



MICRO-CREDENTIAL

CIRCULAR ECONOMY FOR LAND AND WASTE MANAGEMENT

4.- Solid Waste Streams and Material Flows

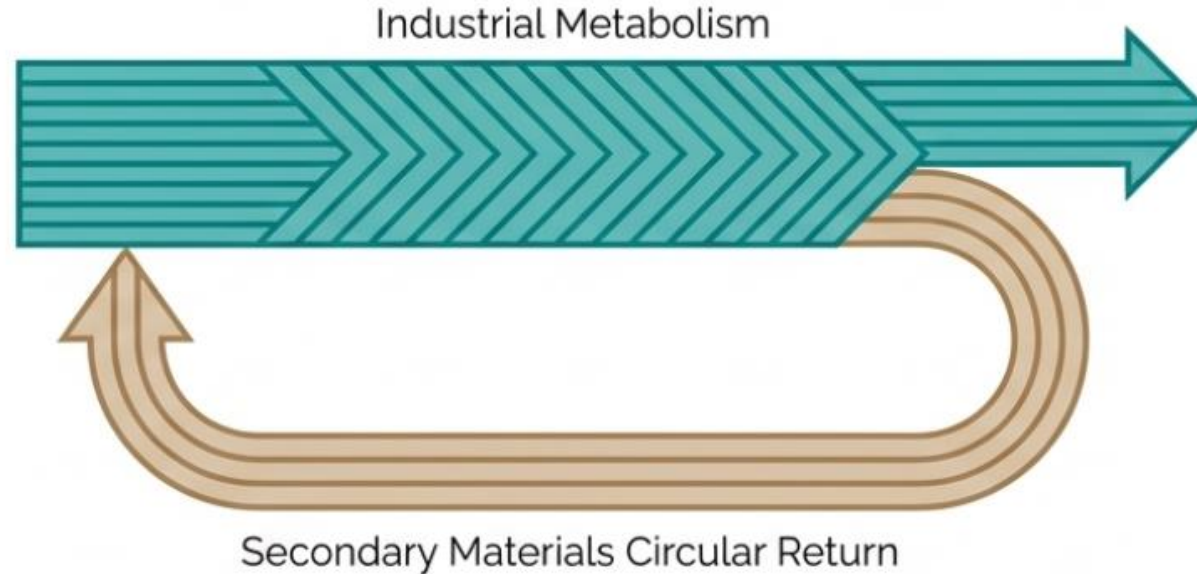
Material Flow Analysis in the Circular Economy

CELWS-W04-V02



Co-funded by
the European Union

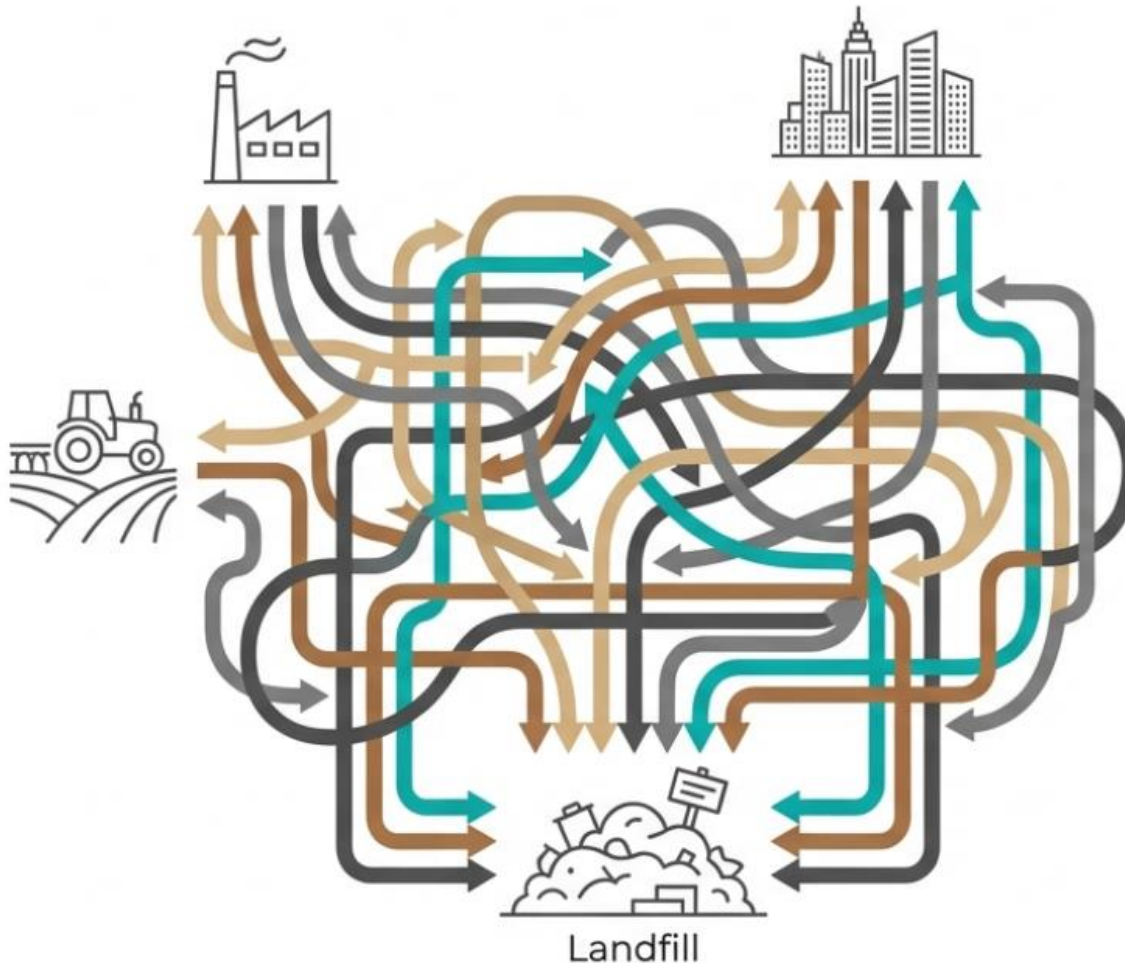




The Blueprint for Circularity and Sustainable Waste Management

A quantitative approach to tracking the sources, paths, and sinks of substances in socio-economic systems.

Introduction: Why Material Flow Analysis is Needed



The Challenge

Anthropogenic material systems are highly complex and continuously expanding.

Drivers of Material Use

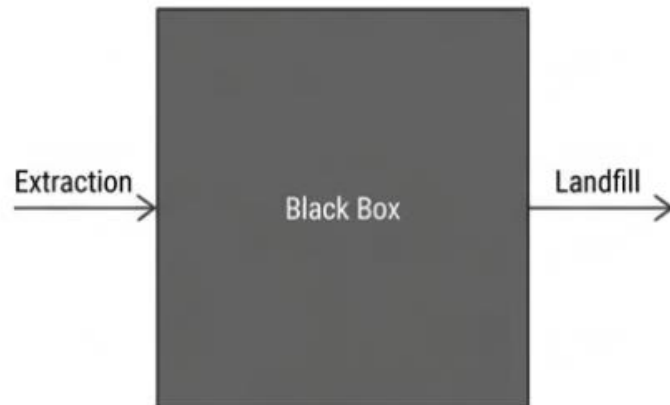
Population growth and economic development exponentially increase inputs.

Waste Generation

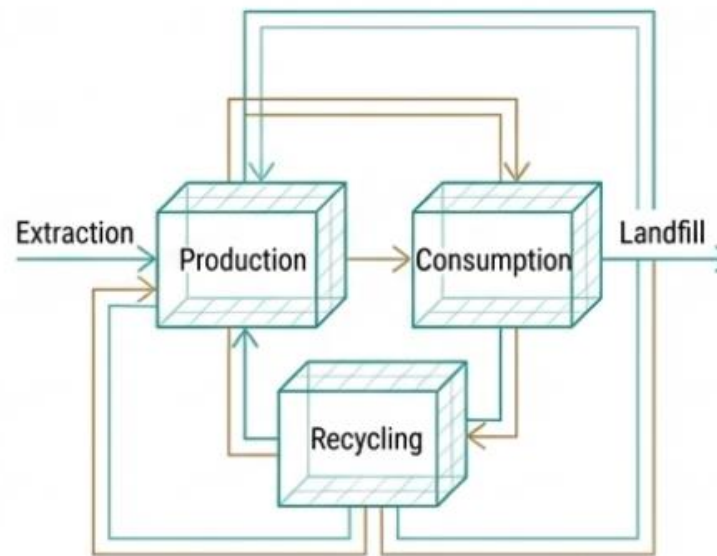
High volumes of mixed waste streams make informal or unmeasured management impossible to sustain.

Introduction: From Blind Spots to Data-Driven Management

Linear Economy



Industrial Metabolism



Traditional View

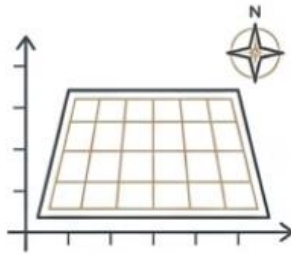
Economies treated natural resource requirements and outputs as an opaque black box with unknown internal dynamics.

The MFA Approach

Conceptualizes the economy through industrial metabolism, quantitatively evaluating the physical processes that convert raw materials into products and waste.

The Four Pillars of Material Flow Analysis

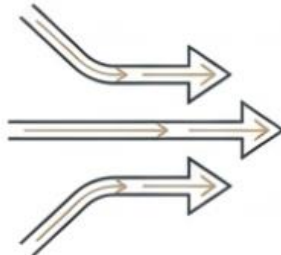
Space



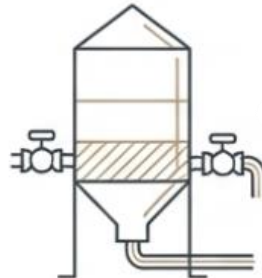
Time



Flows



Stocks

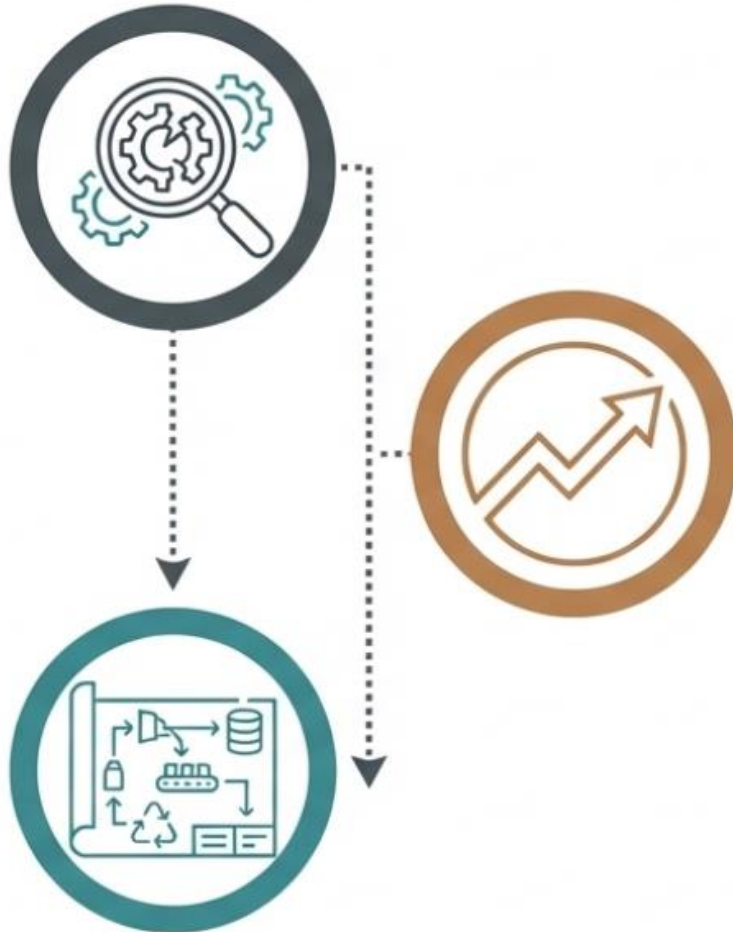


"A systematic assessment of the flows and stocks of materials within a system defined in space and time."

(Brunner & Rechberger, 2016)

Core Function

- Tracks exactly where materials are, how fast they are moving, and where they ultimately accumulate within the anthropogenic system.



1. Identify Inefficiencies

Pinpoint conversion processes in waste management (like sorting or reprocessing) that require immediate improvement.

2. Anticipate Accumulation

Project the future depletion of raw materials or the sudden excess of waste lacking processing capacity.

3. Design Infrastructure

Build compatible material flow systems with exact engineering capacities for collection, treatment, and recovery.

$$\text{Inputs} - \text{Outputs} = \Delta \text{ Stocks}$$

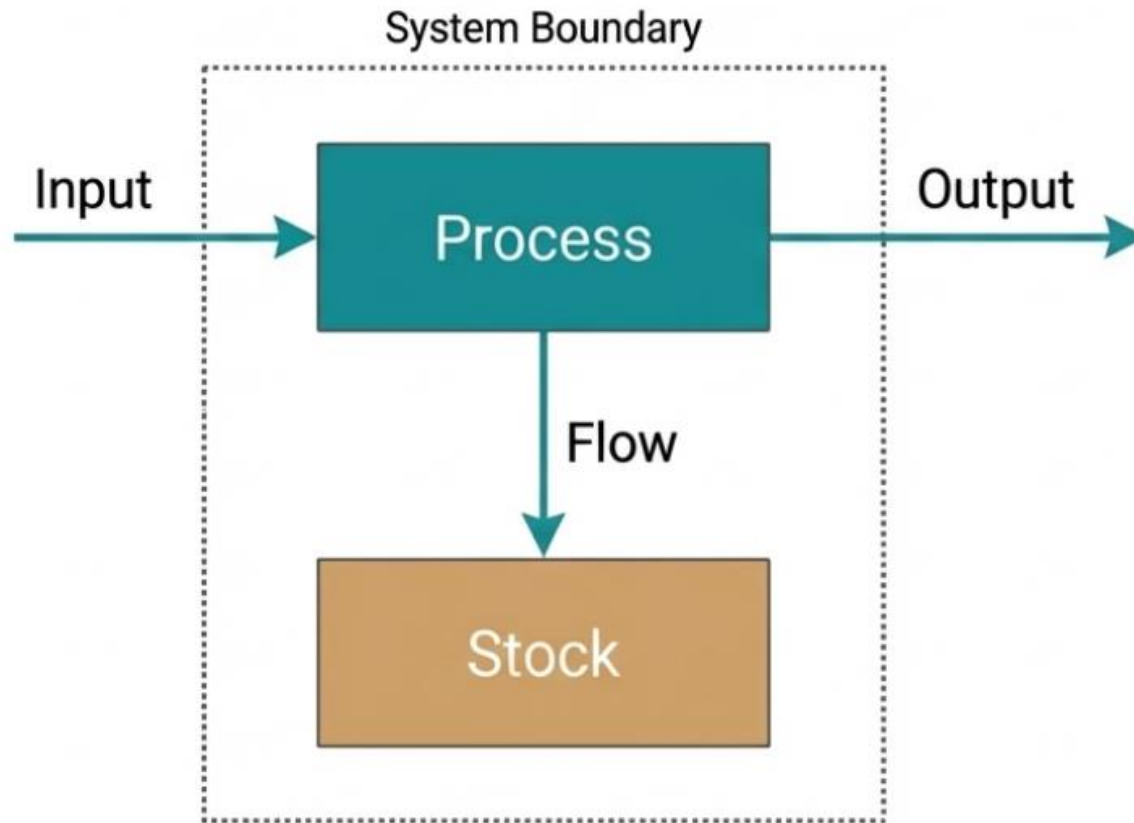


Conservation of Mass

For a closed system, physical mass cannot simply disappear or be created; it only changes form.

Closing Data Gaps

This principle is incredibly powerful. If real-world data is incomplete, knowing any two variables allows the analyst to mathematically calculate the missing third.



Materials

Physical substances (e.g., metals, plastics) entering the socio-economic system.

Processes

Transformation, transport, or storage of materials (e.g., a recycling plant).

Flows

The mass of a material moving between processes per unit of time (e.g., tons per year).



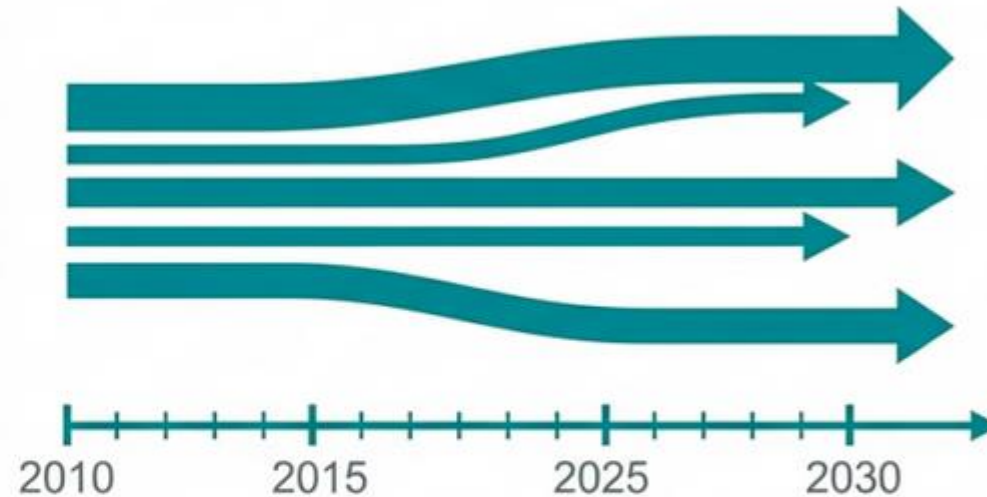
- MFA scales to fit the analytical objective.
- **Micro:** Optimizing a single Material Recovery Facility (MRF).
- **Meso:** Designing an urban municipal solid waste (MSW) network.
- **Macro:** Tracking economy-wide domestic material consumption.

Static MFA

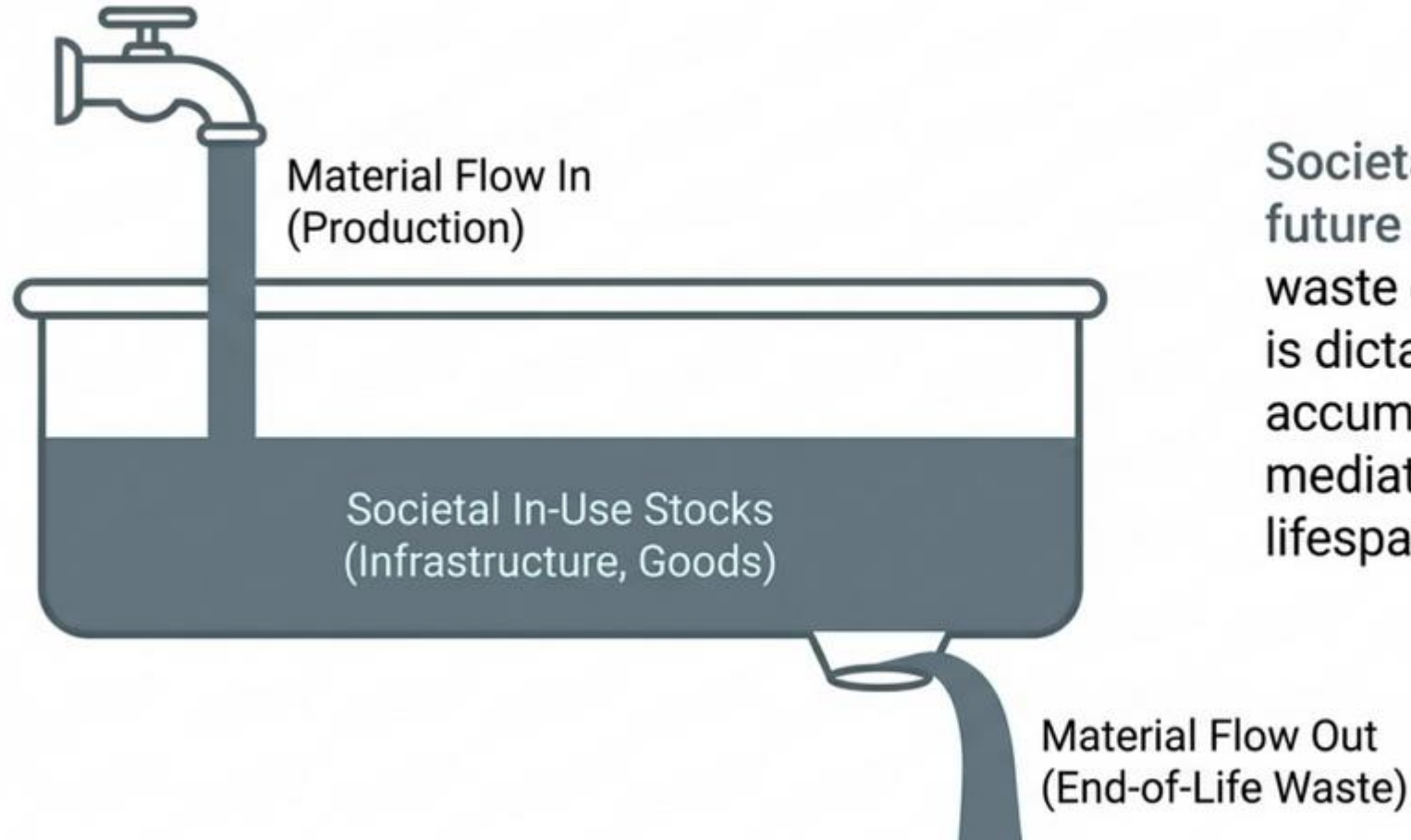


Static MFA: A cross-sectional snapshot of material balances for a single year. Ideal for establishing baseline performance.

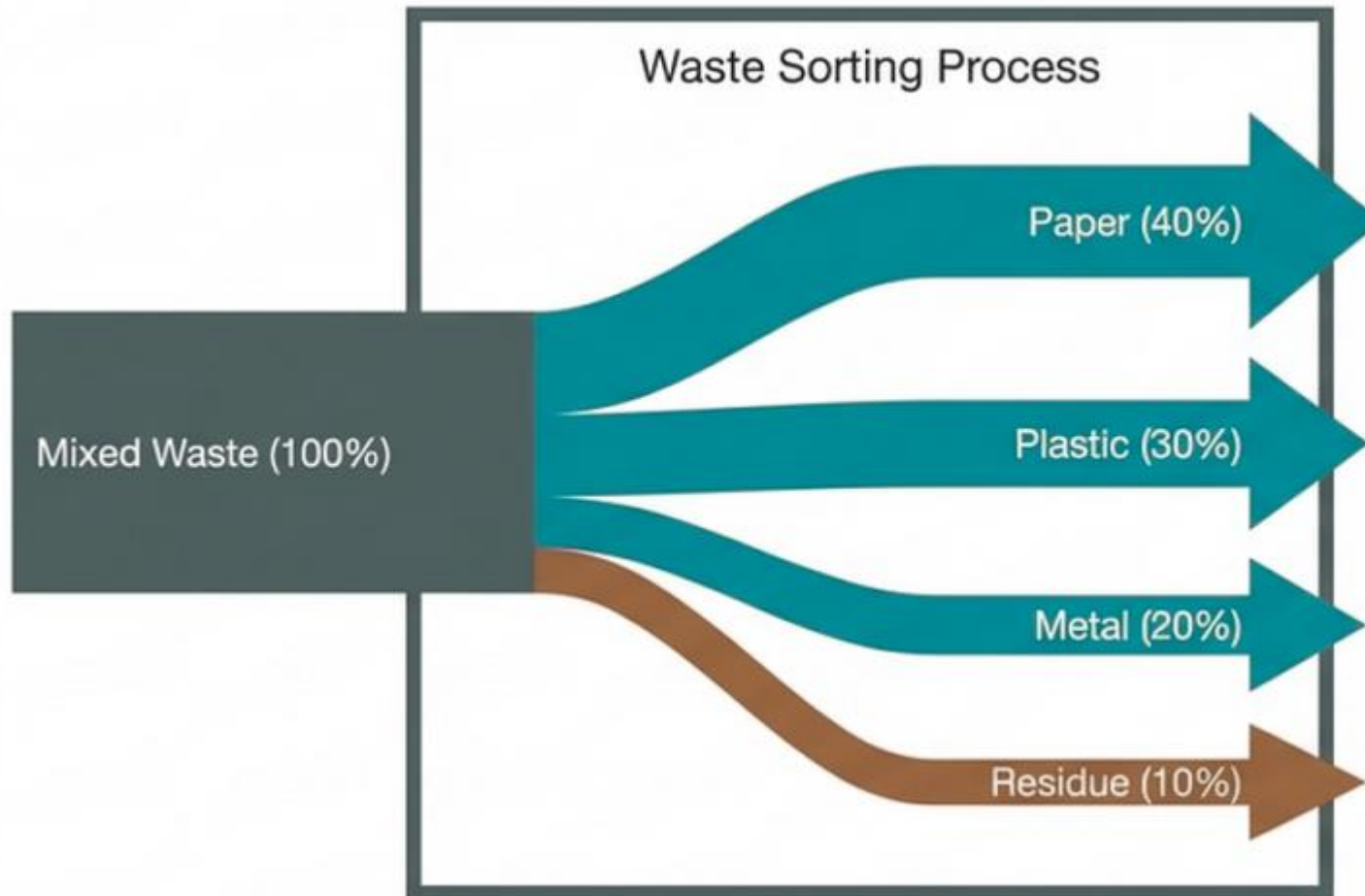
Dynamic MFA



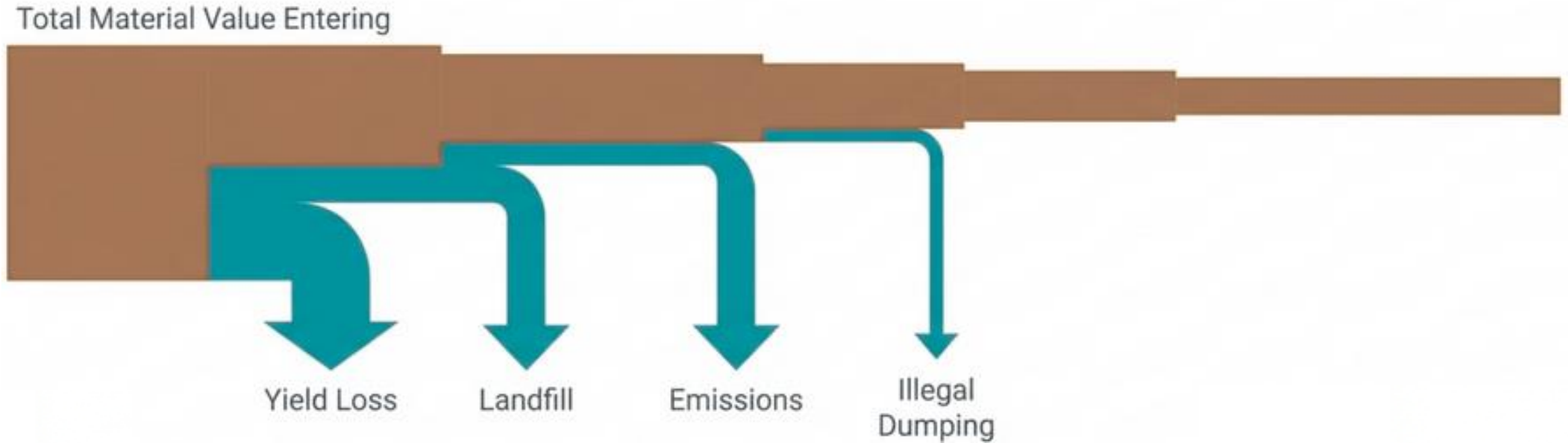
Dynamic MFA: Models how flows and stocks change over a time frame, relying on product lifetimes to forecast future waste outflows.



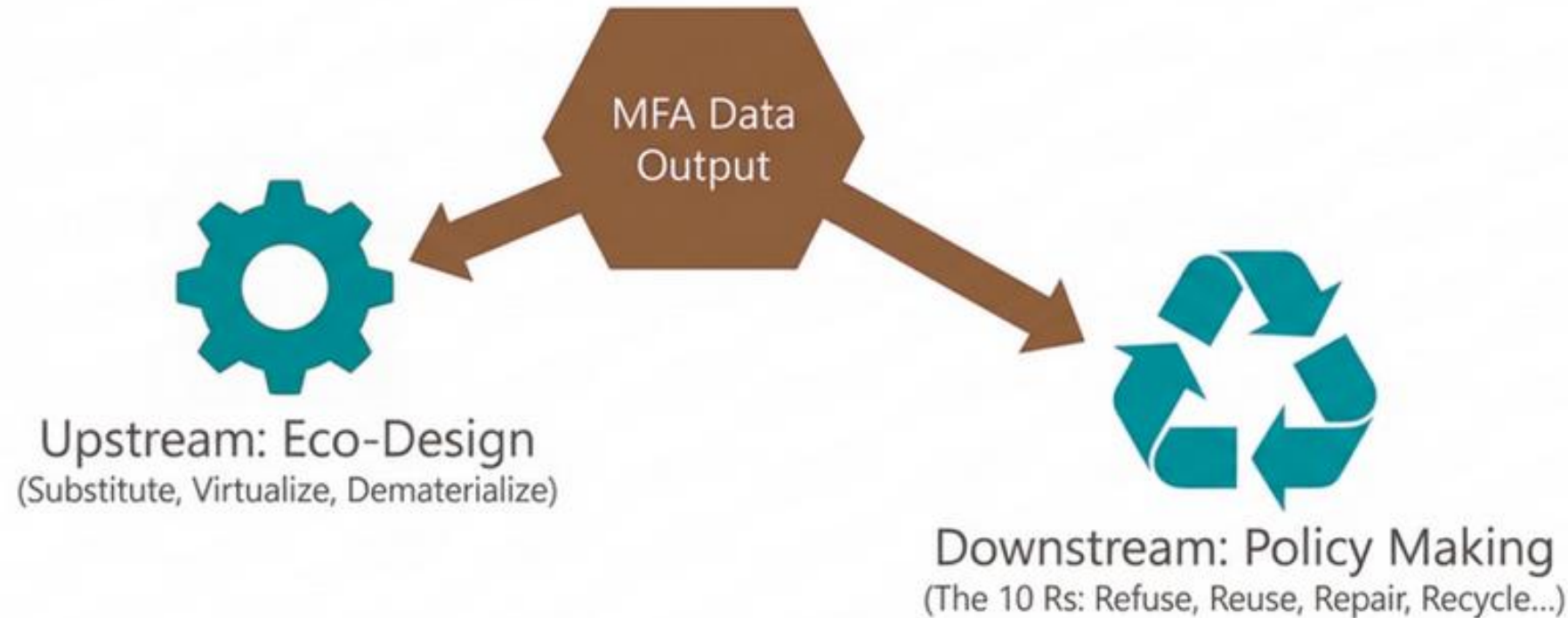
Societal stocks determine future waste. The volume of waste generated tomorrow is dictated by the materials accumulating in use today, mediated by product lifespans.



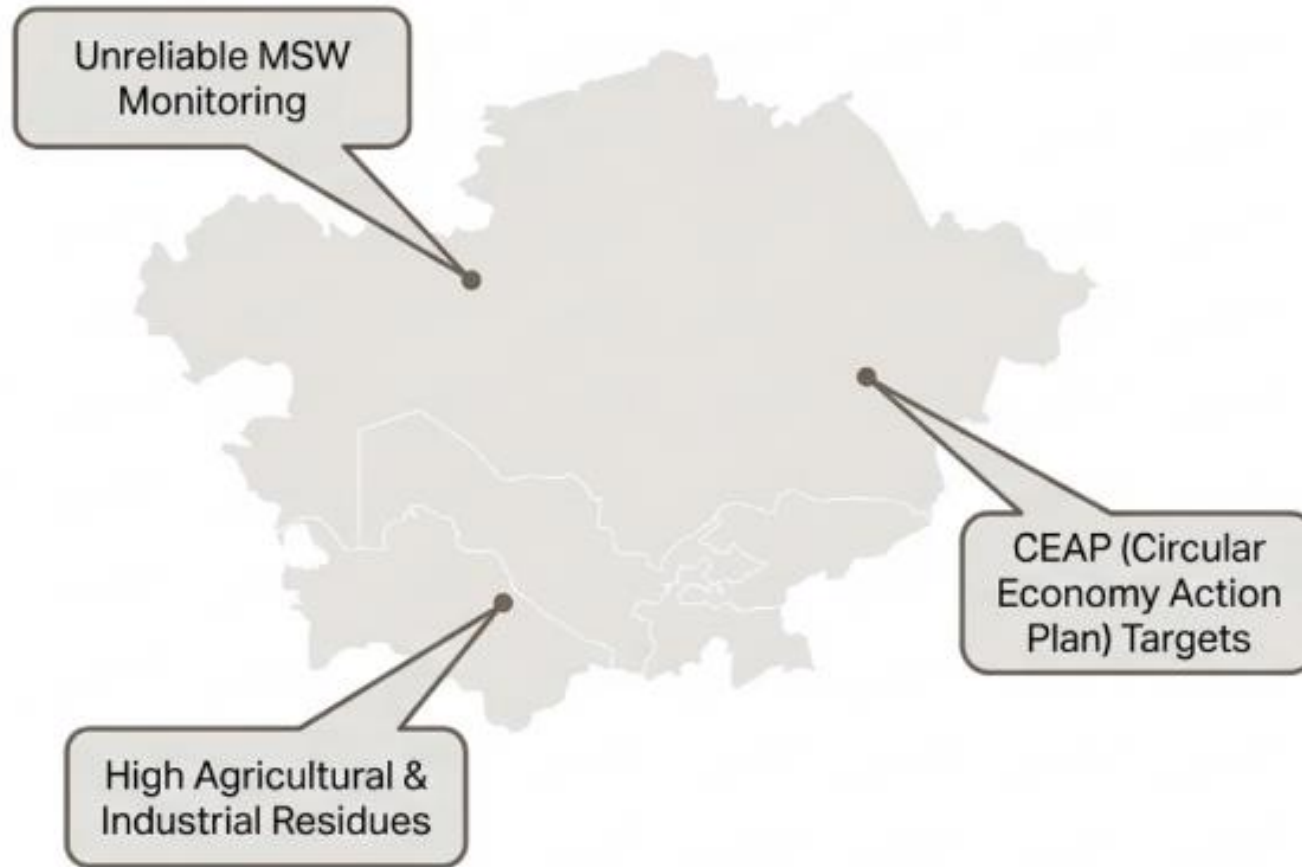
- Transfer coefficients describe the mathematical partitioning of materials within a specific process.
- Whether chemical conversion or mechanical separation, the sum of all output coefficients from a single process must always equal 1 (100%).



- Yield loss occurs during transformation, transport, and consumption.
- By tracking exact mass balances, MFA exposes precisely where and how much raw material value is leaking out of the economic system.



- MFA is the diagnostic engine of the Circular Economy.
- It provides the quantitative baseline required to decouple economic growth from finite resource consumption and design out waste.



- Regional transition requires localized data.
- Implementing MFA in Central Asia addresses critical data gaps in Municipal Solid Waste (MSW) tracking and establishes baselines for national Circular Economy Action Plans.



MICRO-CREDENTIAL

CIRCULAR ECONOMY FOR LAND AND WASTE MANAGEMENT

4.- Solid Waste Streams and Material Flows

Material Flow Analysis in the Circular Economy

CELWS-W04-V02



Co-funded by
the European Union

