**Chapter 9: Food & Agriculture**

**Key Issue 1: Where Did Agriculture Originate?**

**Agriculture** is deliberate modification of Earth’s surface through cultivation of plants and rearing of animals to obtain sustenance or economic gain. Agriculture emerged when humans domesticated plants and animals for their use. Cultivate means “to care for,” and a **crop** is any plant cultivated by people.

**Introducing Food and Agriculture** Agricultural activity began before recorded history, making determinations of its origins difficult. A timeline following the logical series of events based on fragments of information about ancient agricultural practices and historical environmental conditions has been pieced together by scholars.

**Invention of Agriculture** The era when human beings began to domesticate plants and animals and no longer relied entirely on hunting and gathering is known as the **agricultural revolution**.Researchers believe that the agricultural revolution began circa 8,000 b.c., as the world’s population rapidly increased relative to era’s past. The domestication of plants and animals provided humans larger and more stable sources of food, allowing more people to survive. Environmental and cultural factors likely played into the genesis of the agricultural revolution. Environmental factors, such as climate change and the ending of the last ice age, allowed for a wider spatial distribution of humans, animals, and plants. Cultural factors, such as the accidental and deliberate experimentation with the production of plants, likely resulted in a preference for living in a fixed place rather than as nomads.

**Agricultural Hearths** The planting of crops and domestication of animals originated in multiple hearths around the world across different eras. Hearths include Southwest Asia, East Asia, Central and South Asia, sub-Saharan Africa, and Latin America. Around 10,000 years ago, barley, wheat, lentil, and olives were cultivated in Southwest Asia. Between 8,000 and 9,000 years ago, animals such as cattle, goats, pigs, and sheep were domesticated in this hearth. From this hearth, cultivation diffused west to Europe and east to Central Asia. In East Asia, rice is thought to have been domesticated more than 10,000 years ago, along the Yangtze River in eastern China. Chickens are theorized to have diffused from South Asia round 4,000 years ago. In Central Asia, the horse is speculated to have been domesticated, mirroring the diffusion of the Indo-European language. Sorghum was domesticated in central Africa approximately 8,000 years ago, and yams are thought to have been domesticated in this hearth even earlier. In Latin America, beans and cotton are thought to have diffused from Mexico, and the potato is considered to have originated in Peru. Maize (corn) is hypothesized to have emerged from the two hearths independently, diffusing north and south.

**Subsistence and Commercial Agriculture** The key differences in agricultural practices are between those in developing countries and those in developed countries. In developing countries most people work in **subsistence agriculture**,which is the production of food primarily for consumption by the farmer’s family. Very few people in developing countries work in **commercial agriculture** which is the production of food primarily for sales off the farm.

**Percentage of Farmers** In developed countries, roughly 3 percent of the workforce is engaged directly in farming, in contrast to the 42 percent of workers engaged in farming in developing countries. The vast majority of people engaged in farming activity in developed countries work as commercial farmers. Both push and pull factors have contributed to the decline of farmers in the United States. People were pushed away from farms by lack of opportunity to earn a decent income and at the same time they were pulled to higher-paying jobs in urban areas.

**Role of Machinery, Science, and Technology** Beginning in the late eighteenth century, factories produced farm machinery. Inventions in farming in the nineteenth and twentieth centuries made farming less dependent on human and animal power. The building of railroads in the nineteenth century and highways and trucks in the twentieth century have enabled farmers to transport crops and livestock farther and faster. Experiments conducted in university laboratories, industry, and research organizations generate new fertilizers, herbicides, hybrid plants, animal breeds, and farming practices that produce higher crop yields and healthier animals. GPS devices have allowed farmers to assist in the precise planting of seeds and for spreading different types and amounts of fertilizers. On ranches, GPS can be used to monitor the locations of cattle and tractors. Satellite imagery is a valuable resource for measuring crop progress, as well.

**Farm Size** The average farm is relatively large in commercial agriculture. Combines, pickers, and other machinery perform most efficiently at very large scales and their considerable expense cannot be justified on a small farm. Farmers spend hundreds of thousands of dollars to buy or rent land and machinery before beginning operations. Commercial farmers frequently expand their holdings by renting nearby fields. The amount of land devoted to agriculture has increased in the United States primarily due to irrigation and reclamation.

**Key Issue 2: Why Do People Consume Different Foods?**

The modern American or Canadian farm is mechanized and highly productive, especially compared to subsistence farms found in much of the rest of the world. This difference represents one of the most basic contrasts between the more developed and less developed countries of the world.

**Diet and Nutrition** Consumption of food varies around the world, both in total amount and source of nutrients. These differences result from a combination of level of development, physical conditions, and cultural preferences. In more developed countries, people consume a greater amount of food from various sources than people in developing countries. Climate is a determining factor in what can be easily grown and consumed in developing countries. In developed countries, supply chains allow for food to be sourced from many different climates. Some food preferences and avoidances are expressed without regard for physical and economic factors.

**Total Consumption of Food** The amount of food that an individual consumes is known as **dietary energy consumption**. The unit measurement of dietary energy is the calorie in the United States. Most humans derive most of their calories through consumption of a **cereal grain**. A cereal grain is a grass that yields grain for food and the **grain** is the seed from a cereal grass. The three leading cereal grains are wheat, rice, and corn (maize). These three grains together account for 90 percent of all grain production and more than 40 percent of all dietary energy consumed worldwide.

**Dietary Energy Needs** To maintain a moderate level of physical activity, an average individual needs to consume at least 1,844 kcal per day. Average consumption worldwide is approximately 2,902 kcal per day. People in developed countries are consuming 3,400 kcal a day. The United States has the highest consumption, 3,800 kcal per day per person. In sub-Saharan Africa average daily consumption is 2,400 kcal a day. Some people in sub-Saharan Africa are not getting enough to eat and have to spend a high percentage of their income to obtain food.

**Source of Nutrients** The United Nations defines food security as physical, social, and economic access at all times to safe and nutritious food sufficient to meet dietary needs and food preferences for an active and healthy life. Ten percent of the world population is classified as not having food security.

**Protein** Protein is a nutrient needed for growth and maintenance of the human body. Many food sources provide protein of varying quantity and quality. One of the most fundamental difference between developed and developing regions is the primary source of protein. In developed countries, the leading source of protein is meat products, including beef, pork, and poultry. In most developing countries, cereal grains provide the largest share of protein.

**Key Issue 3: Where Is Agriculture Distributed?**

Geographer Derwent Whittlesey mapped the world’s agricultural regions in 1936. Despite many physical and theoretical changes concerning agriculture since his time, his research helped lay the foundation for the modern division of the Earth into agriculture regions.

**Agricultural Regions and Climate** The overlap between agricultural and climate maps is readily apparent. For example, pastoral nomadism is the predominant type of agriculture in Southwest Asia and North Africa, corresponding to a dry climate, while shifting cultivation is the primary type of agriculture in sub-Saharan Africa. Differences in the type of agriculture can be present within developed and developing countries, as well. These variations can be seen in the deserts of eastern South California contrasted with the verdant valleys of the Salinas valley of Central California. Geographers are reluctant to place too much emphasis on climate as a determining factor in global agricultural differences, due to their strained history with environmental determinism. Agricultural differences in places of similar climate can be attributed to variations in cultural preferences and levels of development.

**Subsistence Agriculture in Dry Regions** Whittlesey conceptualized 11 distinct agricultural regions, along with areas where agriculture was not present. Five of these regions are important forms of agriculture in developing countries, while 6 are forms of commercial agriculture important in developed countries. The five agriculture regions primarily seen in developing countries are intensive subsistence, wet-rice dominant; intensive subsistence, crops other than rice dominant; pastoral nomadism; shifting cultivation; and plantation. The six agricultural regions primarily seen in developed countries include mixed crop and livestock; dairying; grain; ranching; Mediterranean; and commercial gardening.

**Hunters and Gatherers** Prior to the agricultural revolution, all humans probably obtained food through hunting for animals, fishing, or gathering plants. Groups of hunters and gatherers generally kept their numbers below 50, as a larger number would quickly exhaust the available resources within walking distance. Groups regularly traveled, with their direction and frequency of migration determined by the movement of game and the seasonal growth of plants at different locations. Men hunted game or fished, while women gathered berries, nuts, and roots. This division of labor is evidenced by archaeological and anthropological findings. Only an estimated quarter-million people of the world’s population still survive by hunting and gathering.

**Pastoral Nomadism Pastoral nomadism** is a form of subsistence agriculture based on the herding of domesticated animals. Pastoral nomads live primarily in the large belt of arid and semiarid land that includes Central and Southwest Asia and North Africa. The animals provide milk, and their skins and hair are used for clothing and tents. Pastoral nomads consume mostly grain and not meat because their animals are usually not slaughtered. Pastoral nomads mostly obtain grain from farmers in exchange for animal products but have been known to plant crops in some circumstances. The camel is the most highly desired animal in North Africa and Southwest Asia, along with sheep and goats.

Pastoral nomads do not wander randomly across the landscape but have a strong sense of territoriality. The goal of each nomad is to control a territory large enough to contain the forage and water needed for survival. The precise migration patterns evolve from intimate knowledge of the area’s physical and cultural characteristics. Pastoral nomadism is now generally recognized as an offshoot of sedentary agriculture, not a primitive precursor of it. It is simply a practical way of surviving on land that receives too little rain for the cultivation of crops. Some pastoral nomads practice **transhumance**, which is seasonal migration of livestock between mountains and lowland pasture areas.

**Subsistence Agriculture in Tropical Regions Shifting Cultivation** is practiced in much of the world’s tropical, or A, climate regions, which have relatively high temperatures, and abundant rainfall. This type of agricultural activity is practiced by approximately 250 million people across 14 million square miles. **Plantation** farming is also found in these areas.

**Shifting Cultivation** Two key features are indicative of shifting cultivation:

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

People who practice shifting cultivation generally live in small villages in the tropics and grow food on the surrounding land. Before planting, they must remove the vegetation that typically covers tropical land. On a windless day the vegetation is burned. The rains wash the fresh ashes into the soil, providing needed nutrients. The cleared area, known as **swidden**, is prepared by hand, perhaps with the help of a simple implement such as a hoe. The cleared land can support crops only briefly, usually three years or less. Soil nutrients are rapidly depleted and the land becomes too infertile to nourish crops. When the swidden is no longer fertile, villagers identify a new site and begin clearing it.

**Crops of Shifting Cultivation** Each village grows crops according to their local custom and taste. The primary crops include upland rice in Southeast Asia, maize (corn) and manioc (cassava) in South America, and millet and sorghum in Africa. Yams, sugarcane, plantain, and vegetables are also grown in some regions. Most families grow only for their own needs, so one swidden may contain a large variety of intermingled crops, which are harvested individually at the best time. A “farm field” appears much more chaotic than do fields in developed countries where a single crop is grown over an extensive area.

**Ownership and Use of Land in Shifting Cultivation** Traditionally, land was owned by the village as a whole rather than separately by each resident. The chief or ruling council allocated a patch of land to each family and allowed them to retain the output. Today, private individuals now own the land in some communities, especially in Latin America. Land used for shifting cultivation covers roughly one-fourth of the world’s land area, a higher percentage than any other type of agriculture, although less than 5 percent of the world’s people are involved in shifting cultivation.

**Future of Shifting Cultivation** According to the United Nations, land used for shifting cultivation is decreasing in the tropics at the annual rate of roughly 30,000 square miles, or 0.2 percent. Less than half of the land area originally occupied by tropical rain forest remains today, as World Bank loans for development in these regions formerly supported deforestation efforts. Today, shifting cultivation is being replaced by logging, cattle ranching, and the cultivation of cash crops. People in developing countries are also abandoning shifting cultivation at increasing rates, as the method can only support a small number of people in an area without causing environmental damage. Many people consider shifting agriculture to be the most environmentally sound approach for agriculture in the tropics. Practices used in other forms of agriculture, such as applying fertilizers and pesticides and permanently clearing fields, may damage the soil, cause severe erosion, and upset balanced ecosystems.

**Plantation Farming** Most plantations are located in the tropics and subtropics, particularly in Latin America, Africa, and Asia. Despite being located in developing countries, many plantations are owned or operated by Europeans or North Americans, and they produce crops intended for markets in developed countries.Among the primary crops grown on plantations are cotton, sugarcane, coffee, rubber, and tobacco.

**Subsistence Agriculture in Population Concentrations** Three-quarters of the world’s population live in developing countries, and most are fed by **intensive subsistence agriculture**. The term intensive suggests that farmers are required to work intensively to subsist on a parcel of land.

**Characteristics of Intensive Subsistence Farming** Intensive subsistence farming is primarily undertaken in East, South, and Southeast Asia. Agricultural practices developed over thousands of years, informed by local environmental and cultural patterns, evolve into intensive subsistence farming methods. Agricultural density (the ratio of farmers to arable land) is extremely high in parts of East and South Asia, forcing families to produce enough food for their survival from a very small area of land. Land is maximized for planting crops; paths are left as narrow as possible, corners of fields and irregularly shaped pieces of land are used rather than left idle, livestock are rarely permitted to graze on land that could be used for growing crops, and land used to grow grain for animal feed is minimized. Land is used even more intensively in parts of Asia by obtaining two harvests per year from one field, a process known as double cropping.

The typical farm in Asia’s intensive subsistence agriculture regions is much smaller than farms elsewhere in the world. Because agricultural density is so high in parts of East and South Asia, families must produce enough food for their survival from a very small area of land. Most of this work is done by hand or animals rather than the machines, in part due to abundant labor, but largely from lack of funds to buy equipment. The consumers of the rice also perform the work, and all family members contribute to the effort.

**Wet-Rice Dominant** The term **wet rice** refers to rice planted on dryland in a nursery and then moved as seedlings to a flooded field to promote growth. Intensive wet-rice farming is the dominant type of agriculture in southeastern China, East India, and much of Southeast Asia. Wet rice is most easily grown on flat land because the plants are submerged in water much of the time. Most wet-rice cultivation takes place in river valleys and deltas. One method of developing additional land suitable for growing rice is to terrace the hillsides of river valleys. A field is generally prepared by animal power, leveling the area for flooding. The field is then flooded with water. This flooded field is called a **sawah** in Indonesia and is increasingly referred to as a **paddy**, which is the Malay word for rice. For the first month, rice seedlings are grown in a nursery and are then transported to the sawah. Rice plants are then harvested with knives, and the chaff (husks) is separated from the seed by threshing the husks on the ground.

**Wet Rice Not Dominant** Agriculture in much of the interior of India and northeastern China is devoted to crops other than wet rice. Wheat is the most important crop, followed by barley. In addition, some crops are grown in order to be sold for cash, such as cotton, flax, hemp, and tobacco. Land is used intensively and worked primarily by human power, with the assistance of some hand implements and animals. In milder parts of the region where wet rice does not dominate, more than one harvest can be obtained some years through skilled use of **crop rotation**, which is the practice of rotating use of different fields from crop to crop each year to avoid exhausting the soil.

**Fishing** The capture of wild fish and other seafood living in Earth’s waters is known as **fishing**. **Aquaculture**, or **aquafarming**, is the cultivation of seafood under controlled conditions. Both fishing and aquaculture are practiced in subsistence and commercial agriculture.

**Fish Production** The world’s oceans are divided into 18 major fishing regions, including seven each in the Atlantic and Pacific oceans, three in the Indian Ocean, and one in the Mediterranean. Fishing is also undertaken in lakes and rivers. The Pacific Northwest and Asia’s inland waterways are the areas with the largest yields. During the past 50 years, global fish production has grown from roughly 36 to 158 million metric tons. The expansion of aquaculture can be attributed to this increase. The capture of wild fish has stagnated since the 1990s, despite population growth and increased demand to consume fish.

**Fish Consumption** Human consumption of fish and seafood has grown from 27 million metric tons in 1960 to 132 million metric tons in 2012. Five-sixths of this increase can be attributed to consumption in developing countries. Despite accounting for only 1 percent of all calories consumed by humans, per capita consumption of fish has nearly doubled in developed and developing countries over the past 50 years.

**Overfishing** China is responsible for one-third of the world’s yield of fish. The populations of some fish species in Earth’s waters have decreased due to overfishing. **Overfishing** is the capturing of fish faster than they can reproduce. The U.N. estimates that one-fourth of fish stocks have been overfished and one-half have been fully exploited, leaving one-fourth underfished.

**Commercial Agriculture: Crop Based** The system of commercial farming found in developed countries has been called **agribusiness** because the family farm is not an isolated activity but is integrated into a large food-production industry. Agricultural products are not sold directly to consumers, but to food processing companies. Around 20 percent of U.S. laborers work in food production and services related to agribusiness-food processing, packaging, storing, distributing, and retailing. Agribusiness encompasses such diverse enterprises as tractor manufacturing, fertilizer production, and seed distribution.

**Grain Farming** A grain is a seed from various grasses, such as wheat, corn, oats, barley, rice, millet, and others. Commercial grain agriculture is distinguished from mixed crop and livestock farming because crops on a grain farm are grown primarily for consumption by humans rather than livestock. Commercial grain farmers sell their output to manufacturers of food products, such as breakfast cereals and breads. Wheat is the most important grain because it is used to make bread flour. Wheat can be stored relatively easily without spoiling. Because wheat has a relatively high value per unit weight, it can be shipped profitably from remote farms to market.

**Mediterranean Agriculture** Most crops in the Mediterranean lands are grown for human consumption rather than animal feed. Mediterranean agriculture exists predominates in lands that border the Mediterranean Sea in Southern Europe, North Africa, and western Asia. Farmers in California, central Chile, the southwestern part of South Africa, and southwestern Australia also practice Mediterranean agriculture. **Horticulture**—which is the growing of fruits, vegetables, and flowers—and tree crops form the commercial base of Mediterranean farming. The hilly landscape typically found in a Mediterranean climate encourages farmers to plant a variety of crops within one farming area. Typically, the three most important crops grown in Mediterranean agriculture are grapes, olives, and wheat. A large portion of California farmland is devoted to fruit and vegetable horticulture, which supplies a large portion of the citrus fruits, tree nuts, and deciduous fruits consumed in the United States.

**Commercial Gardening and Fruit Farming** This type of agriculture is called **truck farming**. Truck farms grow many of the fruits and vegetables that consumers in developed countries demand. Some of these fruits and vegetables are sold fresh to consumers, but most are sold to large processors for canning or freezing. Truck farms are usually large-scale operations that take full advantage of machines at every stage of the growing process. Labor costs are kept down by hiring migrant farm workers who work for very low wages. Farms tend to specialize in a few crops, and a handful of farms may dominate national output of some fruits and vegetables.

**Commercial Agriculture: Mixed Crop and Livestock** Mixed crop and livestock farming is the most common form of commercial agriculture in the United States west of the Appalachians and east of 98° west longitude and in much of Europe, from France to Russia.

**Mixed Crop and Livestock Farming** Most of the crops grown in **mixed crop and livestock farming** agriculture are fed to animals rather than consumed directly by humans. In turn, livestock supply manure to improve soil fertility to grow more crops. A typical mixed crop and livestock farm devotes nearly all land area to growing crops but derives more than three-fourths of its income from the sale of animal products, such as beef, milk, and eggs. Mixed crops and livestock farms permit farmers to distribute the workload more evenly through the year. In the United States, corn is the most frequently planted crop because it generates higher yields per area than do other crops. Soybeans are the second most important crop in the United States. Corn and soybeans are commonly fed to livestock.

**Importance of Access to Markets** In developed countries, the use of land is primarily determined by market forces of supply and demand. The value of the land impacts the form of commercial agriculture practiced on it. The distance from the farm to the market affects the farmer’s choice of crop to plant. Geographers employ the von Thünen model to help explain the importance of proximity to market in the choice of crops on commercial farms. In choosing an enterprise, the farmer considers two costs: the cost of the land and the cost of transporting products to market. The crops grown around cities can be identified using a concentric circle conceptualization, in the form of four rings:

* First ring. Market-oriented gardens and milk producers were located in the first ring out from the cities. These products are expensive to deliver and must reach the market quickly because they are perishable.
* Second ring. The next ring out from the cities contained wood lots, where timber was cut for construction and fuel; proximity to market is key for this commodity because of its weight.
* Third ring. The next ring was used for various crops and for pasture; the particular commodity was rotated from one year to the next.
* Fourth ring. The outermost ring was devoted exclusively to animal grazing, which requires a great deal of space.

This model assumes that all land in a study area has similar site characteristics and was of uniform quality, although von Thünen recognized that the model could vary according to topography and other distinct physical features (e.g. a river or body of water extending into a ring).

**Commercial Agriculture: Animal-based** Dairy farming is the most significant agriculture undertaken near large urban areas in developed countries. Ranching is adapted to semiarid or arid land and is practiced in developed countries where the vegetation is too sparse and soil too poor to sustain crops.

**Dairy Farming** A **dairy farm** specializes in the production of milk and other dairy products. As milk is highly perishable, dairy farms must be located closer to the market than other products. The ring surrounding a city from which milk can be supplied without spoiling is called the **milkshed**.Dairy farmers, like other commercial farmers, usually do not sell their products directly to the consumers. Instead they generally sell their milk to wholesalers, who distribute it in turn to retailers. In general, the farther the farm is from large urban concentrations, the smaller is the percentage of output devoted to fresh milk. Farms located farther from consumers are more likely to sell their output to processors to make butter, cheese, or dried, evaporated, and condensed milk. The reason is that these products keep fresh longer than milk does and therefore can be safely shipped from remote farms. As farming of cows is labor intensive and in some cases cost prohibitive (e.g. the expense of feeding cows during the winter), many dairy farmers have quit.

**Livestock Ranching Ranching** is the commercial grazing of livestock over an extensive area. Commercial ranching is conducted in several developed countries besides the United States, and increasingly in developing countries. As with other forms of commercial agriculture, the growth of ranching has been in developing countries. China is the leading producer of meat, ahead of the United States, and Brazil is third. China passed the United States as the world’s leading meat producer in 1990 and now produces twice as much meat. Developed countries were responsible for only one-third of world meat production in 2013, compared to two-thirds in 1980.

**Key Issue 4: Why Do Farmers Face Sustainability Challenges?**

Seven challenges confront agriculture in providing more food for a growing and hungry world, while preserving and protecting Earth’s agricultural resources for the future:

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

**Losing Agricultural Land** In the past, world food production increased primarily by expanding the amount of land designated for agriculture. As population increased during the Industrial Revolution, people simply staked a claim of unsettled land in uninhabited territory to produce more agricultural land (as seen in the American West during the nineteenth century). Despite only 11 percent of the world’s land area being cultivated, population is growing at a rate that outpaces development of agricultural land.

**Loss of Farmland to Urbanization** Expanding urban areas have caused a significant loss of farmland, especially in the Eastern Seaboard of the United States. In the United States, 200,000 hectares of the most productive farmland, known as **prime agricultural land**, is being encroached upon and replaced by expanding urban areas. This issue is especially evident in Maryland, where geographic information systems (GIS) have been used to identify prime agricultural land to preserve as Baltimore and Washington D.C. continue to grow and coalesce into a continuous built-up area.

**Desertification** In a process called **desertification**, human actions are causing land to deteriorate to a desertlike condition. This process is more precisely referred to as semiarid land degradation. Excessive crop cultivation, animal grazing, and tree felling exhaust the soil’s nutrients and hinder agriculture. The Earth Policy Institute estimates that 2 billion hectares of land have suffered desertification on Earth. Overgrazing is considered to be responsible for 34 percent of the total, deforestation for 30 percent, and agricultural use for 28 percent. The U.N. estimates that desertification removes 27 million hectares of land from agricultural production every year.

**Improving Agricultural Productivity** During the second half of the twentieth century, population increased at the fastest rate in human history. Massive global famine is projected by many experts, as increases in agricultural land cannot keep up with population growth. Increased agricultural productivity has prevented any famines from coming to pass, and has resulted in an expansion of food supply. Today, the same amount of land can produce greater yields due to new agricultural practices.

**Intensification by Subsistence Farmers** For hundreds if not thousands of years, subsistence farming in developing countries yielded enough food for people living in rural villages to survive, assuming that no drought, flood, or other natural disasters occurred. Suddenly in the late twentieth century, developing countries needed to provide enough food for a rapidly increasing population as well as for urban residents, who cannot grow their own food. Subsistence farmers had to increase the supply of food by adopting new farming methods and leaving farm land fallow for shorter periods of time.

**The Green Revolution** The invention and rapid diffusion of more productive agricultural techniques during the 1970s and 1980s is called the **green revolution**. The green revolution involves two main practices: the introduction of new higher-yield seeds and the expanded use of fertilizers. The new miracle seeds were diffused rapidly around the world. To take full advantage of the new miracle seeds, farmers must use more fertilizer and machinery. Farmers need tractors and irrigation pumps to make the most effective use of the new miracle seeds. In developing countries, farmers cannot afford such equipment, fertilizers, and even the fuel for the tractors. To offset these costs, governments in developing countries must allocate scarce funds to subsidize the cost of seed, fertilizers, and machinery.

**Increased Productivity: Commercial Farmers** Recently, productivity has also increased among commercial farmers. New seeds, fertilizers, pesticides, mechanical equipment, and management practices have allowed commercial farmers to obtain greatly increased yields per area of land.

**Conserving Agricultural Resources** Plants and animals require water to survive and thrive. Lack of water is putting stress on agriculture in many regions, while an overabundance of water can cause soil erosion.

**Agriculture and Water in California** California’s limited water supply comes from two main sources: surface water, which is water that travels or gathers on the ground, like rivers, streams, and lakes; and groundwater, which is water that is pumped out from the ground. Recent persistent drought has severely reduced the amount of surface water captured. In years with normal rainfall, 70 percent of California’s water is supplied by surface water. Today, only 40 percent is supplied by surface water as a result of prolonged drought conditions. The distribution of water in California does not mirror the distribution of demand—most water supplies are located in the north, while Central and Southern California is where demand is primarily situated.

**Sustainable Land Management** Soil erosion is an issue in the U.S. Midwest, where nutrient-rich top soil is washed away by excessive rainfall, or made loose by tillage making them susceptible to being washed away or blown away by wind. Conservation tillage is a method of soil cultivation that reduces soil erosion and runoff. Under conservation tillage, some of all of the previous harvest is left on the fields through the winter. **No tillage** leaves all of the soil undisturbed, and the entire residue of the previous year’s harvest is left untouched on the fields. **Ridge tillage** is a system of planting crops on ridge tops. Ridge tillage compares favorably with conventional farming for yields while lowering the cost of production. Ridge tillage will tend to increase organic matter, improve water holding capacity, and usually cause more earthworms. Although more labor intensive than other systems, ridge tillage is profitable on a per-acre basis.

**Applying Biotechnology to Agriculture** In the late twentieth century, developments in genetic modification allow the alteration of genetic composition to ensure the dominance of the most favorable traits for cultivation.

**Genetically Modified Organisms** A **genetically modified organism** (GMO) is a living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology.
A GMO combines genetic material of two or more species that would otherwise not mix in nature.
In 2010, 10 percent of farmland was devoted to genetically modified crops; 77 percent of the world’s soybeans, 49 percent of cotton, and 26 percent of maize were genetically modified in 2010. GM is especially widespread in the United States. Three-fourths of the processed food that Americans consume has at least one genetically modified ingredient. Developing countries are responsible for one-half of the genetically modified food grown, while the United States is responsible for the other one-half. The United States has urged sub-Saharan African countries to increase their food supply in part through increased use of GM crops and livestock. There is strong opposition to GM crops in some African countries, with detractors pointing to potential health problems, export problems, and increased dependence on the United States as issues to consider.

**Global Food Trade** Total agricultural exports from all countries have grown from $0.4 trillion in 2000 to $1.3 trillion in 2012. Exporting countries benefit from increased revenues, and importing countries meet the food needs of their people. Prior to World War II, Europe was the only major food importing region, as they historically used their colonies as suppliers of food. East Asia and the former Soviet Union became net food importers in the 1950s, Southwest Asia and North Africa during the 1970s, South Asia and sub-Saharan Africa during the 1980s, and Central Asia in 2008. Japan is the clear leader in the import of food, followed by the United Kingdom, China, and Russia. The United States passed Public Law 480, the Agricultural, Trade, and Assistance Act of 1954 in response to the growing global demand for food imports.

**Global Trade Patterns** Agricultural products are moving predominantly from the Western Hemisphere to the Eastern Hemisphere on a global scale. Latin America has evolved into the largest exporter of agricultural products, headed by Brazil and Argentina—North America, Southeast Asia, and the South Pacific are other major exporting regions. The overall proportion of exports constituted by the United States has declined rapidly, from 18 to 19 percent of the world total in the 1970s to 10 to 11 percent in the twenty-first century. Agricultural exports from the United States have continued to grow rapidly, but developing regions—particularly Latin America and Southeast Asia—have had more rapid growth.To expand production, subsistence farmers need higher yield seeds, fertilizers, pesticides, and machinery. For many African and Asian countries, the main way to obtain agricultural supplies is to import them from other countries. Most developed countries raise funds through the sale of crops in developed countries. Consumers in developed countries are willing to pay high prices for fruits and vegetables that would otherwise be out of season or for crops such as coffee and tea that cannot be grown in developed countries because of climate. The more land that is devoted to growing export crops, the less that is available to grow crops for domestic consumption.

**Drug Crops** The export crops chosen in some developing countries, particularly in Latin America and Asia, are those that can be converted to drugs. Cocaine is derived from coca leaf. Heroin is derived from raw opium gum, which is produced by the opium poppy plant. Marijuana is produced from the *Cannabis sativa* plant.

**Global Agriculture and Undernourishment** The future of food and agriculture is being pulled in global and local directions. On one hand, an increasingly integrated global agricultural system is devoted to producing the most food at the lowest cost for the world’s 7+ billion people. And in the twenty-first century, food production is higher and undernourishment is lower. However, critics maintain that the global agricultural system is causing major long-term damage to the environment for the sake of short-term production. They believe that GMOs, international trade, deforestation, and other practices are not sustainable ways to meet humanity’s need for food. While demand in developed countries is rapidly growing for locally grown food produced through sustainable farming methods, critics believe that the local and organic movements are unable to provide affordable food for the world’s population.

**Global Scale: Supply and Demand** Food prices, rather than food supply, has emerged as the greatest challenge to world food supply in the twenty-first century. For instance, food prices have more than doubled between 2006 and 2008, remained at record high levels through 2014, and declined sharply in 2015. The U.N. credits the record high prices through 2014 to four factors:

* Poor weather, particularly in major crop-growing regions of the South Pacific and North America.
* Higher Demand, especially in China and India.
* Lower growth in productivity, especially without major new “miracle” breakthroughs.
* Use of crops as biofuels instead of food, especially in Latin America.

Increased supplies precipitated the sharp decline in prices in 2015. Record high food prices have mirrored record high increases in the price of prime agricultural land. The rapid population growth seen in sub-Saharan has strained the ability of farmers to meet local demand, despite increases in food production. The threat of famine is especially severe in the Horn of Africa and the Sahel.

**Undernourishment** **Undernourishment** is dietary energy consumption that is continuously below that needed for healthy life and carrying out light physical activity. According to the U.N., an estimated 795 million people in the world are undernourished, one-half of them in South Asia and East Asia (especially in India and China). India is home to one-quarter of the world’s undernourished population. With regard to percentage of a country’s population, undernourishment is particularly a problem in sub-Saharan Africa and South Asia. Despite these worrying statistics, progress has been made in reducing undernourishment—between 2000 and 2015, the number of undernourished people declined from 924 million to 795 million, and the global percentage declined from 15 percent to 11 in the same period.

**Sustainable Agriculture** Low population growth and market saturation for most products has maintained steady demand for food in developed countries. The most rapid increase in demand has been for organic food, including non-GMO food.

**Organic Farming** 1 percent of farmland (43 million hectares) is classified as organic, according to U.N. estimates. 40 percent of the worldwide total of organic agricultural land is concentrated in Australia. Argentina accounted for 8 percent of the worldwide total, and the United States and China for 5 percent each. According to USDA economists, organic food sales grew from $3.4 billion in 1997 to an estimated $35.9 billion in 2014. In organic farming, crops are grown without application of herbicides and pesticides to control weeds. GMO seeds are not utilized. Animals consume crops grown on the farm and are not confined to small pens. The confinement of animals to small pens leads to surface water and groundwater pollution, while if they are allowed to roam, manure can contribute to soil fertility. Antibiotics are not used to promote weight gain, and are only used for therapeutic purposes.

**How Clean Is Our Produce?** The USDA regularly tests samples of fruits and vegetables for pesticides. Nearly two-thirds of the 3,015 produce samples tested in 2013 contained residues of at least one of 165 different pesticides. These pesticides remain on produce even if washed or peeled. Apples, peaches, nectarines, strawberries, and grapes are the five most pesticide-ridden fruits at market. The five cleanest are avocados, corn, pineapples, cabbage, and frozen sweet peas.

**Government Policies** Commercial farmers suffer from low incomes because they are capable of producing much more food than is demanded by consumers in developed countries. Although the food supply has increased in developed countries, the demand has remained constant because the market for most products is already saturated. The U.S. government tries to encourage farmers to avoid producing crops that are in excess supply. The government will pay farmers when certain commodity prices are low and buy surplus production. The surplus crops are sold or donated to foreign countries. The United States has averaged about $20 billion annually on farm subsidies in recent years. European farms are subsidized at an even higher rate compared to their American counterparts.