Chapter 10: Creating a Stable System of Agriculture to Feed the World’s People
10.1 Hunger, Malnutrition, Food Supplies, and the Environment

- A large segment of the world’s people (most of whom live in Asia, Africa, and Latin America) either:
  - do not get enough to eat
  - or fail to get all of the nutrients and vitamins they need
  - or both

- Nutritional deficiencies make people more susceptible to infectious disease and, if they are severe enough, can cause death.
Hunger, Poverty, and Environmental Decay

- Hunger and malnutrition cause mental and physical retardation.
- This may contribute to widespread poverty, which in turn contributes to environmental destruction.

Figure 10.01: Kwashiorkor. This protein deficiency leads to swelling of the abdomen. The loss of muscle protein results in thin arms and legs.

Courtesy of Dr. Lyle Conrad/CDC
Grain production per capita has been on the decline for over a decade and a half.

This trend bodes poorly for those suffering from hunger and malnutrition—as well as for those trying to provide food for the ever-growing human population.
The challenge today is to find sustainable ways to feed current and future world residents.
10.2 Understanding Soils

What Is Soil?

- Soils consist of four components:
  - inorganic materials
  - organic matter
  - air
  - water

Figure 10.03: Soil profile. Typical soils consist of five distinct layers.
Soil formation is a complex process involving an interaction among:

- Climate
- The parent material, which contributes the mineral components of soil
- Biological organisms
Soils are typically arranged in layers.

For agriculture, the most important are the upper two layers:
- the O horizon, which accumulates organic waste from plants and animals
- the A horizon, the topsoil.
10.3 Barriers to a Sustainable Agricultural System

- Soil Erosion

- Soil is vital to the success of a nation, indeed the world.
- Agricultural soils are being lost at record rates in many countries—a trend that is clearly unsustainable.

Figure 10.04: Soil erosion on rangeland. All soil erosion above replacement level bodes poorly for farmers and the world's people.

Courtesy of Lynn Betts/NRCS USDA
Desertification: Turning Cropland into Desert

- Throughout the world, cropland, rangeland, and pasture are becoming too dry to use because of:
  - climate change (natural and human-induced)
  - poor land management practices such as overgrazing
Desertification and soil erosion are destroying agricultural land worldwide.

This contributes to food shortages and reduces our ability to meet future demands for an expanding human population.
Farmland Conversion

- Each year, millions of hectares of productive agricultural land are lost to human development worldwide.
  - This phenomenon is called farmland conversion.

Figure 10.07: Farmland conversion. Urban sprawl, as shown here in Des Moines, Iowa, swallows up farmland at an alarming rate throughout the world.

Courtesy of Lynn Betts/NRCS USDA
Declines In Irrigated Cropland Per Capita

- Irrigated cropland supplies enormous amounts of food to the world’s people.

- The amount of irrigated cropland per capita is on the decline.

- This trend bodes poorly for world food production.

- Measures that increase the efficiency of water use may prove helpful in providing an adequate supply of irrigation water.
Irrigation can cause waterlogging, the buildup of excess water in the soil.

Waterlogging suffocates plants.

It may also cause salinization, the deposition of salts that are toxic to most plants.

Waterlogging and salinization affect many millions of hectares of land worldwide.
Figure 10.08: Salinization and waterlogging.
The number of species of cultivated plants and domestic animals has declined dramatically.

Reducing diversity results in huge monocultures of genetically similar plants, which make crops more susceptible to:

- Disease
- Adverse weather
- Insects and other pests

It makes plants more dependent on chemical pesticides.
Declining Genetic Diversity in Crops and Livestock

- The Green Revolution was a worldwide effort to improve the productivity of important food crops: wheat and rice.

- It succeeded in its primary objectives but created a steady decline in genetic diversity, which makes world food production more vulnerable to disruption.
Declining Genetic Diversity in Crops and Livestock

- We are losing many wild plant species that gave rise to modern crop species throughout the world, especially in the tropics.

- This erodes our capacity to improve crops and make them more resistant to pests, disease, and drought.

Figure 10.09: Genetic research and conventional cross-breeding have allowed scientists to transform wheat from landraces to high-yielding lines.

Courtesy of International Center for Maize and Wheat Improvement (CIMMYT)
Politics, Agriculture, and Sustainability

- The problems facing world agriculture are not all technical.

- Some result from inadequate or self-defeating policies and governmental intervention.

- Lawmakers throughout the world have unwittingly facilitated the creation of an unsustainable system of agriculture.
10.4 Solutions: Building a Sustainable Agricultural System

- A sustainable system of agriculture consists of practices that produce high-quality food in ways that protect the long-term health and productivity of soils.

- Creating such a system will require a multifaceted approach, including measures to slow and perhaps stop the growth of the human population.
Protecting soil and water resources is the first line of defense in meeting present and future needs for food.

One of the highest priorities in making the transition to a sustainable system of agriculture is putting an end to excessive soil erosion.

Fortunately, there are many simple yet effective measures that can ensure a sustainable erosion rate.
Protecting Existing Soil and Water Resources

- Reducing the amount of land disturbance by minimizing tillage protects the soil from the erosive forces of wind and rain.

- This technique, while effective in reducing energy demand and erosion, often requires additional chemical herbicides to control weeds.
Figure 10.10: Minimum tillage planter. This device is designed to dig furrows in the presence of crop residue, avoiding plowing and discing.
Protecting Existing Soil and Water Resources

- Planting crops perpendicular to the slope—that is, along the land contour lines—reduces soil erosion and increases water retention.

Figure 10.12: Contour farming. This land is farmed along the contour lines to reduce soil erosion and surface runoff, thus saving soil and moisture alike.
Protecting Existing Soil and Water Resources

- Crops can be planted in alternating strips, a practice called **strip cropping**.

- When strip cropping is combined with contour farming, this technique greatly reduces soil erosion.

Figure 10.13: Alternating strips of alfalfa with corn on the contour protects this crop field in northeast Iowa from soil erosion.

Courtesy of Tim McCabe/USDA ARS
Protecting Existing Soil and Water Resources

- Terraces, small earthen embankments that run across the slope of the land, greatly reduce soil erosion.

Figure 10.14A: Terracing. This Iowa corn is grown on sloping land with the aid of terraces that reduce water flow across the surface.

Courtesy of Tim McCabe/NRCS USDA
Protecting Existing Soil and Water Resources

- Gullies form quickly on hilly terrain and grow rapidly.
- If gullies form, they can be regraded and replanted with fast-growing species to prevent their expansion.
Protecting Existing Soil and Water Resources

- **Shelterbelts** are rows of trees planted along the perimeter of fields to block wind and reduce soil erosion.

Figure 10.14B: In Asia, terracing has been used in mountainous regions to grow rice.
Protecting Existing Soil and Water Resources

- Shelterbelts have the added benefit of preventing snow from blowing away from fields, thus increasing soil moisture content.

- Shelterbelts provide habitat for useful species, such as insect-eating birds.
Protecting Existing Soil and Water Resources

- Farmers are sometimes reluctant to take measures to control erosion because of their costs.

- Carefully crafted government policies can provide economic incentives to protect soil erosion.

- Many measures that protect soil from erosion also make it less susceptible to desertification.
Protecting Existing Soil and Water Resources

- When combined with measures to reduce global warming, these steps could help to slow desertification.

- Numerous techniques are available to prevent farmland conversion.

- Water efficiency measures help free up water to expand irrigated cropland.

- More frugal application of irrigation water to crops and special drainage systems can reduce salinization and waterlogging.
Figure 10.17A: Center pivot irrigation. The standard device sprays water into the air, but much of the water evaporates before it hits the ground on hot days.

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Figure 10.17B: By turning the spray nozzles downward, much more water actually makes it to the plant.

Courtesy of Gene Alexander/NRCS USDA
Figure 10.16: Increasing the efficiency of irrigation.

Courtesy of Lynn Betts/NRCS USDA
Farming mines the soil, robbing it of valuable nutrients.

Numerous methods such as applying organic fertilizer and rotating crops can replenish nutrients and maintain the health of the soil.

Use of organic fertilizers helps farmers maintain or even improve soil conditions and boost crop production.

This strategy also returns nutrients to the soil.
Soil Enrichment Programs

- Synthetic fertilizers help boost soil fertility.
- But they only partially replenish agricultural soils, because they contain only three of many nutrients needed for healthy soil:
  - Nitrogen
  - Phosphorus
  - Potassium
Soil Enrichment Programs

- Crop rotation—alternating crops planted in a field one season after another—offers many benefits.

- Planting the proper crops can help replenish soil nutrients.

- It also helps reduce erosion, pest damage, and the need for costly and potentially harmful pesticides.
Increasing the Amount of Land in Production

- Grasslands and forests can be converted to farmland to meet the rising demand for food.

- In many parts of the world, especially in the more developed nations, farmland reserves are small.

- Even in countries where there is an abundance of reserve land, much of this land is covered with poor soils.

- Furthermore, the ecological cost of converting wild land to farmland would be enormous.
Increasing the Productivity of Existing Land: Developing Higher-Yield Plants and Animals

- Numerous efforts are under way to increase the yield of plants and the growth rate of animals to increase food production.

- Geneticists can improve plant and animal strains by selective breeding and genetic engineering.

- Selective breeding has been used for hundreds of years.

- Genetic engineering is the deliberate transfer of genes from one organism to another.
Increasing the Productivity of Existing Land: Developing Higher-Yield Plants and Animals

- Genetic engineering has an enormous potential but poses many ethical questions and may create some serious environmental problems.

- Protecting wild plant species through habitat protection and special seed banks is essential to the future of agriculture.

- It helps to preserve genes that can improve crop yields by providing resistance to insects, disease, and drought.
Figure 10.18: Genetic repository. This room in a government facility is home to cuttings and seeds from plant species that are being preserved for future use.
Developing Alternative Foods

- Many native plant and animal species could be used to provide food.

- Native animals offer many benefits over domestic livestock, including their resistance to disease-causing organisms.
Most of the world’s commercially important saltwater fish populations are in decline and in danger of being seriously depleted.

The decline in wild fish populations has forced many countries to grow fish commercially in ponds, lagoons, and other water bodies.
Eating Lower on the Food Chain

- Efforts to feed the world’s people should focus on food sources low on the food chain—plants and plant products.

- Far more people can be fed on a vegetarian diet than on a meat-based one.
Reducing Pest Damage and Spoilage

- Much of the world’s food production is consumed by pests or rots in storage or in transit.

- Improvements in transit and storage, such as refrigeration, can greatly boost food supplies.
Creating Agricultural Self-Sufficiency in Less Developed Countries

- Many LDCs have lost their ability to produce food as a result of:
  - overpopulation
  - farmland deterioration
  - economic and trade policies

- Reversing these trends could help nations become more self-reliant, which is vital for building a more sustainable future.
Legislation and New Policies: Political and Economic Solutions

- Ending War
  - Violent conflicts among peoples can greatly disrupt the production and distribution of food, often long after war has ended.