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

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

Sensitive Land Management. Sustainable agriculture protects soil in part through ridge tillage and limited use of chemicals. **Ridge tillage** is a system of planting crops on 4-to 8-inch ridges that are formed during cultivation or after harvest. Ridge tillage is attractive for two main reasons: lower production costs and greater soil conservation. Production costs are lower with ridge tillage in part because it requires less investment in tractors and other machinery than conventional planting. Ridge tillage features a minimum of soil disturbance from harvest to the next planting. Over several years the soil will tend to have increased organic matter, greater water holding capacity and more earthworms. The channels left by earthworms and decaying roots enhance drainage. Under sustainable agriculture, farmers control weeds with cultivation and minimal use of herbicides. Ridge tillage compares favorably with conventional farming for yields while lowering the cost of production.

Limited Use of Chemicals. In conventional agriculture, seeds are often genetically modified to survive when herbicides and insecticides are sprayed on the fields. (332) Widespread use of herbicides is artificially selecting for weeds resistant to the herbicide. Sustainable agriculture controls weeds with cultivation and minimal use of herbicides. (333) Researchers have found that combining mechanical weed control with some chemicals yields higher returns per acre than relying solely on one of the two methods. Ridge tillage also promotes decreased use of chemicals, which can be applied only to the ridges.

Integrated Crop and Livestock. Sustainable agriculture attempts to integrate the growing of crops and the raising of livestock as much as possible at the level of the individual farm. Animals consume crops grown on the farm and are not confined to small pens. Mixed crop and livestock is a common form of farming in many MDCs, including the Corn Belt in the United States. In conventional farming, many farmers choose to grow only crops or raise more animals than their crops can feed. Integration of crops and livestock is a return to the historical practice of mixed crop and livestock.

Sustainable agriculture is sensitive to the following complexities of biological and economic interdependencies between crops and livestock:

1. Number of livestock
2. Animal confinement
3. Management of extreme weather conditions
4. Flexible feeding and marketing

Challenges for Subsistence Farmers

Two economic issues discussed in earlier chapters influence the choice of crops planted by subsistence farmers:

- Subsistence farmers must feed an increasing number of people because of rapid population growth.
- Subsistence farmers must grow food for export instead of for direct consumption due to the adoption of the international trade approach to development.

Subsistence Farming and Population Growth

According to Ester Boserup, population growth compels subsistence farmers to consider new farming. For hundreds if not thousands of years, subsistence farming yielded enough food. Suddenly in the late twentieth century, the LDCs needed to provide enough food for a rapidly increasing population.

According to the Boserup thesis, subsistence farmers increase the supply of food through intensification of production, achieved in two ways:

1. **Adoption of new farming methods.** The additional labor needed to perform these operations comes from the population growth.

(334)

2. **Land is left fallow for shorter periods.** Boserup identified five basic stages in the intensification of farmland: Forest Fallow, Bush Fallow, Short Fallow, Annual Cropping, and Multicropping.

First, land is left fallow for shorter periods.

Subsistence Farming and International Trade

To expand production, subsistence farmers need higher-yield seeds, fertilizer, pesticides, and machinery. For many African and Asian countries, the main source of agricultural supplies is importing. To generate the funds they need to buy agricultural supplies, less developed countries must produce something they can sell in MDCs. In an LDC such as Kenya, families may divide by gender between traditional subsistence agriculture and contributing to international trade. The more land that is devoted to growing export crops, the less that is available to grow crops for domestic consumption. Rather than helping to increase productivity, the funds generated through the sale of export crops may be needed to feed the people who switched from subsistence farming to growing export crops.

Drug Crops. The export crops chosen in some LDCs, especially in Latin America and Asia, are those that can be converted to drugs. The United Nations estimated that in 1998 the incomes of 4 million people, primarily in Asia and Latin America, were dependent on cultivation of the opium poppy or coca leaf.

(335)

Afghanistan is the source of 80 percent of the world's opium; most of the remainder comes from Myanmar (Burma). One half of the world's coca leaf is grown in Columbia, and most of the remainder in neighboring Peru and Bolivia. The overwhelming majority of the marijuana that reaches the United States is grown in Mexico.

Strategies to Increase Food Supply

Four strategies increase the world's food supply:

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

Increase Food Supply by Expanding Agricultural Land. Historically, world food production increased primarily by expanding the amount of land devoted to agriculture. Today few scientists believe that further expansion of agricultural land can feed the growing world population. Cultivated land has been expanding in Africa at a rate of 1 percent per year, but population is increasing more than 2 percent per year. Worldwide, despite the recent decline in the natural increase, agricultural land is expanding more slowly than population.

Especially in semiarid regions, human actions are causing land to deteriorate to a desert-like

condition, a process called **desertification** (more precisely, semiarid land degradation). The United Nations estimates that desertification removes 27 million hectares (70 million acres) of land from agricultural production each year, an area roughly equivalent to Colorado.

Excessive water threatens other agricultural areas, especially drier lands that receive water from human-built irrigation systems. The United Nations estimates that 10 percent of all irrigated land is waterlogged, mostly in Asia and South America.

As urban areas grow in population and land area, farms on the periphery are replaced by homes, roads, shops, and other urban land uses.

Increasing Productivity. New agricultural practices have permitted farmers worldwide to achieve much greater yields from the same amount of land. (336) 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 high-yield wheat, rice, and maize seeds were diffused rapidly around the world. India's wheat production, for example, more than doubled in five years. Other Asian and Latin American countries recorded similar productivity increases. The green revolution was largely responsible for preventing a food crisis in these regions during the 1970s and 1980s, but will these scientific breakthroughs continue in the twenty-first century?

To take full advantage of the new miracle seeds, farmers must use more fertilizer and machinery. The problem is that the cheapest way to produce nitrogen-based fertilizers is to obtain hydrogen from natural gas or petroleum. As fossil fuel prices increase, so do the prices for nitrogen-based fertilizers, which then become too expensive for many farmers in LDCs. Farmers need tractors, irrigation pumps, and other machinery to make the most effective use of the new miracle seeds. In LDCs, farmers cannot afford such equipment, nor, in view of high energy costs, can they buy fuel to operate the equipment.

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

Cultivating Oceans. Hope grew during the mid-twentieth century that increased fish consumption could meet the needs of a rapidly growing global population. However the population of some fish species declined because they were harvested faster than they could reproduce. The United Nations estimates that one-quarter of fish stocks have been overfished and one-half fully exploited, leaving only one-fourth underfished.

Developing Higher-protein Cereals. Scientists are experimenting with hybrids of the world's major cereals that have higher protein content. People can also obtain needed nutrition by consuming foods that are fortified during processing with vitamins, minerals, and protein-carrying amino acids. However, fortification has limited application in LDCs, where most people grow their own food rather than buy processed food.

Improving Palatability of Rarely Consumed Foods. A prominent example of an underused food resource in North America is the soybean. Although one of the region's leading crops, most is processed into animal feed, in part because many North Americans avoid consuming tofu, sprouts, and other recognizable products.

(338)
Other products that are made from soybeans but do not look like them are more widely accepted in North America. Krill (small crustaceans) could be an important source of food from the oceans, but unfortunately krill does not taste very good.

Increasing Trade. The fourth alternative for increasing the world's food supply is to export more food from countries that produce surpluses. The three top export grains are wheat, maize (corn), and rice. Few countries are major exporters of food, but increased production in the net-exporting countries could cover the gap elsewhere. The United States remains by far the largest grain exporter, accounting for one-half of global corn exports and one-fourth of wheat. Elsewhere in the world the picture has changed in the twenty-first century. From net importers of grain, South Asia and Southeast Asia have now become net exporters.

Japan is by far the world's leading grain importer, followed by China. On a regional scale, Southwest Asia (with Northern Africa) has become the leading net importer of all three major grains, and Saudi Arabia was the world's leading importer of rice in 2007. Sub-Saharan Africa also ranks among the leaders in net imports of all three grains.

Key Terms

Agribusiness (p.313)
Agriculture (p.309)
Cereal grain (p.323)
Chaff (p.320)
Combine (p.326)
Commercial agriculture (p.311)
Crop (p.309)
Crop rotation (p.321)
Desertification (p.335)
Double cropping (p.321)
Grain (p.325)
Green revolution (p.336)
Horticulture (p.328)
Hull (p.320)
Intensive subsistence agriculture (p.319)
Milkshed (p.324)
Paddy (p.320)
Pastoral nomadism (p.318)
Pasture (p.319)
Plantation (p.322)
Prime agricultural land (p.313)
Ranching (p.326)
Reaper (p.326)
Ridge tillage (p.331)
Sawah (p.320)
Shifting cultivation (p.314)
Slash-and-burn agriculture (p.314)
Spring wheat (p.325)
Subsistence agriculture (p.310)
Sustainable agriculture (p.331)
Swidden (p.315)
Thresh (p.320)
Transhumance (p.319)
Truck farming (p.328)
Wet rice (p.319)
Winnow (p.320)
Winter wheat (p.325)

Test Prep Questions

1) Which of the following was domesticated in the Americas?
A) rice
B) millet
C) corn
D) wheat

2) What region is thought to have been the hearth of the domestication of the largest number of animals useful for agriculture?
A) East Asia
B) Southwest Asia
C) sub-Saharan Africa
D) South America

3) Which of the following was NOT domesticated in the Americas?
A) barley
B) squash
C) beans
D) potatoes

4) Which of the following is NOT one of the principal features that distinguishes commercial agriculture from subsistence agriculture?
A) use of machinery
B) purpose of farming
C) choice of crop
D) farm size

5) What is another term for "shifting cultivation"?
A) sustainable agriculture
B) pastoral nomadism
C) subsistence agriculture
D) slash-and-burn agriculture

6) Which of the following statements about pastoral nomadism/pastoral nomads is FALSE?
A) Today, it is a declining form of agriculture.
B) They consume mostly grain rather than meat.
C) They depend upon animals rather than crops for survival.
D) They raise animals mostly to kill for food.

7) Which of the following is NOT an important plantation crop?
A) wheat
B) rubber
C) sugarcane
D) coffee

8) What type of agriculture typically involves crop rotation?
A) grain farming
B) Mediterranean agriculture
C) mixed crop and livestock farming
D) dairy farming

9) What are the two most important crops in Mediterranean agriculture?
A) citrus and nuts
B) olives and grapes
C) soybeans and corn
D) rice and beans

10) Which of the following is NOT a principal practice that distinguishes sustainable agriculture from conventional agriculture?
A) keeping prices low by reducing costs regardless of environmental impact
B) sensitive land management
C) limited use of chemicals
D) better integration of crops and livestock

Short Essay

1) What features distinguish commercial agriculture from subsistence agriculture?

2) Compare and contrast pastoral nomadism with livestock ranching.

3) Identify the three principal practices that distinguish sustainable agriculture from conventional agriculture and explain how they are sustainable.