Module 6: Agri-Systems Across the Urban-Rural Gradient

Grade 11-12 Agricultural Science Lesson Plan: Urban-Rural Gradient in Agriculture

Module 6: Agri-Systems_ Instructor_Guide

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Grade 11-12 Agricultural Science Lesson Plan: Urban-Rural Gradient in Agriculture

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<td>Grade: 11-12</td>
<td>Subject: Agricultural Science</td>
<td>Topic: Urban-Rural Gradient in Agriculture
Sub-topic: From Balcony to Back-Forty, Climate-Smart Growing Spaces, Tech & Metrics That Matter</td>
<td>Lesson: Multi-day Unit (Lessons A-C + Activity Corners / Worksheets)</td>
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<td colspan="4">Key Question to be Addressed in the Module:
How can we design food systems across urban, peri-urban, and rural zones that are sustainable, equitable, and resilient?

Sub-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?</td>
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<td>Time (lesson length): 3-5 class periods, each 45-55 minutes</td>
<td>Class size: 25-30 students</td>
<td colspan="2">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)</td>
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<td colspan="4">Objectives and Outcomes:
At the end of this module, students should be able to:
● Distinguish urban, peri-urban, and rural food systems and explain differences in food miles, land cost, and labor.
● Identify climate-smart techniques and how they conserve water, reuse waste, and reduce energy use.
● Analyze examples to compare productivity, sustainability, and logistics across zones.
● Explain and apply key efficiency metrics (e.g., L/kg, biomass per kWh) using provided data.
● Design and justify improved or hybrid food-system layouts that close resource loops and balance real-world trade-offs.</td>
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Breakdown

Lesson A - From Balcony to Back-Forty

- **Define:** Urban, peri-urban, and rural food-system contexts, and describe how food miles, land cost, and labor differ across the gradient.
- **Classify & 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

- **Identify & 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.

Lesson C – Tech & Metrics That Matter

- **Define & 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 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.

The Methods and Sequence of Activities

Day 1: Lesson A - From Balcony To Back-Forty

Teacher Activities:	**Student Activities:**	**Duration of Activities:**
Introduction • Warm-Up Discussion: “How is space reshaping where and how we grow food?” • Explain the importance of studying and define the city-rural gradient	• Participate in discussion and brainstorming • Watch the presentation and take guided notes • Engage in activity	Introduction - 15 minutes Activity Corner - 25 minutes Closure - 10 minutes Total - 50 minutes

● Highlight trade-offs in land cost vs. food miles and labor models ● California Spotlight: locations and examples of agriculture across zones ● Gradient planning tools for smarter good systems ● Present examples: urban agriculture, peri-urban greenhouse belts, rural orchards <u>Activity Corner</u> ● Think, Pair, Share Activity: Guided Design Jam: Students design food-production systems for each zone (identify inputs, outputs, and loops) ○ For each zone, include: ■ Key components (e.g. hydro towers) ■ Inputs (water, labor, energy) ■ Outputs (food, by-products) ■ Circular links (e.g. compost → fertilizer) ■ Notes on efficiency (tech used, estimates) <u>Closure</u> ● Review Questions: ○ Define urban, peri-urban, and rural zones in the context of food systems. How do land cost and food miles change across this gradient, and why are they inversely related? ○ What are two sustainability trade-offs between rooftop farming and rural orchards? ○ If you had to grow spinach, strawberries, and almonds for a local market, how would you divide them across urban, peri-urban, and rural zones for optimal efficiency?	corner(s) ● Responses to review questions focusing on land cost, food miles, and sustainability trade-offs	

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<td><u>Materials</u>
Presentation slides, student-guided notes, student activity worksheets</td>
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<td colspan="3">Student Assessment: Student understanding will be assessed through a required quiz covering key concepts from the lesson. The quiz will evaluate how accurately students define and distinguish urban, peri-urban, and rural food-system contexts, and how well they explain differences in land cost, food miles, and labor across the gradient. Items will also measure their ability to analyze trade-offs between rooftop farming and rural orchards and to apply these concepts in allocating crops across zones. Optional activities, such as the food-production system design challenge, will serve as enrichment and are not graded.</td>
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<td colspan="3">Day 2: Lesson B - Climate-Smart Growing Spaces</td>
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<td>Teacher Activities:
<u>Introduction</u>
Warm-Up Discussion: “How do we grow more with fewer resources?”
Explain what climate-smart agriculture is, its core goals, and innovations
Present climate-smart examples:
Urban closed-loop farm
Peri-urban compost-heated greenhouses
Rural renewable dryland farming
Emphasize the loops for each zone
Explain the social impacts across the city-rural gradient
<u>Activity Corner</u>
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.</td>
<td>Student Activities:
Participate in discussion and brainstorming
Watch slide / video presentation and take guided notes
Engage in activity corner(s)
Apply lecture content to review questions</td>
<td>Duration of Activities:
Introduction - 25 minutes
Activity Corner - 15 minutes
Closure - 10 minutes
Total - 50 minutes</td>
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<td><u>Closure</u>
• Review Questions:
  ○ What are the main goals of Climate-Smart Agriculture?
  ○ What are some social benefits of climate-smart agriculture across regions?
  ○ What challenges limit scaling of rooftop urban farms?
<u>Materials</u>
• Presentation slides, student-guided notes, student activity worksheets</td>
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<td colspan="3">Student Assessment: Student understanding will be assessed through a required quiz focused on climate-smart agriculture. The quiz will assess students’ ability to identify and explain climate-smart techniques in urban, peri-urban, and rural zones, describe how these techniques conserve water, reuse waste, or minimize energy, and match practices to zone-specific conditions to show circular resource loops. Optional activities, such as the Zone Sort Challenge and Closed-Loop System sketch, are enrichment opportunities and will not be graded.</td>
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<td colspan="3">Day 3: Lesson C - Tech & Metrics That Matter</td>
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<td>Teacher Activities:
<u>Introduction</u>
• Warm-Up Discussion: “How do we know if a farming system is truly sustainable?”
• Explain why metrics are important
• Present metrics: liters per kg, biomass per kWh, and efficiency trade-offs
• Efficient agricultural design with metrics and vertical-stack math
• Case Study: Smarter citrus example from the Vidalakis Lab</td>
<td>Student Activities:
• Participate in discussion and brainstorming
• Watch the presentation and take guided notes
• Engage in activity corner(s) and be ready to share
• Apply lecture content to review questions</td>
<td>Duration of Activities:
Introduction - 20 minutes
Activity Corner - 10 minutes
Closure - 10 minutes
Total - 50 minutes</td>
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Activity Corner

- Think, Pair, Share Activity: Scenario Optimization: Design a 1-acre farm that balances water + energy limits
    - Plan Your Farm
    - Do the Math
    - Optimize Your Design
    - Prepare Your Pitch

Closure

- Review Questions:
    - Why do we need metrics like "liters per kilogram (L/kg)" or "biomass per kWh" when designing sustainable farming systems?
    - Hydroponic tower lettuce systems often use less water than soil systems. What is the trade-off, and how can it affect system design?
    - What are two key metrics to check farm efficiency?
- Exit Ticket:
    - Which zone would you prioritize for your community?
    - What is one metric you would track, and why?
- Key Takeaways and Mindmap
- Career Pathways

Materials

- Presentation slides, student-guided notes, student activity worksheets

Student Assessment: Student understanding will be assessed through a required quiz and exit ticket. The quiz will measure how well students define and explain key efficiency metrics (e.g., L/kg, biomass per kWh, input–output ratios), calculate and interpret data to compare systems (e.g., hydroponic vs. soil), and explain related trade-offs. The exit ticket will require students to recommend a food

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<tr><td colspan="3">production model for a chosen zone and justify it using at least one metric, clearly defending the trade-offs and resource limits considered. Optional activities (Water Ledger, Scenario Optimization, Guided Design Jam) are enrichment only and not graded.</td></tr>
<tr><td colspan="3">Day 4 / Day 5 - Field Trip(s) + Data Analysis</td></tr>
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<td>Teacher Activities:
<u>Activity Corner</u>
● Water-Budget Ledger (Hands-On Activity):
○ Students set up two growing systems (drip irrigation vs hydroponic) in small groups and measure daily water use and plant growth to calculate Water-Use Efficiency (WUE).
○ They will:
■ Build and label one drip system (soil pot + drip emitter/pinhole bottle) and one hydroponic reservoir system
■ Record daily water use, runoff (drip), and top-up volumes (hydroponic)
■ Track plant growth (height, weight at harvest) and note leaf color/turgor changes
■ Calculate WUE for each system and compare results (L water per kg yield)
■ Discuss which design is more efficient and why
● Urban/Peri-Urban Light BioLab (Hands-On Activity):
○ Students compare how light spectrum (blue vs red) and leaf traits (lettuce vs kale) influence growth and water use across urban hydroponic cups and peri-urban soil+compost pots.
○ They will:
■ Work in three groups, each assigned a treatment:</td>
<td>Student Activities:
● Participate in hands-on activities… TBC</td>
<td>Duration of Activities:
Travel - 0 minutes (within school compounds)
Activity Corner - 1 day for hands-on build, 1 day for data collection, 5-15 minutes across the week for ongoing check-ins OR over 3 days</td>
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            - Group 1: Lettuce under Blue-enriched light
            - Group 2: Lettuce under Red-enriched light
            - Group 3: Kale under Blue-enriched light
        - Each group tests both hydro (Urban CE) and soil+compost (Peri-urban) setups
        - Record growth, water inputs/runoff, and turgor daily
        - Calculate WUE and compare results across treatments
        - Link findings to stomatal biology, leaf morphology, and farming strategies

<u>Proposed Schedule</u>

(Hands-On Activity: Water-Budget Ledger)

- Day 1 – Setup (Full Class, ~50 min)
    - Intro & Instructions (10 min) – Overview of irrigation methods, hydroponics, and WUE
    - Hands-On Build (30 min) – Groups set up drip and hydro units, add initial 500 mL water/nutrient solution, and transplant seedlings
    - Baseline Data (5 min) – Record starting plant height and system description
    - Wrap-Up (5 min) – Students predict which system will use water most efficiently
- Daily Monitoring (5–10 min, Days 2–14+)
    - Measure and record water added
    - Collect and measure runoff (drip) or top-up (hydro)

    - Record plant height and daily notes (leaf color, turgor, leaks)
- Harvest & Analysis (Final Day, ~50 min)
    - Measure plant fresh weight and final height
    - Calculate total water used (drip = added – runoff; hydro = total top-up)
    - Convert yield to kg and calculate WUE (L/kg)
    - Small-Group Analysis (20 min) – Compare results between drip and hydro systems
    - Class Discussion (20 min) – Share findings and connect to water use in agriculture
    - Wrap-Up (10 min) – Teacher emphasizes sustainability and trade-offs between systems

(Hands-On Activity: Urban/Peri-Urban Light BioLab)

- Day 1 – Setup & Baseline (Full Class, ~50 min)
    - Intro & Instructions (10 min) – Overview of stomata, light spectrum, leaf traits, and goals of experiment
    - Hands-On Build (30 min) – Groups set up hydro and soil units, add 50 mL water/nutrient solution, transplant seedlings, and place under assigned lights
    - Baseline Data (5–10 min) – Record plant height, leaf count, soil moisture, and notes on turgor and leaf color
- Daily Monitoring (5–10 min, Days 2–3)
    - Add 20 mL water/nutrient solution per unit
    - Collect runoff from soil pots
    - Record height, leaf size, turgor, and soil moisture

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<td>◦ Optional: Day 2 transpiration bag test (condensation on leaves)
• Final Day – Data Collection & Analysis (~40–50 min)
◦ Compile water use, runoff, and growth data
◦ Calculate WUE (mL/cm growth) for each system
◦ Compare across: Hydro vs Soil, Blue vs Red, Lettuce vs Kale
◦ Small-Group Reflection (15 min) – Answer guiding questions about water use, stomata, and morphology
◦ Class Discussion (20 min) – Share findings and link to farming strategies at urban vs peri-urban scales
◦ Wrap-Up (10 min) – Teacher highlights how experimental results connect to resource efficiency and agroecology principles</td>
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<td colspan="3">Student Assessment: Student understanding will be assessed through their completed data collection worksheets from the Water-Budget Ledger and Urban/Peri-Urban Light BioLab projects. Worksheets will be graded using a rubric that evaluates accuracy and completeness of recorded data (water inputs, runoff/top-ups, plant height, leaf size, and final weights), correct calculations of water-use efficiency (WUE), and clarity of written notes on plant health and observations. Students will also be assessed on their ability to interpret their own results by comparing across treatments (Hydro vs Soil, Blue vs Red, Lettuce vs Kale) and linking findings to biological principles such as stomatal function, leaf morphology, and resource efficiency. Optional activities, such as group graphing of results or class discussions on trade-offs in farming strategies, will serve as enrichment and are not graded.</td>
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<td colspan="3">Day 5 (Optional) Lesson B - Optional Extended Learning: Composting in Closed-Loop Urban CEA</td>
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<td>Teacher Activities:
<u>Introduction</u>
• Revisit the key question: “How do we grow more with fewer resources?” and connect it to waste reuse in urban systems</td>
<td>Student Activities:
• Participate in discussion and take guided notes on composting technologies</td>
<td>Duration of Activities:
Introduction - 10 minutes
Activity Corner - 30 minutes
Closure - 10 minutes</td>
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- Present the concept and process of composting in closed-loop urban controlled environment agriculture (CEA)
    - Composting Urban Waste, Nutrient Looping, CO_2 Capture & Use, Supporting Technologies, Scientific & Technical Risks, Social & Urban Integration, Why It Matters, From Ideas to Action

<u>Activity Corner</u>

- Optional Extended Learning Activity: Optimize Your Compost System: Evaluate and improve a compost diagram
    - Group Design Challenge
        - Evaluate how composting practices impact greenhouse gases and safety

<u>Closure</u>

- Emphasize the importance of composting in closed-loop urban CEA
    - Guide a short discussion on how these concepts could apply locally by posing the question: “How could compost from your cafeteria be used to grow food on your school’s roof? What would you need to make the system safe and efficient?”

<u>Materials</u>

- Presentation slides, student-guided notes, student activity worksheets

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- Brainstorm how local waste streams (e.g., cafeteria scraps) could be reused in an urban farm
- Share ideas on how closed-loop systems might be integrated into existing food systems
- Participate in the activity corner, and share and reflect on their work

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<td>Total - 50 minutes</td>
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<td colspan="3">Student Assessment: Student understanding will be assessed through a required quiz and reflection. The quiz will check how well students explain composting in closed-loop urban CEA and identify practices that make it safe and efficient. The reflection will ask students to describe how compost from their community could be reused in a local food system and what would be needed to make it</td>
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work. Optional activities (compost diagram optimization and circular agri-systems in urban environments) are enrichment only and not graded.