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

Grade 11-12 Agricultural Science Lesson Plan: Foundations of Sustainable Agri-Food Systems & Circular Economy

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Grade 11-12 Agricultural Science Lesson Plan: Foundations of Sustainable Agri-Food Systems & Circular Economy

Grade: 11-12	**Subject:** Agricultural Science	**Topic:** Foundations of Sustainable Agri-Food Systems & Circular Economy **Sub-topic:** Why Food Systems Matter: Planetary Boundaries & SDGs, From Linear to Circular: Rethinking Food Production, Pathways to Action: Diet, Innovation & Policy	**Lesson:** Multi-day Unit (Lessons A-C + Activity Corners / Worksheets)

Key Question to be Addressed in the Module:
How can we redesign food systems to reduce waste and regenerate natural resources instead of depleting them?

Sub-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?

Time (lesson length): 3–4 class periods (45–55 minutes each)	**Class size:** 25-30 students	**Resources:** Wi-Fi, projector, PC, whiteboard, markers, presentation slides, printed student-guided notes, student activity worksheets, materials for design activities (poster boards, graph paper, rulers, colored pencils)

Objectives and Outcomes:
At the end of this module, students should 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.

Breakdown
<u>Lesson A – Why Food Systems Matter: Planetary Boundaries & SDGs</u>

- **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
- **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
- **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

The Methods and Sequence of Activities

Day 1: Lesson A - Why Food Systems Matter: Planetary Boundaries & SDGs

Teacher Activities:	**Student Activities:**	**Duration of Activities:**
Introduction ● Warm-Up Discussion: "How can we design food systems that respect planetary limits while advancing global well-being?" ● Lecture Slides: ○ The definition of a Sustainable Food System (SFS) and the three pillars of sustainability ○ Planetary boundaries and food systems' impact on them	● Participate in discussion and brainstorming ● Watch slide / video presentation and take guided notes ● Engage in activity corner(s) ● Apply lecture content to exit ticket questions	Introduction - 15 minutes Activity Corner - 25 minutes Closure - 10 minutes Total - 50 minutes

○ Sustainable development goals (SDG) impacted by agriculture ● Case Study: ○ The Burger Supply-Chain Footprint ● Lecture-class Interaction slide: Busting the myth of “Double the Food” claim around agricultural productivity and population growth. ○ Groups share surprising links (e.g., beef and climate or packaging waste and Life Below Water) ○ What Demand Really Looks Like ● We Already Grow Enough Calories! ● Why “Double the Old Way” = Disaster <u>Activity Corner</u> ● Food-Print Snap-Shot (Think-Pair-Share): ○ Students take a quick inventory of their lunch or a favorite meal (either by a photo or listing components) ○ Tag each item with possible food miles, resource usage, and waste outputs, then identify at least 3 ○ Share findings in small groups and with the class <u>Closure</u> ● Exit Ticket: ○ What are the three pillars of a sustainable food system, and why must all three be considered when making agricultural decisions? ○ Which planetary boundaries have been most affected by modern food systems, and how do these impacts threaten environmental stability? ○ What’s the flaw in the claim that we must double food production by 2050, and what		

smarter alternatives can reduce pressure on ecosystems? <u>Materials</u> ● Presentation slides, student-guided notes, student activity worksheets, SDG icon visual, student guided notes, paper for inventory		
Student Assessment: Student understanding will be assessed through a required quiz covering key concepts from the lesson. The quiz will evaluate how accurately students identify and explain the three principles of sustainable food systems, define planetary boundaries, and link agricultural activities to these boundaries. Items will also assess students' ability to explain why cutting waste and shifting diets are two major ways to keep feeding people while also lowering waste and destruction of land for agriculture. Students will also be able to explain why the claim that we must double food production by 2050 is flawed, while identifying alternative strategies that reduce environmental pressure. Optional activities, such as the "Food-Print Snapshot," will serve as enrichment and are not graded.		
Day 2: Lesson B - From Linear to Circular: Rethinking Food Production		
Teacher Activities: <u>Introduction</u> ● Warm-Up Discussion: "How can we redesign food systems so nothing goes to waste?" ● Lecture Slides: ○ Rethinking food production: from linear to circular (waste → resources) [Linear vs. Circular Economy] ○ Linear Path Loop: Take, Make; Waste ○ Circular Path Loop: Reduce, reuse, recycle, refurbish, regenerate ○ Agroecology in action, and in combination with circular economy (combination framework) ○ Endless loop ideas for a circular mindset ● Case Study: ○ Sicily's Citrus Super-Loop ○ Bourbon Shrooms <u>Activity Corner</u> ● Loop Rescue Plan (Think-Pair-Share):	**Student Activities:** ● Participate in discussion and brainstorming ● Watch slide / video presentation and take guided notes ● Engage in activity corner(s) ● Apply lecture content to exit ticket questions	**Duration of Activities:** Introduction - 15 minutes Activity Corner - 25 minutes Closure - 10 minutes Total - 50 minutes

○ Students read a short problem brief (e.g. city compost program shut down) ○ They will: ■ Identify where the feedback loop is broken ■ Propose a fix to close the loop ■ List the environmental, economic, and social benefits ■ Draw a before (linear) VS. after (circular) diagram ■ Share your plan in 3 steps (break → fix → outcomes) <u>Closure</u> ● Exit Ticket: ○ How does nature demonstrate that resources can be reused endlessly with no waste? ○ What framework defines the environmental limits humanity must stay within to ensure a stable Earth system? ○ What way of thinking helps us connect our food system choices to environmental and social impacts? <u>Materials</u> ● Presentation slides, student-guided notes, student activity worksheets		
Student Assessment: Student understanding will be assessed through a required quiz covering key concepts from the lesson. The quiz will evaluate how accurately students distinguish between linear and circular food system models, identify waste-to-resource pathways, and explain how they close resource loops. Items will also assess students' ability to analyze case studies by identifying the type of waste used, the end product created, and the environmental benefits achieved, as well as evaluate trade-offs in scalability, economic value, and nutrient recovery potential. Optional activities, such as the "Loop Rescue Plan," will serve as enrichment and are not graded.		
Day 3: Lesson C - Paths to Action: Diet, Innovation, Policy		

Teacher Activities:	**Student Activities:**	**Duration of Activities:**
<u>Introduction</u> ● 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?” ● Lecture Slides: ○ Present the paths to action: Dietary shifts, innovation, and policy ○ Dietary Shifts: Beef VS. Beans ○ Entrepreneurial action of reinventing food chains and resources involved to increase sustainability ○ Policy and collective action from city governments, learning institutions, and financial institutions ● Case Study: ○ Rethinking Diets: Beef VS. Beans: ■ Compare emissions from beef, beans, poultry, etc. ■ Quantify CO_2 equivalents for annual consumption <u>Activity Corner</u> ● Gallery Walk – Innovations & Policies (Think-Pair-Share): ○ Around the room are 4–5 posters or stations, each with either a policy case study (e.g., a city’s composting law, a school “Meatless Monday” program) or an innovation case (e.g., a startup making edible packaging, a new aquaponics system). ○ Students rotate through each station in small groups, reading or watching a quick blurb, and jotting one benefit and one challenge for each solution.	● Participate in discussion and brainstorming ● Watch slide / video presentation and take guided notes ● Engage in activity corner(s) ● Apply lecture content to exit ticket questions	Introduction - 15 minutes Activity Corner - 25 minutes Closure - 10 minutes Total - 50 minutes

○ Regroup and discuss: Which idea seemed most immediately doable? Which was most surprising? <u>Closure</u> ● The Lens of Reflection: To recognize that transforming food systems involves interdisciplinary action ○ Where will you act (planet, people, profit, policy)? ○ Pick a quadrant and jot down an action idea ● Module 1 Key Takeaways and Mindmap ● Exit Ticket: ○ What hotspot did you choose and what kind of waste is there? ○ What's one benefit and one challenge of your prototype system? ○ How could using multiple methods help close the loop on campus? ● Career Pathways ● Sneak Peak of Hands-On Activities <u>Materials</u> ● Presentation slides, student-guided notes, student activity worksheets		
Student Assessment: Student understanding will be assessed through a required quiz covering key concepts from the lesson. The students will be evaluated on the environmental impacts of different diets using water use, and land use data, as well as how well they identify and explain examples of dietary, entrepreneurial, and policy interventions for food system transformation. Items will also assess students' ability to incorporate the 4Ps framework (People, Planet, Profit, Policy) from the previous lessons to evaluate sustainability actions and compare the strengths and limitations of different pathways for systemic change. Optional activities, such as the "Gallery Walk" and "Mind-Map Reflection," will serve as enrichment and are not graded.		
Day 4 / Day 5 - Hands-On Activity: Our Micro Farm		
Teacher Activities:	**Student Activities:** ● Participate in hands-on activities and data collection / analysis	**Duration of Activities:** Travel - 0 minutes (within school compounds)

<u>Activity Corner</u> ● Our Micro-Farm System Mapping (Hands-On Activity): ○ Students work in small groups to design and set up a campus “micro-farm” that applies agroecology principles ○ They will: ■ Collect cafeteria scraps for composting ■ Build a compost bin and prepare planting beds in the school garden ■ Plant crops and track growth, soil moisture, and worm counts over time ■ Map the nutrient loop: Cafeteria scraps → Compost → Soil → Plants → Lunch → Compost ■ Identify one way the loop is already closed and one point where nutrients or resources are lost <u>Proposed Schedule</u> ● Building Activity – Day 1 (Full Class, ~50 min) ○ Intro & Instructions (10 min) – Overview of agroecology, the micro-farm concept, and nutrient loops ○ Hands-On Build (25 min) – Set up compost bins, prepare soil beds/planters, add cafeteria scraps or pre-made compost, and plant seedlings ○ Initial System Mapping (10 min) – In groups, complete two system maps: one for the micro-farm nutrient loop and one for a natural nutrient cycle (e.g., forest) ○ Wrap-Up & Share (5 min) – Each group shares one similarity between the natural and school-based loops ● Ongoing Check-Ins (5–15 min, daily)		Activity Corner - 1 day for hands-on build, 1 day for data collection, 5-15 minutes across the week for ongoing check-ins

○ Measure plant height and leaf growth ○ Record soil moisture, temperature, and worm counts ○ Note compost decomposition stages and any visible changes in soil quality ○ Add observations to group journals or update system maps with new data ● Data Collection & Analysis (20–30 min, final day of the week) ○ Compile all recorded growth, soil, and compost data from the project period ○ Calculate averages, identify trends, and compare growth against initial conditions ○ Link findings to agroecology principles and soil health benefits ○ Present conclusions on how the micro-farm closed nutrient loops and improved soil health		
Student Assessment: Student understanding will be assessed through a required quiz covering key concepts from the micro-farm project. The quiz will evaluate how accurately students describe agroecology principles, outline the nutrient loop of the micro-farm (Cafeteria scraps → Compost → Soil → Plants → Lunch → Compost), and identify points where the loop is closed versus where nutrient losses occur. Items will also assess students' ability to interpret growth, soil health, and compost decomposition data, and explain how these findings demonstrate circular economy principles in agriculture. Optional activities, such as the ongoing system-mapping updates and group presentations of results, will serve as enrichment and are not graded.		
Day 5 (Optional) Lesson C - Extended Learning: Systems Thinking & Nature as the Ultimate Circular Model		
Teacher Activities: <u>Introduction</u> ● Warm-Up Discussion: "Have you ever solved a problem by thinking about how everything is connected?" ● Lecture Slides:	**Student Activities:** ● Participate in the discussion and take guided notes on metabolic modeling ● Participate in the activity corner, and share and reflect on their work	**Duration of Activities:** Introduction - 15 minutes Activity Corner - 25 minutes Closure: 10 minutes Total - 50 minutes

○ Introduce systems thinking as a framework that helps us understand complex, interconnected problems ■ Define components of systems: inputs, processes, outputs, feedback loops ○ Present nature as a circular model: nothing wasted, everything reused ■ Show nature's loops (e.g., nutrient cycling in a forest) and connect to food systems (e.g., compost → soil → plant → food → waste) ● Case Studies: ○ Nature's Circular Systems: Forest VS. Farm: ■ Forest: leaf litter → decomposers → nutrients → root uptake ■ Farm: food scraps → compost → soil amendment → crops Compare and discuss: What's missing in the farm that's present in the forest? <u>Activity Corner</u> ● Systems Thinking Mapping Activity Optional Extneded Learning Activity: ○ Distribute a worksheet with two blank system diagrams: one for a natural system (e.g., forest) and one for a school-based system (e.g., cafeteria) ○ Students work in pairs to fill in inputs, outputs, loops, and feedbacks for each ○ Guiding questions: ■ "What closes the loop in nature?" ■ "What breaks the loop in our food system?" ○ Extra Challenge for Advanced Learners:		

■ Add a policy or innovation intervention to help repair or strengthen one broken loop ■ E.g., “What if our school composted all cafeteria food waste—how would that change the system?” <u>Closure</u> ● Reflection Questions: ○ Nature’s Lesson: What is one lesson nature teaches us about designing better food systems? ○ System Gaps: Where in our school or community’s food system do you see a “broken loop”? ○ Action Step: What’s one change—big or small—you could suggest to help close that loop? <u>Materials</u> ● Presentation slides, student-guided notes, system-mapping worksheets, visual diagram of forest nutrient loop, colored pencils or sticky notes for mind-mapping		
Student Assessment: TBD		