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

Instructor Guide

Module Overview

This module introduces students to the core concepts of sustainable food systems, planetary boundaries, and the circular economy. Students explore how food systems intersect with environmental limits, economic viability, and social equity, and how linear "take–make–waste" models can be redesigned into regenerative loops. Through real-world case studies, data comparisons, and design challenges, students investigate how diet, innovation, and policy can work together to create sustainable change. The module emphasizes systems thinking—seeing the connections between production, consumption, waste, and regeneration.

Materials Provided

- Slide deck with speaker notes
- Optional student-facing worksheets
- Extended learning activity on systems thinking & nature as the ultimate circular model
- Case studies and circular design sprint materials
- Vocabulary list and student notes
- Instructor lesson plan and optional lab activities

What Should Students Walk Away With

This module offers students a systems-level introduction to sustainable agri-food systems and the circular economy, framing food production, consumption, and waste as interconnected parts of a global system that must operate within planetary limits. While the module does not require deep prior knowledge of environmental science, economics, or policy design, it provides multiple opportunities for students to engage with these concepts in real-world contexts. Students practice systems thinking, case study analysis, and solution design, while also connecting food choices, innovations, and policies to climate action, biodiversity conservation, and resource regeneration.

By the end of the module, students be able to:

- Explain the three principles of sustainable food systems and planetary boundaries, and link food systems to SDGs
- Distinguish linear vs. circular food systems using real-world examples
- Assess waste-to-resource solutions for scalability, value, and nutrient recovery
- Propose circular uses for food by-products using CE and agroecology principles
- Evaluate environmental impacts of diets using CO_2e, water, and land data
- Design an action plan combining diet, innovation, and policy solutions
- Compare strengths and limits of each pathway and how they work together for system change

Key Question:

How can we redesign food systems to reduce waste and regenerate natural resources instead of depleting them?

Essential Questions:

- How can we design food systems that respect planetary limits while advancing global well-being?
- How can we redesign food systems so nothing goes to waste?
- Is there a single most powerful change — on your plate, in a business, or in law — that could make our food system more sustainable?

Lesson A: Why Food Systems Matter: Planetary Boundaries & SDGs

Summary: Lesson A establishes why sustainable food systems are crucial. Students are introduced to the High Level Panel of Experts (HLPE) definition of a Sustainable Food System (SFS) – a food system that provides food security and nutrition for all without compromising economic, social, or environmental bases for future generations. They learn about the "three pillars" of sustainability (People, Planet, Profit) and examine the concept of planetary boundaries – critical ecological limits (climate, biodiversity, nutrient cycles, etc.) that humanity should not exceed. Students discover that our modern food system is a major driver of crossing these limits (e.g. agriculture's role in deforestation, greenhouse emissions, nutrient pollution). The lesson also connects food systems to the 17 U.N. Sustainable Development Goals (SDGs), underscoring that every SDG (from Zero Hunger to Climate Action) links to food mdpi.com. Students then apply these ideas by evaluating the sustainability of a single meal item from their lives.
Focus: Understanding the triple bottom line and how food systems intersect with Earth's safe operating limits.
Slides: 3-19

Lecture Notes:

- Warm-Up Discussion: "How can we design food systems that respect planetary limits while advancing global well-being?"
- Introduce the definition of a Sustainable Food System (SFS) and the three pillars of sustainability
- Explain the planetary boundaries and food systems' impact on them
- Walk through the sustainable development goals (SDG) impacted by agriculture
- Delve into a case study on the Burger Supply-Chain Footprint

Student Activities (Optional):

- Food-Print Snap-Shot (Think-Pair-Share): Students will take a quick inventory of their lunch or a favorite meal (either by a photo or listing components), and tag each item with possible food miles, resource usage, and waste outputs, then identify at least 3

Key Vocabulary:

- Sustainable food system (SFS), three pillars of sustainability (3 Ps), planetary boundaries, UN Sustainable Development Goals (SDGs)

Objectives:

- **Remember:** The three pillars of sustainable food systems (People, Planet, Profit) and define the concept of planetary boundaries
- **Explain:** How food systems impact multiple planetary boundaries and contribute to crossing safe environmental limits
- **Apply:** Use a common meal as an example to identify how food systems connect to specific Sustainable Development Goals (SDGs)
- **Analyze:** How food system activities influence multiple planetary boundaries, and explain how these environmental limits interact with social and economic goals

Lesson B: From Linear to Circular: Rethinking Food Production

Summary: Lesson B explores how we can redesign food production systems. Students compare the conventional "linear" agricultural paradigm (take–make–waste) with circular economy models and agroecological principles. They learn that the agri-food sector is currently one of the greatest waste-producing sectors, with significant losses and by-products at every stage (aimspress.com). Circular economy thinking – reducing waste, reusing biomass, recycling nutrients and energy – is presented as a valid solution to make agriculture more sustainable (aimspress.com). Students discover real examples of waste valorization pathways: composting and anaerobic digestion turn food scraps to fertilizer and energy; innovations like insect farming or biochar production convert waste into animal feed or soil amendments. They also discuss agroecology, which applies ecological principles to farming (e.g. nutrient cycling, biodiversity) to create regenerative systems. Through a hands-on brainstorm, students identify wastes in their school or community and propose creative "waste-to-resource" ideas – reinforcing that resources can be looped back instead of lost.
Focus: Moving from wasteful linear systems to regenerative circular models.
Slides: 20-39

Lecture Notes:

- Warm-Up Discussion: "How can we redesign food systems so nothing goes to waste?"
- Introduce rethinking food production: from linear to circular (waste → resources), and walk through 3 / 5Rs of a circular economy: reduce, reuse, recycle, refurbish, regenerate

- Present agroecology in action, and in combination with circular economy (combination framework), as well as endless loop ideas for a circular mindset
- Delve into case studies on Sicily's citrus super-loop and bourbon shrooms

Student Activities (Optional):

- Loop Rescue Plan (Think-Pair-Share): Students will read a short problem brief, identify where the feedback loop is broken, and propose a fix to close the loop

Key Vocabulary:

- Circular economy (CE), linear economy (take-make-waste), agroecology, regenerative agriculture, waste-to-resource

Objectives:

- **Apply:** Identify linear and circular food system features using real-world agri-food examples from case studies
- **Analyze:** Compare real-world case studies of waste-to-resource solutions by identifying what waste is used, what new products are made, and how the process helps the environment
- **Evaluate:** Assess trade-offs among case study pathways considering scalability, economic value, and nutrient recovery potential

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

Summary: Lesson C empowers students with what actions can drive sustainable change. It frames solutions across four domains ("4 Ps") – Planet, People, Profit, Policy, echoing research that a holistic 4-P approach is needed for food system sustainability (mdpi.com). Students first examine personal and cultural choices ("People/Planet") by looking at diets: for instance, they calculate the carbon footprint difference between a meat-heavy meal (beef) and a plant-rich alternative (beans), seeing how a simple diet swap can cut emissions. Next, they explore innovations and entrepreneurship ("Profit") that add sustainability to the food system: from plant-based proteins to farming tech that reduces waste. They might analyze start-up caselets or technological solutions (e.g. food waste apps, novel recycling tech) and consider how businesses can profit while being eco-friendly. Then, students consider the role of public policy ("Policy"): through a gallery walk of policy ideas (like school composting programs, incentives for sustainable farming, or laws reducing food waste), they see how government and community initiatives enable circular, sustainable practices. Finally, students are prompted to envision their own role: each sketches or pitches an action loop they can influence – whether a personal habit change, a community project, or an advocacy idea – reinforcing that multi-level action is needed for food system transformation.

Focus: Pathways to action through innovation, policy, and behavior

Slides: 40-77

Lecture Notes:

- Warm-Up Discussion: "Is there a single most powerful change — on your plate, in a business, or in law — that could make our food system more sustainable?"
- Present the paths to action: dietary shifts, innovation, and policy
- Break down the paths by starting with dietary shifts: beef VS. beans
- Proceed to the second path on entrepreneurial action of reinventing food chains and resources involved to increase sustainability
- Conclude with the last path on policy and collective action from city governments, learning institutions, and financial institutions
- Delve into a case study on beef VS. beans to compare emissions of protein and quantify CO_2 equivalents for annual consumption

Student Activities (Optional):

- Gallery Walk – Innovations & Policies (Think-Pair-Share): Students will rotate through each station on either a policy case study or innovation case, jot down one benefit and one challenge for each, and discuss in small groups

Key Vocabulary:

- Food carbon footprint (CO_2e), 4 P's framework (for solutions)

Objectives:

- **Apply:** Use provided data and tools to compare the environmental impacts of different food choices (e.g., beef vs. beans) in terms of CO_2e, water use, and land use
- **Create:** Develop an action plan that combines at least one personal, one entrepreneurial, and

one policy solution to advance a more sustainable and circular food system in your community
- **Evaluate:** Justify your innovation's feasibility, projected environmental benefits, and potential social or economic co-benefits in a short peer pitch
- **Analyze:** Compare the strengths and limitations of diet, innovation, and policy pathways, and explain how they can work together to drive systemic change

Optional Extension Learning:
- Extended Learning: Systems Thinking & Nature as the Ultimate Circular Model – Comparing nutrient cycling in forests vs. farms and identifying broken loops.
- Think-Pair-Share Activity Corner: Systems Thinking Mapping Activity
- Career Pathways: Sustainable Agriculture Specialist, Circular Economy Analyst, Food Policy Advocate, Environmental Educator, Agroecology Researcher.

Optional Extension Learning: Systems Thinking & Nature as the Ultimate Circular Model
- Students will compare nutrient cycling in nature vs. farms and identifying circular loops.
- Think-Pair-Share Activity Corner: Systems Thinking Mapping Activity
- Career Pathways: Sustainable Agriculture Specialist, Circular Economy Analyst, Food Policy Advocate, Environmental Educator, Agroecology Researcher.

Hands-On Labs (Optional, 45 min–90 min):
- Our Micro-Farm System Mapping: Students will work in small groups to design and set up a campus "micro-farm" that applies agroecology principles

Assessment & Wrap-Up:
- Use the student worksheet (think-pair-share) to guide notetaking, exit tickets, and small-group review
- Use review questions at the end of each lesson for formative checks
- Assign a short reflection: "How can we redesign food systems to reduce waste and regenerate natural resources instead of depleting them?"

Teaching Tips:
- You do not need to cover all activities or notes—adapt to your students and your schedule
- Use the speaker notes to guide flow, but feel free to personalize delivery
- Vocabulary and mind map can be used as review tools or built upon throughout the module

Recommended Duration:
Approximately 3–5 class periods (45–55 minutes each). Lessons A, B, and C can be completed in one class period, with two-three additional periods suggested for hands-on lab activities or extension projects. The module's timeline is flexible: educators may extend the design project or include the optional labs described below to deepen inquiry and real-world skill development.

Recommendations for Instruction:
- **Begin with relevance:** Connect the module to prior knowledge or local context. For example, ask students about food waste they see in the cafeteria or their homes as a segue into sustainability issues.
- **Reinforce systems thinking:** Emphasize links between topics – e.g. how changing diets (Lesson C) can alleviate pressure on planetary boundaries (Lesson A), or how circular strategies (Lesson B) address problems introduced earlier. Encourage students to see the food system as an interconnected web.
- **Use interactive tools:** Incorporate the student **"Food-Print" worksheet/log and vocabulary list** provided to reinforce major themes. Visual aids like a planetary boundaries chart or an SDG wheel can help students grasp abstract concepts.
- **Encourage local observation:** Have students apply concepts to familiar settings. For instance, identify a local food waste issue and brainstorm solutions (to ground Lesson B ideas), or discuss which SDGs a nearby community garden might advance.
- **Differentiate as needed:** All suggested activities are flexible. Depending on time and class level, you may shorten lectures and spend more time on discussions or vice versa. Each lesson offers at least

one hands-on or minds-on “mini activity” to keep students engaged. Feel free to extend these or add your own to deepen learning.

- **Sustain positivity:** While addressing serious challenges, keep the tone hopeful by highlighting solutions and success stories. This first module should inspire students and combat the notion that “sustainability” is just about sacrifice; it’s about smart improvements and opportunities for innovation.

Need Support?

Contact the curriculum team:

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