



**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**

6.- Recycling and Material Recovery

Activity 1

***Comparative table: recycling benefits vs
land/environmental costs***



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 critically assess recycling and material recovery options by comparing their environmental benefits with the land, energy, water and pollution costs that may arise during collection, sorting, processing and final management.

Recycling is generally preferable to extracting virgin raw materials and disposing of waste. However, recycling processes are not impact-free. Material recovery facilities require land, energy, water, infrastructure and transport. Some recycling processes generate wastewater, emissions, dust or residual waste that still requires treatment or disposal.

By completing this activity, students should understand that a circular economy decision should not be based only on the amount of material recycled. It should also consider environmental performance across the whole material cycle.

Background

In a linear economy, materials are extracted, transformed into products, used and discarded. This system consumes natural resources and generates waste that may occupy landfill space, contaminate soil and groundwater, or create long-term environmental liabilities.

Recycling and material recovery can reduce these impacts by keeping materials in productive use. Metals, paper, glass, plastics, organic waste and construction materials can often be recovered and returned to production cycles.

However, different materials have different environmental profiles. Recycling aluminium may generate large energy savings compared with primary production, whereas contaminated mixed plastics may be technically difficult to recycle and can generate residues requiring disposal. Composting organic waste can return nutrients and organic matter to soil, but poor-quality compost may introduce plastics, salts or contaminants.

The purpose of this activity is therefore to compare both sides of the decision:

What environmental benefits are achieved through recycling, and what environmental costs are created by the recovery process itself?

Scenario

A regional authority is developing a new circular economy strategy. The region generates municipal, agricultural, commercial and construction waste. Current waste management relies heavily on landfill disposal.

The authority is considering expanding recovery and recycling for the following material streams:

1. Paper and cardboard.
2. Glass.
3. Metals.
4. Plastics.
5. Organic waste.
6. Construction and demolition waste.

Students must compare the benefits of recycling each material with the possible land and environmental costs associated with collection, sorting, processing, transport and management of residual waste.

Student task

Complete **Table 1** for each material stream.

Table 1. Comparative assessment of recycling benefits and environmental costs

Material stream	Main recycling or recovery option	Main environmental benefits	Land-use implications	Possible environmental costs	Residual waste generated	Overall assessment
Paper and cardboard	Fibre recycling	Reduces virgin fibre demand, saves landfill space, may reduce energy and water demand compared with primary production	Requires collection, sorting and processing facilities	Energy use, water consumption, wastewater, sludge generation	Rejects, contaminated fibres, inks and sludge	
Glass	Crushing and remelting into new glass products	Reduces use of virgin raw materials and landfill disposal	Requires storage and processing areas	Energy for transport and melting, noise and dust during crushing	Ceramics, stones, mixed-colour rejects	
Metals	Separation and remelting	Avoids mining impacts, conserves ores and usually provides major energy savings	Requires scrap yards and processing facilities	Energy use, emissions from melting, contaminated residues	Slag, dust, coatings and non-metallic fractions	

Plastics	Mechanical or chemical recycling	Reduces demand for fossil raw materials and plastic waste disposal	Requires sorting, washing and processing infrastructure	Energy use, wastewater, microplastic losses, additives and rejected mixed plastics	Non-recyclable plastics, sludge and contaminated fractions	
Organic waste	Composting or anaerobic digestion	Reduces landfill methane, recovers nutrients and organic matter, may produce biogas	Requires treatment areas and buffer zones	Odour, leachate, ammonia emissions, contamination risks if feedstock is poorly separated	Screening rejects, contaminated compost fractions	
Construction and demolition waste	Crushing and recovery of aggregates, metals and reusable components	Reduces extraction of virgin aggregates and landfill use	Requires relatively large processing and storage areas	Dust, noise, transport, energy use and possible contamination by hazardous materials	Fine fractions, asbestos-containing materials or contaminated debris	

Step 1. Identify the environmental benefits

For each material stream, identify the main benefits associated with recycling or recovery.

Possible benefits include:

- reduction in extraction of virgin raw materials;
- reduction in landfill disposal;
- lower demand for land for waste disposal;
- reduction in greenhouse gas emissions;
- energy savings;
- water savings;
- recovery of nutrients or organic matter;
- reduced mining impacts;
- reduced soil disturbance;
- reduced risk of landfill leachate generation.

Students should avoid assuming that all benefits are equally important for all materials.

For example, metal recycling may create major benefits by avoiding mining and primary metal production. Organic waste recovery may be especially important because it reduces biodegradable waste sent to landfill and can return nutrients to soil.

Step 2. Identify land-use implications

Students should evaluate how recycling changes land demand.

Recycling can reduce the amount of land needed for:

- raw-material extraction;
- quarrying;
- mining;
- landfill disposal;
- waste storage.

However, recycling itself requires land for:

- collection centres;
- material recovery facilities;
- composting sites;
- scrap yards;
- storage areas;
- treatment plants;
- access roads and transport infrastructure.

The correct comparison is therefore not simply “**recycling uses land**” versus “**landfilling uses land**”, but which option creates the lower total long-term pressure on land and ecosystems.

Step 3. Identify environmental costs

Students should identify environmental impacts that may occur during material recovery.

Examples include:

- electricity or fuel consumption;
- transport emissions;
- water use;

- wastewater generation;
- dust;
- noise;
- odours;
- leachate;
- air emissions;
- microplastic release;
- contaminated residues;
- occupational risks;
- land disturbance.

Not every recycling process has the same environmental cost. The impact depends on technology, scale, transport distance, contamination level and quality of source separation.

Step 4. Evaluate residual waste

Recycling does not normally eliminate waste completely. Most recycling processes generate residual fractions.

Examples include:

- non-recyclable plastics from sorting facilities;
- contaminated paper fibres;
- wastewater sludge;
- glass and ceramic rejects;
- ash or slag;
- screenings from compost;
- fine fractions from construction waste;
- hazardous components that require specialised disposal.

Students should identify what happens to these residual materials. A recycling system cannot be considered environmentally successful if it simply transfers pollution from one waste stream to another.

Step 5. Provide an overall assessment

For each material stream, classify the overall recycling option using one of the following categories:

- **Highly favourable**
- **Favourable with controls**
- **Conditionally favourable**
- **Limited benefit under current conditions**

Students must justify the classification.

A possible assessment could be:

Metal recycling: highly favourable because of major reductions in mining and primary production impacts, provided that air emissions, slag and contaminated scrap are properly managed.

Or:

Mixed plastic recycling: conditionally favourable because benefits depend strongly on polymer purity, contamination, transport distance and the amount of residual non-recyclable material.

Guiding questions

1. Which material provides the greatest environmental benefit when recycled?
2. Which recycling process may require the most land?
3. Which recycling process generates important wastewater flows?
4. Which material stream may create significant contamination risks if source separation is poor?
5. Why is metal recycling generally associated with major environmental benefits?
6. Why can contaminated plastics be difficult to recycle?
7. How does composting reduce pressure on landfill disposal?
8. What risks arise if compost contains plastics, metals or other contaminants?
9. Why must transport distance be considered when assessing recycling?
10. Can a recycling process be technically successful but environmentally poor? Give one example.

Required output

Students should submit:

1. A completed comparative table covering all six material streams.
2. A short written assessment of **500–700 words**.
3. A ranking of the six material streams from highest to lowest environmental benefit.
4. Identification of the **three most important environmental costs** associated with recycling.
5. One recommendation for improving the environmental performance of material recovery in the region.

Suggested discussion structure

The written assessment should include four short sections:

1. Highest-benefit materials

Identify the materials where recycling provides the clearest environmental advantages.

2. Main environmental costs

Discuss energy, water, land, emissions and residual waste.

3. Trade-offs

Explain cases where recycling creates benefits but also relevant environmental impacts.

4. Recommendation

Identify which recycling systems should be prioritised and what environmental safeguards are needed.

Example of a short comparative assessment

Metal recycling is generally one of the most environmentally favourable recovery options because it reduces demand for mining and primary ore processing, which are highly energy- and land-intensive activities. However, metal recycling still requires controlled processing, air-emission management and safe handling of slag and contaminated scrap.

Organic waste recovery also provides major benefits where food and green waste are currently landfilled. Composting or anaerobic digestion can reduce methane emissions and return nutrients or organic matter to productive use. Nevertheless, poor source separation can introduce plastics, glass or hazardous substances into compost.

Plastic recycling is more complex. Clean, separated polymer streams may be effectively recycled, whereas mixed or contaminated plastics may require intensive washing, produce wastewater and generate large quantities of rejects. Therefore, better collection and product design are essential to improve plastic circularity.

The main conclusion is that recycling should be evaluated as a complete system. High recycling rates alone are not sufficient. The objective should be to maximise material recovery while minimising land occupation, energy consumption, water use, emissions and residual pollution.

Assessment criteria

Criterion	Description
Understanding of recycling benefits	Correctly identifies avoided extraction, disposal and environmental impacts
Land-use analysis	Considers both avoided landfill/extraction impacts and land required for recovery facilities
Environmental cost analysis	Identifies realistic energy, water, emission and pollution impacts
Residual waste awareness	Recognises that recycling processes generate rejects and secondary residues
Comparative reasoning	Distinguishes clearly between material streams
Critical analysis	Avoids assuming that recycling is automatically impact-free
Circular economy relevance	Connects material recovery with resource conservation and Sustainable Land Management
Clarity	Table and written assessment are coherent and technically justified

Expected learning outcome

After completing this activity, students should be able to compare recycling options using a life-cycle and land-management perspective. They should understand that recycling can reduce raw-material extraction, landfill pressure and environmental degradation, but that recovery processes also require energy, water, land, infrastructure and pollution controls.

The key lesson is that **effective circular economy strategies should maximise material recovery without transferring environmental costs from one place, medium or generation to another.**