



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

Think Pair Share: Scenario Optimization

Red Notes

Lesson C

Grouping: Pairs or small groups (3–4)

Time: 25-30 minutes

Materials:

- Printed worksheet or digital copy
- Pencils or pens
- Calculator (or spreadsheet)
- Poster paper or whiteboard (for group sharing, optional)

Objective:

Design a 1-acre sustainable farm by choosing components from the menu below.

Your goal: maximize food yield while staying within these resource limits:

- Water Budget: 20,000 L per season
- Energy Budget: 2,500 kWh per season

This challenge will help you practice systems thinking, efficiency trade-offs, and sustainability-focused farm design.

Instructions:

1. **Plan Your Farm**
 - a. Choose components from the farm **menu**.
 - b. You may reuse items (e.g., 2x lettuce beds = 0.5 acre).
 - c. Total area cannot exceed 1 acre.
2. **Do the Math**
 - a. Record **acreage, water, energy, and yield** for each component.
 - b. Add totals for your design.
 - c. Check: Do not exceed 20,000 L or 2,500 kWh.
3. **Optimize Your Design**
 - a. If over budget, revise choices.
 - b. Aim for **high yield per unit of water/energy**.
4. **Calculate Efficiency**
 - a. **Water-Use Efficiency = Total Water ÷ Total Yield (L/kg)**
 - b. **Energy-Use Efficiency = Total Energy ÷ Total Yield (kWh/kg)**
5. **Prepare Your Pitch**
 - a. Present your design to peers in 2–3 minutes.
 - b. Include: why your system is sustainable, efficiency compared to “business as usual,” and any trade-offs you faced.

You may use the internet to explore additional data sources like USDA, FAO, or local extension services. This can help you validate your numbers and add credibility to your final pitch.

Skills You'll Use:

- Data organization and unit comparison
- Collaborative problem solving
- Sustainability system design
- Mathematical reasoning with real-world data
- Understanding efficiency trade-offs

Your task:

Plan Your Farm

- Use the 1-acre “menu” of farm components. Select crops and systems that fit within the 20,000 L water budget and 2,500 kWh energy budget. You can repeat components if you want (e.g., 2 lettuce beds = 0.5 acre).

Do the Math

- Add up total water, total energy, and total yield for your design. Make sure you do not exceed your limits. Calculate efficiency: $\text{Water-Use Efficiency} = \frac{\text{Total Water}}{\text{Total Yield}}$ $\text{Energy-Use Efficiency} = \frac{\text{Total Energy}}{\text{Total Yield}}$

Optimize Your Design

- If you're over budget, revise your choices. Try to balance high yield with smart resource use.

Prepare Your Pitch

- Create a short explanation of your design: What crops/systems you chose, why your design is sustainable, how your efficiency compares to “business as usual” farming (Optional) Sketch or show your design on poster paper or a whiteboard.

System Component Menu:

| Component | Acreage | Water Use | Energy Use | Yield | Notes |
|------------------------|---------|-----------|------------|--------|-------------------------------|
| Drip-Irrigated Lettuce | 0.25 ac | 2,000 L | 150 kWh | 200 kg | Low water, high efficiency |
| Hydroponic Greens | 0.25 ac | 1,500 L | 300 kWh | 180 kg | Higher energy, very efficient |
| Outdoor Soil Veggies | 0.25 ac | 3,000 L | 120 kWh | 150 kg | Basic but reliable |
| Vertical Indoor Greens | 0.25 ac | 1,200 L | 600 kWh | 240 kg | High-tech yield |
| Solar Irrigation | 0.25 ac | — | -250 kWh | 0 | Offsets other energy |
| Rain Catchment | 0.25 ac | -1,000 L | 0 | 0 | Offsets water use |
| Fruit Trees | 0.5 ac | 6,000 L | 200 kWh | 350 kg | Seasonal, high reward |
| Greenhouse Peppers | 0.25 ac | 2,500 L | 400 kWh | 220 kg | Moderate efficiency |
| Polyculture Bed | 0.25 ac | 2,800 L | 200 kWh | 260 kg | Diverse crops, good yield |

Design Planner:

| Component | Acres | Water (L) | Energy (kWh) | Yield (kg) |
|------------------------|-------|-----------|--------------|------------|
| Drip-Irrigated Lettuce | 0.25 | 2,000 | 150 | 200 |
| Hydroponic Greens | 0.25 | 1,500 | 300 | 180 |
| Vertical Indoor | 0.25 | 1,200 | 600 | 240 |

| | | | | |
|-------------|------|-------|-----|-----|
| Greens | | | | |
| Fruit Trees | 0.25 | 3,000 | 100 | 175 |

Total:

Total Water = 2,000 + 1,500 + 1,200 + 3,000 = **7,700 L**

Total Energy = 150 + 300 + 600 + 100 = **1,150 kWh**

Total Yield = 200 + 180 + 240 + 175 = **795 kg**

Final Calculations:

- Total Yield: 795 kg

- Total Water: 7700 L

- Total Energy: 1150 kWh

- Water-Use Efficiency (L/kg): 9.7 L/kg

Water-Use Efficiency = 7,700 L ÷ 795 kg ≈ 9.7 L/kg

- Energy-Use Efficiency (kWh/kg): 1.4 kWh/kg

Energy-Use Efficiency = 1,150 kWh ÷ 795 kg ≈ 1.4 kWh/kg

Sketch or Layout Map (Optional):

Use this space to draw a simple map of your farm layout. Label each component and how much space it uses. You can divide your acre into quarters (0.25 ac), halves (0.5 ac), etc.

 Drip Lettuce (0.25ac) | Hydro Greens (0.25ac) |

 Vertical Greens (0.25ac) | Fruit Trees (0.25ac) |

Each quarter = 0.25 acre.

Lettuce and hydro greens balance water-efficient leafy greens.

Vertical greens provide high-yield efficiency.

Fruit trees add diversity and resilience.

Reflection: What component gave you the highest yield per unit of water? Energy? What trade-offs did you make between water and energy? Could your system support a community or market goals? If you had to lower your carbon footprint, what would you change?

Best Water Efficiency: Vertical Indoor Greens (1,200 L for 240 kg = 5 L/kg).

Best Energy Efficiency: Drip-Irrigated Lettuce (150 kWh for 200 kg = 0.75 kWh/kg).

Trade-Offs:

- Vertical systems save water but require more energy.
- Drip irrigation is low-energy and reliable but uses more land and water per acre.

Sustainability Rationale:

- Combining low-energy drip irrigation with high-yield vertical greens balances the system.
- Adding fruit trees diversifies crops and builds resilience.

If lowering carbon footprint:

- Add solar irrigation (-250 kWh offset) or rain catchment (-1,000 L offset) to further reduce external resource demand

Optional: Explore Other Metrics

Experts use many ways to measure efficiency. Some examples:

- CWP (kg/m^3): Yield per total water
- IWU: Incremental yield from added irrigation
- Intrinsic WUE: Plant-level water use efficiency
- Energy Use Index (EUI): kWh per hectare or per kg
- Carbon Footprint: CO_2 from energy use
- Energy Balance: Input vs. output energy