Module 1 – Foundations of Sustainable Agri-Food Systems & Circular Economy

Student Notes

These notes are designed to help you understand the main ideas, vocabulary, and concepts from Module 1. Each section matches the learning outcomes and activities discussed in class. Use these notes to study for quizzes, complete projects, and participate in discussions.

Note: Vocabulary words marked with an asterisk (*) are required knowledge. Unmarked words are included for personal enrichment.

Lesson A – Why Food Systems Matter

Learning Outcomes:

- **Remember:** Define a sustainable food system and explain its 3 pillars (social, environmental, economic).
- **Understand:** Recognize how agriculture impacts planetary boundaries (climate, biodiversity, etc.) and overshoots some limits.
- **Apply:** Connect food and farming issues to multiple UN Sustainable Development Goals (SDGs)
- **Analyze:** Evaluate the sustainability of a meal item by analyzing its “food print” (resource use & waste).

Key Concepts:

1. **Sustainable Food Systems**
   - Deliver nutritious food for all while sustaining environmental, economic, and social foundations.
   - Ensure food security for current and future generations.
2. **The Three Pillars**
   - **People** – Social well-being.
   - **Planet** – Environmental health.
   - **Profit** – Economic viability.
3. **Planetary Boundaries**
   - 9 environmental limits humanity must stay within for a stable Earth system.
   - 6 of the 9 have been crossed: including climate change, biosphere integrity, nutrient cycles (N & P), land-system change, freshwater change, and novel entities.
   - Food systems are key drivers of exceeding boundaries, especially as nutrient pollution, land conversion, and biodiversity loss.
4. **Food Systems’ Footprint**
   - Responsible for ~25% of global GHG emissions
   - Major driver of deforestation, biodiversity loss, and nutrient pollution.
   - Half of Earth’s green land is used for crops and pasture.
5. **Sustainable Development Goals (SDGs)**
   - 17 global goals to end poverty, protect the planet, and ensure prosperity by 2030.
   - Food systems link directly or indirectly to most SDGs.
6. **The “Double the Food” Myth**
   - Claim: Food must double by 2050 to feed 10 billion people.
   - Reality: We already produce 1.5x enough calories — waste and diet inefficiencies are the real issue.

Think About:

- What might happen if one of the three principles (People, Planet, Profit) is ignored?
- How do your daily food choices connect to planetary boundaries?
- Why might focusing on reducing waste and shifting diets be more effective than expanding farmland?

Important Vocabulary/Word Bank:

A. Sustainable Food System*
B. People – Planet – Profit (Triple Bottom Line)*
C. Planetary Boundaries*

D. Biosphere Integrity*
E. Greenhouse Gas (GHG) Emissions*
F. Sustainable Development Goals (SDGs)*
G. Deforestation*
H. Nutrient Pollution*
I. Food Security*
J. Circular Economy*

Vocabulary in Context- Fill in the Blanks using Word Bank

1. The three pillars of a sustainable food system are **_____, _____,** and **_____**.
2. _____ boundaries define the environmental limits we must stay within for a stable planet.
3. Clearing forests for farmland contributes to _____ loss.
4. The _____ Goals set a 2030 roadmap for ending poverty and protecting the planet.
5. Food systems are responsible for about _____% of global greenhouse gas emissions.
6. Producing more food without addressing waste may harm the _____ principle.
7. _____ pollution from nitrogen and phosphorus leads to algae blooms and dead zones.
8. Ensuring all people have reliable access to healthy food is called _____.

Folder/cover paper here and test your knowledge

Self-Test Using Word Bank:

1. A _____ delivers nutritious food while protecting environmental, economic, and social foundations.
2. The three principles of sustainability are _____.
3. _____ are the environmental limits humanity must stay within to maintain a stable Earth system.
4. Protecting _____ helps maintain species diversity and ecosystem stability.
5. Agriculture is a major contributor to global _____.
6. The _____ aim to end poverty, protect the planet, and ensure prosperity by 2030.
7. Clearing forests for farmland contributes to _____.
8. Excess fertilizer runoff leads to _____, harming water systems.
9. Ensuring all people have reliable access to nutritious food is called _____.

10. A _____ keeps resources in use and minimizes waste by cycling materials back into the system.

Reflection Questions

- How do your daily food choices (like what you eat for lunch) connect to planetary boundaries such as biodiversity, land use, or climate change?

- What might happen if one of the three principles of sustainability (People, Planet, Profit) is ignored in designing a food system?

- Do you think producing more food is the solution to global hunger, or should we focus more on reducing food waste and diet inefficiencies? Why?

Lesson B – From Linear to Circular: Rethinking Food Production

Learning Outcomes:

- **Remember:** Define linear, circular, and agroecological farming models. Identify typical inputs, outputs, and resource flows for each.
- **Understand:** Explain at least two circular economy strategies in agriculture (e.g., composting, anaerobic digestion, recycling water) and their benefits. Describe key agroecology principles such as biodiversity and nutrient cycling.
- **Apply:** Compare resource use and waste generation in linear, circular, and agroecological systems.
- **Analyze:** Propose a simple waste-to-resource idea and explain how it could benefit a farming system.

Key Concepts:

1. **Linear Food Systems**
    - Follow a “take → make → waste” path.
    - Extract resources, produce goods, and discard leftovers — leading to resource depletion and pollution.
2. **The Waste Meter**
    - 6 garbage trucks of edible food are wasted every second globally.
    - Less than 2% of food nutrients are recovered in cities; most end up in landfills or incinerators.
3. **Circular Economy Principles**
    - Mimic nature’s loops — waste becomes a resource.
    - Keep organic materials toxin-free for composting and soil health.
    - Circulate nutrients and materials to stay in use longer.
    - 5Rs: Key Principles of Circularity:
        - Reduce
        - Reuse
        - Recycle
        - Refurbish
        - Regenerate
4. **Biological & Technical Cycles**
    - **Biological**: Compost, digest, return nutrients to soil.
    - **Nature Powered Farming:**

        - **Agroecology**: Treat the farm as a living ecosystem; use crop diversity, nutrient cycling, and natural pest control.
        - **Regenerative Agriculture**: Go beyond sustainability to restore soil health, water cycles, and biodiversity.
            - Examples like: build soil carbon → locks away CO_2 + feeds microbes, and improving water cycles → sponge-like soil buffers drought
5. **Case Studies**
    - **Citrus Peel to Cattle Feed** – Turning fruit waste into livestock pellets and biogas.
        - Old way:
            - peels rot → methane
        - New loop:
            - peels (dry and mill) → high-fiber cattle pellets
        - Cuts landfill waste & methane
        - Replaces pricey grain for ranchers = win-win
    - **Spent Grain to "Bourbon Shrooms"** – Using brewery waste to grow gourmet mushrooms, then composting leftovers.
        - Essential oils extracted first (perfume, cleaning products)
        - Leftover pulp → animal feed & biogas energy
        - Regional waste turned into revenue & renewable power—a full circular chain!
6. **Circular Economy + Nature-Based Solutions = Perfect Loop**
    - **Cut External Inputs**
        - Reduce synthetic fertilizers & pesticides
        - Where Waste can = a Resource
        - Manure, husks are reused in the system
7. **Farmers in the Driver's Seat**
    - Local solutions, not one-size-fits-all
    - Long-Term Sustainability
    - Closed-loop systems support soil, water & communities over time

Think About:

- How does a circular economy approach benefit farmers, communities, and the environment?
- Which case study inspired you the most, and why?
- What is one waste stream in your own community that could be turned into a resource?

Important Vocabulary/Word Bank:

A. Linear Economy*
B. Circular Economy *
C. Agroecology*
D. Regenerative Agriculture*
E. Nutrient Cycling*
F. Biological Cycle*
G. Technical Cycle*
H. By-product*
I. Composting*
J. Waste-to-Resource *

Vocabulary in Context- Fill in the Blanks using Word Bank

1. A _____ follows the path "take → make → waste," leading to resource loss.
2. The _____ approach keeps resources cycling and reduces waste.
3. Farming with crop diversity, nutrient cycling, and natural pest control is called _____.
4. Going beyond sustainability to restore soil and water cycles is _____.
5. The movement of nutrients back into soil for reuse is _____.

6. Returning organic waste to the soil through decomposition is _____.
7. Packaging materials that are repaired or reused belong to the _____ cycle.
8. A leftover material from production, such as citrus peel, is called a _____.
9. The process of turning waste into usable materials or products is called _____.
10. Using brewery grain to grow mushrooms is an example of _____ innovation.

Folder/cover paper here and test your knowledge

Self-Test Using Word Bank:

1. A _____ design leads to waste accumulation and resource depletion.
2. _____ systems close the loop and mimic nature's recycling processes.
3. A _____ is leftover material that can be transformed into something useful.
4. _____ involves breaking down organic matter into soil nutrients.
5. The _____ keeps materials like metals and plastics in use through repair and recycling.
6. _____ restores ecosystems while improving agricultural productivity.
7. In _____, farms operate as living ecosystems with biodiversity and nutrient reuse.
8. The _____ returns nutrients from organic waste to the soil.
9. _____ innovation creates value from discarded materials.
10. Growing mushrooms from brewery waste is an example of _____ practice.

Reflection Questions

- How does shifting from a linear food system ("take–make–waste") to a circular food system benefit farmers, communities, and the environment?

- Which circular economy case study (e.g., citrus peel to cattle feed, brewery grain to mushrooms) inspired you the most, and why?

- In your own community, what is one waste stream (like cafeteria leftovers, yard clippings, or coffee grounds) that could be turned into a resource?

Lesson C – Pathways to Action: Diet, Innovation, & Policy

Learning Outcomes:

- **Remember:** Identify personal and community actions that can reduce food system impacts (e.g., dietary shifts, reducing food waste).
- **Apply:** Use data to compare the environmental footprint of different foods or habits (e.g., calculating CO_2 or waste saved).
- **Understand:** Explore examples of sustainable innovation (technology or business) and policy measures in food systems.
- **Create:** Synthesize and propose a solution or action, and explain its expected benefits in a mini-presentation or written reflection.

Key Concepts:

1. **Three Pathways to Action**
    - **Dietary Shifts**: Reduce environmental footprint by aligning diets with ecological limits and health goals.
    - **Innovation**: Redesign food production and supply chains to cut waste and regenerate resources.
    - **Policy**: Enact regulations, incentives, and programs that enable sustainable practices.
2. **Dietary Shifts – Beef vs. Beans**
    - Cattle use two-thirds of agricultural land but provide only ~3% of global calories.
    - Beef has 10–20× higher CO_2 emissions per gram of protein compared to beans.
    - Shifting to plant-based proteins saves water, land, and emissions.
3. **Innovation Examples**
    - **Alternative proteins** (plant-based, lab-grown, insect-based) – lower land/water use and aim for same taste with lighter footprint.
    - **Urban farming technologies** – vertical farms, hydroponics, aquaponics; reduce transport, enable year-round greens, and integrate renewables & compost loops.
    - **Food-waste apps** – e.g., *Too Good To Go*, *Olio*; rescue surplus meals, reduce landfill waste.
    - **Rethink packaging** – bioplastic cups, recyclable foil lids; design for zero landfill.
    - **Circular business models** – e.g., mushrooms grown on spent grain, fungi grown on coffee grounds; start-ups converting curbside scraps into fertilizer pellets & biogas.
    - **Waste-to-resource innovations** – grease to biofuel, fruit pits to textile dyes.
    - **Community & start-up initiatives** – local enterprises redesigning the food chain with “profit with purpose.”
4. **Policy Solutions**
    - **Food-waste reduction targets** (e.g., SDG 12.3) – goal of halving waste by 2030; France requires supermarkets to donate edible food; schools redirect unsold lunches to local shelters or compost.
    - **Incentives for regenerative agriculture** – pay farmers for carbon-rich soils and biodiversity, subsidize cover crops and agroforestry.
    - **Urban farming and composting policies** – zoning for community gardens/rooftop farms, mandatory compost pick-up, grants for urban agriculture, zero-waste targets.
    - **Regulations on harmful inputs** – phase out toxic pesticides, reduce excess nitrogen fertilizer, implement anti-deforestation laws, sustainable intensification, and carbon/nitrogen pricing.

- **Public procurement & dietary shifts** – 50% local/regenerative food in public institutions (e.g., schools), Meatless Mondays, using public programs to model sustainable practices.
- **Multi-level policy alignment** – coordinate international, national, local, and campus-level actions to make sustainable choices easy and profitable.
- **Collaborative system change** – encourage joint action between scientists, farmers, businesses, governments, and citizens; "no single hero" approach to policy change.
-

5. **Systems Thinking**
   - Combining diet changes, innovations, and policies creates reinforcing feedback loops that accelerate sustainability goals.

Think About:

- Which pathway do you think could make the biggest impact in your community?
- How could dietary shifts be encouraged without food shaming?
- What's one example of a policy and an innovation that would work well together?

Important Vocabulary/Word Bank:

A. Dietary Shifts*
B. Innovation*
C. Policy*
D. CO_2e (Carbon Dioxide Equivalent)*
E. Alternative Proteins*
F. Urban Farming*
G. Circular Business Model
H. Food-Waste Target*
I. Regenerative Agriculture Incentives
J. Systems Thinking*

Vocabulary in Context- Fill in the Blanks using Word Bank

1. Reducing meat consumption in favor of plant-based proteins is an example of _____.
2. Creating new technologies or processes to reduce waste is known as _____.
3. Laws or incentives that encourage sustainable food practices are examples of _____.
4. The measure _____ is used to compare greenhouse gas emissions across activities.
5. Plant-based burgers and lab-grown meat are examples of _____.
6. Farming that uses vertical space or rooftops in cities is called _____.
7. A _____ turns waste into profitable resources.
8. A government commitment to halve edible food waste by 2030 is a _____.
9. Financial rewards for farmers who use soil-building methods are called _____.
10. Looking at all parts of a food system and how they interact is _____.

Folder/cover paper here and test your knowledge

Self-Test Using Word Bank:

1. _____ align eating habits with environmental and health goals.

2. Designing new solutions for food production and waste reduction is called _____.
3. Creating rules and incentives for sustainable practices is an example of _____.
4. Greenhouse gas emissions are often measured in _____.
5. Edible insect flour and plant-based meats are examples of _____.
6. Growing food in buildings or on rooftops is _____.
7. A _____ captures value from materials that would otherwise be discarded.
8. Halving edible waste by a specific date is an example of a _____.
9. Payments to farmers for using eco-friendly practices are _____.
10. Understanding how different parts of the food system influence one another is _____.

Reflection Questions

- Of the three pathways—dietary shifts, innovation, and policy—which do you think could make the biggest impact in your community, and why?

- How could dietary shifts (like eating more beans instead of beef) be encouraged in positive ways without food shaming?

- Give an example of a policy and an innovation that could work together to make food systems more sustainable.