Chapter 12
Food, Soil, and Pest Management

There are two spiritual dangers in not owning a farm. One is the danger of supposing that breakfast comes from the grocery, and the other that heat comes from the furnace.

- Aldo Leopold
Core Case Study: Organic Agriculture Is on the Rise

Organic agriculture

- Crops grown without using synthetic pesticides, synthetic inorganic fertilizers, or genetically engineered seeds

- Animals grown without using antibiotics or synthetic hormones

- U.S. in 2008: .6% cropland; 3.5% food sales
## Industrialized Agriculture vs. Organic Agriculture

### Industrialized Agriculture
- Uses synthetic inorganic fertilizers and sewage sludge to supply plant nutrients
- Makes use of synthetic chemical pesticides
- Uses conventional and genetically modified seeds
- Depends on nonrenewable fossil fuels (mostly oil and natural gas)
- Produces significant air and water pollution and greenhouse gases
- Is globally export-oriented
- Uses antibiotics and growth hormones to produce meat and meat products

### Organic Agriculture
- Emphasizes prevention of soil erosion and the use of organic fertilizers such as animal manure and compost, but no sewage sludge to help replace lost plant nutrients
- Employs crop rotation and biological pest control
- Uses no genetically modified seeds
- Reduces fossil fuel use and increases use of renewable energy such as solar and wind power for generating electricity
- Produces less air and water pollution and greenhouse gases
- Is regionally and locally oriented
- Uses no antibiotics or growth hormones to produce meat and meat products
12-1 What Is Food Security and Why Is It Difficult to Attain?

- **Concept 12-1A** Many people in less-developed countries have health problems from not getting enough food, while many people in more-developed countries have health problems from eating too much food.

- **Concept 12-1B** The greatest obstacles to providing enough food for everyone are poverty, political upheaval, corruption, war, and the harmful environmental effects of food production.
Many People Have Health Problems Because They Do Not Get Enough to Eat

Food security

- All or most people in a country have daily access to enough nutritious food to lead active and healthy lives

Food insecurity

- Chronic hunger and poor nutrition
- Root cause: poverty
- Political upheaval, war, corruption, bad weather
Starving Children in Sudan Collect Ants
What Nutrients Do Human Need?

**Macronutrients**
- Carbohydrates
- Proteins
- Fats

**Micronutrients**
- Vitamins
- Minerals

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Food Source</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>Animals and some plants</td>
<td>Help to build and repair body tissues</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>Wheat, corn, and rice</td>
<td>Provide short-term energy</td>
</tr>
<tr>
<td>Lipids (oils and fats)</td>
<td>Animal fats, nuts, oils</td>
<td>Help to build membrane tissues and create hormones</td>
</tr>
</tbody>
</table>
Chronic Hunger & Famine

- **Chronic undernutrition**, hunger
- **Chronic malnutrition** (deficiency of protein & nutrients)
- 1 in 6 people in less-developed countries is chronically undernourished or malnourished
- **Famine**
  - Drought, flooding, war, other catastrophes
Many People Do No Get Enough Vitamins and Minerals

Most often vitamin and mineral deficiencies in people in less-developed countries

- Iron (anemia, fatigue)
- Vitamin A (go blind before age 6)
- Iodine (thyroid disorders)
Many People Have Health Problems from Eating Too Much

**Overnutrition**

- Excess body fat from too many calories and not enough exercise

- Similar health problems to those who are underfed
  - Lower life expectancy
  - Greater susceptibility to disease and illness
  - Lower productivity and life quality
12-2 How Is Food Produced?

Concept 12-2
We have used high-input industrialized agriculture and lower-input traditional methods to greatly increase supplies of food.
Food Production Has Increased Dramatically

• Three systems produce most of our food
  • Croplands: 77% on 11% world’s land area
  • Rangelands, pastures, and feedlots: 16% on 29% of world’s land area
  • Aquaculture: 7%

• Importance of wheat, rice, and corn
  → 48% calories of the calories people consume directly
  → 2/3 of world depend on them
Industrialized Crop Production Relies on High-Input Monocultures

• **Industrialized agriculture, high-input agriculture**
  - Heavy equipment
  - Financial capital
  - Fossil fuels
  - Water
  - Inorganic fertilizers
  - Pesticides

• Goal is to steadily increase crop yield
  • **Plantation agriculture**: cash crops (bananas, soybeans, sugarcane, etc)
    • Primarily in less-developed countries
  • Increased use of greenhouses to raise crops
Plantation Agriculture: Oil Palms on Borneo in Malaysia
Case Study: Hydroponics: Growing Crops without Soil

**Hydroponics**: growing plants in nutrient-rich water solutions rather than soil

- Grow indoors almost anywhere, year-round
- Grow in dense urban areas
- Recycle water and fertilizers
- Little or no need for pesticides
- No soil erosion
- Takes money to establish
- Help make the transition to more sustainable agriculture
Traditional Agriculture Often Relies on Low-Input Polycultures

**Traditional subsistence agriculture**
- Human labor and draft animals for family food

**Traditional intensive agriculture**
- Higher yields through use of manure and water
Traditional Agriculture Often Relies on Low-Input Polycultures (2)

Polyculture

• Benefits over monoculture

Slash-and-burn agriculture

• Subsistence agriculture in tropical forests
• Clear and burn a small plot
• Grow many crops that mature at different times
• Reduced soil erosion
• Less need for fertilizer and water
INTEGRATED POLYCulture FARMING - MODEL

DEMONSTRATION PLOT - 10 ACRES

3 ACRE : PADDY
1 ACRE : BANANA
1 ACRE : SUGARCANE
2 ACRE : GRASS
1 ACRE : FISHERIES
1 ACRE : HORTICULTURE
1 ACRE : CATTLE FARM, POULTRY FARMING, WINDMILL, FARMHOUSE, LABOUR QUARTESR, GOBAR GAS PLANT
Science Focus: Soil Is the Base of Life on Land

Soil composition

- Eroded rock
- Mineral nutrients
- Decaying organic matter
- Water
- Air
- Microscopic decomposers
Soil Formation and Generalized Soil Profile

Layers (horizons) of mature soils

- **O horizon:** leaf litter
- **A horizon:** topsoil
- **B horizon:** subsoil
- **C horizon:** parent material, often bedrock
A Closer Look at Industrialized Crop Production

**Green Revolution**: increase crop yields

1. Monocultures of high-yield key crops
   - Rice, wheat, and corn
2. Large amounts of fertilizers, pesticides, water
3. Multiple cropping

Second Green Revolution

- Fast growing dwarf varieties

- World grain has tripled in production
Global Outlook: Total Worldwide Grain Production (Wheat, Corn, and Rice)

Fig. 12-7, p. 285
Case Study: Industrialized Food Production in the United States

Agribusiness

• Average farmer feeds 129 people
• Annual sales greater than auto, steel, and housing combined

Food production: very efficient

• Americans spend 10% of income on food

• Hidden costs of subsidies and costs of pollution and environmental degradation
Crossbreeding and Genetic Engineering Produce New Crop/Livestock Varieties (1)

- First gene revolution
  - Cross-breeding through artificial selection
    - Slow process
    - Amazing results

- Genetic engineering = second gene revolution
  - Alter organism’s DNA
  - Genetic modified organisms (GMOs): transgenic organisms
Crossbreeding and Genetic Engineering Produce New Crop/Livestock Varieties (2)

• Age of Genetic Engineering: developing crops that are resistant to
  • Heat and cold
  • Herbicides
  • Insect pests
  • Parasites
  • Viral diseases
  • Drought
  • Salty or acidic soil

• Promise and potential perils
A GMO IS:
The direct human manipulation of an organism’s DNA in a laboratory environment.

A GMO IS NOT:
Plants and animals that are traditionally bred to achieve specific characteristics such as breeding dogs or cross-pollination of plants.

SCIENCE OF GMOS
Genetic modification may include the ADDITION OF DNA from species that would NOT BREED in nature.
Cross-species—or transgenic—genetic manipulation has gone so far as to COMBINE FISH DNA WITH STRAWBERRIES and tomatoes.

GMO foods have only existed in groceries since the late 1990's.
GMO food can be patented.

GMO varieties of corn and potatoes are engineered to PRODUCE THEIR OWN PESTICIDES.

STUDIES OF GMOS
NO LONG-TERM TESTING.
It took decades for the dangers of Trans-Fats (another artificial food) to become understood.

Mice fed GM pesticide-producing corn over four generations showed ABNORMAL structural and chemical changes to various organs and significantly reduced fertility.

PREVALENCE OF GMOS
You probably eat GMOs EVERY DAY.
30,000 different GMO-polluted Grocery items defined. Generally because of these genetically engineered foods, not only does the average person not know what they are eating, but the liability is "shoulder to shoulder".

PERCENT OF GMOS IN TOTAL CROP PRODUCTION (2015 USA):
Soybeans 54% 
Corn 30% 
Canola 16% 

PUBLIC OPINION OF GMOS
Both consumers and farmers believe that a significant majority of their food is not defined as GMO, which leads to the purchase of GMO food.

OUT OF A CBS NEWS POLL:
87% want GMOs labelled
33% would not buy genetically modified food

NATIONAL OPINIONS OF GMOS:
The USA is the largest producer of GMO crops and does not mandate labels for GMO food.

In 23 other countries there are laws or restrictions on the production of GMOs, because they are not consumed proven safe.
Prop 37: Your right to know.
GMOS: Corporate Charlatans Versus Organic Heroes

Corporate agribusiness fighting Prop 37
$23,500,000

Monsanto
DONATED: $4,208,000

Izze
DONATED: $1,716,300

Honest Tea
DONATED: $1,164,400

Alexia
DONATED: $1,076,300

Kashi
DONATED: $699,000

Morning Star
DONATED: $432,000

Larabar
DONATED: $387,000

Counsel for Biotechnology Information
DONATED: $375,000

GMOs Manufacturers Association
DONATED: $375,000

Biotechnology Industry Organization
DONATED: $250,000

Organic leaders supporting Prop 37
$2,600,000

Dr. Joseph Mercola [MERCOLA.COM]
DONATED: $500,000

Organic Consumers Association
DONATED: $600,000

Michael Funk
DONATED: $50,000

As California Goes, There Goes the Nation.

Democratic and Republican administrations, and Congress, have repeatedly ignored the overwhelming majority of Americans who favor labeling genetically engineered (GE) food in the marketplace. Our politicians seem to be listening to the corporate executives (donors) instead of the citizenry. But in California, the people have a right to craft laws of their choosing. Proposition 37, on the ballot in California on November 6, would mandate labeling of foods containing GE ingredients. If we win this fight in California, manufacturers will likely begin to label food nationally for GE ingredients.

Please make your voice heard by signing the petition at cornucopia.org
Meat Production and Consumption Have Grown Steadily

- Animals for meat raised in
  - Pastures and rangelands
  - Feedlots

- Meat production increased fourfold between 1961 and 2007
  - Increased demand for grain
  - Demand is expected to go higher
Fish and Shellfish Production Have Increased Dramatically

- Fishing with fleets depletes fisheries and uses many resources

- **Aquaculture**, blue revolution
  - World’s fastest-growing type of food production
  - Dominated by operations that raise herbivorous species
Industrialized Food Production Requires Huge Inputs of Energy

• Mostly nonrenewable energy – oil and natural gas
  • Farm machinery
  • Irrigate crops
  • Produce pesticides (petrochemicals)
  • Commercial inorganic fertilizers
  • Process and transport food
• 19% of total fossil fuel energy use in U.S.
• U.S. food travels an average of 2,400 kilometers
Concept 12-3  Food production in the future may be limited by its serious environmental impacts, including soil erosion and degradation, desertification, water and air pollution, greenhouse gas emissions, and degradation and destruction of biodiversity.
Producing Food Has Major Environmental Impacts

- Harmful effects of agriculture on
  - Biodiversity
  - Soil
  - Water
  - Air
  - Human health
Natural Capital Degradation: Food Production

**Natural Capital Degradation**

**Food Production**

**Biodiversity Loss**
- Loss and degradation of grasslands, forests, and wetlands in cultivated areas
- Fish kills from pesticide runoff
- Killing wild predators to protect livestock
- Loss of genetic diversity of wild crop strains replaced by monoculture strains

**Soil**
- Erosion
- Loss of fertility
- Salinization
- Waterlogging
- Desertification
- Increased acidity

**Water**
- Water waste
- Aquifer depletion
- Increased runoff, sediment pollution, and flooding from cleared land
- Pollution from pesticides and fertilizers
- Algal blooms and fish kills in lakes and rivers caused by runoff of fertilizers and agricultural wastes

**Air Pollution**
- Emissions of greenhouse gas CO$_2$ from fossil fuel use
- Emissions of greenhouse gas N$_2$O from use of inorganic fertilizers
- Emissions of greenhouse gas methane (CH$_4$) by cattle (mostly belching)
- Other air pollutants from fossil fuel use and pesticide sprays

**Human Health**
- Nitrates in drinking water (blue baby)
- Pesticide residues in drinking water, food, and air
- Contamination of drinking and swimming water from livestock wastes
- Bacterial contamination of meat

Fig. 12-10, p. 289
Topsoil Erosion Is a Serious Problem in Parts of the World

• **Soil erosion**
  - Movement of soil by wind and water
  - Natural causes
  - Human causes

• Two major harmful effects of soil erosion
  - Loss of soil fertility
  - Water pollution
Natural Capital Degradation: Gully Erosion in Bolivia

Fig. 12-12, p. 290
Wind Removes Topsoil in Dry Areas

Fig. 12-13, p. 290
Natural Capital Degradation: Global Soil Erosion

Fig. 12-14, p. 291
Drought and Human Activities Are Degrading Drylands

• Desertification
  • Moderate
  • Severe
  • Very severe

• Human agriculture accelerates desertification

• Effect of global warming on desertification
Severe Desertification
Natural Capital Degradation: Desertification of Arid and Semiarid Lands

Fig. 12-16, p. 292
Excessive Irrigation Has Serious Consequences

- **Salinization**
  - Gradual accumulation of salts in the soil from irrigation water
  - Lowers crop yields and can even kill plants
  - Affects 10% of world croplands

- **Waterlogging**
  - Irrigation water gradually raises water table
  - Can prevent roots from getting oxygen
  - Affects 10% of world croplands
Natural Capital Degradation: Severe Salinization on Heavily Irrigated Land

Fig. 12-17, p. 292
Agriculture Contributes to Air Pollution and Projected Climate Change

- Clearing and burning of forests for croplands

- One-fourth of all human-generated greenhouse gases

- Livestock contributes 18% of gases: methane in cow belches
  - Grass-fed better than feedlots
Food and Biofuel Production Systems Have Caused Major Biodiversity Losses

- Biodiversity threatened when
  - Forest and grasslands are replaced with croplands – tropical forests

- Agrobiodiversity threatened when
  - Human-engineered monocultures are used

- Importance of seed banks
  - Newest: underground vault in the Norwegian Arctic
Genetic Engineering Could Solve Some Problems but Create Others

**Trade-Offs**

**Genetically Modified Crops and Foods**

**Advantages**
- Need less fertilizer
- Need less water
- More resistant to insects, disease, frost, and drought
- Grow faster
- May need less pesticides or tolerate higher levels of herbicides
- May reduce energy needs

**Disadvantages**
- Unpredictable genetic and ecological effects
- Harmful toxins and new allergens in food
- No increase in yields
- More pesticide-resistant insects and herbicide-resistant weeds
- Could disrupt seed market
- Lower genetic diversity
There Are Limits to Expanding the Green Revolutions

- Usually require large inputs of fertilizer, pesticides, and water
  - Often too expensive for many farmers

- Can we expand the green revolution by
  - Irrigating more cropland?
  - Improving the efficiency of irrigation?
  - Cultivating more land? Marginal land?
  - Using GMOs?
  - Multicropping?
Industrialized Meat Production Has Harmful Environmental Consequences

Trade-Offs

Animal Feedlots

**Advantages**
- Increased meat production
- Higher profits
- Less land use
- Reduced overgrazing
- Reduced soil erosion
- Protection of biodiversity

**Disadvantages**
- Large inputs of grain, fish meal, water, and fossil fuels
- Greenhouse gas ($CO_2$ and $CH_4$) emissions
- Concentration of animal wastes that can pollute water
- Use of antibiotics can increase genetic resistance to microbes in humans
Producing Fish through Aquaculture Can Harm Aquatic Ecosystems

**Trade-Offs**

**Aquaculture**

**Advantages**
- High efficiency
- High yield
- Reduced over-harvesting of fisheries
- Low fuel use
- High profits

**Disadvantages**
- Large inputs of land, feed, and water
- Large waste output
- Loss of mangrove forests and estuaries
- Some species fed with grain, fish meal, or fish oil
- Dense populations vulnerable to disease
12-4 How Can We Protect Crops from Pests More Sustainably?

- **Concept 12-4** We can sharply cut pesticide use without decreasing crop yields by using a mix of cultivation techniques, biological pest controls, and small amounts of selected chemical pesticides as a last resort (integrated pest management).
Nature Controls the Populations of Most Pests

• What is a pest?
  • Interferes with human welfare

• Natural enemies—predators, parasites, disease organisms—control pests
  • In natural ecosystems
  • In many polyculture agroecosystems

• What will happen if we kill the pests?
Natural Capital: Spiders are Important Insect Predators
We Use Pesticides to Try to Control Pest Populations

- **Pesticides**
  - Insecticides
  - Herbicides
  - Fungicides
  - Rodenticides

- Herbivores overcome plant defenses through natural selection: coevolution
PESTICIDES

• First-generation pesticides
  • Borrowed from plants

• Second-generation pesticides
  • Lab produced: DDT and others
  • Benefits versus harm

• Broad-spectrum and narrow-spectrum agents

• Persistence varies
Individuals Matter: Rachel Carson

• Biologist

• Silent Spring

• Potential threats of uncontrolled use of pesticides
Modern Synthetic Pesticides

ADVANTAGES

• Save human lives
• Increases food supplies and profits for farmers
• Work quickly
• For many, health risks are very low relative to benefits
• New pest control methods: safer and more effective
Modern Synthetic Pesticides

DISADVANTAGES

• Accelerate rate of genetic resistance in pests
• Expensive for farmers
• Some insecticides kill natural predators and parasites that help control the pest population
• Pollution in the environment
• Some harm wildlife
• Some are human health hazards
Pesticide Use Has Not Reduced U.S. Crop Losses to Pests

• David Pimentel: Pesticide use has not reduced U.S. crop loss to pests
  • 1942-1997: crop losses from insects increased from 7% to 13%, even with 10x increase in pesticide use
  • High environmental, health, and social costs with use
  • Use alternative pest management practices

• Pesticide industry disputes these findings
Trade-Offs: Conventional Chemical Pesticides

**Advantages**
- Save lives
- Increase food supplies
- Profitable
- Work fast
- Safe if used properly

**Disadvantages**
- Promote genetic resistance
- Kill natural pest enemies
- Pollute the environment
- Can harm wildlife and people
- Are expensive for farmers

Fig. 12-22, p. 299
What Can You Do? Reducing Exposure to Pesticides

Reducing Exposure to Pesticides

- Grow some of your food using organic methods
- Buy certified organic food
- Wash and scrub all fresh fruits, vegetables, and wild foods you pick
- Eat less meat, no meat, or certified organically produced meat
- Trim the fat from meat
Case Study: Ecological Surprises: The Law of Unintended Consequences

- 1955: Dieldrin sprayed to control mosquitoes
- Malaria was controlled
- Dieldrin didn’t leave the food chain
- Domino effect of the spraying
- Happy ending
Laws and Treaties Can Help to Protect Us from the Harmful Effects of Pesticides

• U.S. federal agencies and laws
  • EPA, USDA, FDA
  • Fungicide and Rodenticide Act, 1947
  • Food Quality Protection Act, 1996

• Effects of active and inactive pesticide ingredients are poorly documented
  • U.S. exports many banned pesticides

• Circle of poison
PESTICIDES ALTERNATIVES

Fool the pest
• Crop rotation; changing planting times

Provide homes for pest enemies
• Polyculture

Implant genetic resistance – genetic engineering

Bring in natural enemies
• Predators, parasites, diseases
PESTICIDE ALTERNATIVES

- Use insect perfumes
  - pheromones

- Bring in hormones
  - Interfere with pest life cycle

- Alternative methods of weed control
  - Crop rotation, cover crops, mulches
Solutions: An Example of Genetic Engineering to Reduce Pest Damage

Fig. 12-24, p. 302
Natural Capital: Biological Pest Control

Fig. 12-25, p. 302
Integrated Pest Management Is a Component of Sustainable Agriculture

- **Integrated pest management (IPM)**
  - Coordinate: cultivation, biological controls, and chemical tools to reduce crop damage to an economically tolerable level
  - Reduces pollution and pesticide costs

- Disadvantages
  - Requires expert knowledge
  - High initial costs
  - Government opposition
WHAT IS IPM?

Farmers use Integrated Pest Management (IPM) strategies to prevent crop damage from insect, weed, and disease pests.

IPM PRACTICES INCLUDE:

- Susceptible vs. Resistant
- Pest Resistant Varieties
- Pest Monitoring
- Cultivation
- Natural Control

WHY SHOULD YOU CARE?

Because IPM practices help farmers:
- conserve our environment
- produce quality crops
- maintain farm profitability
12-5 How Can We Improve Food Security?

- **Concept 12-5** We can improve food security by creating programs to reduce poverty and chronic malnutrition, relying more on locally grown food, and cutting food waste.
Use Government Policies to Improve Food Production and Security

- Control prices to make food affordable
- Provide subsidies to farmers
- Let the marketplace decide—
  - Working in New Zealand and Brazil
Other Government and Private Programs are Increasing Food Security

• Immunizing children against childhood diseases
• Encourage breast-feeding
• Prevent dehydration in infants and children
• Provide family planning services
• Increase education for women

• One-half to one-third of nutrition-related deaths in children can be prevented for $5-10 per year
• **Concept 12-6** More sustainable food production will require using resources more efficiently, sharply decreasing the harmful environmental effects of industrialized food production, and eliminating government subsidies that promote such harmful impacts.
Reduce Soil Erosion

• **Soil conservation**, some methods
  • Terracing
  • Contour planting
  • Strip cropping with cover crop
  • Alley cropping, agroforestry
  • Windbreaks or shelterbelts
  • Conservation-tillage farming
    • No-till
    • Minimum tillage

• Identify erosion hotspots
Soil Conservation: Terracing
Soil Conservation: Contour Planting and Strip Cropping

Fig. 12-27, p. 305
Soil Conservation: Windbreaks

Fig. 12-29, p. 306
Case Study: Soil Erosion in the United States—Learning from the Past

- What happened in the Dust Bowl in the 1930s?
- Migrations to the East, West, and Midwest
- 1935: Soil Erosion Act
- More soil conservation needed
Natural Capital Degradation: The Dust Bowl of the Great Plains, U.S.
Restore Soil Fertility

- Organic fertilizer
  - Animal manure
  - Green manure
  - Compost

- Manufactured inorganic fertilizer
  - Nitrogen, phosphorus, calcium

- Crop rotation
Reduce Soil Salinization and Desertification

• Soil salinization
  • Prevention
  • Clean-up

• Desertification, reduce
  • Population growth
  • Overgrazing
  • Deforestation
  • Destructive forms of planting, irrigation, and mining
Solutions: Soil Salinization

**Prevention**
- Reduce irrigation
- Switch to salt-tolerant crops

**Cleanup**
- Flush soil (expensive and wastes water)
- Stop growing crops for 2–5 years
- Install underground drainage systems (expensive)
Solutions: More Sustainable Aquaculture

- Protect mangrove forests and estuaries
- Improve management of wastes
- Reduce escape of aquaculture species into the wild
- Raise some species in deeply submerged cages
- Set up self-sustaining aquaculture systems that combine aquatic plants, fish, and shellfish
- Certify and label sustainable forms of aquaculture
Case Study: Raising Salmon in an Artificial Ecosystem

• Cooke Aquaculture in the Bay of Fundy, New Brunswick, Canada

• Mimic a natural system with 3 species:
  • Salmon in cages
  • Shellfish in socks filter waste
  • Kelp uses some of added nutrients
Produce Meat More Efficiently and Humanely

- Shift to more grain-efficient forms of protein
- Beef from rangelands and pastures, not feedlots
- Develop meat substitutes; eat less meat
Efficiency of Converting Grain into Animal Protein

<table>
<thead>
<tr>
<th>Animal</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef cattle</td>
<td>7</td>
</tr>
<tr>
<td>Pigs</td>
<td>4</td>
</tr>
<tr>
<td>Chicken</td>
<td>2.2</td>
</tr>
<tr>
<td>Fish (catfish or carp)</td>
<td>2</td>
</tr>
</tbody>
</table>
Shift to More Sustainable Agriculture

1. Sustainable agriculture uses fewer inputs, creates less pollution, and contributes less to global warming

2. Organic farming
   - Many benefits
   - Requires more labor
Shift to More Sustainable Agriculture

(2)

- Strategies for more sustainable agriculture
  - Research on organic agriculture with human nutrition in mind
  - Show farmers how organic agricultural systems work
  - Subsidies and foreign aid
  - Training programs; college curricula
  - Encourage hydroponics
  - Greater use of alternative energy
Solutions: More Sustainable Organic Agriculture

More Sustainable Agriculture

**More**
- High-yield polyculture
- Organic fertilizers
- Biological pest control
- Integrated pest management
- Efficient irrigation
- Perennial crops
- Crop rotation
- Water-efficient crops
- Soil conservation
- Subsidies for sustainable farming

**Less**
- Soil erosion
- Soil salinization
- Water pollution
- Aquifer depletion
- Overgrazing
- Overfishing
- Loss of biodiversity and agrobiodiversity
- Fossil fuel use
- Greenhouse gas emissions
- Subsidies for unsustainable farming

Fig. 12-34, p. 310
Solutions: Organic Farming

Organic Farming

- Improves soil fertility
- Reduces soil erosion
- Retains more water in soil during drought years
- Uses about 30% less energy per unit of yield
- Lowers CO₂ emissions
- Reduces water pollution by recycling livestock wastes
- Eliminates pollution from pesticides
- Increases biodiversity above and below ground
- Benefits wildlife such as birds and bats

Fig. 12-35, p. 311
Solutions

Organic Farming

- Improves soil fertility
- Reduces soil erosion
- Retains more water in soil during drought years
- Uses about 30% less energy per unit of yield
- Lowers CO₂ emissions
- Reduces water pollution by recycling livestock wastes
- Eliminates pollution from pesticides
- Increases biodiversity above and below ground
- Benefits wildlife such as birds and bats
Science Barge: Prototype of Sustainable Urban Farm in Yonkers, New York

Fig. 12-36, p. 311
Science Focus: Sustainable Polycultures of Perennial Crops

- Polycultures of perennial crops

- Wes Jackson: natural systems agriculture benefits
  - No need to plow soil and replant each year
  - Reduces soil erosion and water pollution
  - Deeper roots – less irrigation needed
  - Less fertilizer and pesticides needed
Comparison of the Roots between an Annual Plant and a Perennial Plant

Fig. 12-C, p. 312
Buy Locally Grown Food, Grow More Food Locally, and Cut Food Waste

• Supports local economies

• Reduces environmental impact on food production

• Community-supported agriculture
What Can You Do? Sustainable Organic Agriculture

- Eat less meat, no meat, or organically certified meat
- Use organic farming to grow some of your food
- Buy certified organic food
- Eat locally grown food
- Compost food wastes
- Cut food waste
Three Big Ideas

1. More than 1 billion people have health problems because they do not get enough to eat and 1.1 billion people face health problems from eating too much.

2. Modern industrialized agriculture has a greater harmful impact on the environment than any other human activity.