculture systems have multiple markets; rarely is just one market available.
There was one transportation system	Planes, trains, and trucks (especially modern refrigerated transportation) have changed distance considerations for farmers.
The market was situated in the center of an isotropic plain	Differences in land formation, soil fertility, and climate exist in agricultural regions, making isotropic plains uncommon

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *How is the von Thünen model used to explain patterns of agricultural production at various scales?*

Concepts of the von Thünen Model	Application of the Concepts

KEY TERMS

location theory
von Thünen model
isotropic plain
horticulture
bid-price curve (bid-rent curve)
free-market economy
comparative advantage

5.9

The Global System of Agriculture

Essential Question: How is there interdependence among regions of agricultural production and consumption?

Globalization has become a firmly entrenched aspect of the economy of most countries, particularly in food production. Part of this has been the spatial expansion of the **supply chains,** all the steps required to get a product or service to customers. The physical distance from producers to consumers can cover thousands of miles. For example, research and development of new seeds might take place in a laboratory in the United Kingdom. The new seeds could then be sent to Ghana where the crop is grown and harvested. After some minor processing or refining in Ghana the product could be frozen and transported to China where it is manufactured into a finished product. Once packaged, it could be sent to the United States where it is sold to consumers.

The level of interdependence, or connections among regions of the world, has increased greatly. If one country experiences a problem such as crop failure, damaged infrastructure, or disruptions in trade due to political decisions, the repercussions could be significant for many countries.

Regional Interdependence

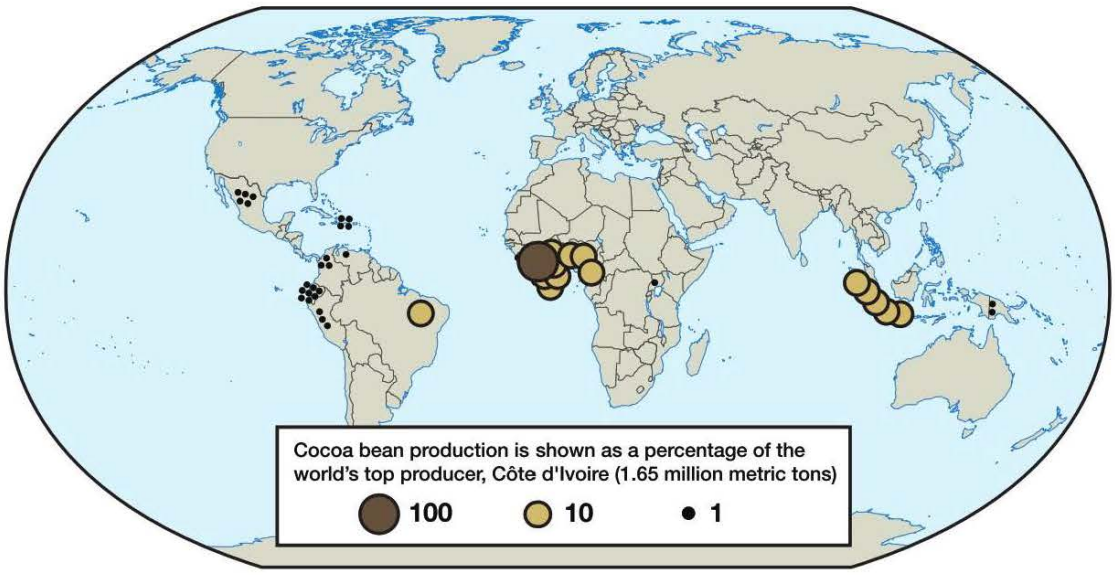
The globalization of agriculture has increased interdependence among countries of differing levels of development. Developed countries such as the United States rely on producers in Mexico, other countries with warm climates, and ones in the Southern Hemisphere, for fresh fruits and vegetables year-round.

Food on a Global Scale

Developed countries also sell food to around the world. For example, nearly half of U.S.-grown soybeans are exported. Purchasers of significant amounts of U.S. agricultural products include China, Mexico, and countries in Europe.

Low-latitude countries with tropical climates produce crops such as coffee, tea, bananas, and pineapples that are desired in core countries. **Luxury crops** are not essential to human survival but have a high profit margin. These crops including cocoa beans, which are eventually processed into chocolate, are often grown on large plantations commonly controlled by transnational companies. Plantations usually practice monoculture, specializing in only one crop. The transnational companies, which are usually controlled by shareholders in core countries, provide the capital necessary to develop and run the plantations. They take advantage of the opportunity for inexpensive land and labor, and a favorable climate. In some situations, they also take advantage of weak labor and environmental laws, which allow them to reduce costs and increase profits.

COCOA BEAN PRODUCTION, 2012



Source: Wikimedia Commons

As with most plantation agriculture of luxury items, cocoa is produced in the periphery but consumed primarily in the core.

For periphery and semiperiphery countries, the globalized commodity chain provides both markets for products and problems:

- Farmers who produce luxury crops might not be able to afford to purchase what they produce.
- As the supply of locally grown food decreases, prices for local consumers can increase. A farmer in Honduras who grows chili peppers for the global market is not growing corn, beans, or other foods for local consumers.
- Countries may become very dependent on one or two export commodities. When global markets shift these countries' economies become vulnerable and unstable.
- Competition to sell products might cause farmers to follow practices that cause soil erosion or chemical pollution, which endanger the long-term use of the land.

Political Systems, Infrastructure, and Trade

The efficient exchange of food around the world depends on effective political systems, strong infrastructure, and supportive trade policies. These conditions have evolved over time to make agricultural trade vital in most countries.

Colonialism and Neocolonialism Many connections that exist between Europe and the developing world were established through colonization. Although there are very few colonies in the world today, the economic relationship between core countries and periphery and semiperiphery countries resembles certain aspects of colonialism. **Neocolonialism**, the use of economic, political, and social pressures to control former colonies, can be one way to describe the current state of global food distribution.

For example, while growing and processing coffee beans is expensive, the profit margin in selling brewed coffee drinks is very high. Most of the revenue generated from coffee remains with the transnational corporation based in the wealthy country while very little revenue finds its way back to the coffee growers in developing countries.

The image shows a coffee plantation in Brazil. People who live in nearby villages provide the labor for the plantation.

Fair Trade In recent years, many consumers have become more aware of the disparity between the high incomes of those in developed countries, who manage trade, and the low incomes of the producers in the developing world. One result of this awareness is the **fair trade movement**, which started with the Fair Trade certificates for coffee in 1988. It is an effort to promote higher incomes for producers and more sustainable farming practices. Other fair trade agreements between retailers and producers have been reached for crops grown in the developing world, including bananas, cane sugar, cocoa, and cotton. While these agreements often increased the price for consumers slightly, they provided a bigger share of revenue to producers and growers.

To reduce poverty for farmers and workers in the periphery, the fair trade movement promoted numerous basic principles:

- Direct trade that will eliminate the intermediary. Transactions directly between the producer and the importer ensure more money to the producer.
- Fair price paid promptly to farmers by importers. Also, the producer must pay workers a fair price.
- Decent conditions are provided for laborers, such as a safe working environment and no use of child or forced labor.
- Environmental sustainability that required farmers to use environmentally safe practices and prohibited genetically modified organisms (GMOs).
- Respect for local culture through shared agricultural techniques with farmers.

The fair trade industry has made significant gains since 1988. More than 1.5 million farmers and workers participate in fair trade and their standard of living has improved, particularly for those in the coffee industry. However, the

movement faces the challenge that many consumers feel they cannot afford to pay higher prices for fair trade products.

Government Subsidies and Infrastructure Governments across the world often provide **subsidies**, or public financial support, to farmers to safeguard food production. Examples of directly subsidized crops include rice in Japan, wheat and corn in the United States, and soybeans in China. The subsidies are designed to achieve these goals the goevernment believes are in the best interest of the public:

- protect national security by ensuring a dependable food supply
- help farmers by increasing agricultural exports
- help consumers by reducing food costs

Transportation infrastructure is critical to move agricultural products locally, nationally, and globally. **Infrastructure** includes the roads, bridges, tunnels, ports, electrical grids, sewers, telecommunications, etc. of a country. Global systems of agriculture would not be possible without this infrastructure. Governments, communities, and companies pay to build and maintain a quality infrastructure.

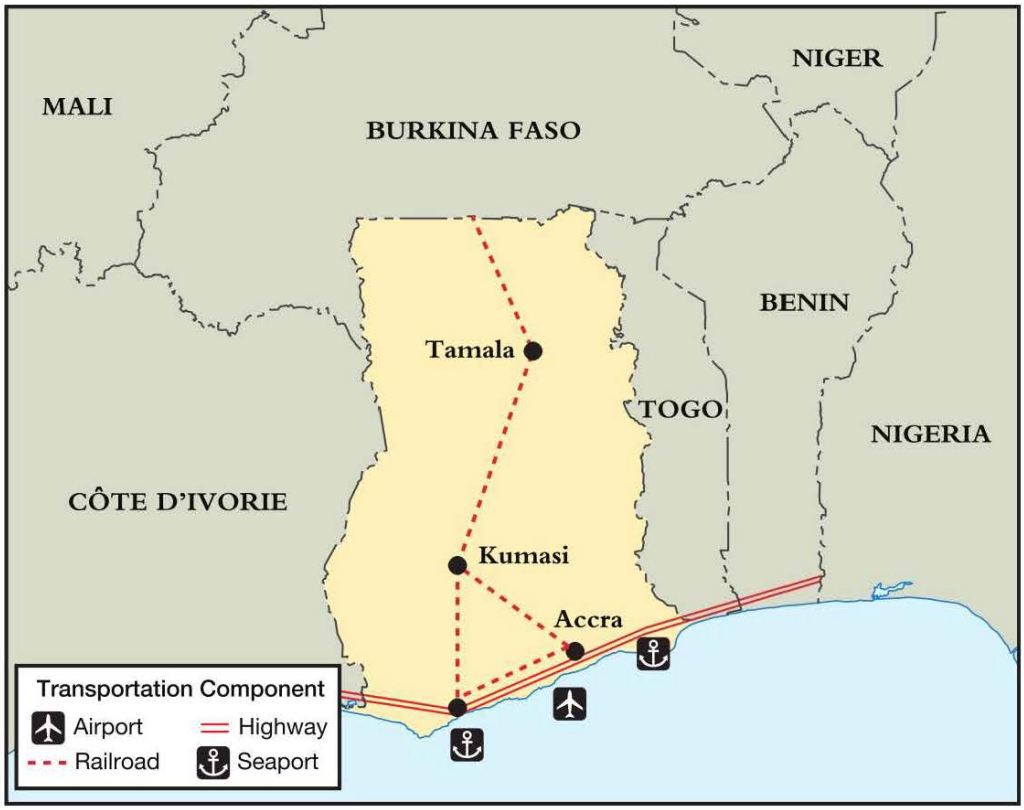
For example, the U.S. government indirectly subsidizes the exports of corn, soybeans, and other agricultural products from the Midwest by spending money to make the Mississippi River navigable for barge traffic. Because water transportation is inexpensive compared to land travel, these products enter the global food supply chain with a lower price than they would have without government support. Because of subsidies, consumers in Mexico City can purchase corn more cheaply from the United States than from rural Mexico. These U.S. policies help people in Mexico City, but at the expense of Mexican farmers.

Similarly, Canada protects its dairy farmers from competition with U.S. dairy producers. This helps Canada's farmers, but raises costs for Canadian consumers.

Most infrastructure improvements in developing countries connect resources to ports so goods can be exported. Often, other infrastructure in the country is lacking. As the map of the west African country Ghana on the next page shows, the major rail lines in the country connect the interior, where resources are located, to the ports where they can be exported to the developed world.

Ghana has significant mineral and agricultural resources. However, much of revenue from selling these resources leaves the country. Agricultural products commonly exported from Ghana include cocoa, cotton, coffee, palm oil, and cassava, and gold is the main mineral export. Consequently, there was little money to spend on additional infrastructure, and the population received few benefits from the mineral wealth. See Geographic Perspectives: Ghana as a Case Study in Development (page 327), to learn more about its development strategies.

TRANSPORTATION ROUTES IN GHANA



Ghana's major rail line connects ports to the mines and agricultural regions in the interior of the country.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *How is there interdependence among regions of agricultural production and consumption?*

Causes of Increased Interdependence	Effects of Increased Interdependence

KEY TERMS

supply chain
luxury crops
neocolonialism
fair trade movement
subsidies
infrastructure

GEOGRAPHIC PERSPECTIVES: *GHANA AS A CASE STUDY IN DEVELOPMENT*

In the mid-1990s, the president of Ghana presented a framework known as Ghana Vision 2020, which included long-term plans for economic and social development policies, including agricultural and industrial programs. The goal was to raise Ghana into the ranks of the middle-income countries of the world by 2020. For example, the plan stated, "by the year 2020, Ghana would have achieved a balanced economy and middle-income country status and standard of living, with a level of development close to the present level of development in Singapore."

In addition to social development, Ghana Vision 2020 focused on rapid economic growth. Ghana attempted to accelerate economic growth with improvements such as modernizing agricultural inputs, increasing private investment, and developing transportation infrastructure. The purpose of these efforts was to raise income and improve living conditions for Ghanaians, thereby stabilizing the economy.

Ghana does not appear to have fully reached all of its goals for 2020, but it is poised to continue its social and economic development in the future. Offshore oil has generated significant new wealth and could provide a boost in the future to the country's development efforts—as long as the revenue from the petroleum is well managed and stays within the country. A February 2020 report from Bloomberg Opinion recognized the gains of the past two decades and suggested that Ghana is Africa's top candidate for an economic leap. The country's continued dependence on raw materials is the biggest obstacle that has to be overcome.

Source: Wikimedia Commons

A busy street in the capital city of Accra, Ghana, with bustling markets, cars, and economic activity.

1. Explain why Ghana wants to diversify its economy and not rely on just mining or agriculture.
2. Explain the importance of transportation infrastructure for Ghana's economy.

THINK AS A GEOGRAPHER: *EXPLAINING PATTERNS IN MEXICAN EXPORTS*

At the scale of a country, Mexico is a vitally important region for the food that people in the United States eat. Around 45 percent of the vegetables imported by the United States come from Mexico. But at the scale of states in Mexico, the distribution of food throughout the country is not even, nor are the exports consistent throughout the year. Mexico exports twice as much in the six months from December through May as it does in the other six months of the year.

Use the map to answer the questions below.

EXPORTS OF FRUITS AND VEGETABLES FROM MEXICAN STATES

1. Suggest one or more possible reasons to explain why Mexican exports have the seasonal pattern you see on the map.
2. What might explain the spatial pattern in Mexican exports?
3. The state of Veracruz has a climate similar to part of the east coast of India. Why does Veracruz export more fruits and vegetables to the United States than do similar regions in India?

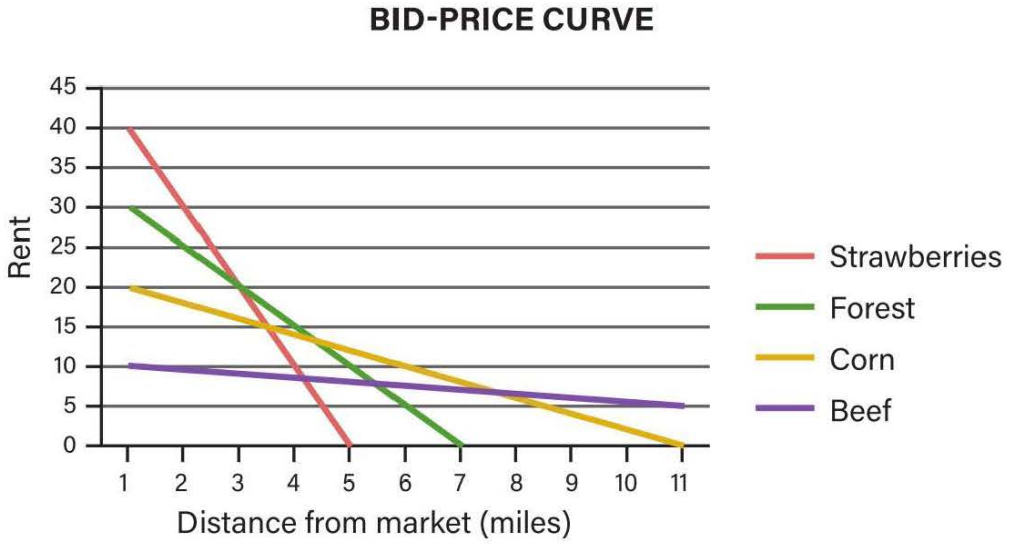
CHAPTER 13 REVIEW:
Spatial Arrangement of Agriculture

Topics 5.6–5.9

MULTIPLE-CHOICE QUESTIONS

1. The von Thünen model has changed because of developments in transportation. The change that is most evident is that the
   (A) market is no longer at the center
   (B) width of the rings has increased
   (C) width of the rings has decreased
   (D) rings now stretch along rivers
   (E) model now includes a ring for transportation

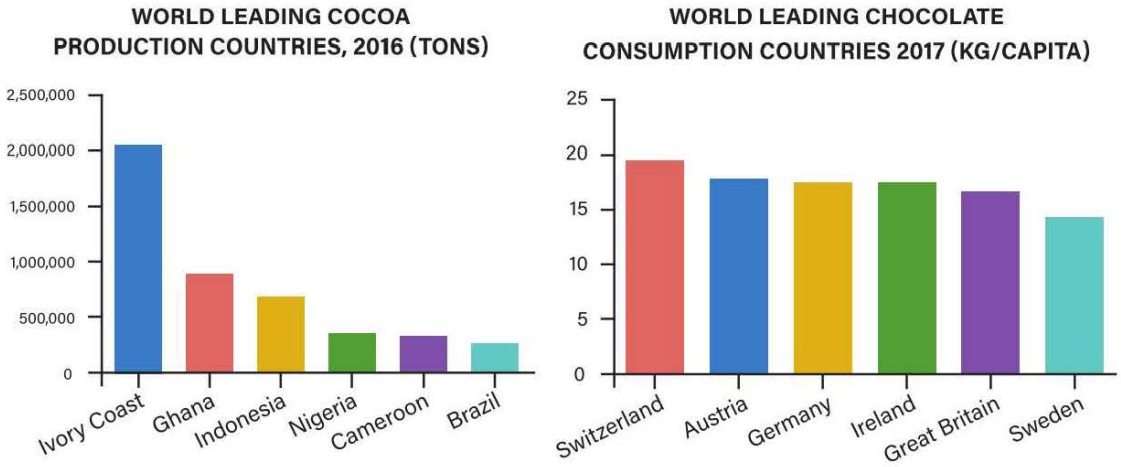
Question 2 refers to the image below.



2. Based upon the bid-price curve above, in which zone should corn be grown?
   (A) 1.0 mile to 11.0 miles
   (B) 3.5 miles to 4.5 miles
   (C) 4.5 miles to 7.6 miles
   (D) 7.6 miles to 11.0 miles
   (E) 4.5 miles to 11.0 miles

3. One result of the development of cool chains is that they
   (A) eliminated the need for air transport of agricultural products
   (B) decreased the use of high-speed rail for transporting food
   (C) increased the distance that fresh fruits and vegetables could travel
   (D) reduced agricultural productivity
   (E) caused a need for large ships to transport meat products

Question 4 refers to the graphs below.



Source: International Institute for Sustainable Development

4. The two graphs shown above provide support for which of the following statements regarding cocoa production and chocolate consumption?
   (A) Cocoa production is highest in equatorial regions and chocolate consumption is greatest in tundra regions.
   (B) Cocoa production is highest in periphery and semiperiphery countries and chocolate consumption is greatest in core countries.
   (C) Cocoa production is highest in the Eastern Hemisphere and and chocolate consumption is greatest in the Western Hemisphere.
   (D) Cocoa production is highest in core countries and and chocolate consumption is greatest in semiperiphery countries.
   (E) Cocoa production is highest in the Northern Hemisphere and and chocolate consumption is greatest in the Western Hemisphere.

5. Which statement best explains why a large quantity of agricultural products are imported into the United States from Chile?
   (A) Inexpensive labor in Chile reduces the cost of production.
   (B) The growing season in Chile allows U.S. consumers to have fresh fruits and vegetables in the winter.
   (C) Subsidies in the United States make agricultural products cheaper.
   (D) Better technologies have increased Chile's agricultural output.
   (E) The number of U.S. farmers has declined so significantly that the country cannot produce enough food for consumers.

6. Which lists products in the order in which they will be produced, starting closest to the market, according to von Thünen's model?
   (A) Grain, forest, beef cattle, dairy cattle
   (B) Tomatoes, grain, forest, beef cattle
   (C) Dairy cattle, beef cattle, forest, grain
   (D) Dairy cattle, forest, grain, beef cattle
   (E) Forest, tomatoes, beef cattle, dairy cattle

7. A very large corporate farm in the United States is most likely to take advantage of which of the following opportunities?
   (A) Fair trade certifications
   (B) Traditional farming techniques
   (C) Local markets to sell its products
   (D) Vertical integration strategy
   (E) Low-wage child labor

FREE-RESPONSE QUESTION

1. There are a variety of types of agriculture that occur around the world and range from commercial to subsistent. Coffee is one of the world's most valuable traded commodities and is considered a luxury crop.

COFFEE PRODUCTION, 2016	
Country	**Production (in tons)**
Brazil	3,019,051
Vietnam	1,460,800
Colombia	745,084
Indonesia	639,305
Ethiopia	469,091
World total	9,221,534

Source: FAOSTAT of the United Nations

(A) Describe the difference between subsistence agriculture and commercial agriculture.

(B) Identify TWO globally traded crops other than coffee that are currently grown on commercial plantations today.

(C) Using any of the countries listed in the sources, describe ONE advantage it has in the production of coffee.

(D) Identify a world region where most of the coffee is grown for export.

(E) Explain ONE problem facing countries when they dedicate large tracts of land to the production of a luxury export crop, such as coffee.

(F) Explain the view that coffee production is neocolonialism.

(G) Describe the primary goal of fair trade in coffee production.

CHAPTER 14

Challenges and Consequences of Agricultural Practices

Topics 5.10–5.12

Topic 5.10 Consequences of Agricultural Practices

Learning Objective: Explain how agricultural practices have environmental and societal consequences. (IMP-5.A)

Topic 5.11 Challenges of Contemporary Agriculture

Learning Objective: Explain challenges and debates related to the changing nature of contemporary agriculture and food-production practices. (IMP-5.B)

Topic 5.12 Women in Agriculture

Learning Objective: Explain geographic variations in female roles in food production and consumption. (IMP-5.C)

For hunger is a direct affront not only to the physical integrity but also to the very dignity of the human person. Hunger is an insult to the fundamental values of the international community.

—UN Secretary-General, Boutros Boutros-Ghali,
World Food Summit, 1996

Source: Alamy

In Malawi, Africa, women receive training on farm equipment, such as this hand tractor, which allows them to be more productive farmers. (See Topic 5.12 for more on the changing role of women in food production.)

5.10

Consequences of Agricultural Practices

Essential Question: What are the environmental and societal consequences of agricultural practices?

In the modern era, commercial agriculture has almost completely replaced subsistence farming. Many farming operations evolved from small enterprises owned by a single family into large-scale, capital-intensive businesses. This shift has put more stress on the environment than ever before.

In addition to dealing with the environmental consequences, agricultural challenges now include, developing new farmland, growing more food, and managing agriculture at a different scale. It is not simply changing subsistence farmers into commercial farmers, but how all farmers alter their practices to accommodate the changing needs and desires of the population.

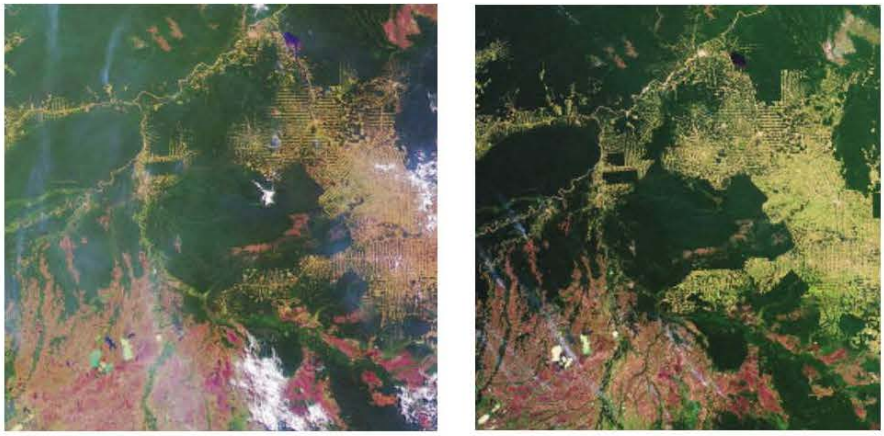
Women have always played a crucial role in food production, and in recent years, their contributions have become even more important. Women are often the leaders in finding methods to improve the productivity of farms, in spite of the obstacles of gender inequality.

Environmental Effects of Modern Food Production

Although there are tremendous differences in the efficiency of farming practices throughout the world, most practices have evolved to effectively use the soil quality and climate in various locations. Technological innovations have allowed for massive increases in food production, but at a cost. It is usually modern and intensive forms of farming that have the greatest environmental impact. Regardless of the type of farming practiced, humans have an impact on the environment when they alter natural ecosystems.

Land Cover Change

Changes in land use occur as the world's population grows, due to increased pressure to grow more food and develop more land for homes. **Land cover change** is the study of how land is used and the impact of changing land use. Geographers are particularly interested in loss of natural land areas to agriculture and the loss of agricultural land to the expansion of urban areas. (See Topics 5.11 and 6.11.) Geographers use data and satellite images to map and analyze changes in land use.



Images taken from space show parts of western Brazil in 2000 (left) and 2012 (right). Deforestation and agriculture have impacted the rainforests of this region. The dark areas are forest and the light areas are farmland. Describe the changes of land use from 2000 to 2012.

Pollution

Pollution is often associated with industrial processes, but farming also contributes to air, water, and soil pollution. The most intensive forms of agriculture are usually responsible for the worst agricultural pollution. Farmers' use of chemical fertilizers, insecticides, pesticides, and herbicides has increased tremendously over the past several decades, and resulted in polluted air, water, and land. Their use has also resulted in health issues for those exposed to the chemicals. To ensure minimal damage to the environment and people, many governments have regulated the amount and types of chemicals that can be used, in addition to how and when they can be applied.

Desertification

Alteration of the natural vegetation in arid areas causes fertile land to become infertile, or **desertification**. For example, desertification is caused by the removal of forests or overgrazing livestock which can allow for increased wind erosion and result in the loss of the topsoil. Even common farming practices, such as plowing or irrigation, done irresponsibly can expose the soil to excessive erosion.

Soil Salinization

Improper use of irrigation or water high in salt content can cause salinization of the soil. **Salinization** occurs when salts from water used by plants remain in the soil. Salinization decreases a plant's ability to uptake water and nutrients, which results in lower yields and may render soil useless. Evaporation also leaves salts behind in the soil, so if there is excess water, either in the soil or on the surface, salinization rates increase.

Protecting Natural Ecosystems and Conservation Efforts

Economic benefits of agriculture conflict with conservation and environmental efforts in many regions. In response, an increasing number of individuals, non-government organizations, and government agencies are becoming involved

with conservation efforts. Their goal is to counter the damaging effects of destroying the natural landscape, and the various flora and fauna that inhabit it, through the expansion and development of farmland.

National and local governments have instituted regulations on the use of agricultural chemicals, development and possible destruction of fragile natural environments, and preservation of valuable farmland. Governments have also educated farmers and the general public on the environmental effects of farming.

Individual farmers effect change by pursuing more environmentally friendly practices, such as reducing the use of agricultural chemicals, using more natural pest control solutions, monitoring irrigation usage, and growing crops organically. Individual consumers show support for farmers who use more sustainable practices by purchasing their products, even at higher prices.

Another practice to defend the environment is to create protected zones, forests, or preserves where development is not allowed. Some countries set aside land that has biodiversity or endangered species in order to preserve and protect the land, plants, and animals. Debates about how much protection is warranted and what types of activities should be allowed in protected areas occur on a local, national, and global scale.

An example of environmental protection at a global scale occurred in the 1980s. People from many nations joined the "Save the Rainforest" movement that supported farming and logging practices that did not damage the Brazilian rainforest.

Humans Altering the Landscape for Agriculture

Ever since the first humans began to farm, they altered the landscape to their advantage. Things that people now consider natural—building earthworks, redirecting streams, or removing natural obstacles—were at one time innovations. Far from natural, these undertakings were fresh, creative solutions to challenges faced by the earliest agriculturalists.

Terracing

One of the earliest human alterations of the landscape was **terrace farming**, in which farmers build a series of steps into the side of a hill. This creates flat surfaces, which have several benefits over steeply graded hillsides:

- The amount of arable land increases in areas with steep hillsides.
- The land collects rainfall that sustains the crops, rather than allowing it to run down a sloped hillside.
- The reduction in water running down the hillside limits soil erosion.

However, if terraces are not carefully maintained, a heavy rainfall can cause disastrous and deadly mudslides.

Terrace farming has long been used throughout the world. In East Asia, terrace farming is often used to grow rice. In South America, potatoes and

maize (corn) are the main crops. In northern Africa, people often grow fruit and olive trees on terraced land.

Managing Water

The process of applying controlled amounts of water to crops using dams, canals, pipes, sprinkler systems, or other manufactured devices rather than relying on just rainfall, is called **irrigation**. Humans have used irrigation to increase food production and increase their standard of living for thousands of years. In modern times, the successful use of large-scale irrigation contributed greatly to feeding the rapidly growing population of the world. Irrigation systems can turn deserts and semi-arid regions into productive farmland. An example is California, particularly the dry central and southern regions of the state.

Types of Irrigation Systems Dams turn streams or rivers into reservoirs that are used to maintain large quantities of water throughout the year. While beneficial to preserve and distribute water, dams destroy river ecosystems and people are often displaced from their land when the reservoirs are created.

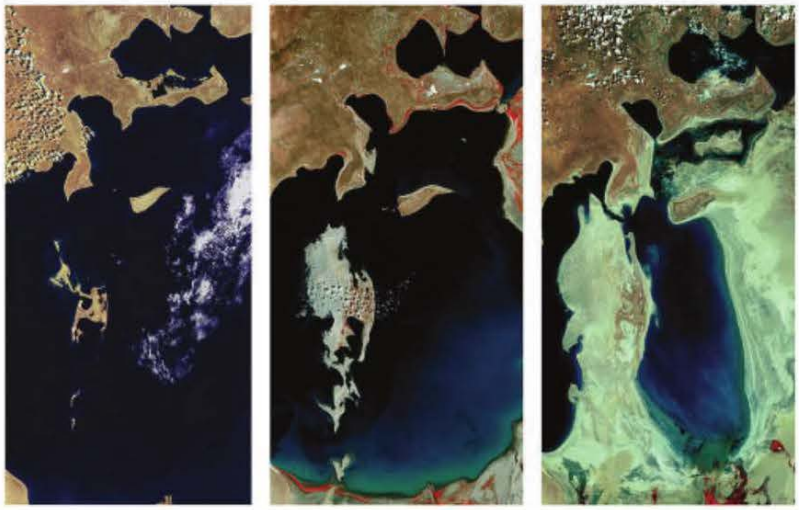
Aquifers are underground reserves of fresh groundwater which can be used to water crops. Wells must be built to access the water and then it is piped to the fields. Overuse of aquifers is a concern because the supply of water is often limited.

A system developed in the mid-20th century is **center-pivot irrigation,** in which watering equipment rotates around a pivot and delivers specific amounts of water, fertilizer, or pesticides to the field. These systems create large circular patterns in fields, which are visible from the sky. (See image on page 270.) This capital-intensive system is common with large-scale commercial farming because of its efficiency.

Problems From Irrigation When misused, irrigation can cause severe problems. It can disrupt the natural drainage of water and reduce the normal regeneration of soils caused by natural flooding. Irrigation can reduce the amount of surface water in rivers and lakes. Overwatering leads to water contaminated with chemicals seeping into rivers and underground water systems.

In the 1960s, the Soviet Union tried to divert water from rivers that flowed into the Aral Sea to increase cotton production in the region. The Aral Sea, once the fourth-largest lake in the world, was reduced to 10 percent of its former size by 1997. The project was poorly done and much of the water went to waste. The water that remained was extremely saline, which destroyed a flourishing fishing industry and caused economic hardship for the population that lived near the lake. Some of the former lakebed is now classified as a desert and cannot be farmed.

In recent years, the government of Kazakhstan has been successful in revitalizing one small part of the lake. The destruction of the lake has provided a lesson regarding the consequences of manipulating the natural environment.



The Aral Sea evolved into four smaller lakes as it dried up over several decades. As the process continued, the lakes became progressively smaller and the easternmost lake completely disappeared.

Draining Wetlands

Low-lying areas that contain a significant amount of water at or near the surface are **wetlands**. Many people viewed wetlands as not serving any useful role. Therefore, when developers looked for land, the fertile soil of wetlands is seen as a viable option to be converted into other land use, especially for farmland.

When wetlands are converted to agricultural or other land use, numerous benefits are lost. There are many positive impacts of wetlands:

- providing a significant biodiversity in both plants and animals
- acting as natural filters that protect surface water and groundwater quality
- trapping sediment and protect against shoreline and stream bank erosion
- averting flood damage during periods of potential flooding by holding and then slowly releasing water
- buffering the local water supply by holding water during periods of drought
- reducing greenhouse gases by building and storing soil carbon

Clearing Trees and Other Vegetation

The removal of large tracts of forest, or **deforestation**, has occurred throughout human history as a common solution to the need for additional farmland. Northern and central Europe were once heavily forested. Now, the region is mostly farmland and urban areas. Deforestation today occurs mostly in Southeast Asia, parts of Africa, and, most notably, in the rainforests of South America.

Cutting down trees can result in local problems, such as soil erosion, decreased rainfall, warmer temperatures, and desertification. In addition, it can cause devastating global environmental damage. In particular, the rainforests

absorb so much carbon dioxide that shrinking them leads to an increase in atmospheric carbon dioxide, which contributes to worldwide climate change.

Shifting Cultivation

Slash-and-burn agriculture, an early agricultural practice and type of shifting cultivation (see Topic 5.1), takes place when all vegetation in an area of forest is cut down and burned in place. The ash provides nutrients to the soil, and the land can be farmed for a few years before the soil becomes depleted and the plot is abandoned. The plot then returns to a natural, if somewhat altered state, while the farmers move on to burn and plant in a new space. Because slash-and-burn agriculture requires people to move regularly, it is classified as shifting cultivation. On a small scale, this system is beneficial to humans, but the environment recovers slowly. However, as population pressure increases, slash-and-burn agriculture on a large scale does not allow the ecosystem to recover, causing permanent damage.

One such environmental damage from shifting cultivation is soil erosion. Farmers usually remove vegetation by burning it, cutting it down, pulling it out, or killing it with herbicides. On the Great Plains and prairies of the United States, farmers removed the tall prairie grasses in order to plant wheat and other grains. These new crops lacked the extensive root systems of prairie grass. Without the anchor of strong roots and with dry conditions, valuable topsoil simply blew away. During this period, known as the Dust Bowl, it is estimated that nearly 35 million acres of arable land became useless. This era was one of the worst ecological disasters in U.S. history.

Pastoral Nomadism

Nomadic herding (see Topic 5.1) is an extensive agricultural activity that involves groups of people moving often and raising animals as their main means of survival. A herder's willingness to move frequently allows for a much larger number of animals to be kept, which reduces danger of the lose of a few animals. With pastoral nomadism, the farmer will keep the animals in one area only until the supply of food reaches the point that further grazing will do permanent damage to the land. If the livestock are not moved at that point, then overgrazing can lead to desertification since the animals will have eaten much of the grass, and even pulled up the roots. This makes the soil susceptible to wind erosion. This type of environmental pressure is occurring in the Sahel region of Africa.

It may appear as if pastoral nomadism is an undesirable and inefficient type of agriculture. In reality, if practiced in an environmentally sensitive way, it is an extremely efficient way to use poor quality land. The families that depend on this practice use the livestock in numerous ways. They use hides for clothing and shelters, consume meat and milk for nutrition, and trade animals when other necessities are required.

Similar to slash-and-burn agriculture, pastoral nomadism is not as common as it once was. Individuals involved in both do not usually own the

land they use but rely on customary systems of communal land usage. Since governments rarely recognize these systems, maintaining these lifestyles has been difficult.

Societal Effects of Agricultural Practices

The development of agriculture has altered landscapes and resulted in environmental challenges that have had a substantial impact on society. It has influenced the size of the world's population, dietary practices, the role of women in society, economic development, and globalization.

Changing Diets

A challenge of the global food supply is the changing dietary preferences of people, especially in semiperiphery countries. As the citizens of these countries enjoy improved standards of living, they seek a more western-style diet involving meat, dairy products, and processed and convenience foods. The demand for and the use of these products can lead to significant problems.

Animals are inefficient food converters since they consume more calories than they produce. Farmers feed approximately 35 percent of the world's crops to livestock so these animals, which are used to produce meat and dairy products, will grow larger in size and number. This means fewer crops are available for human consumption.

Livestock production also puts much more demand on the environment than crop production does. Two environmental issues with raising livestock are the large amount of fresh water required by the animals and disposal of the waste they produce.

As processed food is prepared, it can be cooked, canned, frozen, packaged, or modified with preservatives. Some foods are minimally processed such as canned vegetables, while others are heavily processed such as frozen pizzas. Large agricultural food companies efficiently process food in the field or factory. These companies then advertise the convenience and cost effectiveness of ready to eat foods. Processed foods have changed peoples' diets in many communities. Agriculture continues to change to address growing concerns about the effects of diets heavy in processed foods, such as high blood pressure, elevated cholesterol, and obesity.

Role of Women in Agricultural Production

Women play an important role in agriculture throughout the world, especially in periphery and semiperiphery countries. Traditionally, women helped men in the fields and in processing and storing the harvest. Also, women performed the task of selecting the best seeds to plant the following year.

Recent economic development in periphery and semiperiphery countries has resulted in jobs in different sectors of the economy. Men are more likely to leave the farm and accept these jobs in urban centers. If the centers are close enough to commute to on a daily basis, then men might continue to be

involved in the family farm. If the jobs are in centers that require men to leave their homes, then women take on much larger roles in running and managing family farms.

This feminization of agriculture has led international aid agencies to recognize that agricultural education and training, and more financial assistance, should be extended to women. The International Assessment of Agricultural Knowledge, Science, and Technology for Development (IAASTD), an initiative of the World Bank, found that women tend to be more cautious than men in making economic decisions and are less likely to accept high-risk ventures. Therefore, women are unlikely to invest in capital-intensive, large-scale commercial operations to compete in international markets.

Even if female farm owners were willing to purchase the inputs for a larger-scale operation, it is unlikely that banks or lending institutions would provide loans to them. The IAASTD has suggested that if women had equal access to production resources as men, productivity would likely rise by 20 to 30 percent.

In core countries, women usually have more opportunities to work in nonagricultural jobs than in non-core countries. There is a large number of women in rural areas of the United States who have found employment off the farm. As large agribusinesses become more common, there is an increasing number of agriculture-related jobs in management, research and development, operation of sophisticated machinery, processing, distribution, and marketing. Many of these jobs are filled by women. As agricultural changes, so do the related jobs and the mixture of people who do them.

Economic Purpose

Agriculture is an important part of most countries' economies. Agricultural products are used as food, fiber, fuel, and raw materials. Each use adds to the economic value of agricultural goods. For example, the fibers of cotton are used to manufacture clothing and other textiles, trees for building materials, corn and sugar for ethanol, and other plants are used to make medicines. Some of these products are at a local scale, near where they are grown. However, most are produced for national- and global-scale trade economies.

Agriculture contributes to the Gross Domestic Product (GDP) of countries, or the dollar amount of all final goods and services produced within a country in one year. (See Topic 7.3.) As seen in the table on the following page, agriculture is responsible for a small percentage of U.S. and Canadian GDPs. Yet, this is a small percentage of two very large GDPs (over $22 trillion in 2019), so the actual value of agriculture is over $200 billion. The Afghani and Ghanaian GDPs are so much smaller ($85 billion together), that even a large percentage of those countries' GDPs equals a smaller total value of agricultural goods compared to the United States and Canada.

AGRICULTURAL DATA, 2017 (FROM SELECTED COUNTRIES)		
Country	**Percentage of GDP from Agriculture**	**Percentage of Labor Force in Agriculture**
United States	0.9	1.3
Canada	1.6	2.0
Afghanistan	23.0	44.3
Ghana	18.3	44.7

Source: CIA World Factbook

Agriculture in the United States and Canada makes up a tiny percentage of the GDP, yet in Afghanistan and Ghana it is a much larger percentage. A similar situation exists for the percentage of the labor force working in agriculture among the four countries. What does this mean about the importance of agriculture in Afghanistan and Ghana?

In both the United States and Canada, food producers do a significant amount of processing to food, which adds to the total value of agriculture. In Ghana and Afghanistan, very little value is added to the agricultural products through manufacturing.

In terms of the percentage of the labor force, the low numbers in the United States and Canada reflect the significant amount of mechanization used on farms, so the labor force required is very small. In Afghanistan and Ghana, farms use much less mechanization and there are far fewer job opportunities in other sectors of the economy, so the percentage of people involved in agriculture is very high.

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are the environmental and societal consequences of agricultural practices?*

Agricultural Practices	Impact on Environment or Society

KEY TERMS

land cover change
desertification
salinization
terrace farming
irrigation
center-pivot irrigation
wetlands
deforestation
slash-and-burn agriculture

5.11

Challenges of Contemporary Agriculture

Essential Question: What are the challenges and debates related to the changing nature of contemporary agriculture and food-production practices?

Many different patterns of agricultural production and consumption have developed across the globe as a result of how farmers respond to various factors. For each of the different factors, farmers decide how to take advantages of opportunities and how to overcome challenges to be successful.

Perhaps the most obvious factor influencing the patterns of production and consumption is the physical environment. How a farmer uses a flat piece of land with good soil and favorable weather will obviously be different from a rugged landscape with poor soil and unfavorable weather. Other factors that can influence the patterns of production and consumption include government policies, transportation linkages within the region and beyond, the level of economic well-being of the citizens of the region, social and cultural traditions and expectations, access to the results of agricultural research, and the proximity to large markets.

Agricultural Innovations

During the Third Agricultural Revolution, scientists researched ways to increase yields to feed growing populations, improve foods' nutritional value, and increase the profitability of farming. While agricultural innovations often accomplish at least one of these three goals, people disagree if negative consequences are outweighed by the benefits. As noted in Topic 5.5, the Green Revolution was both successful and controversial. Similarly, other innovations often raise concerns.

Biotechnology and Genetically Modified Organisms

Biotechnology is a recent controversial innovation that is used to improve the quality and health of plants and animals. Biotech includes the development of **genetically modified organisms** (GMOs), which are plants or animals that scientists have modified by extracting genes of one species and inserting them into the DNA of another species. Compared to traditional foods, GMOs can be more nutritious, resistant to weather and pest-related damage, and

less susceptible to spoilage. The use of GMO seeds usually results in farmers drastically reducing chemical usage to control disease, weeds, and pests.

While the term genetic modification is commonly used, the terms genetic engineering and genetic improvement are also used. Biotechnology can also involve other sophisticated practices that advances peoples' health, such as molecular markers, molecular diagnostics, vaccines, and tissue culture.

GMO crops were first produced in the 1970s and started becoming widely used in the 1990s. The majority of scientists have found these processes safe for humans. Today, most corn, soybeans, and cotton grown in the United States, are GMO varieties. However, only a few other countries, such as Brazil and Argentina, produce large amounts of GMO crops. Many countries, particularly in Europe, have restricted the use of GMOs due to concerns:

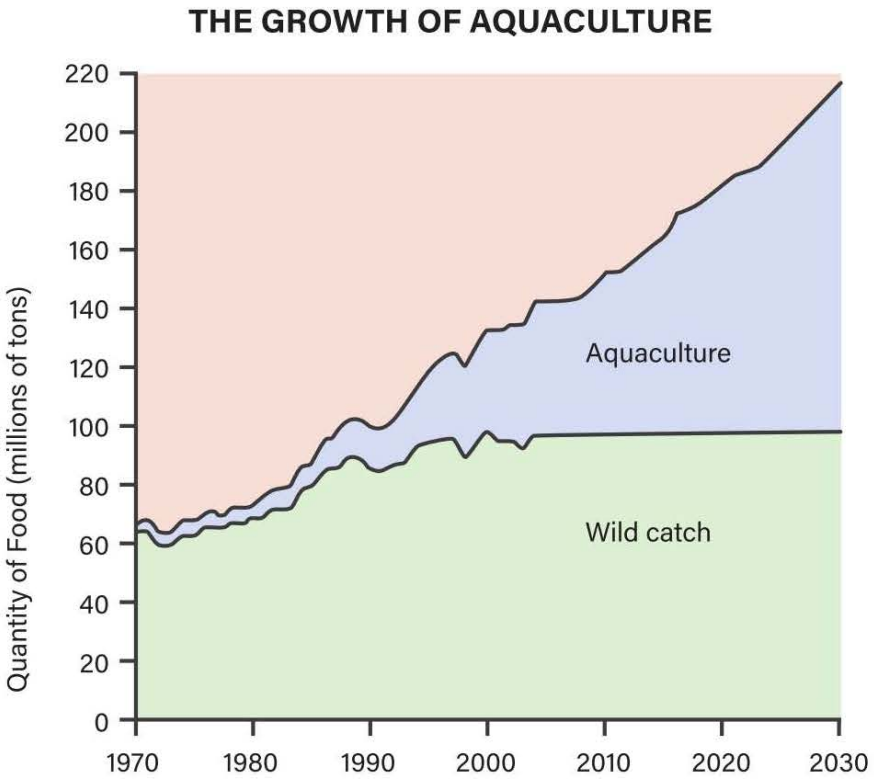
- GMO seeds are too expensive for poor farmers to use, in part because they are often sterile, so new seeds must be purchased each year.
- GMO seeds that are resistant to pests and herbicides might lead to the development of superpests or superweeds.
- GMOs might have potential long-term risks to consumers, such as organ problems or reduced immunity to diseases, that have yet to be identified and studied.

Aquaculture

Population growth has increased the demand for food which has led to overfishing, or the depletion of fish in oceans and lakes. In response, **aquaculture,** or **aquafarming**, the practice of raising and harvesting fish and other forms of food that live in water, has become more common. People in China and Southeast Asia have practiced aquaculture for thousands of years, but it is newer in the rest of the world. Often referred to as the **Blue Revolution**, the practice is now the fastest growing form of food production on the planet and responsible for approximately 50 percent of the world's seafood.

As with other forms of food production, there are environmental concerns related to aquaculture. Critics of open-pen systems—in which a cage or net is moored to the seafloor and the fish are able to interact with the wild surroundings to some extent—point out numerous problems:

- High fish density in enclosures means diseases and parasites thrive and spread easily.
- Parasites and diseases can easily spread from fish in the enclosures to the nearby wild stock.
- Chemicals and antibiotics used to counter parasites and diseases can damage the ecosystem around the enclosures.
- Fish can escape pens and may breed or compete with native stocks of fish.
- Excess feed and the concentration of fish waste can produce dangerously high levels of organic matter in local bodies of water.



Source: futuretimeline.net
Describe the trend of both aquaculture and wild caught seafood since 1970.

There are also social concerns regarding aquaculture. The installation of fish farms can challenge traditional fishing and lead to conflicts between the two groups of fishers, disrupting the local way of life. Another concern is that owners of the aquaculture operations may unethically exploit the local labor and local environment. Some people are concerned that fish from fish farms contain high levels of pesticides that could harm humans.

Debates continue on issues of sustainability of both wild seafood and aquaculture. Without aquaculture, demand for wild caught fish increases stress on ocean and sea ecosystems. Quotas, regulated fishing seasons, and zones have helped wild seafood stock to rebound, but challenges remain. As the world's demand for seafood increases, striking a balance between the two systems will be critical to maintain a sustainable system.

Environmental Issues Related to Agriculture

Modern agriculture has dramatically modified the natural landscape. Some of these changes constitute significant environmental damage.

Agricultural Chemicals and Fossil Fuels

Much of the environmental impact of farming comes from the use of chemicals. Farmers have long used fertilizers to replace nutrients in the soil. Traditionally, the fertilizer was human or animal waste. When used properly, these products provided the soil with nutrients and disposed of wastes. While some farmers still use waste as fertilizer, most rely more on chemical fertilizers. If too much is applied, the excess contaminates nearby water supplies, causing significant

environmental damage, including growth of toxic algae that uses the oxygen in the water, which kills fish and other organisms.

A second group of potentially harmful chemicals includes those designed to kill unwanted insects or plants. Pesticides, insecticides, and herbicides destroy parts of the natural ecosystem. When used or disposed of incorrectly, they can cause significant damage to other life forms, including humans.

Another group of powerful chemicals are those given to livestock, such as antibiotics to prevent disease and hormones to promote growth. Many consumers fear the consequences of consuming meat from animals given these chemicals. The primary concern is that the practice can lead to the development of antibiotic resistant bacteria, or superbugs, that could be transferred to humans and lead to serious illnesses. There is not agreement within the scientific community on the associated risks.

Modern farming machines, such as combines and tractors, run on fossil fuel. The use of these machines results in air pollution from the exhaust, depletion of fossil fuel reserves, and leaks or spills of various petroleum products that can contaminate soil and water.

Depletion of Water Supplies

The misuse of water by farmers can also damage the environment. On a worldwide scale, approximately 70 percent of all accessible fresh water is used for agriculture. Some of this water is wasted through inefficient irrigation. At times, farmers are wasteful with water by using more for crops than needed, using irrigation systems with pipes that leak, or growing crops in arid places that require excessive amounts of water. Poor irrigation can cause several problems including salinization and water depletion. (See Topic 5.10.)

Loss of Biodiversity

Changes in agriculture often reduce biodiversity. As improved varieties of crops are developed, farmers often abandon older varieties. In addition, farmers grow fewer varieties of crops than ever before. Specializing in one crop, which is known as monocropping, or monoculture, then reduces the diversity of the insects, animals, and other organisms that depend on other varieties of plants. Biodiversity also decreases as land cover uses change from wild ecosystems to agriculture or urban uses. (See Topic 5.10.)

Soil Degradation and Erosion

Many people believe grazing animals has very little impact on the natural landscape. In a large open area, the animals will simply wander from area to area seeking grass and allow the grazed areas time to recover. In restricted areas, farmers move their herds between enclosures to allow for the recovery of the grasslands.

However, if the density of animals is greater than even expansive grasslands can support, animals will **overgraze** in the search for food. This damages the grasslands to the extent that the vegetation will not refresh itself even after the

animals leave. Overgrazing most often occurs when farmers or herders have too many animals, they control too little land, or climatic conditions worsen and there is less pasture available than usual. With the right combination of overgrazing and environmental circumstances, soil erosion become a danger. The Sahel region of Africa is an example of where this pressure is occurring.

Overgrazing is increasing in pastoral nomadism as the amount of land available to herders and their families has shrunken in recent decades. Since there is less land available for the migratory herders, they have to remain longer in fewer locations, significantly increasing the risk of overgrazing. Several changes have decreased the availability of pastureland, which makes overgrazing more likely:

- Governments have become more protective of their borders, which makes it difficult for some herders to follow their traditional migratory routes that often cross international borders.
- Some former pastureland is now irrigated and used for growing crops and housing permanent residents.
- Areas of former pastureland are now used for mining and petroleum operations.

Once overgrazing occurs, the grasses will not recover as quickly, if at all. Similar results occur when soil is overtilled, or poor plowing techniques are used. When farmers drain the soil of nutrients from practices such as overuse, lack of crop rotation, or failure to replace nutrients, the soil loses its ability to support plant growth. All of these practices can result in soil being susceptible to erosion by wind and water.

Sustainability and Agriculture

Farmers today face many challenges to operate in ways that are sustainable in the long term. Maintaining soil fertility without degrading the soil is possible, but it takes careful planning. Sustainable grazing and tilling practices help to minimize soil erosion. Managing chemical levels and sedimentation in bodies of water, conserving water, employing renewable energy resources, and preserving biodiversity are all part of an environmentally sustainable perspective. Farmers have to constantly analyze their decisions in order to strike a balance between immediate profitability and long-term sustainability.

Farmers face many challenges as they maintain sustainable agriculture. Today, they use GIS software to manage chemical application, reduce the impact of plowing techniques on soil, and slow runoff and soil erosion.

Changes in Food Production and Consumption

The broad trends in agriculture over the past century have been toward larger farms, corporate ownership, intensive use of machinery and chemicals, and higher output. However, smaller trends are also evident, such as the increase in fair trade, organic farming and value-added crops.

Fair Trade

Some consumers support the fair trade movement. The goal of this movement is to get more money into the hands of the small farmers in poor countries, rather than supporting large transnational corporations that manage trade in agricultural products. The most widely sold fair-trade products are bananas, chocolate, coffee, and tea. (See Topic 5.9 for more on the fair-trade movement.)

Organic Foods

In the United States, people spent more than $50 billion for organic food in 2020—an increase of almost 5 percent from the previous year. In order to be classified as an **organic food**, crops must be non-GMO, produced without pesticides or synthetic fertilizers, and use sustainable growing practices. According to the USDA, animals must be fed 100 percent organic feed and ranchers cannot administer antibiotics or hormones to the animals.

Many consumers believe that organic is healthier for them and safer for the environment. Since organic farming tends to be more labor-intensive than other forms of agriculture, it creates more jobs, but the food produced is more expensive.

Organic agriculture has possible drawbacks. One potential environmental cost is the need for more land to produce the same quantity of food. Also, some organic production of commodities, such as milk, cereal, and pork, create more greenhouse gases than conventional farming techniques. And while organic farming regulations prohibit the use of synthetic pesticides, they do allow farmers to use naturally occurring chemicals that can also be harmful to humans and other life forms.

Value-Added Specialty Crops

Increasing revenue and profits is a goal of all businesses. Farmers' and ranchers' profit margins have been in decline, so they have tried new approaches, such as raising value-added specialty crops or practicing value-added farming. **Value-added crops** are those for which consumers are willing to pay more because of special qualities or because they are difficult to acquire:

- organically grown crops and meats
- rare subtropical plants, such as passion fruit, cherimoya, longan, and star fruit
- grass-fed beef and free-range chickens and eggs

Value-added farming occurs when farmers process their crops into high-value products, rather than simply selling it as it comes from the field. The tremendous growth in grape production and the development of small wineries is a good example. Turning strawberries and other fruits into jams and jellies or using tomatoes and peppers to produce salsa, are also examples. Dairy producers create added value by making and selling their own cheese or ice cream.

Local-Food Movement

Another trend among some consumers is a **local-food movement,** or seeking out food produced nearby. Advocates, sometimes called "locavores," have pointed out that this supports local farmers and reduces the use of fossil fuel used to transport products. Starting in the 1990s, farmers markets, where consumers can purchase fruits, vegetables, and other food items directly from farmers, became more popular. Many farmers cater to local consumers by producing specialty crops, such as herbs, mushrooms, and eggs from free-range chickens, in small quantities but at relatively high prices.

Urban Farming

Urban farming refers to the production of farm goods within an urban area with the goal of providing locally grown food. It may be practiced in different forms, but all assume a level of commerce—meaning the products will be sold and not used for personal consumption. The greatly reduced distances between producer and consumer allow consumers to enjoy fresh products. Farms may be owned by a traditional farmer but could follow a nontraditional ownership model, such as a few friends, a nonprofit group, or a neighborhood group. The food produced could be sold locally at grocery stores, restaurants, or farmers' markets. Additionally, the food could be used at a local soup kitchen, church, or shelter. Cities like Detroit, Michigan, have large urban farming communities.

An increasingly popular variation of the urban farming model is **community gardens**. People use community gardens to share agricultural products with family, friends, and perhaps those in need rather than as a business. These garden plots allow people to grow and harvest their own fresh food, grown organically, if they wish. They also allow economically disadvantaged citizens to acquire high-quality food that otherwise they would have unlikely been able to access. These plots of farmland may be found in many different areas in the city such as parks, abandoned lots, or even on top of buildings.

A new type of urban farming is called vertical farming. **Vertical farms** grow crops inside in stackable trays, using greenhouses, artificial lights, and hydroponics. **Hydroponics** allows crops to grow without soil using mineral-enriched solutions. These processes use less water and less land since trays can be stacked vertically. One criticism is the substantial amount of energy needed to power the lights to grow the crops.

Source: Wikimedia Commons

Much less space is needed to grow crops using vertical farms.

Community-Supported Agriculture

One strategy used within the local-food movement is **community-supported agriculture (CSA)** that brings producers and consumers into a type of partnership. Consumers buy a share, or subscribe to a certain quantity of crops for a season. The food is made available to the consumer throughout the growing season. This ensures the consumers a local supply of fresh products and the farmer receives revenue throughout the season, rather than only at the end. It also allows for a connection between consumers and producers because consumers can often participate in the process of growing and harvesting the food. Consumers usually develop an appreciation of the challenges of production, while producers develop a better understanding of consumer wants.

Challenges of Feeding a Global Population

The development of agriculture of all types has resulted in the availability of massive amounts of food. There is enough food for everyone in the world, yet almost 1 billion people do not get sufficient food. Factors causing the food shortages include food distribution networks and the cost of the food. A distribution network is challenged by transportation difficulties, storage problems, political unrest or conflicts, or when large amounts of food are diverted to feed animals. Also, much of the food produced in developing countries is exported to wealthy countries. When food is available, people in the greatest need often cannot afford to purchase sufficient food or it can be denied because of local conflict or government corruption.

Food Insecurity

When households lack access to adequate food because of limited money or other resources, they experience **food insecurity**. People who experience food insecurity often have to make the choice between between purchasing food or other necessities. Children are particularly vulnerable to food insecurity since it hinders their ability to learn and negatively affects growth.

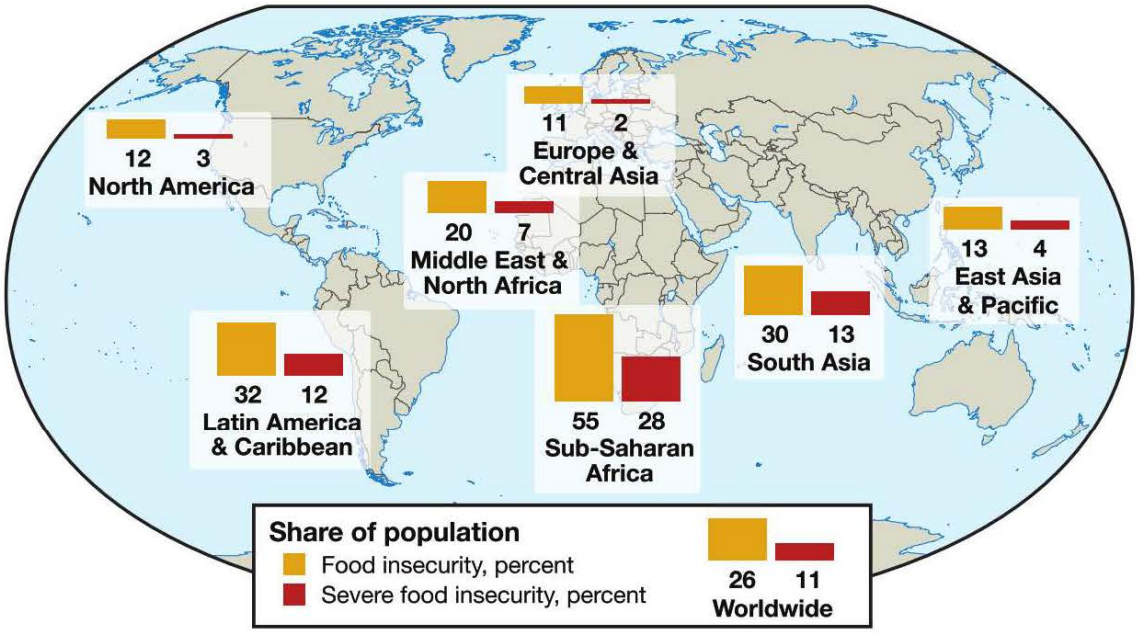
This problem does not exist in only periphery and semiperiphery countries. The United States is one of the richest countries in the world, yet it is estimated that over 50 million people, or more than 14 percent of the population, suffer from some level of food insecurity. In the periphery and semiperiphery regions of the world, the rate of food insecurity is approximately 30 percent. In sub-Saharan Africa, 55 percent of the people experience food insecurity. As a result of the COVID-19 pandemic, food insecurity numbers increased dramatically around the world.

The underlying causes of food insecurity in the United States—poverty, unemployment, and under-employment—are interconnected. Poverty and employment situations are also causing food insecurity in periphery and semiperiphery countries. Additional problems in non-core countries, such as high population growth, political instability, and environmental challenges, intensify food insecurity.

Food insecurity rarely exists to the same degree throughout an entire country. In the United States, it is most prevalent in poor neighborhoods and among the homeless of both major cities and rural areas. It is least noticeable in suburban areas and smaller cities.

In poorer countries, the landless poor and female-headed households in both urban and rural settings are most vulnerable. When people move from farms to find a job, they can no longer grow the foods to support their family, and often lack the financial resources to afford food. Additionally, assistance programs in the periphery often lack the resources to combat food insecurity.

FOOD INSECURITY AND SEVERE FOOD INSECURITY, 2017



There is a tremendous variation in the levels of food insecurity between the core, the periphery, and the semiperiphery. Countries at war or dealing with high levels of poverty are particularly vulnerable.

Food Deserts

A neighborhood where residents have little to no access to healthy and affordable food is a **food desert**. The USDA defininition involves two elements. The first is the area has low income and high poverty. The second element is an urban area with 33 percent of the population located more than 1 mile from a grocery store, or more than 10 miles away in a rural area.

These neighborhoods are usually home to racial and ethnic minorities or large percentages of elderly or disabled people. Due to economic and physical constraints, the residents often do not have the means to travel to grocery stores outside of their area of the city. Car ownership may be rare and city buses may be too expensive or not readily available. As a result, the residents are forced to shop in their own neighborhoods. Often, grocery chains have eliminated stores in these neighborhoods due to lower than acceptable levels of profits. What usually remains are small independently-owned grocery stores and convenience stores. It is challenging for these small stores to maintain

selections of healthful food at affordable prices. Consequently, many of the residents suffer from poor diets and the ensuing health issues.

Problems with Distribution Systems

A network of trade and transportation that get food from farms to consumers is a **food distribution system**. Food distribution challenges exist at multiple scales. At the local scale, both farmers and consumers are hindered by their inability to get to a market. If farmers cannot reach the market with their surplus products, the food will go to waste. If people require additional food beyond what they can grow, but cannot access the closest market, then the problems of malnutrition and hunger emerge.

At the regional and global scale, modern transportation systems and advances in food storage have vastly improved distribution, but there are still obstacles. A ship, transport truck, or train can move large quantities of food efficiently, but these systems work well only if there are suitable ports, roads, and rail lines. Often those in the greatest need of food live in remote areas without good transportation links.

Governments can affect food distrubution systems. Political leaders will often use food as a weapon during times of political unrest to suppress opposition. Other times, govenment officials are forced to make decisions on food allocation when accessible food supplies are insufficient.

Adverse Weather

Farmers are intense weather watchers because a slight change in the weather can impact their crops and animals. In core countries, farmers often have crop insurance to provide some financial protection from weather disasters. Crop insurance is not nearly as common in non-core regions. In regions with little surplus that can be stored for future needs, the loss of crops and livestock can have a devastating impact on the population unless another region can step in and quickly deliver necessary food to the affected population.

Farmers are among those who could be most affected by global climate change. However, scientists are unsure of how this trend will express itself over the next several decades. Climate change might increase the frequency and intensity of droughts and severe storms, threatening crop yields and livestock. In areas which already have suitable weather, warmer weather could cause problems of drought and for livestock farmers heat-wave deaths, reduced milk production in dairy cattle, and reduced weight gain for beef cattle.

Global warming could have positive effects for farmers in some regions. For farmers practicing at the fringes of agricultural zones, an extended growing season due to shorter and milder winters could allow farmers to be more successful. Warmer weather could also benefit livestock farmers in these areas through lower feed costs, increased survival rates of the young animals, and reduced energy costs.

Land Use Lost to Suburbanization

Existing farmland is threatened by the expansion of cities and suburbs. Millions of acres of farmland worldwide are converted to land use for suburban housing, shopping centers, business parks, or other types of urban development. Many view the continual loss of fertile land as a significant threat to the ability to feed a growing population.

Because most cities originally developed as agricultural centers, these cities are located near fertile land. The region of Canada with the best soil and most productive farms have recently experienced growth. This growth has consequently placed tremendous pressure on the surrounding farmland. Each time a new subdivision or some other urban land use is created, hundreds, even thousands, of acres of Canada's best farmland is lost to development.

Similar problems exist in nearly all expanding towns and cities surrounded by agricultural land around the world. Land-use planners are aware of these concerns and try to control the expansion of cities, but growing populations and the associated houses, businesses, and infrastructure have to be nearby. One solution to alleviate urban expansion issues and loss of farmland is to find ways to increase the densities within the existing cities, thus containing the growing population.

Factors Affecting Food Production

The decisions farmers make are influenced by numerous factors, including the location of food processing facilities and markets, economies of scale, distribution systems, and government policies.

Location of Food Processing Facilities and Markets

The transformation of agricultural products into food or taking food items and transforming them into a different type of food is **food processing**. One example is taking wheat and milling it into flour, which then can be either sold to consumers or sold to factories for making bread. Transportation systems and relative distance from the processing location are important factors and can vary depending on the product. The von Thünen model introduced some elements of this concept. (See Topic 5.8.) Core countries have advanced infrastructure that can move agricultural products rapidly with minimal waste. In periphery countries, product loss can be substantial because of poor transportation infrastructure and lack of access to processing plants.

Traditionally, companies located food processing facilities in rural areas or small towns. By locating facilities close to where the harvest occurs, companies could work with fresh products and benefit from the lower labor and land costs in rural areas. However, improvements in roads, truck efficiencies, and storage techniques have prompted many companies to close older, smaller facilities and open new, more-efficient ones. These larger and more-modern facilities allow companies to process more product at a lower cost per unit, thus taking advantage of economies of scale.

Economies of Scale

In farming, as in any business, taking advantage of economies of scale allows producers to increase profits. This occurs at every scale, although it is often associated with larger farming operations. The key is to alter farming practices to make the operation more efficient, and reduce the cost per unit of production. On a smaller farm, the farmer might take advantage of economies of scale by increasing the level of fertilization and irrigation of a crop. By doing so, the farmer increases expenses by 10 percent, but if the harvest increases by 25 percent, then the cost per unit will decrease, and once again, profits will increase.

Distribution Systems

In commercial farming, people have to transprot products from farm to market before consumers can purchase them and suppliers can make profits. That means the products have to arrive at a food processor, wholesaler, and eventually, market in a timely manner.

If the crops are perishable, such as tomatoes or strawberries, the distribution system from the farm to the market must allow for frequent pickup and delivery to the market. If this is not possible, then the farmers and the shipper must have access to a storage system that can preserve the quality of the crop for a few extra days. However, agricultural industries, like other industries, have adopted a system of *just-in-time delivery* to reduce the need for storage space. The COVID-19 pandemic illustrated that when just-in-time delivery systems were interrupted and product shortages occurred.

In the case of regional and global distribution, different markets might demand different products, and therefore, farmers have to adapt their production accordingly. The differences in the demand could relate to preparation and storage options available at the destination, eating traditions and taste preferences, and religious beliefs.

However, if bad weather, transportation breakdowns, or other problems delay a delivery to a grocery store, then the consumers will often have to do without the desired product. With food, this might be an inconvenience or a a serious concern, especially in a region where the population is struggling to survive.

Government Policies

Food is vital to national security, so governments often adopt policies to protect agriculture. However, many governments let market forces determine exactly what and how much farmers produce. Government policies can influence food production and farmers in several ways:

- Regulations governing migrant workers who often work in food production industries
- Financial assistance, such as low-interest loans and transportation subsidies

- Investment in transportation and storage (grain elevators) infrastructure to increase efficiency and storage capacity
- Regulations on the amount of a product grown or sold to prevent surplus or shortages
- Taxes to discourage production and use of products considered unhealthy, such as tobacco
- Changes in environmental and health regulations influence which products farmers will grow

International politics can also lead to changes in production. A trade agreement with another country could open new markets for farmers and encourage increased production. As part of a larger trade deal, a country might have to reduce exports of a certain crop which could lead to less production. On occasion, countries will impose a **tariff** (tax on imports) or a **quota** (limit the quantity of a good imported) to protect domestically produced goods. These trade restrictions raise the price of imports and make domestic goods more competitive in price within the country in which they were produced. If these restrictions continue for an extended period, farmers alter their production of crops. Between 2018 and 2020, the United States and China both raised their tariffs on traded products. (See Topic 7.6.)

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are the challenges and debates related to the changing nature of contemporary agriculture and food-production practices?*

Contemporary Agriculture and Food-Production Practices	Associated Challenges With Practices

KEY TERMS

genetically modified organisms (GMOs)
aquaculture (aquafarming)
Blue Revolution
overgraze
organic foods
value-added crops
value-added farming
local-food movement
urban farming
community gardens
vertical farms
hydroponics
community-supported agriculture (CSA)
food insecurity
food desert
food distribution system
food processing
tariff
quota

5.12

Women in Agriculture

Essential Question: What are the variations in female roles in food production and consumption?

Women play a crucial role in global agriculture. This role has changed and is continuing to change as women become more important in the world's efforts to eliminate hunger. The importance of women's role in agriculture is reflected in the following suggestion made in a report by the UN's Food and Agriculture Organization, "if women farmers gain access to the same resources as their male counterparts, the entire world will eat, too."

Gender Roles in the Food System

In most cultures throughout history, males and females had distinct roles in producing and preparing food. However, some of these roles have changed as technology has changed.

Food Production Women have played a major role in agriculture since humans first started farming. Today, they make up about 40 percent of the world's agricultural labor force. In regions where subsistence farming remains common, that figure is 70 percent, and the contributions of women are changing regardless of the type of farming:

- In many areas of the developing world, men migrate to urban areas in search of employment, while women stay at home and work their farms along with children. In operations where farmers sell their products at local market, women are often the sellers.
- Where farming has modernized and machines have been introduced, women have become less involved with the field work.
- In large-scale agribusinesses, women have taken on additional roles. Besides raising crops, tending animals, and processing products, they work in management, sales, distribution, and research.

Food Preparation As people have changed where they live and work, they have changed how they prepare food. As people moved from rural areas to urban areas, they grew less food and purchased more of it. Today, women are more likely to work outside the home, so they spend less time preparing food than in previous generations.

People purchase more convenience foods than previously, from cake mixes to entire meals that simply need to be heated. The demand for these foods has grown so much that food companies are committing significant research

money to developing visually appealing, tasty, and healthful food products. In addition, men have become more involved in food preparation in the regions of the world with greater gender equality, particularly in households where both partners are working. Another result is that people eat in restaurants more than ever before. In 2015, for the first time in history, Americans spent more money eating out than they spent on groceries.

Gender Equality and Agriculture: Hope for the Future

The unequal opportunities, treatment, or rights of a person based on gender is considered **gender inequality.** It is a reality throughout all parts of the world and affects all aspects of society, such as educational and leadership opportunities, reproductive rights, employment options, and property ownership. Over the past few decades some progress toward gender equality has occurred, but not in all countries. (See Topic 7.4.)

In agriculture, the lack of gender equality has a very significant impact on productivity. Especially in periphery countries, where the majority of economically active women are employed in farming, women have assumed increased responsibilities. Increasingly, men are taking nonfarming jobs in urban areas, leaving women to run the farm and care for children. In spite of the added work and responsibility, women still often have little authority in the eyes of the government officials, businesses, society, or male farmers.

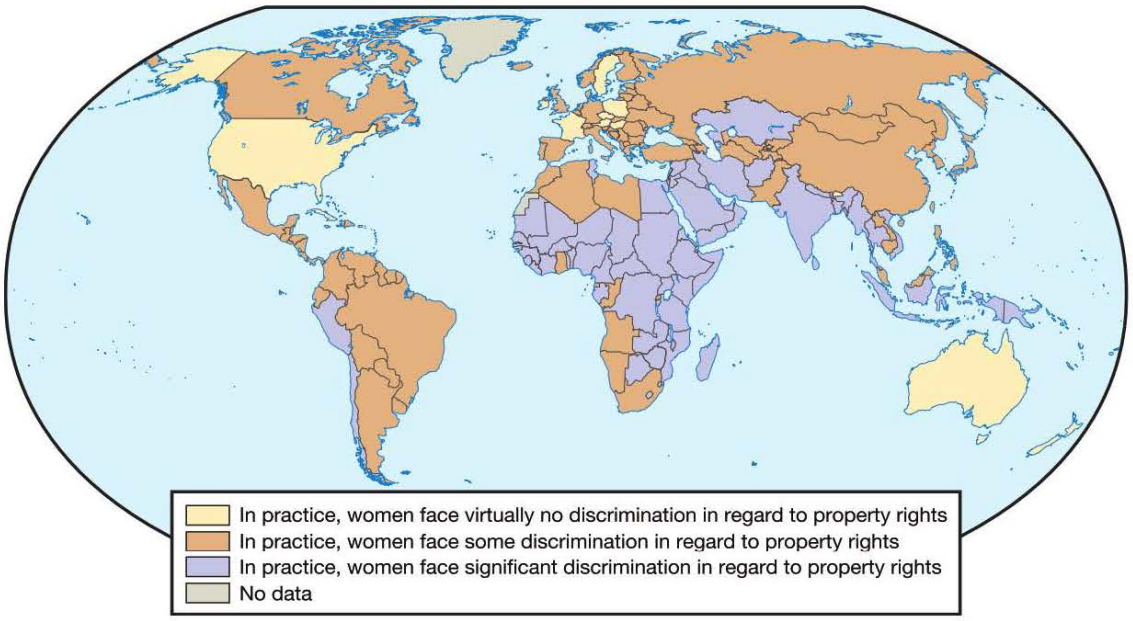
Women face **gender-specific obstacles,** or discriminatory practices that prevent female farmers from reaching their potential productivity:

- Women are denied access to finance and capital. It is much more difficult for women to secure the necessary financing for farm inputs, such as machinery and agricultural chemicals. Therefore, female farmers are often not able to modernize and increase productivity.
- Women are denied training and education. Women are often excluded from opportunities to become familiar with new and improved practices to improve productivity and safety on their farms.
- Women are denied property ownership. Female property ownership is rare throughout the world, especially in the peripheral countries.
- Women have limited mobility. In cultures where women face restrictions to their mobility, such as needing their husbands' or fathers' consent to leave their homes, it is difficult for women to either take farm products to the market to sell or trade, or to go to the market to acquire food .
- Women lack political power. When development projects are planned, women are rarely allowed leadership positions or consulted. Consequently, plans are implemented without the knowledge and ideas of the women who will play a role in shaping the plan's success or failure.

In terms of productivity, the lack of gender equality has resulted in a **crop gap** of 20 to 30 percent between male- and female-run farms. Female-run farms are much less productive because of gender-specific obstacles. The worst food insecurities in the world are found in the periphery, the same area where

the gender-specific obstacles are the most prevalent. The Food and Agricultural Organization (FAO) of the United Nations estimated that if gender equality existed, the crop gap would disappear, and that female-run farms could even exceed the productivity of male-run farms. This would result in tremendous economic growth and increase the amount of food available in the periphery.

PROPERTY RIGHTS FOR WOMEN, 2017



Source: womenstats.org

Describe the patterns of property rights of women. What is the relationship between the patterns and gender equality in agriculture?

REFLECT ON THE ESSENTIAL QUESTION

Essential Question: *What are the variations in female roles in food production and consumption?*

Challenges Due to the Role of Females in Food Production and Consumption	Contemporary Solutions

KEY TERMS

gender inequality
gender-specific obstacles
crop gap

Farmers, like business owners, try to utilize their resources and attract new sources of revenue and profit. Two strategies to increase revenue are agritourism and organic farming.

Agritourism

An additional potential revenue source for farmers is the growing trend of agritourism—where tourists visit farms for recreational reasons. It has become more common for farms to provide entertainment and hospitality experiences for consumers. Agritourism is especially important to smaller family farms.

Tourists may be involved in U-pick activities or purchase fresh products from a farm stand. The farm may provide experiences such as a corn maze, a petting zoo with farm animals, or a hayride. Educational opportunities for school groups or interested individuals might be another service the farm provides. Some farms host overnight stays to allow the guests to experience a true farm lifestyle, whether it is waking up to the crowing of a rooster, gathering fresh eggs to cook for breakfast, or helping with chores.

Farmers benefit from the revenue collected from agritourism activities such as a corn maze. Agritourism is also a great way for the non-farming public to become educated about farming practices and gain an appreciation for where food comes from

Organic Trends

Organic agricultural sales have boomed over the past decade with revenue in 2019 of nearly $50 billion in the United States. While non-organic modern agriculture produces food for the masses and is often sold globally, organic food has been largely seized upon by local-food movements. Organic farming—which is more expensive—has proven to be profitable because many people will pay more for organic foods.

The Distribution of the Organic Food Market

The location of organic food consumption can be best explained through the spatial analysis of economic factors, such as income. The concentration of organic food sales is predictably uneven. Farmers markets and supermarkets that offer organic foods are largely found in wealthier regions. Almost half

of all organic food is sold and consumed within 100 miles of its production. Moreover, most consumption and production in the United States takes place around wealthy urban areas and organic hotspots along the West Coast and in the Northeast.

1. Describe TWO ways that farmers are trying to increase revenue.
2. Describe why some farmers are choosing to grow organic crops.
3. Explain why organic farming is unlikely to work on a global scale.

THINK AS A GEOGRAPHER: *USE SCALE TO ANALYZE FAIR TRADE*

FAIR TRADE IMPORTS TO THE UNITED STATES, 1998–2015				
Year	**Coffee**	**Tea**	**Cocoa**	**Sugar**
1998	76,059	no data	no data	no data
2000	4,249,534	no data	no data	no data
2005	44,585,323	490,645	1,036,696	271,680
2010	105,251,476	1,483,666	4,392,674	18,146,124
2015	163,630,275	2,347,699	38,492,988	38,173,065
Total, 1998 to 2015	1,359,418,892	16,002,044	129,087,925	151,248,397

Source: *Fair Trade USA 2015 Almanac. Quantities measured in pounds or other units.*

The concept of scale is useful to analyze how the principles of fair trade work in practice. The underlying principle of fair trade is to ensure that agricultural producers are fairly compensated for their work. Other principles of fair trade include fair pricing, poverty alleviation, mutual benefit (seller-producer), gender equity, safe working conditions, and environmental responsibility.

At the global scale, fair trade works when consumers in core countries desire fair trade products from the periphery countries of the world. The concept can also be applied at the neighborhood or family scale. (See Topic 5.9 for more on fair trade.)

Apply the concept of scale to the principle of fair trade in each question.

1. At the household scale, how does a family that grows food in a garden for their own consumption demonstrate some, but not all, of the principles of fair trade?
2. At the community scale, how does a farmers market demonstrate the principles of fair trade?
3. At the global scale, how does the data suggest that the idea of fair trade is becoming more widespread?
4. How does the practice of fair trade affect each of the following groups: producers in periphery countries, multinational companies, and consumers in highly developed countries?

CHAPTER 14 REVIEW:
Understanding the Challenges and Consequences of Agriculture

Topics 5.10–5.12

MULTIPLE-CHOICE QUESTIONS

Questions 1 and 2 refer to the following image.

1. Which concept is demonstrated in the picture above?

(A) The results of the enclosure movement
(B) The impact of the Green Revolution
(C) The significance of carrying capacity
(D) The use of terrace farming
(E) The effects of deforestation

2. Which is a major concern related to the practice shown in the image?
(A) The amount of arable land is increased
(B) The practice decreases the efficient use of water resources
(C) Soil erosion increases dramatically
(D) Maintenance of the fields is difficult
(E) The use of large-scale capital-intensive machinery to grow crops

3. Deforestation has resulted in

(A) more farmland in some places but more desertification in others

(B) more farmland in some places and less desertification in others

(C) less farmland in some places but more desertification in others

(D) less farmland in some places and less desertification in others

(E) no noticeable change in the amount of farmland or desertification

4. In which group of countries are GMOs used most widely?

(A) United States, Brazil, and Argentina

(B) France, Germany, and the Netherlands

(C) Kenya, Tanzania, and Ethiopia

(D) India and Bangladesh

(E) Australia and New Zealand

5. Slash-and-burn agriculture is often used in areas that have

(A) soil that lacks sufficient nitrogen to grow food crops quickly

(B) a climate of extremes, with very hot summers and very cold winters

(C) a shortage of rain throughout the year, such as an arid region

(D) very high elevations, such as in mountain ranges

(E) a combination of climate and physical features that result in crops growing very slowly

6. What is the main reason that female farmers in periphery countries are not as productive as male farmers?

(A) Gender inequalities prevent female farmers from access to the same resources as male farmers.

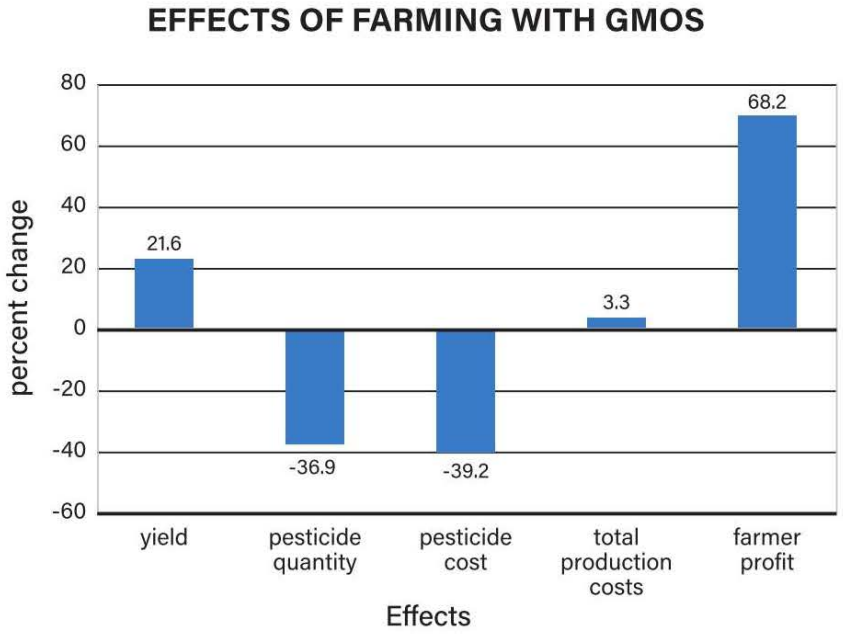
(B) Male farmers have more farming experience and their farming knowledge is passed down from fathers to sons.

(C) Men have a greater natural talent (aptitude) for farming.

(D) Farming is a physically demanding activity and males are stronger.

(E) Women in periphery countries consider farming as a hobby and just practice it in their spare time.

Question 7 refers to the following graph.



Source: Science in the News

7. What does the graph indicate about the effects of farming with genetically modified crops?
   (A) The use of both pesticides and fertilizer drop significantly.
   (B) Farm revenue goes up but production costs go up more.
   (C) Yields increase and farm profits increase even more.
   (D) Total production costs drop because pesticide costs decrease.
   (E) Farm profits go up due to increased prices internationally.

FREE-RESPONSE QUESTION

There have been many changes in the production, distribution, and marketing of food over the past few decades.

(A) Explain why farmers using GMOs often use less insecticides and pesticides than farmers growing traditional crops.

(B) Explain why some people consider supporting the local-food movement to be more environmentally friendly than purchasing food from a large grocery chain.

(C) In order to increase profits some farmers are relying on value-added farming. Identify an example of value-added farming.

(D) Describe how community-supported agriculture typically works.

(E) Describe TWO differences between a coffee plantation and a fair-trade coffee farm.

(F) Compare the food purchasing options available to people living in a food desert and a suburban area of a city.

UNIT 5 REVIEW:
Connecting Course Skills and Content

APPLYING GEOGRAPHIC SKILLS

Applying and utilizing geographic skills is critical for success on the AP® Exam. For each skill listed, write a one-paragraph response that illustrates your understanding of that course skill. Support your response with specific examples and evidence. Refer to the Unit 1 introduction (pages 3–8) for tips on how to apply geographic skills.

1E Explain strengths, weaknesses, and limitations of von Thünen's Model.

2D Explain similarities and differences of agricultural processes in the core and periphery regions of the world.

3B Use one map and one data table from Unit 5 that contains quantitative data and describe two spatial patterns for each map and table.

4C Choose one of the sets image in Topic 5.10 (western Brazil or the Aral Sea) and explain a pattern and change within the images. Also, explain a reason for and an impact of the pattern or change.

5C Compare how large-scale global food production is different than small-scale subsistence farming. Describe one way the two systems can interact on a local scale.

WRITE AS A GEOGRAPHER: *USE RELEVANT INFORMATION*

One problem students face when answering a free-response question is to decide what information actually supports their claim. Students should leave out all other information that is not clearly, directly related to the question. For example, a free-response question might ask: Explain how farmers in Mexico make decisions about what crops to grow.

Which of the following statements are relevant to answering this question? For ones that are not, explain why they are not.

1. Most of southern Mexico has a warm, moist climate that supports growing many fruits and vegetables.
2. Brazil has areas of heavy rainfall that are excellent for growing sugar and rice.
3. Improvements in the ports in New Orleans and on the Florida coast reduced the cost of importing goods.
4. Concerns about the long-term effects of soil erosion and fertilizer runoff have persuaded some farmers to consider changing the crops they grow.
5. Von Thünen's model can be used to study decisions by farmers.
6. The primary language spoken throughout Mexico is Spanish.