Chapter 2: Food Systems and Sustainability

Learning Domain - Cognitive

Level of Learning – Comprehension

Time Allocation – Approximately 65 minutes

Learning Objectives:

- Describe food systems.
- List five major segments of a food system.
- Discuss the concept of sustainability.
- Identify three allied industries of a food system.
- List three effects of urbanization on a food system.
- List 13 standards for sustainability.
- Discuss why changes in the food system need to be science-based.
- Identify three trends in global food demand that effect food systems.
- Name two social or political aspects of a food system.
- Identify three renewable energy sources that could be used in a food system.
- Explain the role agriculture plays in water use and water consumption.
- Discuss the role of income level on the food system.
- Describe the importance of soil conservation to a successful food system.
- Describe integrated pest management represents a sustainable method of pest control.
- Identify how a food system contributes to strong communities.
- List three types of water pollution that can adversely affect food systems.

Vocabulary Introduced:

- anaerobic
- aquaponics
- beneficials
- bio-intensive
- biosecurity
- entomophagy
- food insecure
- food system
- genomics

- market niches
- nutraceuticals
- probiotics
- risk
- risk assessment
- science
- sustainable
- urbanization

Needed Equipment/Materials:

Instructor: PowerPoint presentation equipment
Student: paper, pencil

References: *Introduction to Food Science and Food Systems, Second Edition*

I. Introduction

[Time Allocation: 5 min.]

A. In simple terms, a food system includes all processes and infrastructures involved in feeding a population
B. Sustainable refers to anything that can be maintained at a certain rate or level
C. When applied to food and food production, these definitions can have a wide range of interpretations and can become quite complex emotionally and politically
D. Regardless of the definitions, emotions, and politics, the challenge is to feed a growing global population of nearly 7.5 billion people

Reference: *Introduction to Food Science and Food Systems* , p. 23
Slide: 2-5

II. Food System Definitions

[Time Allocation: 5 min.]

A. Overview
   1. The food industry and food science involve more than grocery stores and restaurants
   2. Food systems can be divided into five major segments:
      a. Production
      b. Manufacture
      c. Distribution
      d. Marketing
      e. Consumption
   3. Perhaps a sixth segment should also be added:
      a. Waste and disposal
   4. These five or six divisions overlap one another
      a. A food system must be able to plan for and synchronize its divisions to be successful
B. Allied Industries
   1. Many companies do not sell food directly but still are deeply involved in the food industry
   2. These allied industries produce nonfood items that are required for food marketing
   3. Examples include:
      a. Packaging industry
      b. Chemical manufacturers
      c. Food machinery and equipment manufacturers
      d. Monitoring and regulatory agencies

C. International Activities
   1. Food is a global commodity
   2. Foods are traded and shipped around the world
      a. Products move around the world by air freight in hours or days
      b. Communications take place around the world in seconds

D. Interrelated Operations
   1. Food production relies on a highly advanced and organized industry
   2. The industry is a systematic and rhythmic process
   3. Throughout production, costs of manufacturing, distribution, and marketing and availability are carefully monitored and controlled

Reference: *Introduction to Food Science and Food Systems*, pp. 23-25
Slides: 2-6 through 2-9

III. Food System Trends

[Time Allocation: 10 min.]

A. Overview
   1. National and international trends drive changes in a food system
   2. The total food consumed by each individual (per capita food consumption) has changed little over the years
      a. The kind of foods consumed continually change
      b. This contributes to competition and frequent changes in the food system
   3. As income grows, consumers in lower income countries shift their food purchases
      a. Away from carbohydrate-rich staple foods
      b. Toward more expensive sources of calories such as meat and dairy products

B. Food Consumption Patterns
   1. Changes driven by income growth and demographic factors
      a. Urbanization
      b. Away-from-home employment of women
      c. Increased levels of information
   2. ERS analysis of global food demand
      a. Low-income countries spend more on food; richer countries spend more on luxuries such as recreation
      b. Low-value staples account for more of the food budget in poorer countries; in richer countries, it's high-value items
      c. Overall, low-income countries are more responsive to changes and make larger adjustments in food-consumption patterns
      d. Adjustments to price and income changes are not uniform across all food categories

i. Staple food consumption changes the least
ii. Consumption of higher-value food items changes the most

C. Retail Trends
1. Packaged food accounts for large shares of total food expenditures among consumers in high-income countries
a. United States
b. European Union
c. Japan
2. In developing countries, intermediate products account for the bulk of retail sales
a. Vegetable oils
b. Dry pasta
c. Other dried products
3. Market trends indicate strong growth in sales of packaged food products among developing countries
4. Trends in the soft drink and beverage sector often indicate consumers' ability to purchase higher-value foods
5. Changes in government regulation require the food industry to be responsive to change
a. Food additives
b. Food composition standards
c. Labeling

Reference: *Introduction to Food Science and Food Systems*, pp. 25-27
Slides: 2-10 through 2-12

IV. Defining Sustainability

[Time Allocation: 5 min.]

A. Simply Defined
1. Sustainable means using a harvesting method or resource so that the resource is not depleted or permanently damaged

B. Overview
1. Nevertheless, sustainability means different things to different people
a. For some, it is any food production system that depends on nonrenewable resources such as oil is not sustainable
b. Other people argue that this is not important and because alternative energy sources will be found
c. Others see it as meeting today's needs without compromising the ability of future generations to meet their needs
2. The Food, Agriculture, and Trade Act: Seven Key Features
a. Will meet human needs for food now and far into the future
b. Integrate plant and animal production

c. Rely as much as possible on natural processes and cycles
d. Are designed specifically to fit the biological, social, and economic conditions of specific places
e. Provide a livable income for farm families
f. Protect natural resources
g. Enhance the quality of life for farmers and for society as a whole

3. Many scientists and leaders see sustainable food production as being environmentally, economically, and socially sustainable
4. Many industries set and rely on standards to ensure consistency and uniformity
   a. To evaluate the sustainability of an operation
   b. To make changes in an operation or a system, standards are needed

Reference: *Introduction to Food Science and Food Systems* , pp. 27-28
Slides: 2-13 through 2-15

V. Standards of Sustainable Food Production

[Time Allocation: 30 min.]

A. Overview
   1. Often people just seem to know that *sustainable* is good without really understanding what is involved
   2. The concept is presented here within the framework of 13 standards
B. Standard 1: Base Direction and Changes Based on Science
   1. Science deals only with rational propositions—hypotheses—that can be verified or disproved by observation or experiment
   2. Through scientific research, improvements continue to be made
      a. Ongoing research and the use of science
         i. Genetic improvement
         ii. Animal health management
         iii. Reproduction and early development
         iv. Plant and animal growth, development, and nutrition
         v. Production systems
         vi. Sustainability and environmental compatibility food-system components
         vii. Quality, safety, and variety of food products for consumers
C. Standard 2: Follow Market Principles
   1. A sustainable food system follows market principles:
      a. A market
      b. Marketing
      c. A marketing plan

   d. Profits from sales
2. Market niches
   a. Specialization in a specific and limited market sector
   b. Take advantage of the following:
      i. Specific microclimates
      ii. Regional demands
      iii. Special knowledge or skills
   c. Marketing specialized products or services can be more difficult and riskier, but also more profitable

D. Standard 3: Increase Profitability and Reduce Risks
1. To succeed, those engaged in the food system seek to increase profitability by reducing risk
2. The ability to minimize risk is a major factor in a successful sustainable venture
   a. Risk is manageable, and uncertainty must be accepted
      i. Do not risk more than you can afford to lose
      ii. Do not risk a lot for a little
      iii. Understand the likelihood and severity of possible losses
3. Noninsurance risk-management options include production risks and marketing risks
   a. The management of production risks can include:
      i. Changing husbandry practices
      ii. Building redundancy (backup) into the operation
      iii. Improving management
      iv. Employing stringent biosecurity measures
      v. Minimizing the chance of disease introduction and cross contamination
      vi. Knowing appropriate treatments
   b. Management of marketing risks can include:
      i. Diversification to include other products and categories of production
      ii. Creation of a unique identity (brand)
      iii. Development of a niche market or value-added products

E. Standard 4: Satisfy Human Need for Fiber and Safe, Nutritious Foods
1. Providing food and shelter are the primary purposes of a food system
   a. Sufficient fiber (protection from the elements)
   b. Safe and nutritious food for people
2. In its 2015 report, the FAO states that global hunger has continued to gradually decline
   a. This decline has been most pronounced in developing countries despite significant population growth
   b. A key factor in reducing undernourishment has been economic growth, but only when it is inclusive
3. Food security and food insecurity

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a. *Food security* means that households have access to enough food so that all members maintain active, healthy lives
b. *Food insecure* means that a household is uncertain whether it could acquire enough food to meet the needs of all members

4. Urbanization
   a. Around the world, people are migrating from the country into cities; this is called urbanization
   b. A continuous and massive amount of food is required to feed this growing urban population
      i. Worldwide, the number of cities with populations of 10 or more million will increase to 26
      ii. Every city this size requires 6,000 tons of food shipped in each day or about 2.2 million tons per year
      iii. Even cities with populations of less than 10 million require thousands of tons of food each day

F. Standard 5: Conserve and Seek Energy Resources
   1. Conservation
      a. Conservation can mean using less or using an alternative and renewable source
      b. This can be using technology to increase the efficiency of some energy consuming practice associated with food production
         i. Pumping
         ii. Transportation
         iii. Storage
         iv. Harvesting
   2. Energy flow and alternative energy
      a. Various parts of the food system are considering renewable and alternative energy resources
         i. Wind
         ii. Solar
         iii. Bioenergy (biogas, butanol, and ethanol)
         iv. Hydrogen (fuel cells)
         v. Nuclear
      b. Current related research includes:
         i. Algal biofuels technology development
         ii. Hydrogen production from algal systems
         iii. Geothermal energy use
         iv. Conservation and efficient use of energy
         v. Solar energy development
         vi. Biomass energy use

G. Standard 6: Create and Conserve Healthy Soil
   1. Healthy soils are crucial for the following:
      a. Ensuring the continued growth of natural and managed vegetation
      b. Providing feed, fiber, fuel, medicinal products
      c. Ensuring climate regulation and oxygen production

2. Conservation methods include:
    a. Tillage
    b. Vegetation
    c. Mulching
    d. Cropping patterns
3. Management of the land directly influences how well organisms living in the soil perform their important functions:
    a. Purifying water and air
    b. Detoxifying pollutants
    c. Recycling crop nutrients
    d. Decomposing plant residues
    e. Promoting soil structure
    f. Preventing disease outbreaks
4. Critical information for conservation and soil-health planning includes:
    a. Soil depth
    b. Soil type
    c. Drainage characteristics
    d. Slope of the land
    e. Chemical usage
    f. Tillage practices

H. Standard 7: Conserves and Protects Water Resources
1. A sustainable food system conserves and protects water resources
    a. Chronic or acute water shortage is increasingly common in many countries with fast-growing populations
    b. Agriculture and food production are major users of groundwater and surface water in the United States
        i. Accounts for approximately 80% of the nation's water use
        ii. Accounts for 90% in many Western states
    c. Efficient irrigation systems and water-management practices
        i. Help maintain farm profitability
        ii. Reduce the impacts of irrigation on offsite water quantities and quality
        iii. Conserve water for growing nonagricultural demands
2. Water quality
    a. Chemical fertilizer and pesticide residues can wash into streams or leach through the soil into groundwater
    b. Irrigation can move salt and other dissolved minerals to surface water
    c. Livestock operations produce large amounts of waste that can:
        i. Threaten human health
        ii. Contribute to excess nutrient problems in streams, rivers, lakes, and estuaries

   d. Improvements in water quality can reduce production costs and thus market prices to consumers
3. Food processing
   a. Water is extensively used in the food-processing industries
   b. To conserve water and to maintain water quality, food processors:
      i. Develop unit operations that use less water or optimize water use
      ii. Recycle or reuse water (following reconditioning)
      iii. Find alternative sources of potable or clean water

I. Standard 8: Recycle and Reduce Waste Products
1. Resources out of place
   a. Agricultural residues or wastes might better be regarded as "resources out of place" rather than simple waste
   b. With appropriate techniques, wastes can be recycled to produce:
      i. A source of energy
      ii. Natural fertilizer
      iii. Feed
   c. Five popular recycling methods for agricultural wastes include:
      i. Anaerobic digestion
      ii. Refeeding
      iii. Land application
      iv. Composting
      v. Incineration
2. Anaerobic decomposition
   a. Biogas is produced when organic matter degrades in the absence of oxygen
   b. Animal wastes in particular can be used to generate biogas
   c. Like other gas fuels, biogas can be used for cooking, lighting, and running small engines

J. Standard 9: Select Animals and Crops Appropriate for an Environment and Available Resources
1. **Aquaponics** is the combination of raising aquatic animals and producing some plants
   a. Aquatic animal effluent accumulates in water as a by-product of keeping them in a closed system or tank
   b. The effluent-rich water becomes high in plant nutrients that are toxic to aquatic animals
   c. In a hydroponic system, plants are able to use the nutrient-rich water
   d. The plants take up the nutrients, reducing or even eliminating the water's toxicity for aquatic animals
2. Several factors determine the type of animal or plant grown in a sustainable food system

a. Climate
b. Resources
c. Producer abilities
d. Demand
e. Distribution
f. Markets

3. With current demands and population growth, serious consideration is now being given to **entomophagy**
   a. Entomophagy is the practice of eating insects
   b. This includes arachnids (tarantulas) and myriapods (centipedes)

K. Standard 10: Manage Pests with Minimal Environmental Impact
   1. Sustainable practices manage pests with minimal environmental impact
      a. Pest management is a challenge, especially for those dedicated to sustainable, low-input practices
   2. Integrated pest management (IPM)
      a. IPM promotes minimized pesticide use, enhanced environmental stewardship, and sustainable systems
      b. Bio-intensive IPM is a systems approach based on an understanding of pest ecology
      c. Biological control uses living organisms such as to maintain pest populations below economically damaging levels
         i. Parasites
         ii. Predators
         iii. Pathogens
      d. Mechanical or physical controls use some physical component of the environment that are detrimental to pests
         i. Temperature
         ii. Humidity
         iii. Light
      e. Correctly identifying pests is crucial in the effectiveness of any IPM program
   3. About one-third of the worldwide food supply is lost to pests
      a. Pest control is essential to a sustainable food system

L. Standard 11: Encourage Strong Communities
   1. A sustainable food system must create and implement projects and industry that generate new wealth and jobs
   2. Lack of jobs (opportunities) and low-wage jobs are serious concerns
   3. Sustainable food systems increase the capacity of individuals and communities to work together to respond to constant changes

M. Standard 12: Use Appropriate Technology
   1. Good planning and judgment are needed to select those technologies that will benefit a food system
      a. Equipment used

b. To the methods of pest control
c. To the types of seed used

2. Among the factors to consider when selecting technology for a sustainable food system are:
   a. Current technology being used
   b. Local and national infrastructure
   c. Local and national regulations
   d. Finances
   e. Local cultural customs
   f. Local institutions
   g. The local environment

N. Standard 13: Promote Social and Environmental Responsibility
1. A sustainable food system that addresses the first 12 standards will automatically address standard 13
   a. New technologies spawn economic, social, and political changes
   b. A diversity of strategies and approaches are necessary to create a more sustainable food system
2. Food and agriculture represent the union of human rights with community and environmental issues
   a. Every person relies on agricultural products for survival
   b. The global marketplace creates increasingly complex supply chains along with ever-more challenging demands
3. Food and agriculture companies are faced with an increasing assortment of international regulations
   a. Some food and agriculture companies are adopting international standards and certification schemes
   b. They are engaging with environmental, human rights, and development organizations
   c. These companies are increasing the transparency of their operations, policies, and practices

Reference: *Introduction to Food Science and Food Systems* , pp. 28-40
Slides: 2-16 through 2-29

VI. Sustainable Standards Scorecard

[Time Allocation: 5 min.]

A. Overview
1. Considering all of its components, the difficulty in defining *sustainability* should be obvious
2. A scorecard can be used to rate the sustainability level
   a. Rating the sustainability level of each of the 13 standards provide at least a starting point

b. To approach sustainability, each standard must receive a score of at least 3
   i. A total score of 53 to 65 indicates a high level of sustainability
   ii. A score of less than 53 suggests the system needs more work to become sustainable
   iii. A score of less than 3 indicates that an operation is not meeting all 13 standards and is not truly sustainable

Reference: *Introduction to Food Science and Food Systems*, p. 40
Slide: 2-30

VII. Summary

[Time Allocation: 5 min.]

- Reliance on food production systems that are not environmentally sound could lead to the destruction of the natural resources needed to produce food
- One key goal in sustainable food-production systems is to protect and conserve the natural resources on which food production depends
- Water is a critical resource for all agricultural production and food processing
- The 13 standards provide guidelines for developing sustainable operations and a means for evaluating sustainable operations

Reference: *Introduction to Food Science and Food Systems* , pp. 40-41
Slide: 2-31

VIII. Assignment – Read Chapter 3 in *Intro. to Food Science and Food Systems*

Lab Exercises
Answers to Questions

LAB EXERCISE: CRITICAL ANALYSIS OF A WEBSITE

Answers will vary based on the sites the students choose.

LAB EXERCISE: EATING LOCALLY

1. **If you relied on local foods, what would your diet be like?**
   Answers will vary but should connect back to the table completed by the students.

2. **How does the cost of local foods compare to the cost of the same food in a grocery store?**
   Answers will vary, but in general the cost of food in a grocery store will be lower.

3. **What is the average distance that local foods travel to get to market?**
   Answers will vary and should relate back to the table completed by the students.

4. **Could you sustain yourself by eating locally? Why or why not?**
   Answers will vary. Students should consider the components of a healthy diet, a diet with some variety and their individual tastes.

5. **Would you consider the local producers sustainable as related to the 13 standards in this chapter?**
   Answers will vary. With some investigation students should be able to evaluate the sustainability by completing an evaluation using Figure 2-12 *in chapter* 2.

LAB EXERCISE: EXTRACTING GLUTEN AND STARCH FROM WHEAT FLOUR

1. **Describe your yield of starch and gluten. What factors affected your yield?**
   Answers will vary depending on student technique and type of wheat flour used.

2. **Describe the physical properties of your gluten and the starch?**
   Gluten is stretchy and elastic-like. Starch is smooth, slick-feeling and powdery.

3. **Why is it important to mix the dough, then pound it and stretch it?**
   This develops the gluten. Water coaxes the two wheat proteins glutenin and gliadin to combine and form gluten. Gluten is developed in the dough when the proteins absorb water and are pulled and stretched in the kneading process. As the proteins are worked, they become long, flexible strands.

Chapter 2

Answers to Review Questions

1. List 13 standards for sustainability.
   Standard 1: Base Direction and Changes Based on Science
   Standard 2: Follow Market Principles
   Standard 3: Increase Profitability and Reduce Risk
   Standard 4: Satisfy Human Need for Fiber and Safe, Nutritious Food
   Standard 5: Conserve and Seek Energy Resources
   Standard 6: Create and Conserve Healthy Soil
   Standard 7: Conserves and Protects Water Resources
   Standard 8: Recycle and Reduce Waste Products
   Standard 9: Select Animals and Crops Appropriate for an Environment and Available Resources
   Standard 10: Manage Pests with Minimal Environmental Impact
   Standard 11: Encourage Strong Communities
   Standard 12: Use Appropriate Technology
   Standard 13: Promote Social and Environmental Responsibility

2. List five major segments of a food system.
   production
   manufacturing
   distribution
   marketing
   consumption

3. What are three effects of urbanization on a food system?
   Urbanization is likely to significantly alter consumers' diets with greater consumption of meats, fruit, vegetables, and processed foods.
   A continuous and massive amount of food is required to feed a growing urban population.
   A sustainable food system will need to increase its ability to meet the human need for safe, abundant, and nutritious foods.

4. Name three allied industries in a food system.
   Any three of the following:
   packaging industry
   chemical manufacturers
   food machinery and equipment manufacturers
   monitoring and regulatory agencies

5. How does a food system contribute to strong communities?
   Sustainable food systems encourage strong communities, providing opportunities for young people, access to health care, living wage jobs, and access to quality education.

6. List and describe three possible renewable energy sources that could be used in a food system.
   Any three of the following:
   wind
   solar
   bioenergy (biogas, butanol, and ethanol)
   hydrogen (fuel cells)
   nuclear

7. Name three trends in global food demand.
   Low-income countries spend a greater portion of their budget on necessities such as food.
   Low-value staples such as cereals account for a larger share of the food budget in poorer countries.
   Overall, low-income countries are more responsive to changes in income and food prices and therefore make larger adjustments in their food-consumption patterns.
   Adjustments to price and income changes are not uniform across all food categories.

8. Discuss the concept of sustainability.
   Sustainable means using a harvesting method or resource so that the resource is not depleted or permanently damaged.

9. Why is soil conservation so important to a food system?
   Healthy soils are crucial for ensuring the continued growth of natural and managed vegetation, providing feed, fiber, fuel, medicinal products, and other ecosystem services such as climate regulation and oxygen production.

10. Describe how integrated pest management contributes to a sustainable food system.
    Integrated pest management promotes minimized pesticide use, enhanced environmental stewardship, and sustainable systems.

11. How can water pollution adversely affect food systems?
    When pollutants degrade water quality, they impose costs on water users in the form of degraded ecosystems, reduced recreational opportunities, reduced commercial fishing catches and shellfish bed closings, increased water-treatment

costs, threats to human health, and damage to reservoirs and water-conveyance systems.

12. Explain why changes in a food system need to be science-based.
Scientific research uses the scientific process or method. Science deals only with rational beliefs propositions – hypotheses – that can be verified or disproved by observation or experiment. Through scientific research, improvements continue to be made in production, manufacturing, distribution, marketing, consumption, and waste disposal, as well as in the allied industries.