Module 6: Agri-Systems Across the City-Rural Gradient
Instructor Guide

MOD6_LP_TCH_FV_092025

Module Overview:
This module examines how urban, peri-urban, and rural zones shape food production systems. Students investigate how space, resources, and labor differ across these zones, explore climate-smart practices that close loops and reduce waste, and apply metrics to compare and design sustainable systems. The module builds systems thinking and challenges students to consider equity, efficiency, and resilience in agriculture.

Module Objectives:
- Distinguish urban, peri-urban, and rural growing zones and describe differences in food miles, land cost, and labor.
- Identify climate-smart techniques that conserve water, reuse waste, and minimize energy across zones.
- Apply metrics (e.g., L/kg, biomass per kWh) to evaluate and compare systems.
- Design and justify food-system layouts that close resource loops and balance trade-offs.

Materials Provided:
- Slide deck with speaker notes
- Optional Student-facing worksheets
- Student notes with vocabulary list
- Module mind map
- Optional lab activity instructions and reflection prompts

What Should Students Walk Away With:
This module provides students with a systems-level introduction to how urban, peri-urban, and rural zones interact within food systems, framing agriculture not only as a set of isolated practices but also as a network of spatial, economic, and environmental decisions that shape sustainability and equity.

While the module does not delve deeply into the mechanics of soil science, plant physiology, or advanced engineering, it intentionally provides students with opportunities to think out loud, sketch systems, and work hands-on with simplified data and design prompts. Through these activities, students see how concepts such as land cost, labor, and food miles influence design choices, and how tools like climate-smart techniques and efficiency metrics help evaluate those choices in real-world contexts. Students begin to understand that growing food is not just about land and crops—it requires decisions about where to grow, how to reuse resources, how to balance energy and water use, and how to integrate technology and planning tools to build systems that are fair, efficient, and resilient.

By the end of the module, students should be able to:
- Recognize how food systems differ across urban, peri-urban, and rural zones, and how land cost, labor availability, and food miles trade off across the gradient.
- Identify and explain climate-smart practices (e.g., closed-loop urban farms, compost-heated greenhouses, renewable irrigation) and how they conserve water, reuse waste, and reduce energy use.
- Apply and interpret sustainability metrics (e.g., liters per kilogram, biomass per kWh) to compare systems and understand efficiency trade-offs.
- Propose and justify hybrid or improved designs that close resource loops and balance competing demands (space, labor, resources) in different zones.

This curriculum is designed to amplify and contextualize other high school/AP science courses. When paired with coursework in biology, environmental science, or economics, this module helps students connect their disciplinary knowledge to pressing interdisciplinary challenges:
- How do spatial planning tools influence environmental outcomes?
- How do efficiency metrics guide decision-making?
- How do waste management and resource loops create new opportunities in agriculture?

Ultimately, students walk away with a broadened perspective: Agriculture becomes a dynamic case study for exploring spatial design, sustainability trade-offs, and innovation, giving students insight into their own potential role in shaping food systems that are sustainable, equitable, and resilient.

Key Question:
How can we redesign food systems to reduce waste & regenerate natural resources instead of depleting them?

Essential Questions:
- *How is space reshaping where and how we grow food?*
- *How do we grow more with fewer resources?*
- *How do we know if a farming system is truly sustainable?*

Lesson A: From Balcony to Back-Forty
Summary: Students begin by defining the urban-to-rural gradient and categorizing agricultural examples based on spatial characteristics. Using sample farm case studies, they classify systems as urban, peri-urban, or rural based on size, proximity to consumers, and infrastructure. The lesson focuses on evaluating the productivity, food miles, land costs, and logistical trade-offs in each zone. Students assess the viability of growing specific crops in various locations, considering environmental, economic, and social factors.
Focus: Understanding how space and location shape food systems and sustainability.
Slides: 3-19

Lecture Notes:
- Begin by posing the question: “How is space reshaping where and how we grow food?”
- Define and illustrate the urban–peri-urban–rural gradient, highlighting how food miles, land cost, and labor differ across zones.
- Present examples from California: rooftop gardens, peri-urban greenhouse belts, and large rural orchards.
- Introduce gradient planning tools—simple frameworks used to decide where to place production zones or technologies.
- Emphasize trade-offs: why urban systems reduce food miles but have high land costs, and why rural systems offer scale but depend on long-distance transport.
- Conclude with a discussion of how combining these zones can serve different community needs.

Student Activities (optional):
- Group Design Challenge: Form small teams (2-3 students) and design a food-production system: Urban, Peri-Urban, or Rural zone
- Quick Discussion: What is the most significant sustainability advantage of your design in this zone?

Key Vocabulary:
- Urban agriculture, peri-urban, rural agriculture, rooftop farm, greenhouse belt, orchard, rooftop kale beds, shipping container farms, wind-powered pump, soil moisture probes, pulse drip irrigation, hydroponics, vertical LED, field crops, composting piles

Objectives:
- **Remember/Understand**: Define and distinguish urban, peri-urban, and rural food-system contexts, and describe how food miles, land cost, and labor differ across the gradient.
- **Apply/Analyze**: Classify and analyze farming systems from visual/text examples, noting trade-offs in productivity, sustainability, and logistics.
- **Create/Evaluate**: Design and justify a modified city-region food layout that optimizes space and labor under real-world constraints.

Lesson B: Climate-Smart Growing Spaces
Summary: This lesson highlights climate-smart strategies tailored to specific spatial zones. Students investigate how rooftop gardens, hydroponics, drip irrigation, and other innovations contribute to water and energy efficiency in urban, peri-urban, and rural systems. Through diagrams and data interpretation, students

illustrate input–output loops and evaluate how waste streams (e.g., water, nutrients) can be reused. The focus is on designing systems that close the loop and reduce resource intensity.
Focus: Exploring techniques that close loops and improve resource efficiency.
Slides: 20-50

Lecture Notes:

- Open with a warm-up question: "How do we grow more with fewer resources?" • Introduce climate-smart agriculture (CSA) and its core goals—resilience, efficiency, and sustainability.
- Present real examples:
    - Urban: Closed-loop rooftop farms that reuse water and compost.
    - Peri-urban: Compost-heated greenhouses that recycle organic waste.
    - Rural: Renewable-powered irrigation systems in dryland farming.
    - Highlight how these systems form circular loops by turning waste into inputs
    - Discuss social impacts across zones—community access, labor opportunities, and scaling challenges
- Emphasize the loops for each zone
- Explain the social impacts across the city-rural gradient.

Student Activities (optional):

- Think, Pair, Share Activity: Climate-Smart Strategy Initiative: Create a pitch for a Climate-Smart strategy that uses cafeteria waste and captures roof runoff to grow leafy greens for school lunches.

Key Vocabulary:

- Closed-loop system, climate-smart agriculture, resource loops, compost-heated greenhouse, renewable irrigation

Objectives:

- **Remember/Understand**: Identify and explain climate-smart techniques used in each zone (urban, peri-urban, rural) and how they conserve water, reuse waste, or minimize energy.
- **Apply/Analyze**: Match and deconstruct techniques to zone-specific conditions, showing how they form circular resource loops.
- **Create/Evaluate**: Design and defend a hybrid system that integrates strategies from at least two zones to close resource loops and increase long-term sustainability.

Optional Extension Learning:

- **Extended Learning**: Composting in closed-loop urban controlled-environment agriculture (nutrient cycling, CO_2 reuse, and energy recovery).
- **Career Pathways**: Urban Planner, Rooftop Farm Project Manager, Greenhouse Systems Engineer, Controlled-Environment Agriculture Specialist, Precision Irrigation Technician, Soil & Water Conservation Scientist, Renewable Energy Integration Specialist.
- **Capstone Project**: Optimize Your Compost System: Evaluate and improve a compost diagram, and Circular Agri-Systems in Urban Environments: Pick a persona and create a closed-loop food production system with a team.

Lesson C: Tech & Metrics That Matter:

Summary: Students apply quantitative reasoning to evaluate the efficiency of agricultural practices. Key metrics, such as liters per kilogram (L/kg) for water use and biomass per kilowatt-hour (biomass/kWh) for energy use, are introduced. Students analyze data from drone overlays and sample datasets to assess system performance and propose farm designs that meet specific sustainability targets. Through group collaboration, learners justify their proposed systems using real-world metrics and evidence.
Focus: Using metrics and data to evaluate and optimize food systems.
Slides: 51-63

Lecture Notes:

- Warm-up: "How do we know if a farming system is truly sustainable?"
- Introduce why metrics matter for evaluating trade-offs and guiding decisions.
- Present key metrics with examples:
    - Liters per kilogram (L/kg): Water use efficiency.
    - Biomass per kilowatt-hour: Productivity relative to energy input.

    - Input–output ratios: Overall resource efficiency.
  - Show how metrics highlight trade-offs: e.g., hydroponics uses less water but may require more energy.
  - Share a case study: Smarter Citrus Example from the Vidalakis Lab
  - Emphasize how metrics guide design improvements.

  Student Activities (optional):
  - Water Ledger Activity: Calculate L/kg for lettuce grown in hydroponic and soil systems.
  - Scenario Optimization: Plan a 1-acre farm balancing water and energy limits.

  Key Vocabulary:
  - L/kg, biomass per kWh, input–output ratio, efficiency trade-off, design optimization

  Objectives:
  - **Remember/Understand**: Define and explain key efficiency metrics (e.g., L/kg, biomass per kWh, input–output ratio) and their purpose.
  - **Apply/Analyze**: Calculate and interpret resource-use metrics (e.g., water per yield) from provided or classroom data to compare systems.
  - **Evaluate/Create**: Recommend and justify a food production model using sustainability metrics, clearly defending trade-offs and resource constraints.

Hands-On Labs (Optional, 45 min–90 min):
- In Progress

Assessment & Wrap-Up:
- Use the student worksheet (think-pair-share) to guide notetaking, exit tickets, and small-group review after each lesson.
- Assign a short reflection: "If you were designing a food system for your city, what mix of zones (urban, peri-urban, rural) and climate-smart techniques would you use, and how would you keep it efficient and fair?"
- Optional: Assign a synthesis task or project presentation, for example: "Design a hybrid food system that integrates strategies from at least two zones. Show how your design closes resource loops and justify your choices using at least one sustainability metric."

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). Each lesson can be completed in one period, with two to 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.

Need Support?
Contact the curriculum team:
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