



**LAND MANAGEMENT, ENVIRONMENT & SOLID-WASTE:
INSIDE EDUCATION AND BUSINESS IN CENTRAL ASIA
ERASMUS-EDU-2023-CBHE Project Number: 101129032**

MICRO-CREDENTIAL

**CIRCULAR ECONOMY FOR LAND AND WASTE
MANAGEMENT**

9.- Circular Economy in Agriculture and Rural Areas

Activity 1

Design a circular farm model



Co-funded by
the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Objective

The objective of this activity is to help students apply the principles of circular agriculture by designing a simple farm model in which nutrients, biomass, water and organic residues are reused as productive resources.

Students should demonstrate that a circular farm is not simply a farm that recycles waste. A well-designed circular system should first reduce unnecessary resource use and losses, then safely recover materials that can remain in productive use.

After completing the activity, students should be able to:

- identify the main material and resource flows within a farm;
- distinguish between useful products, by-products, wastes and environmental losses;
- propose practical loops connecting crops, livestock, soil, water and organic residues;
- apply the biomass cascade principle;
- recognise environmental risks associated with unsafe reuse;
- explain how circular farming can contribute to soil health, water efficiency and Sustainable Land Management.

Scenario

You are asked to design a circular model for a **mixed farm located in a semi-arid rural area of Central Asia**.

The hypothetical farm includes:

- 100 hectares of irrigated cropland
- wheat and maize production
- a 10-hectare vegetable area
- 80 cattle
- crop residues such as straw and maize stalks
- livestock manure
- an irrigation canal
- a small reservoir
- electricity and diesel consumption

- some food and vegetable residues
- plastic irrigation materials and pesticide containers

The farm currently operates mainly according to a linear model. Mineral fertilisers, water, feed, energy and agricultural materials enter the system. Crops and animal products leave the farm. Part of the manure is stored poorly, some crop residues are burned, irrigation water is used inefficiently, and several waste streams have no organised recovery system.

Your task is to redesign the farm according to circular economy principles.

Step 1. Map the current linear farm system

Begin by identifying the main **inputs, productive activities, outputs, by-products and losses**.

Use Table 1 to describe the baseline situation.

Table 1. Baseline resource-flow assessment

System element	Examples for the farm	Current destination or use	Main problem or opportunity
Water inputs	Canal irrigation, reservoir water	Applied to crops	Possible conveyance and application losses
Nutrient inputs	Mineral N and P fertilisers	Applied to fields	Possible over-application and nutrient losses
Livestock feed	Farm-produced and imported feed	Fed to cattle	Imported nutrient dependency
Crop biomass	Wheat straw, maize stalks	Partly burned or removed	Loss of organic matter and useful biomass
Livestock manure	Solid and liquid manure	Partly stored or applied	Nutrient losses, odour, methane, leaching
Vegetable residues	Unsold or damaged vegetables	Disposed of	Potential composting or digestion feedstock
Energy	Electricity and diesel	Machinery, pumping	Fossil-energy dependence
Agricultural plastics	Irrigation pipes, films, containers	Partly discarded	Soil and waste-management risk

As shown in Table 1, the first task in circular design is to identify where valuable resources are currently lost.

Step 2. Design the circular loops

Your farm model should include at least **six circular loops**.

Possible loops include the following.

- Loop A. Crop residues to soil

Part of the straw and maize residues can remain on the field as mulch or be incorporated into soil to protect against erosion and contribute organic matter.

- Loop B. Crop residues to livestock

Residues of suitable quality may be used as livestock bedding or feed, depending on nutritional value and treatment needs.

- Loop C. Manure to nutrients

Manure can be collected, stored properly and applied according to crop nutrient requirements. Composting or anaerobic digestion may improve management.

- Loop D. Manure and organic residues to biogas

Livestock manure and suitable vegetable residues can be treated through anaerobic digestion to produce biogas and digestate.

- Loop E. Digestate or compost to soil

Recovered nutrients and organic matter can return to cropland according to a nutrient-management plan.

- Loop F. Water efficiency and controlled reuse

Irrigation efficiency can be improved through better scheduling, drip irrigation or soil-moisture monitoring. Suitable water streams may be reused where quality permits.

- Loop G. Renewable energy to farm operations

Biogas or solar energy may partially supply irrigation pumping, heating or electricity.

- Loop H. Agricultural plastics to organised collection

Plastic films, pipes and pesticide containers should be separated and transferred to authorised recovery or management systems.

Step 3. Apply the biomass cascade principle

Students must decide the preferred use of each biomass stream.

A simplified hierarchy is:

Food → Feed → Bio-based products → Energy recovery → Nutrient return to soil

This hierarchy should not be applied mechanically. The selected use must depend on quality, local needs, transport distance, soil requirements and environmental performance.

For example, edible vegetables should not be sent directly to anaerobic digestion when redistribution or food use is feasible. Straw should not necessarily be completely removed for energy if maintaining soil organic matter requires part of it to remain in the field.

Step 4. Produce the farm diagram

Students must prepare a simple visual model showing at least the following components:

- soil
- crops
- livestock
- crop residues
- manure
- composting and/or anaerobic digestion
- energy
- water
- food or vegetable residues
- external inputs
- products leaving the farm
- residual wastes

Arrows should clearly distinguish:

- **resource inputs**
- **productive outputs**
- **internal circular flows**
- **environmental losses that should be minimised**

Suggested diagram structure

At the centre of the model, place:

SOIL – CROPS – LIVESTOCK

Around this central system, add:

Organic-residue recovery → Compost / Digestate → Soil

Manure → Anaerobic digestion → Biogas + Digestate

Water supply → Efficient irrigation → Crops → Controlled return/reuse where feasible

Crop residues → Soil / Feed / Higher-value use / Energy

Agricultural plastics → Separate collection → Recycling or controlled management

Step 5. Identify risks and limits

A circular farm should not reuse materials blindly.

Students must identify at least five potential risks. Examples include:

- excessive manure application causing nitrate pollution;
- salinity accumulation from poorly controlled water reuse;
- contamination of compost with plastics;
- nutrient imbalance in digestate application;
- complete removal of crop residues causing soil organic-matter decline;
- methane leakage from poorly operated digesters;
- pesticide-contaminated containers entering inappropriate recycling streams.

Warning: maximum reuse is not the same as maximum sustainability. A circular system must protect soil, groundwater, crops, ecosystems and human health.

Student task

Complete Table 2 for your proposed circular farm.

Table 2. Circular farm design matrix

Resource or waste stream	Current linear practice	Proposed circular use	Environmental benefit	Main risk or limitation	Monitoring indicator
Crop residues					
Livestock manure					
Vegetable waste					
Irrigation water					
Nutrients					
Energy					
Agricultural plastics					

Required output

Students should submit:

1. A completed circular farm diagram.
2. The completed **Table 2**.
3. A written explanation of **700–1,000 words**.
4. At least six proposed circular loops.
5. Three priority interventions for implementation during the first year.
6. Five monitoring indicators.
7. A short explanation of how the design supports Sustainable Land Management.

Guiding questions

1. Which resource is currently lost in the largest quantity?
2. Which loop would provide the greatest environmental benefit?
3. Which circular intervention would be easiest to implement?
4. Which would require the greatest capital investment?
5. How much crop residue should remain on the field?

6. Could livestock manure fully replace mineral fertilisers?
7. What information is needed before applying digestate?
8. How can water reuse create salinity problems?
9. Which actors outside the farm may be needed?
10. Is the farm able to close all loops internally, or is territorial cooperation necessary?

Suggested answer outline

A strong circular farm model should combine several interventions rather than rely on one technology.

For example, crop residues could be divided among soil protection, livestock use and, where surplus exists, bioenergy or other higher-value applications. Manure could be collected and processed through composting or anaerobic digestion, with nutrients returned to fields according to crop demand. Irrigation efficiency could be improved using scheduling and soil-moisture monitoring. Vegetable residues could be composted or co-digested. Renewable energy could partly support pumping or farm facilities.

However, the system should also recognise constraints. Complete residue removal may reduce soil quality. Excess digestate may pollute groundwater. Recycled water may increase salinity. Agricultural plastic recovery may require cooperation with an external collection system.

The best answer will therefore present the farm as an **integrated system with controlled loops and monitored trade-offs**.

Assessment criteria

Criterion	Description
Resource-flow analysis	Inputs, outputs, residues and losses are correctly identified
Circular design	At least six technically realistic loops are proposed
Nutrient management	Nutrient return is linked to crop demand and environmental protection
Biomass cascading	Higher-value uses are considered before energy recovery
Water management	Efficiency, reuse opportunities and salinity risks are recognised
Risk awareness	Student identifies limits and environmental trade-offs
Monitoring	Appropriate indicators are proposed
SLM relevance	Design supports soil, water, land productivity and resilience
Diagram quality	Flows are clear and logically represented