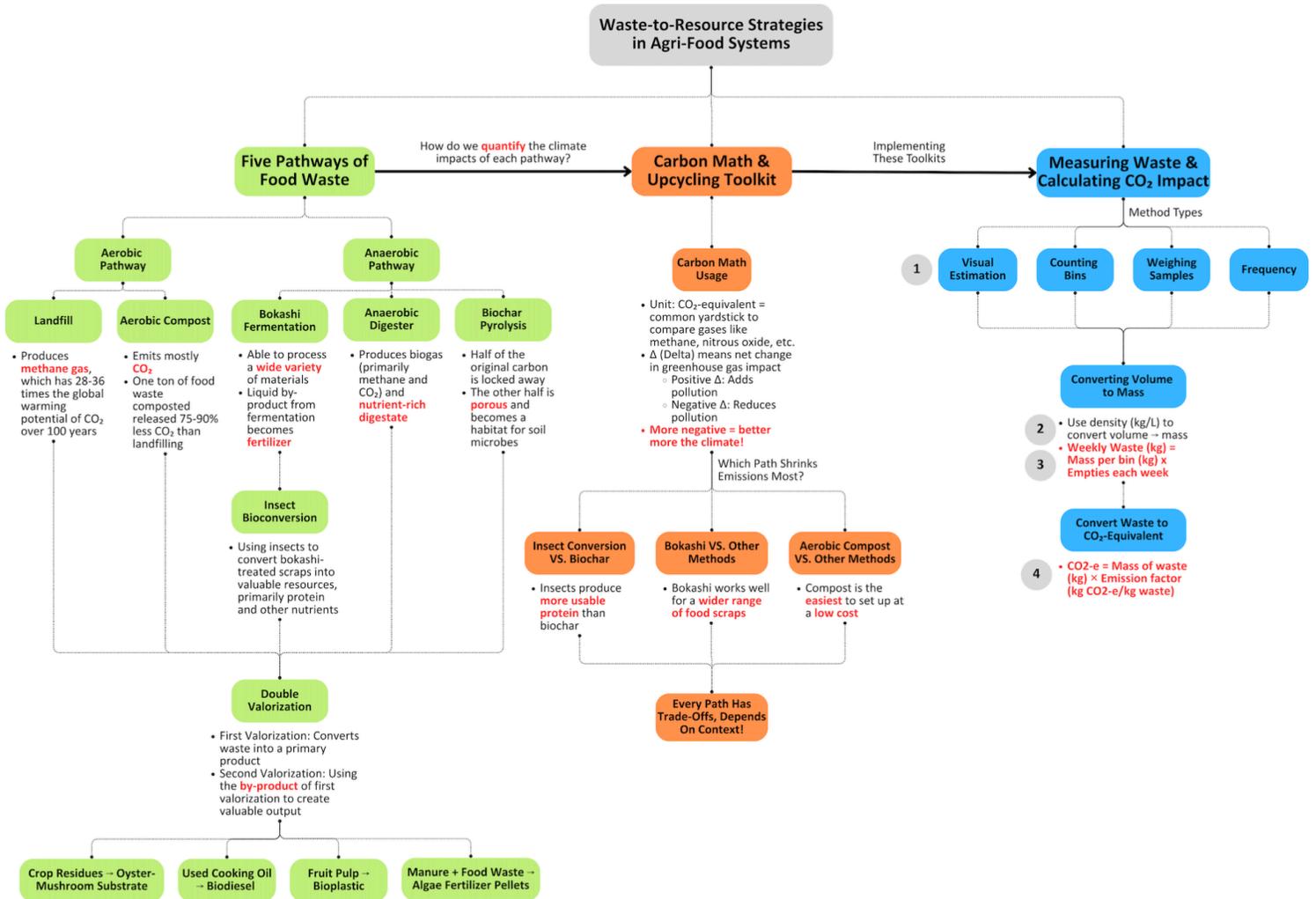




# Module 2: Waste-to-Resource Strategies in Agri-Food Systems

## What You'll Learn

### Comprehensive Mindmap



This module explores how agricultural waste can be turned into valuable resources to cut greenhouse gas emissions and support a circular economy. You'll examine five waste-valorization pathways—landfill, composting, anaerobic fermentation/digestion, biochar pyrolysis, and insect bioconversion—comparing their processes, outputs, and climate benefits. Using data, carbon-math tools, and design activities, you'll evaluate trade-offs, identify the most climate-friendly options, and prototype systems that close nutrient and energy loops.

## Lesson A: Beyond the Trash: The Five Pathways of Food Waste

- **Identify:** Five major waste-valorization pathways—landfill, aerobic composting, anaerobic fermentation / digestion (Bokashi & digesters), biochar pyrolysis, and insect bioconversion
- **Describe:** Inputs, process conditions, and primary outputs of each pathway
- **Compare:** Greenhouse-gas profiles of the five pathways and determine which emit or avoid the most CO<sub>2</sub>-equivalent
- **Predict:** Which pathway would deliver the greatest carbon reduction for a given food-waste scenario

## Lesson B: Carbon Math & Upcycling Toolkit

- **Understand:** Recognize the ΔCO<sub>2</sub>-equivalent for landfilling 1 kg of food waste versus treating it with alternative valorization options, using provided emission factors or data.
- **Create:** Design an optimal valorization route for a specific real-world waste stream (e.g. cafeteria leftovers or farm waste), supporting the recommendation with evidence from carbon calculations and practical considerations.
- **Evaluate:** Assess the trade-offs of each pathway – considering factors like cost, scalability, speed, and nutrient recovery – to justify which option might be preferable in a given context.
- **Rank:** Categorize different waste-to-resource technologies by their net carbon impact (most to least climate-friendly) and also compare their energy requirements and useful co-products.

## Lesson C: Measuring Waste & Calculating CO<sub>2</sub> Impact

- **Analyze:** Quantify their campus's waste-generation hotspots, estimating weekly amounts of food, yard, and paper waste at key locations and computing the associated CO<sub>2</sub>-equivalent emissions for each.
- **Apply:** Utilize the feasibility and projected carbon savings of their proposed solution in a brief presentation or “mini-pitch,” using data (emission reductions, etc.) and practical reasoning to persuade peers.
- **Create / Evaluate:** Design a prototype waste-to-resource system for one selected hotspot or waste stream, specifying how the waste could be collected and processed (composted, fermented, fed to insects, etc.) to close the nutrient or energy loop.
- **Reflect:** How can implementing multiple different valorization routes in parallel move the entire campus toward a circular economy, and identify challenges and next steps for making it happen.

## Important Vocabulary/Terms

Term	Definition	Example
Organic Waste	Biodegradable material from plants, animals, or food that can be broken down naturally.	Fruit peels, yard trimmings, or leftover food.
Valorization	Turning waste materials into useful products, energy, or resources.	Making fertilizer from food scraps.
Circular Economy	An economic model focused on reusing, recycling, and minimizing waste.	Designing packaging to be reused instead of thrown away.
Greenhouse Gases (GHGs)	Gases that trap heat in the atmosphere and contribute to climate change.	Carbon dioxide and methane.
Methane (CH <sub>4</sub> )	A powerful greenhouse gas produced by organic matter breaking down without oxygen.	Gas released from landfills or cow manure.
CO <sub>2</sub> -equivalent (CO <sub>2</sub> -e)	A way to compare the warming effects of different greenhouse gases to carbon dioxide.	1 ton of methane equals about 28 tons of CO <sub>2</sub> -e.

Landfill	A site where waste is buried under layers of soil.	Municipal trash being dumped at a landfill.
Aerobic Composting	Breaking down organic matter with oxygen to make compost.	A backyard compost pile.
Anaerobic Digestion	Breaking down organic matter without oxygen to make biogas and digestate.	A sealed digester processing food waste.
Biochar Pyrolysis	Heating organic material without oxygen to make biochar.	Converting wood chips into biochar.
Insect Bioconversion	Using insects to process organic waste into protein and fertilizer.	Black soldier flies eating food scraps.
Carbon Sequestration	Capturing and storing carbon to reduce its impact on the atmosphere.	Trees absorbing CO <sub>2</sub> through photosynthesis.
Nutrient Cycling	The natural movement of nutrients through ecosystems.	Nitrogen moving from soil to plants to animals.
Renewable Energy	Energy from sources that are naturally replenished.	Solar panels, wind turbines, or biogas plants.
Compost	A soil amendment made from decomposed organic matter.	Finished compost used in gardens.
Biogas	A renewable gas (mainly methane and CO <sub>2</sub> ) produced by anaerobic digestion.	Biogas used to power a generator.
Biochar	A charcoal-like material made through pyrolysis, used to improve soil and store carbon.	Mixing biochar into farmland soil.
Sustainable Development Goals (SDGs)	UN goals to guide global sustainability efforts.	SDG 12: Responsible Consumption and Production.
Waste Reduction	Minimizing the amount of waste generated.	Bringing your own cup instead of using disposable ones.