



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

### Hands-On Activity: Water-Budget Ledger

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#### Instructions Worksheet for Module 6 HOA A

**Grouping:** 2–3 students per group

**Time:** ~30 minutes for initial setup, then 5–10 minutes daily (quick measurements & notes) over the growing period (2–3 weeks until harvest)

**Overview:** In this hands-on activity, you will compare two ways of watering plants – a drip-irrigated **soil pot** (OPEN SYSTEM) and a simple **hydroponic** unit (CLOSED SYSTEM), to see which one uses water more efficiently. You'll set up a small “**water-budget ledger**”, tracking every milliliter of water you add and lose each day. This activity connects a tiny “**balcony**” garden to a big “**back-forty**” farm idea, helping you think about watering plants in both city and rural settings. By the end, you'll understand how design choices (like soil vs. soilless growing) affect water use, and how we can save water in different farming systems.

**Why Are We Doing This?** This experiment shows how **urban and rural farming** methods handle water. Drip irrigation (standard on farms) and hydroponics (popular in urban or indoor farming) both aim to grow plants with limited water. By measuring water inputs and outputs, you'll practice **systems thinking** – seeing the flow of water in a mini “system” – and apply sustainability principles to get “more crop per drop.” The goal is to learn how to **budget water** wisely, whether for a potted plant on a balcony or rows of crops in a field.

#### Precautions and Hazards

- **Water & Spills:** Water can make floors slippery. Clean up spills right away to prevent falls.
- **Electric Equipment & Lights (if used):** Keep all water away from plugs, cords, or LED fixtures. Never handle plugs with wet hands.
- **Nutrient Solution (if hydroponic fertilizer is added):** Can irritate skin/eyes. Wear gloves when handling. Wash your hands after use. Never taste or ingest.
- **Soil/Compost (for drip system):** May contain microbes or allergens. Wear gloves if possible and wash your hands after handling.
- **Cutting/Sharp Edges:** Some drip bottles, tubing, or hydro setups may need trimming or cutting. **Handle scissors/knives carefully.**
- **Glassware/Graduated Cylinders:** Breakable if dropped. Handle with care.
- **Plastic Bags (if used for catch basins):** Never place over face or head. Bags are for plant systems only.
- **Lifting/Carrying Water:** Buckets or reservoirs can be heavy. Lift carefully and ask for help if needed.

#### Materials (per team):

- 1 small **plant or seedling** for soil (e.g., a fast-growing leafy plant)
- 1 container or **pot with soil** (to grow the plant with drip irrigation) (Open System)
- 1 **plastic bottle or drip emitter** (with a tiny pinhole or drip nozzle to slowly water the soil) (Open System)
- 1 **catch tray** for soil pot runoff (to collect excess water draining out) (Open System)
- 1 small **hydroponic container** (e.g., a jar/cup for water with no soil)
- 1 **seedling or cutting** for the hydroponic unit (same type of plant as in soil, if possible)
- **Water** (to irrigate the soil and fill the hydroponic jar) – you will measure this daily
- **Measuring cup or syringe** (marked in mL, to measure water added)
- (Optional) A **ruler** or tape measure (to track plant growth, e.g., height or number of leaves)
- **Data worksheet** (the Water-Budget Ledger log, to record daily water use and observations)
- **Pen/pencil** for recording data

## Objective

To set up and compare two plant-growing systems—drip irrigation and hydroponic cultivation—in order to measure and evaluate Water Use Efficiency (WUE). Students will calculate the total amount of water required to produce one kilogram of plant biomass (L/kg) and analyze the trade-offs between soil-based and hydroponic growing methods.

In this HOA, you'll apply the Lesson A question, "**How is space reshaping where and how we grow food?**", to real and hypothetical examples of farms across the urban–peri-urban–rural gradient. This HOA helps you **design and test a small piece of a larger circular system** by tracking how water and inputs move through different growing setups and exploring how smart design can reduce waste and climate impacts.

## Experimental Procedure

### A. System Setup (Day 1)

Begin by preparing a clean workspace and organizing all necessary materials. Label one unit as a Drip System and the other as a Hydroponic System. These two systems represent contrasting water-delivery methods: drip irrigation mimics controlled soil watering in traditional fields, while hydroponics models water recirculation in modern, controlled environments.

- **For the Drip System**, place one seedling into a small pot containing soil. Install a drip emitter or create a small pinhole in a plastic water bottle positioned above the plant to allow a slow, consistent drip of water onto the soil surface.
- **For the Hydroponic System**, place a matching seedling into a net cup or rockwool cube suspended above a nutrient solution reservoir. Ensure that the plant roots make direct contact with the water or nutrient mixture, and that the catch basin is positioned to collect any overflow.

**Initial Watering:** Add the same initial water volume (e.g., 500 mL) to each system to standardize starting conditions. Record all baseline measurements, including the initial plant height (cm), total water added (mL), and a simple sketch or photo of both setups. These measurements form your experimental baseline for later WUE calculations.

### B. Daily Monitoring (Days 2–14+)

Over the following two to three weeks, maintain both systems through consistent care and measurement. This monitoring phase models how farmers and researchers track growth trends in irrigation trials.

**Soil plant:** Feel the soil or use a moisture meter if available. Add a measured amount of water (in mL) to keep the soil moist. Add slowly to minimize runoff. **Record** the volume of water you add. If water spills into the tray, measure the runoff and record it as well. You can pour the runoff water out after measuring (or return it to a collection jug if instructed).

**Hydroponic plant:** Check the water level in the container. If it's lower than your initial mark (due to the plant using water or evaporation), add water to bring it back to the original level. **Measure and record** how much you add – this is the daily water "top-up" for the hydroponic system. (If your hydroponic system has a lot of algae or issues, note that as an observation.)

**Observations:** Each day, also jot down any notes: How do the plants look? Are they wilting or thriving? New leaves? Approximate height? Any qualitative notes (e.g., "soil plant looks a bit droopy today" or "hydro water is getting greenish")? These notes help explain the numbers.

**Ongoing Care:** Ensure each system is functioning correctly. Keep the drip bottle or emitter in place for the soil plant and the hydro plant's roots submerged in water. If a plant shows signs of stress, note it – differences in plant health may affect water use. **Keep conditions as similar as possible** (both plants in the same location, with the same light and temperature, if possible) so that water use is the primary variable.

### C. Harvest (End of Experiment, ~2–3 weeks)

At the end of the growing period, carefully remove the plants from each system for harvest. Gently blot roots dry to remove surface water before weighing. Record the final plant height (cm) and fresh biomass (g) using a scale.

Convert the weight to kilograms for WUE calculations using the formula:

$$\text{Weight (kg)} = \frac{\text{Weight (g)}}{1000}$$

Next, determine the total water used for each system:

- OPEN SYSTEM Drip system:  $\text{Total water used} = \text{Total water added} - \text{Total runoff collected}$
- CLOSED SYSTEM Hydroponic system:  $\text{Total water used} = \text{Sum of all water topups}$

Finally, calculate Water Use Efficiency (WUE) using:

$$\text{WUE} = \frac{\text{Total Water Used (L)}}{\text{Yield (kg)}}$$

Compare and interpret your results. Which system used water more efficiently? Did one produce a higher yield per liter of water? Consider what these findings suggest about sustainable agriculture and water conservation. In real-world farming, similar calculations inform irrigation design and hydroponic optimization, balancing resource efficiency with productivity.

**Analysis & Discussion:** Answer the reflection questions on your worksheet or in your lab notebook. Discuss within your team (and class) what the results mean:

1. Which system was more water-efficient, and by how much?
2. What factors might explain the difference? (Think about where water might be “lost” in each system: e.g., soil absorbs water and some may not be accessible to the plant, some evaporates; in hydro, water is reused, but there might be evaporation, etc.)
3. What are the **design trade-offs** between a soil drip system and a hydroponic system? Consider factors such as simplicity, cost, nutrients, and scalability. For instance, hydroponics might use less water but needs nutrient inputs and careful monitoring; drip irrigation is simpler and cheaper for large fields but can waste water if overused or not captured.
4. How does this small experiment connect to real-world farming? (Where might you find hydroponic systems? Where are drip irrigation systems used? How do urban farmers vs. rural farmers approach watering?)
5. Brainstorm ways to improve water efficiency in both systems. (Could you recirculate runoff water on a farm? Could you cover a hydroponic tank to reduce evaporation? etc.)

**Wrap-Up:** Be prepared to share your findings. You might create a brief summary or mini-presentation with your team, for example, a chart of the water used by each system, along with a conclusion about which one was better and why. Also, reflect on what surprised you and what you learned about sustainable water use.

**Remember:** The big picture is to connect this to **sustainability and systems thinking**. In a system, water doesn't just disappear – it goes somewhere. By keeping a ledger of water inputs and outputs, you're acting like a water accountant for your mini-farm! This skill is crucial for designing future farms that **conserve water**, whether it's a rooftop hydroponic setup in the city or a drip-fed crop in a rural field.

**Tips for Success:**

- Measure carefully (use the same student each day for consistency).
- Record at the same time each day to minimize variation.
- Avoid spilling or losing runoff water.
- Keep seedlings healthy — check for pests, ensure adequate light, and inspect the system for leaks.

**Skills You'll Use:**

- Daily measurement and record-keeping
- Using lab tools (graduated cylinders, rulers, scales)
- Calculating efficiency (L/kg)
- Comparing system designs (drip vs hydroponic)
- Communicating findings with evidence