



MICRO-CREDENTIAL

CIRCULAR ECONOMY FOR LAND AND WASTE MANAGEMENT

13.- Assessment Tools and Indicators of Circular Economy

Life Cycle Assessment basics

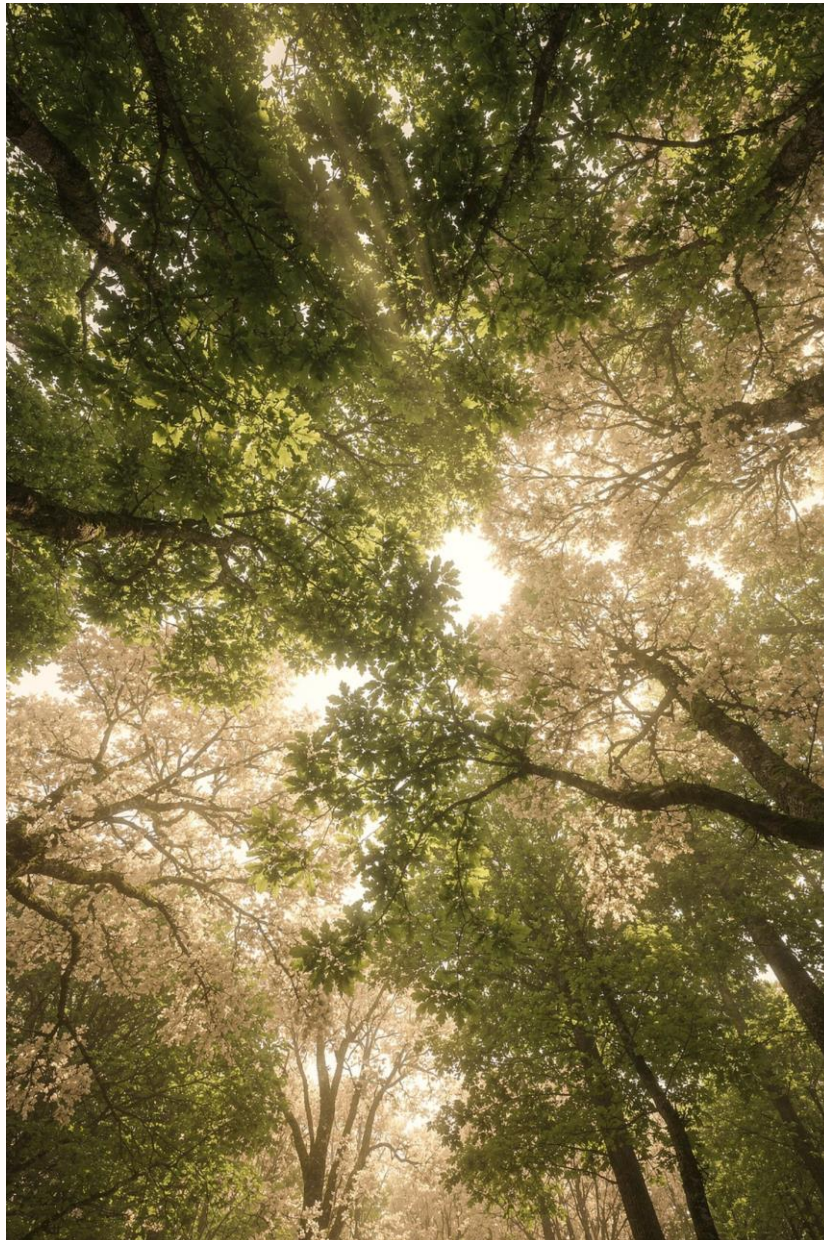
CELWS-W13-V03

Life Cycle Assessment (LCA) & Circular Economy Indicators

Tools for a Sustainable Future —
exploring how standardized
methodologies and circularity metrics
drive smarter, resource-efficient
decision-making.



Understanding Life Cycle Assessment (LCA)



A deep dive into the foundational methodology that quantifies environmental impacts across a product's entire journey — from raw material extraction to end-of-life disposal.

Standardized Methodology

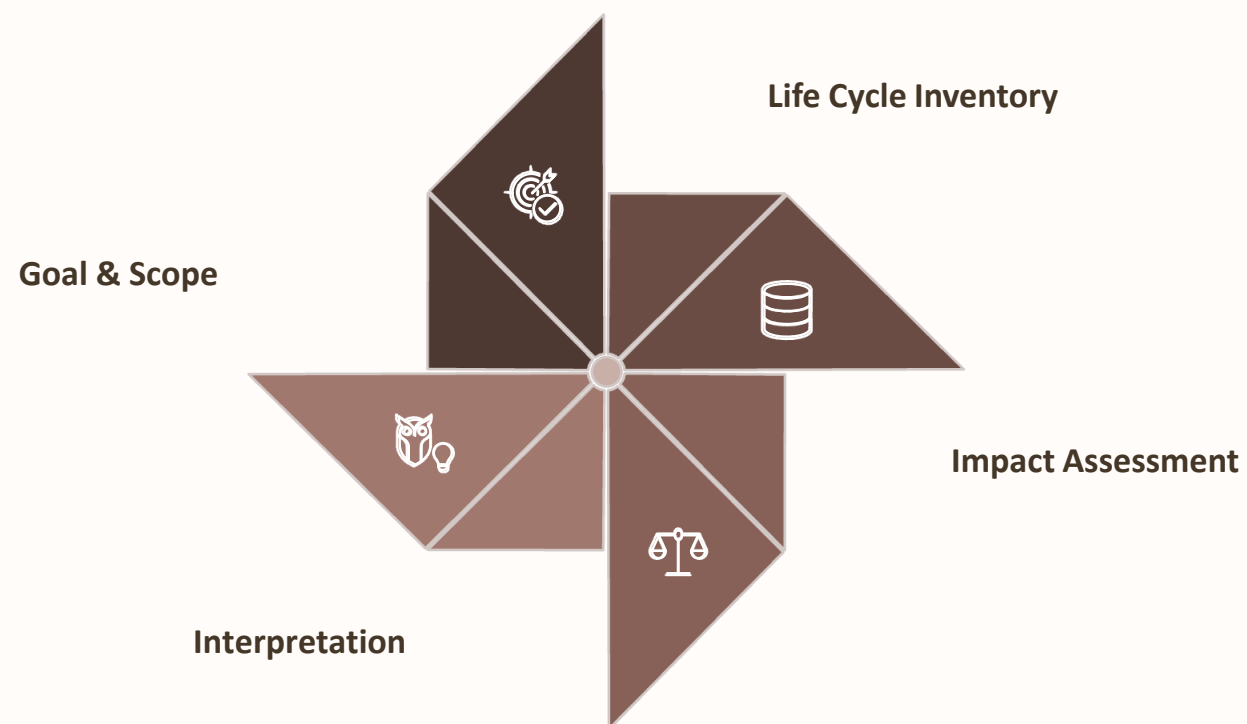
LCA is governed by ISO 14040 and ISO 14044, providing a globally recognized framework to evaluate the environmental impacts of a product system throughout its entire life cycle — from "cradle to grave."

What It Measures

LCA systematically compiles and evaluates all relevant inputs — such as raw materials and energy — and outputs — including emissions, waste, and co-products — to assess potential environmental burdens at every stage of a product's existence.

- Raw material extraction and processing
- Manufacturing and production
- Use, maintenance, and operation
- End-of-life treatment and disposal

The LCA Cycle at a Glance



The four phases of LCA are inherently iterative. Findings from the Interpretation phase often prompt revisiting earlier phases, refining assumptions, and improving data quality to ensure robust and credible conclusions.

LCA in Action: The European Commission's JRC

Joint Research Centre (JRC)

The JRC provides LCA practitioners with comprehensive handbooks, databases, and methodological guidance, acting as the scientific backbone for EU environmental policy and product sustainability legislation.

ILCD Handbook

The International Reference Life Cycle Data System (ILCD) handbook offers detailed guidance on conducting high-quality LCA studies, ensuring consistency, transparency, and scientific rigor across industries and sectors.

Environmental Footprint (EF)

The European Environmental Footprint methods establish harmonized impact assessment approaches, enhancing comparability of LCA studies across EU member states and enabling credible green claims in the marketplace.

Introducing Circularity Indicators



As circular economy principles gain global momentum, the need for robust, standardized tools to measure and verify circularity performance has never been greater.

The Core Goal

The circular economy aims to **decouple economic growth from resource consumption** — keeping materials, components, and products in use for as long as possible at their highest value.

- Reduce virgin resource extraction
- Minimize waste generation
- Regenerate natural systems

Why Measurement Matters

As the global transition to a circular economy accelerates, organizations, governments, and investors require reliable, quantifiable evidence of circularity performance. Without robust assessment tools, claims of "circularity" risk becoming vague or misleading greenwashing.

Circularity Assessment (CA) methodologies are still evolving — different frameworks emphasize different dimensions, from material flow efficiency to product longevity and business model innovation.

What the Series Addresses

- **ISO 59004:** Circular economy vocabulary, principles, and guidance
- **ISO 59010:** Business model and value network transition guidance
- **ISO 59020:** Measuring and assessing circularity performance
- **ISO 59040:** Product circularity data sheet

These standards aim to create a common language across industries, enabling consistent, comparable, and credible circularity reporting at every scale.

A Global Standard

The International Organization for Standardization (ISO) is actively developing the **ISO 59,000 family of standards** — a landmark effort to establish universal terminology, frameworks, and measurement approaches for the circular economy worldwide.

Key Circularity Indicators

Material Circularity Indicator (MCI)

Developed by the Ellen MacArthur Foundation, the MCI measures how well materials are kept in use across product life cycles, scoring products from 0 (fully linear) to 1 (fully circular).

Longevity Indicator

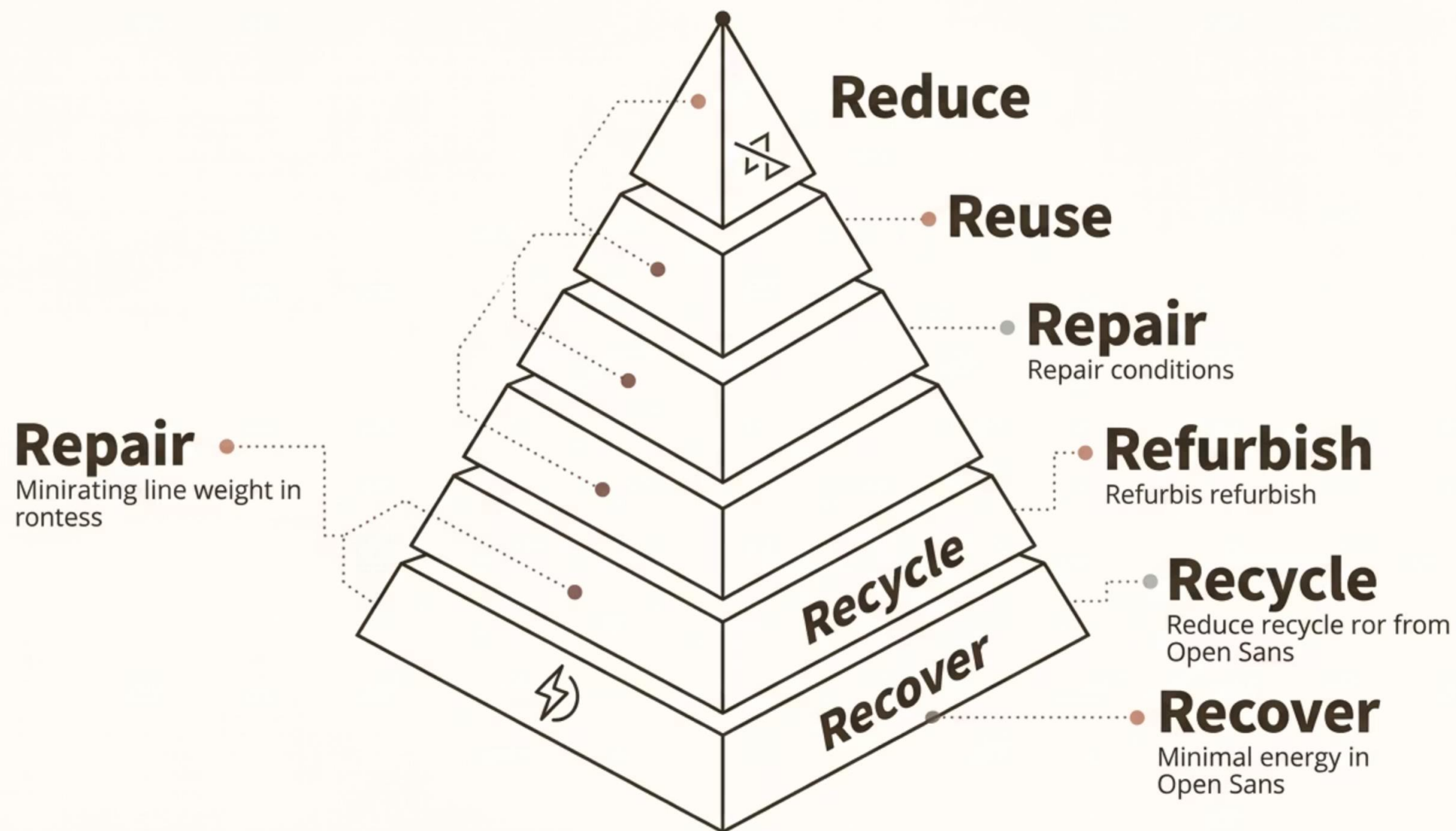
Evaluates the lifespan and durability of products, rewarding design choices that extend useful life through repairability, upgradability, and robust construction.

Circularity Measurement Toolkit

A practical, accessible toolkit tailored for manufacturing SMEs, enabling smaller businesses to quantify and improve their circularity performance without requiring specialist expertise.

Product Circularity Indicator

Assesses the circularity performance of a specific product, considering material composition, recovery pathways, and design-for-disassembly principles.



Integrating LCA and Circularity Assessment



Bringing LCA and Circularity Assessment together unlocks a more complete, nuanced picture of sustainability — bridging environmental performance with circularity measurement for truly informed decision-making.

Why Integration Matters

LCA and Circularity Assessment are powerful individually, but combining them addresses their complementary blind spots. LCA excels at quantifying environmental impacts across life cycle stages, while CA measures the degree to which a system keeps materials and products in circulation. Together, they provide a holistic view that neither tool can achieve alone.

Researchers worldwide are actively exploring frameworks to integrate these methodologies, recognizing that a circular product is not automatically an environmentally optimal one — and vice versa.

→ Embedding CA into the LCA Framework

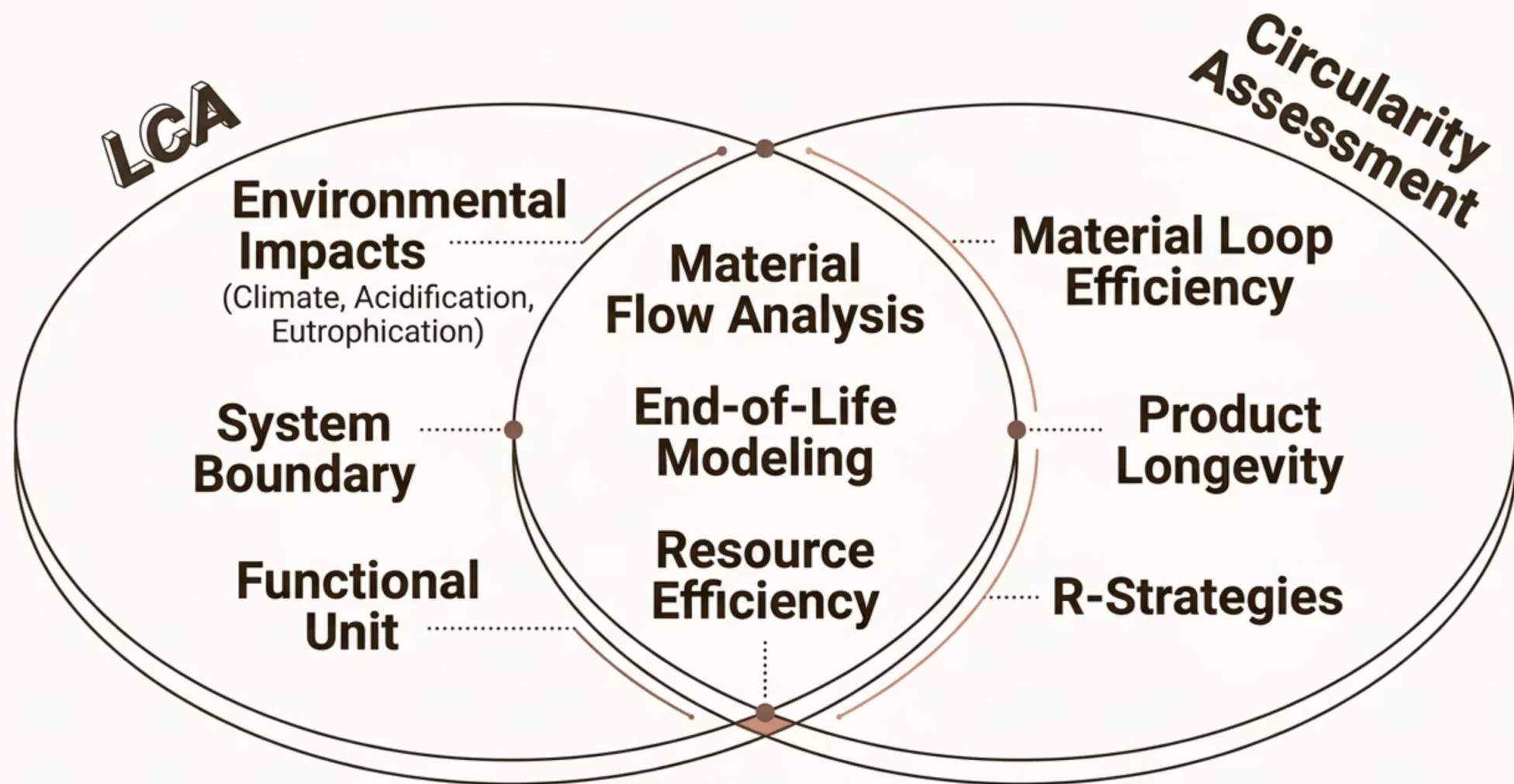
Circularity indicators are incorporated directly into the four-phase ISO 14040 structure — most commonly within the Inventory Analysis and Interpretation phases — allowing circularity metrics to complement standard environmental impact results.

→ Adapting LCA for CE Design Strategies

The LCA methodology is adapted to explicitly model circular design strategies such as remanufacturing, cascaded material use, and closed-loop recycling, enabling designers to compare the environmental performance of different circularity scenarios.

Integrating LCA with Specific Indicators

LCA results are combined with dedicated circularity metrics — particularly the Material Circularity Indicator (MCI) — creating dual-score assessment frameworks that communicate both environmental performance and circularity level simultaneously.



Diverse CE Interpretations

The circular economy concept is interpreted differently across disciplines, industries, and geographies. Without a shared definition, comparing or combining assessments becomes methodologically inconsistent and can lead to contradictory findings.

Environmental Dimension Dominance

Many existing integration studies focus overwhelmingly on environmental impacts, systematically neglecting the equally important social and economic dimensions of sustainability. This creates an incomplete picture that may overlook critical trade-offs.

Limited System-Level Perspective

Most assessments remain at the individual product or company level, failing to capture the systemic, value-chain-wide insights necessary for truly transformative policy and business decisions. Scaling to sector or economy-wide analysis remains a major research challenge.

The Circular Life Cycle Sustainability Assessment (C-LCSA) Framework

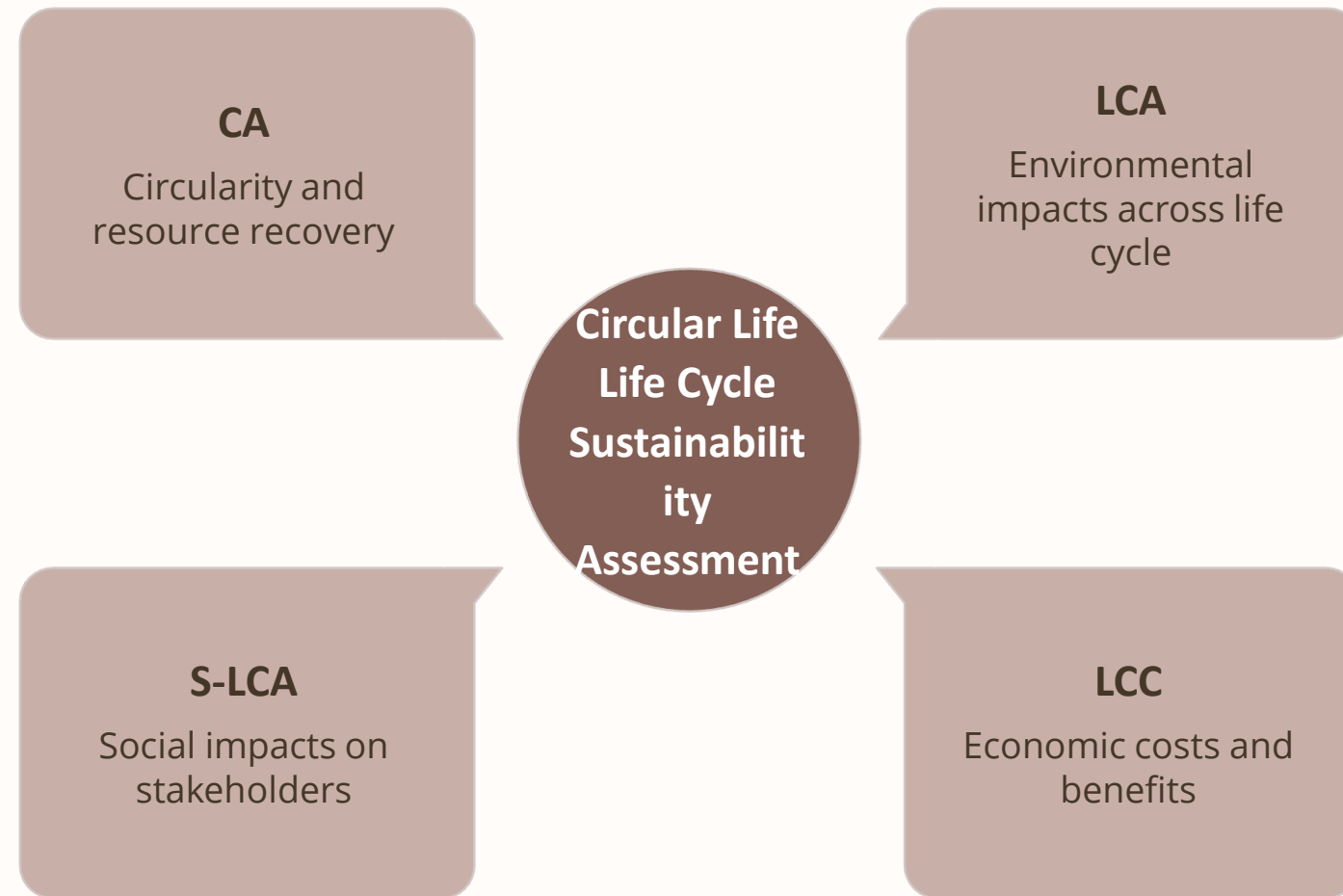
Origins and Authors

Developed by **Luthin, Traverso, and Crawford (2024)**, the C-LCSA framework represents a significant academic and practical advance in integrated sustainability assessment. It responds directly to the limitations of single-dimension tools and fragmented methodologies.

The framework's core equation:

$$\text{C-LCSA} = \text{LCA} + \text{LCC} + \text{S-LCA} + \text{CA}$$

The C-LCSA Framework: An Integrated Integrated Vision



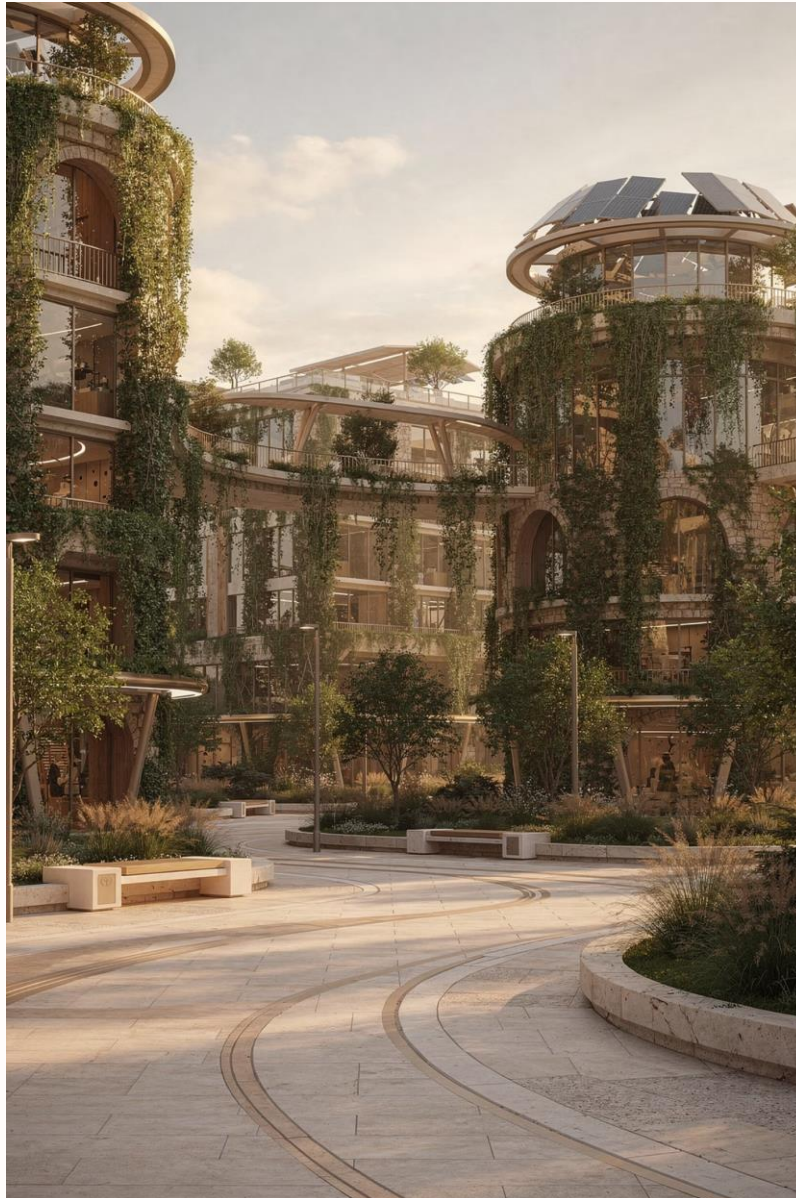
The C-LCSA framework is more than the sum of its parts. By integrating all four assessment components, it ensures that improving circularity does not come at the hidden cost of worsening social conditions or economic viability — enabling truly responsible and sustainable system design.

A Systematic Selection Process

Identifying the right circularity indicators for inclusion in the C-LCSA framework requires a rigorous, criteria-based selection methodology. Not all indicators are equally suitable — they must align with LCA's functional unit approach and provide additive rather than redundant information.

Key selection criteria include:

- **Performance:** Does the indicator reliably measure what it claims to measure?
- **Loops:** Does it capture the relevant circularity loops (inner vs. outer)?
- **Unit:** Is it expressed in compatible, quantifiable units?
- **Dimension:** Which sustainability pillar does it primarily address?
- **Transversality:** Can it be applied across different sectors and products?



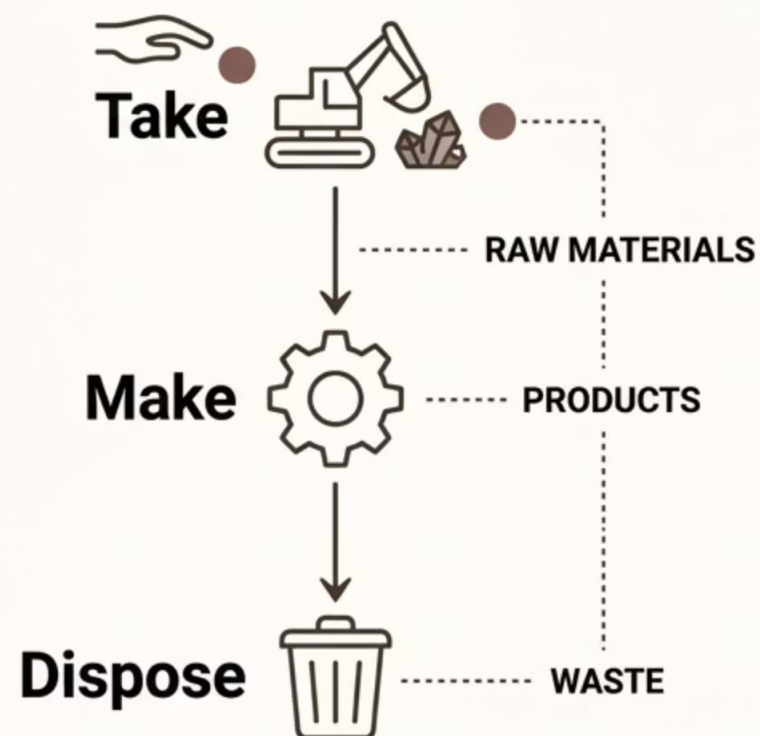
From evaluating real-world circular product systems to guiding policy and engaging diverse stakeholders — integrated LCA and circularity tools are shaping the next generation of sustainable design and decision-making.

Applying LCA to Circular Systems

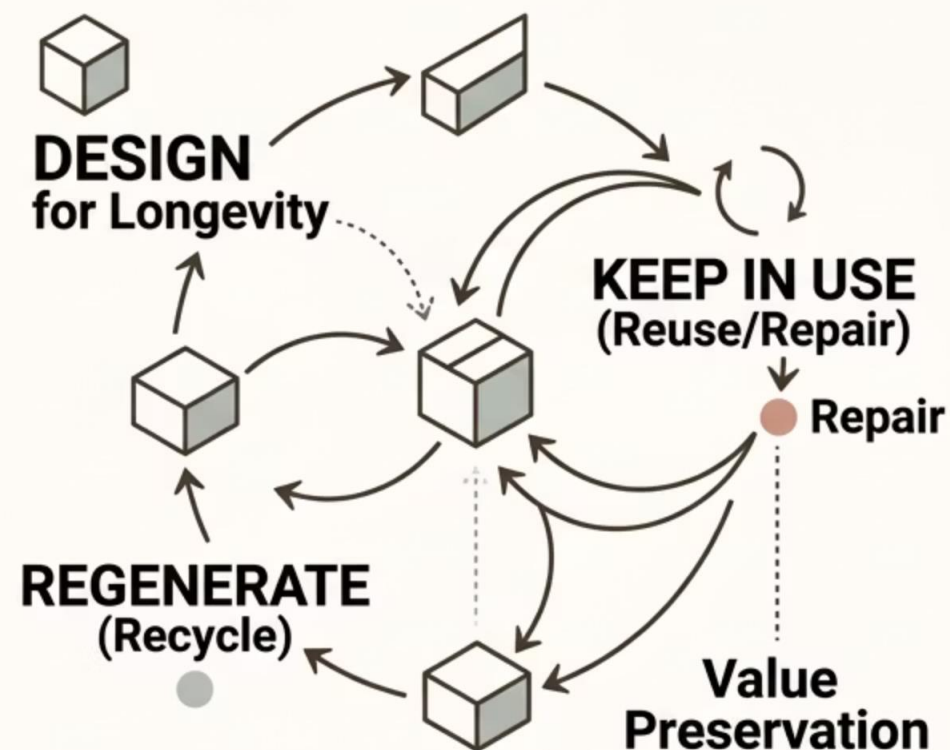
LCA can be applied to evaluate fully circular product systems — modeling scenarios where materials flow through multiple use cycles, remanufacturing loops, and cascaded applications. This enables quantification of both the environmental benefits and potential burdens of circularity strategies.

Transforming Linear to Circular

Emerging frameworks are being developed to systematically guide the transformation of conventional linear product systems into circular ones, identifying the most impactful intervention points and redesign opportunities within existing value chains.



Linear Economy:
Take, Make, Dispose.
One-directional flow leads to depletion and waste.



Circular Economy: Design to reuse, repair, remanufacture, recycle. Closed loops promote efficiency and value.

The Role of Stakeholders

Why Stakeholder Engagement is Essential

Integrated LCA and circularity assessments do not exist in isolation — their value is realized through the decisions they inform. Meaningful stakeholder engagement ensures that assessments reflect real-world priorities, constraints, and values across the entire value chain.

From product designers and manufacturers to consumers, regulators, and civil society, diverse perspectives must be incorporated throughout the assessment process — particularly in the Goal and Scope Definition phase, where system boundaries and priorities are established.

Towards a Truly Sustainable Circular Circular Economy

Integrated Tools are Essential

LCA and circularity assessment, used together within frameworks like C-LCSA, provide the evidence base needed for credible, comprehensive sustainability decision-making — moving beyond single-metric greenwashing.

A Multi-Dimensional Vision

True sustainability requires balancing environmental performance, economic viability, and social equity — the three pillars that C-LCSA is designed to address simultaneously, alongside rigorous circularity measurement.

The Path Forward

By advancing standardization (ISO 59,000), refining integration methodologies, and broadening stakeholder engagement, we can build a genuinely resource-efficient, regenerative, and equitable circular economy for future generations.