



## Module 6: Agri-Systems Across the City-Rural Gradient

### Extended Learning & Differentiated Content

#### Differentiated content:

**Option 1 (broad):** This content connects to biology, environmental science, and sustainability practices. It aligns with NGSS concepts like energy and matter flow in ecosystems, urban ecology, and the cycling of carbon and nutrients in managed systems.

#### Option 2 (specific):

Relevant NGSS science topics:

- Biogeochemical cycles (carbon, nitrogen)
- Human impacts on Earth systems (urban waste reuse, sustainable agriculture)
- System design and optimization
- Ecosystem services and closed-loop thinking

#### Option 1: Compost in Urban Controlled-Environment Agriculture (CEA):

##### Overview of What Is Closed-Loop Farming?

Today we're exploring a cutting-edge approach in urban agriculture — compost-integrated closed-loop systems. These systems recycle organic waste to grow more food in controlled spaces like rooftops, greenhouses, or vertical farms. It's about making farming smarter, more circular, and less wasteful.

#### Key Components of the System:

- **Composting Urban Waste**
  - Food scraps, plant residues, and other biowastes are composted. This turns “trash” into resources:
    - $\text{CO}_2$  → used to boost plant growth
    - Nutrients → reused as organic fertilizer
    - Heat → reused to warm greenhouses
- **Nutrient Looping**
  - Instead of relying on synthetic fertilizers, nutrients from compost are cycled back to crops.
  - Example: Nitrogen (N), phosphorus (P), and potassium (K) are reabsorbed through bioptic or soil systems.
- **$\text{CO}_2$  Capture & Use**
  - $\text{CO}_2$  released from composting (normally a byproduct) can be funneled back into the growing space to speed up plant photosynthesis—closing the carbon loop.
- **Supporting Technologies**
  - To make it work in cities, the system may include:
    - Biofilters for air quality
    - Ozonation or UV treatment for pathogen control
    - Energy recovery systems (e.g., compost heat exchangers)
- **Scientific & Technical Risks**
  - Gas Management: Composting releases  $\text{CO}_2$ ,  $\text{CH}_4$ , and  $\text{NH}_3$ . Without filters or scrubbers, these contribute to air pollution and climate forcing
  - Pathogens & Food Safety: Improper composting may leave harmful microbes that contaminate crops. Heat treatment, ozonation, or UV are required
  - System Trade-Offs: Must balance cost, space efficiency, and energy recovery
- **Social & Urban Integration**
  - Air Quality & Regulations: City codes limit emissions and odors
  - Public Perception & Trust: Communities may resist composting sites if they associate them with pests or health risks

- Equity & Food Access: Compost loops can be designed to benefit underserved neighborhoods, but must balance efficiency vs. inclusion
- Urban Planning Constraints: Zoning and space are limiting factors
- **Why it Matters**
  - Cuts food miles and chemical inputs, reducing reliance on long supply chains that are vulnerable to disruptions
  - Turns urban waste into reimages (circular farming)
  - Makes city farming more efficient and sustainable, especially with the growing urban population
- **From Ideas to Action**
  - Compost can:
    - Cycle nutrients back into crops
    - Provide CO<sub>2</sub> and heat as byproducts
    - Raise challenges (pathogens, gases, space, community trust)

## Option 2: Technical Lecture on Compost Loop Optimization in Urban Systems

### Introduction: Composting in CEA as a Sustainable System Design

We're studying a framework where urban food systems recycle carbon and nutrients to reduce waste, emissions, and resource consumption. This fits directly into human systems design and circular economy practices.

#### System Inputs and Outputs

Component	Input	Output
Compost Unit	Biowaste	CO <sub>2</sub> , heat, organic nutrients
Hydroponic Grow	Nutrients, water, CO <sub>2</sub>	Edible biomass
Sanitation/Filter	Gas emissions, compost liquid	Clean air, treated fertigation

#### Gas Pathways and Management:

CH<sub>4</sub> & NH<sub>3</sub> production risks exist when compost is not well-aerated or managed. The paper proposes:

- Aeration + bulking agents → promote aerobic conditions
- Biofilters → reduce VOCs and CH<sub>4</sub> from compost gas
- Compost heat → captured and reused in greenhouses

#### Circular Design Metrics:

Goals of the system:

- Cut food miles and synthetic inputs
- Close resource loops (carbon, nutrients, water)
- Safely integrate waste reuse in small, urban spaces
- Balance technical optimization with community acceptance
- Track sustainability metrics: emissions avoided, % synthetic fertilizer replaced, energy recovered

This is not just waste management—it's urban ecosystem engineering.

#### Urban Challenges Addressed:

- Space efficiency
- Pathogen control in reused materials
- Energy costs and sustainability metrics
- Social trust in compost-integrated systems

#### Ask Students:

Which gas emissions would you be most concerned about in a rooftop compost system? What methods could reduce them while still using the compost byproducts effectively? If you were a city planner, how would you balance technical efficiency with public concerns about odor and safety?

### **NGSS Integration and Student Reflection**

Relevant NGSS Science Topics:

- Human impacts on Earth systems (ESS3.C)
- Interdependent Relationships in Ecosystems (LS2)
- Engineering design and optimization (ETS1.A/B)

### **Engage students by asking:**

- 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?
- What challenges (odor, safety, fairness) would you need to solve to make the system safe and accepted in the community?