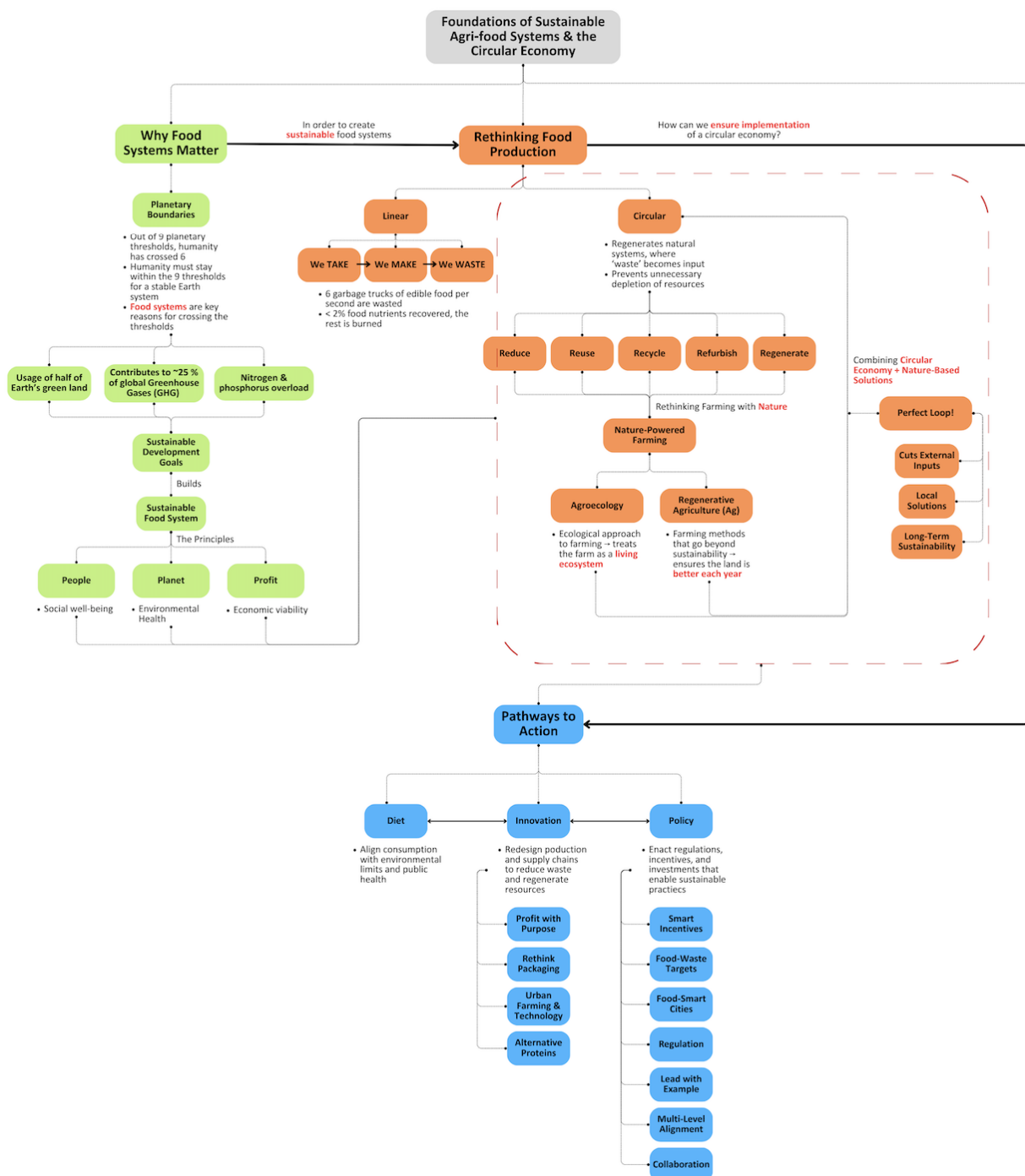




Module 1 – Foundations of Sustainable Agri-Food Systems & Circular Economy

What You'll Learn

Comprehensive Mindmap



This module explores how agricultural and food waste can be transformed into valuable resources that reduce greenhouse gas emissions and support a circular economy. You'll examine five major waste-valorization pathways—landfill, aerobic composting, anaerobic fermentation/digestion, biochar pyrolysis, and insect bioconversion—analyzing their inputs, processes, outputs, and climate impacts. Through real-world scenarios and carbon-math calculations, you'll compare the trade-offs of each method,

design waste-to-resource systems for specific hotspots, and evaluate how combining multiple pathways can close nutrient loops, recover resources, and build more sustainable agri-food systems.

Lesson A: Why Food Systems Matter: Planetary Boundaries & SDGs

- **Remember:** The three pillars of sustainable food systems (People, Planet, Profit) and define the concept of planetary boundaries
- **Explain:** How food systems impact multiple planetary boundaries and contribute to crossing safe environmental limits
- **Apply:** Use a common meal as an example to identify how food systems connect to specific Sustainable Development Goals (SDGs)
- **Analyze:** How food system activities influence multiple planetary boundaries, and explain how these environmental limits interact with social and economic goals

Lesson B: From Linear to Circular: Rethinking Food Production

- **Apply:** Identify linear and circular food system features using real-world agri-food examples from case studies
- **Analyze:** Compare real-world case studies of waste-to-resource solutions by identifying what waste is used, what new products are made, and how the process helps the environment
- **Evaluate:** Assess trade-offs among case study pathways considering scalability, economic value, and nutrient recovery potential

Lesson C: Pathways to Action: Diet, Innovation & Policy

- **Apply:** Use provided data and tools to compare the environmental impacts of different food choices (e.g., beef vs. beans) in terms of CO₂e, water use, and land use
- **Create:** Develop an action plan that combines at least one personal, one entrepreneurial, and one policy solution to advance a more sustainable and circular food system in your community
- **Evaluate:** Justify your innovation's feasibility, projected environmental benefits, and potential social or economic co-benefits in a short peer pitch
- **Analyze:** Compare the strengths and limitations of diet, innovation, and policy pathways, and explain how they can work together to drive systemic change

Important Vocabulary/Terms

Term	Definition	Example
Sustainable Food System (SFS)	A food system that delivers food security and nutrition for all in a way that doesn't compromise the economic, social, and environmental foundations for future generations. In short, it's a way of producing and consuming food that can last long-term without wrecking people or the planet.	A community that grows enough healthy food for everyone using farming methods that preserve soil, pay farmers fairly, and emit minimal greenhouse gases is aiming to be a sustainable food system.
Three Pillars of Sustainability (3 Ps)	The three core aspects we must balance for sustainability: People (social equity & well-being), Planet (environmental health), Profit (economic viability). All three are interdependent.	An urban farm project might provide jobs and fresh food in a neighborhood (People), use organic methods and solar power (Planet), and turn a profit or at least break even (Profit). All pillars are addressed.
Planetary Boundaries	Critical natural limits identified by scientists (like climate change, biodiversity loss, freshwater use, etc.). Staying within these boundaries keeps Earth stable; overshooting them (going into the red zone) risks triggering severe environmental changes.	The carbon emission boundary relates to climate change: exceeding it (too much CO ₂ in atmosphere) leads to global warming. Currently, agriculture is a major contributor to pushing us past this climate boundary through deforestation and methane from livestock.
Circular Economy (CE)	An economic system that keeps materials in use for as long as possible, through reuse, repair, recycling, and composting, rather than a take–make–dispose model. In a circular economy, waste is designed out – it becomes a feedstock for something else.	In a circular food economy, yesterday's food waste might become today's fertilizer or animal feed. Example: A juice company collects orange peels and sends them to a facility that extracts oils for cleaners and then composts the remainder. Nothing useful goes to landfill.
Agroecology	A farming approach that applies ecological principles to agriculture. It often means diversifying farms (crops +	An agroecological farm might plant a mix of crops and border them with flowers that attract pest-eating

	animals), recycling nutrients and energy on the farm, and working with natural processes (like predatory insects for pest control) to create a sustainable, self-regulating system.	insects, use manure from cows on the farm to fertilize fields, and rotate crops to naturally replenish soil nutrients. The farm functions more like an ecosystem than an industrial operation.
Regenerative Agriculture	A farming approach that focuses on restoring and enhancing soil health, biodiversity, and ecosystem functions while producing food. It goes beyond “sustainable” practices by actively rebuilding degraded soils, improving water cycles, and capturing carbon in the ground. Core methods often include minimal tillage, diverse crop rotations, cover cropping, integrating livestock, and compost application.	A regenerative farm might plant cover crops in the off-season to protect and enrich the soil, rotate livestock through fields to naturally fertilize and aerate the land, and avoid heavy plowing to preserve soil microbes. Over time, the farm’s soil becomes richer in organic matter, holds more water, and draws down more carbon—making it healthier, more productive, and more resilient than before.
Waste-to-Resource	A concept and practice of taking something that would be thrown away and turning it into something valuable. It’s a key idea in circular economies. Instead of “waste management,” think “resource management.”	Waste-to-resource in action: a brewery’s spent grain (leftover barley mash) is dried and milled into high-protein flour for baking – turning brewing waste into a nutritious ingredient. Another example: composting cafeteria food scraps into soil for the school garden.
Biosphere Integrity	The ability of ecosystems and biodiversity to remain resilient and support life. It’s one of the key planetary boundaries.	Protecting pollinators like bees to ensure crops can continue to be grown sustainably.
Greenhouse Gas (GHG) Emissions	Gases (like CO ₂ , methane, nitrous oxide) released into the atmosphere that trap heat and drive climate change.	Methane released from cattle farming contributes significantly to GHG emissions.
Sustainable Development Goals (SDGs)	A set of 17 global goals adopted by the UN in 2015 to address poverty, inequality, climate change, and environmental degradation by 2030.	SDG 2 – Zero Hunger aims to end hunger by promoting sustainable agriculture and equal food access.
Deforestation	The clearing or thinning of forests for agriculture, logging, or development, leading to biodiversity loss and climate impacts.	Cutting down large areas of the Amazon rainforest to grow soybeans or graze cattle.

Nutrient Pollution	Excess nitrogen and phosphorus from fertilizers or waste entering soil and waterways, harming ecosystems.	Agricultural runoff causing algal blooms in rivers and lakes, killing fish and disrupting aquatic life.
Food Security	The condition in which all people have consistent access to sufficient, safe, and nutritious food to live healthy lives.	Community food banks improving food security for low-income families.
Linear Economy	A traditional “take–make–dispose” system where resources are extracted, used to make products, and discarded as waste at the end of their life.	Producing plastic bottles, using them once, and throwing them in a landfill.
Nutrient Cycling	The natural process of reusing nutrients like nitrogen and phosphorus in ecosystems to sustain life.	Dead leaves decomposing into soil, providing nutrients for plants to grow
Biological Cycle	In a circular economy, the process where organic materials are returned safely to the environment through natural cycles like composting or digestion.	Food scraps being composted and turned into soil nutrients.
Technical Cycle	In a circular economy, the cycle where non-biodegradable products (like metals, plastics) are reused, repaired, or recycled instead of being discarded.	Old smartphones being refurbished and resold instead of thrown away.
By-product	A secondary product that is created during the production of a main product.	Molasses is a by-product of sugar production from sugarcane.
Composting	The controlled decomposition of organic waste (like food scraps, leaves, and manure) into nutrient-rich soil.	A household compost bin turning kitchen scraps into fertilizer for a garden.
Dietary Shifts	Changes in the way populations eat, usually toward more sustainable, healthy, and environmentally friendly diets.	Moving from a meat-heavy diet to a plant-based or flexitarian diet to reduce environmental impact.
Innovation	The creation or adoption of new methods, technologies, or ideas to solve problems or improve systems.	Developing vertical farms that grow crops indoors using hydroponics and LED lights.

Policy	Rules or guidelines set by governments, organizations, or institutions to influence decisions and behaviors.	A city introducing a tax on single-use plastics to reduce pollution.
Food Carbon Footprint CO₂e (Carbon Dioxide Equivalent)	A metric used to compare the warming effect of different greenhouse gases by expressing them in terms of the equivalent amount of CO ₂ .	One ton of methane emissions is about 28 tons of CO ₂ e in terms of climate impact.
Alternative Proteins	Protein sources that serve as substitutes for traditional animal-based proteins.	Plant-based burgers made from pea protein or lab-grown meat.
Urban Farming	The practice of cultivating, processing, and distributing food in or around cities.	Rooftop gardens in New York City providing fresh vegetables to local communities.
Food-Waste Target	A measurable goal set by governments or companies to reduce the amount of food wasted along the supply chain.	The UN's target to cut global food waste by 50% by 2030.
Systems Thinking	An approach that views problems as part of a larger interconnected system, focusing on relationships and feedback loops.	Understanding how food waste reduction affects not only landfill use but also supply chains, farmer income, and consumer habits.
4 P's Framework (for solutions)	A way to categorize sustainability actions into four spheres: People (individual or cultural change), Planet (environmental conservation/restoration efforts), Profit (market-driven or technological innovation), and Policy (government laws and regulations). It's used to ensure we're looking at all angles of change.	To fix the food system: <i>People</i> might choose to eat less meat and not waste food; <i>Profit</i> sector might innovate meat alternatives or food-sharing apps; <i>Policy</i> makers could enforce food waste bans or incentives for organic farming; <i>Planet</i> efforts include replanting forests or protecting soil health. We need all four!