**X CONVEGNO**
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Rete Italiana LCA

# A PROPOSAL OF CUSTOMIZED LIFE CYCLE MODEL TO CIRCULARITY CHALLENGES IN THE OLIVE-OIL SUPPLY CHAIN

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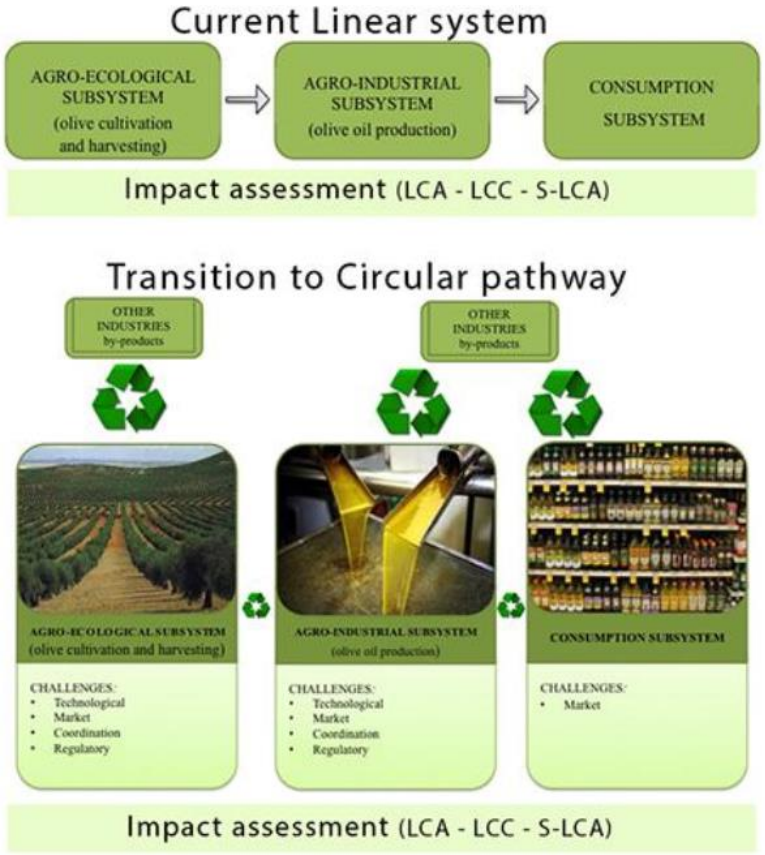
# GOAL AND SCOPE OF THE RESEARCH

- The research concerns the design of a **customized Life Cycle-based model** within the project of relevant national interest - **PRIN, 2017**, entitled "**DRiving the itAlian agri-food SysTem Into a Circular economy model**" (**DRASTIC**), funded by the Italian Ministry of Education, University, and Research (MIUR), to verify the environmental, economic, and social sustainability of circular economy strategies in the olive-oil sector.
- DRASTIC project was born with the objective of conceptualize the circular paradigm in the agri-food sector, with a focus on the edible olive oils, suggesting and comparing closed-loop solutions.
- Particularly, this study takes place within a specific work package, "**WP4 - Impact assessment**", of the PRIN project, aimed to implement Life Cycle (LC) approaches at the agro-ecological and agro-industrial subsystems of olive oil edible chain to capture all sustainability dimensions in a circular way.

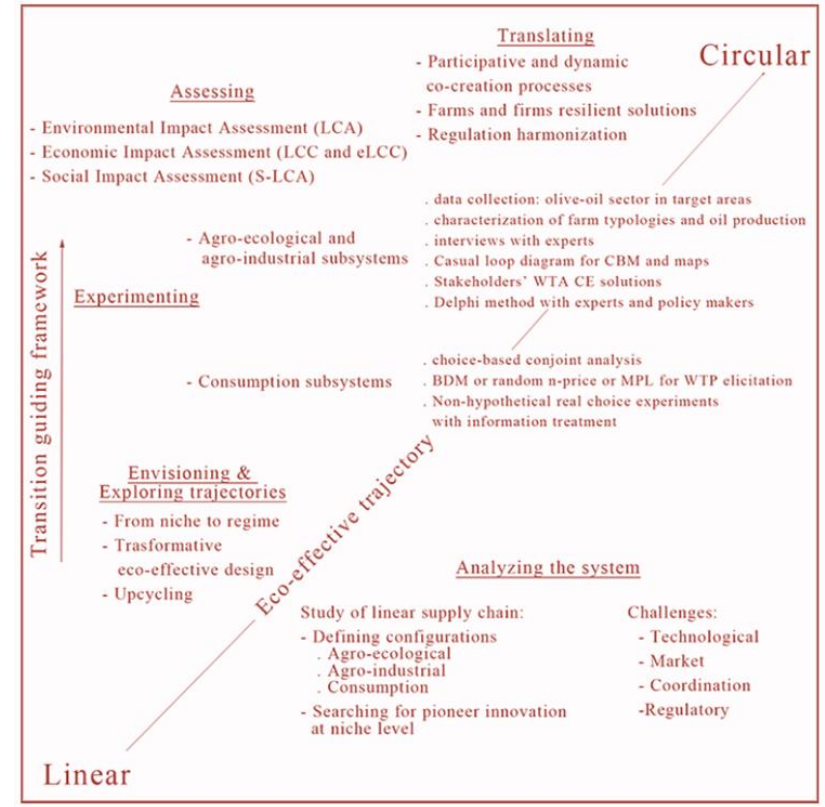
# DRASTIC RESEARCH PROJECT



DRASTIC
DRiving the itAlian food SysTem Into a Circular economy model

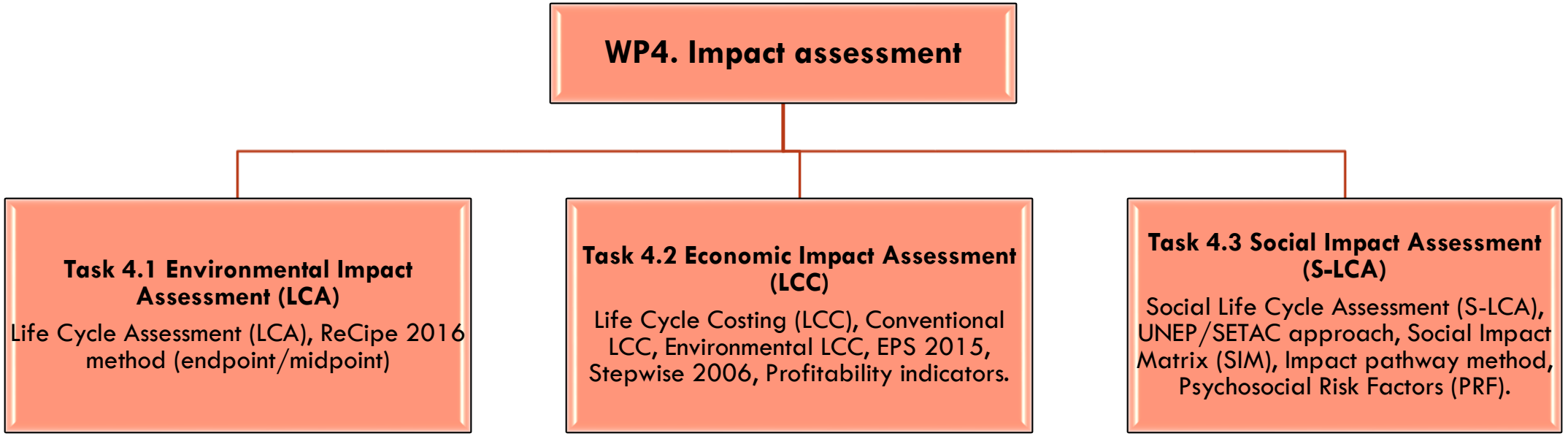



Project partners

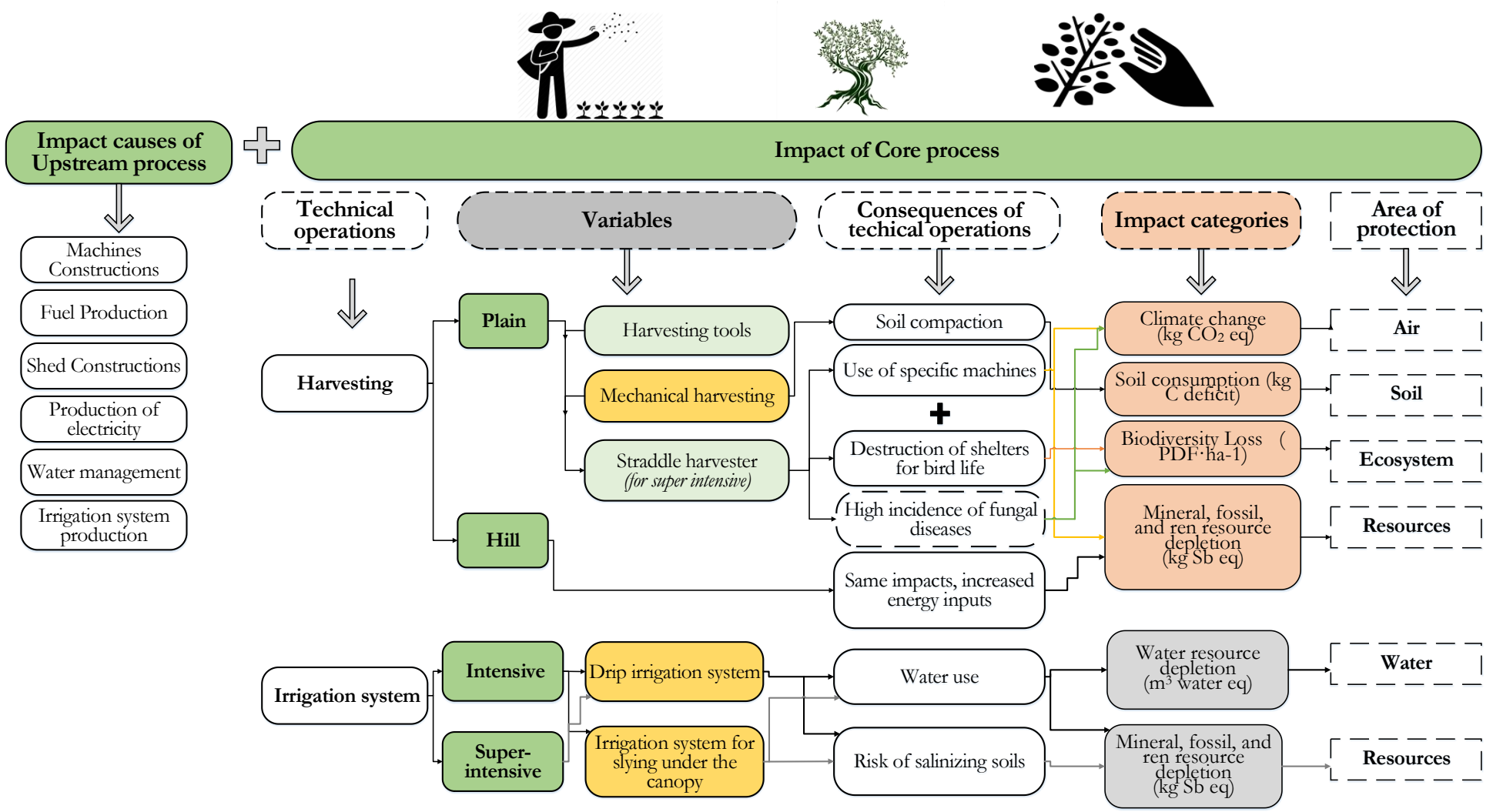



*This research is part of DRASTIC PRIN 2017 research project, project code: 2017JYRZFF, funded by the Italian Ministry of Education, University, and Research (MIUR).*

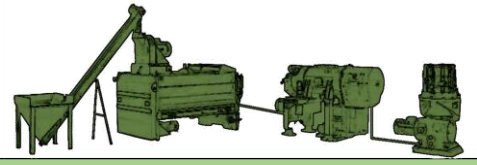
# WP4 "IMPACT ASSESSMENT" WITHIN THE DRASTIC PROJECT FRAMEWORK



# ENVIRONMENTAL CONCERNS OF SOME AGRICULTURAL OPERATIONS IN THE OLIVE OIL CHAIN



# ENVIRONMENTAL CONCERNS OF THE INDUSTRIAL PHASE IN THE OLIVE OIL CHAIN



**Impact causes of Upstream process**

- Machines Constructions
- Fuel Production
- Production of electricity
- Shed Constructions

**Impact of Core process**

**Stages of industrial transformation into an oil mill**

- Leaf removal and olive washing
- Malaxation

**Consequences of technical operations**

- Water use
- High energy inputs

**Stages of industrial transformation into an oil mill**

- Separation
- Discontinuous and continuous three-phase cycle
  - Discontinuous cycle produces: between 400 and 600 liters of vegetation water per ton of olives.
  - Continuous three-phase cycle produces: between 800 and 1000 liters of vegetation water for ton of olives
- Continuous two-phase cycle
  - Pomace with low water content
  - Pomace with high water content

**Consequences of techical operations**

- High water use
- OMW production
  - High water added
  - Acid reaction, repercussion C.S.C
  - Eutrophication
  - In water a dark fil is formed which does not let light through
  - Pollution by polyphenols (g. -1 L)
  - Cod (g.O2 L-1), Bod (g.O2 L-1)

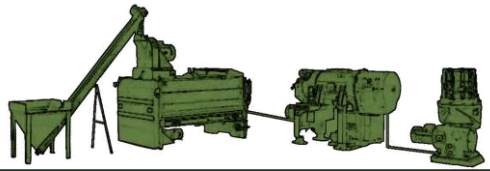
**Impact categories**

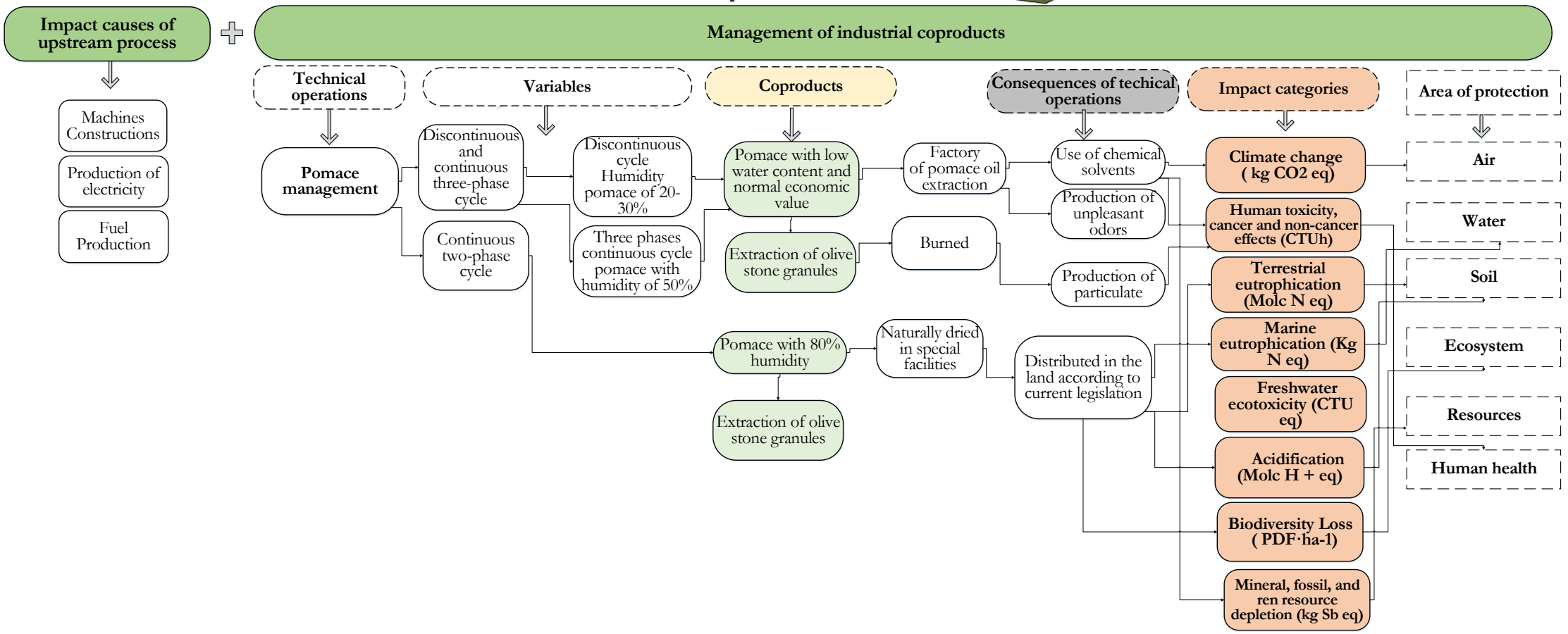
- Climate change ( kg CO2 eq)
- Mineral, fossil, and ren resource depletion (kg Sb eq)
- Human toxicity, cancer and non-cancer effects (CTUh)
- Terrestrial eutrophication (Molc N eq)
- Marine eutrophication (Kg N eq)
- Freshwater ecotoxicity (CTU eq)
- Water resource depletion (m3 water eq)
- Acidification (Molc H + eq)
- Biodiversity Loss ( PDF·ha-1)

**Area of protection**

- Air
- Water
- Soil
- Ecosystem
- Resources
- Human health

# ENVIRONMENTAL CONCERNS OF THE OLIVE-OIL COPRODUCT MANAGEMENT





# COMMON ISSUES WHEN COMPARING LCA AND MCI APPROACHES

- ***LCAs*** are traditionally defined using system boundaries that typically extend ***from the creation of the product to its disposal*** and are often bound by region specific assumptions (for example energy mix). The **Material Circularity Indicator** (**MCI**) similarly ***considers a product from the source of its materials to the destination of those materials through the use of the product*** and also requires region specific assumptions (for example recycling infrastructure).

- ***The circular economy doesn't*** commonly ***stop with a single product lifecycle*** and we are instead encouraged to think beyond the initial product to the reuse of components, their remanufacture and recycling. ***For biological materials, we are*** similarly ***encouraged to consider where these originate, how to maintain them as uncontaminated materials and to return them to the biological cycle as accessible nutrients.***

*Fonte: Goddin, J.; Marshall, K.; Pereira, A.; Herrmann, S. (2019) Circularity Indicators - An Approach to Measuring Circularity. Methodology. The Ellen MacArthur Foundation*

# COMMON ISSUES WHEN COMPARING LCA AND MCI APPROACHES

- **As products designed for the circular economy will contain components with different durability, and as the life and use of each cycle will differ depending upon the nature of the user, it is clear that the *circularity of the first lifecycle of a product will most likely be different to the second, third, etc.***

- When we start thinking about multiple life cycles, it also quickly becomes apparent that the additional transportation, for reverse logistics for example, starts to contribute more significantly in some cases to the overall economic and environmental assessment of the product. Such impacts would commonly be missed by the typical system boundaries of a more traditional linear LCA focused on a single life cycle of a product.

*Fonte: Goddin, J.; Marshall, K.; Pereira, A.; Herrmann, S. (2019) Circularity Indicators - An Approach to Measuring Circularity. Methodology. The Ellen MacArthur Foundation.*

# FINDINGS OF A SYSTEMATIC AND CRITICAL REVIEW OF LIFE CYCLE APPROACHES TO ASSESS CIRCULAR ECONOMY PATHWAYS IN THE AGRI-FOOD SECTOR

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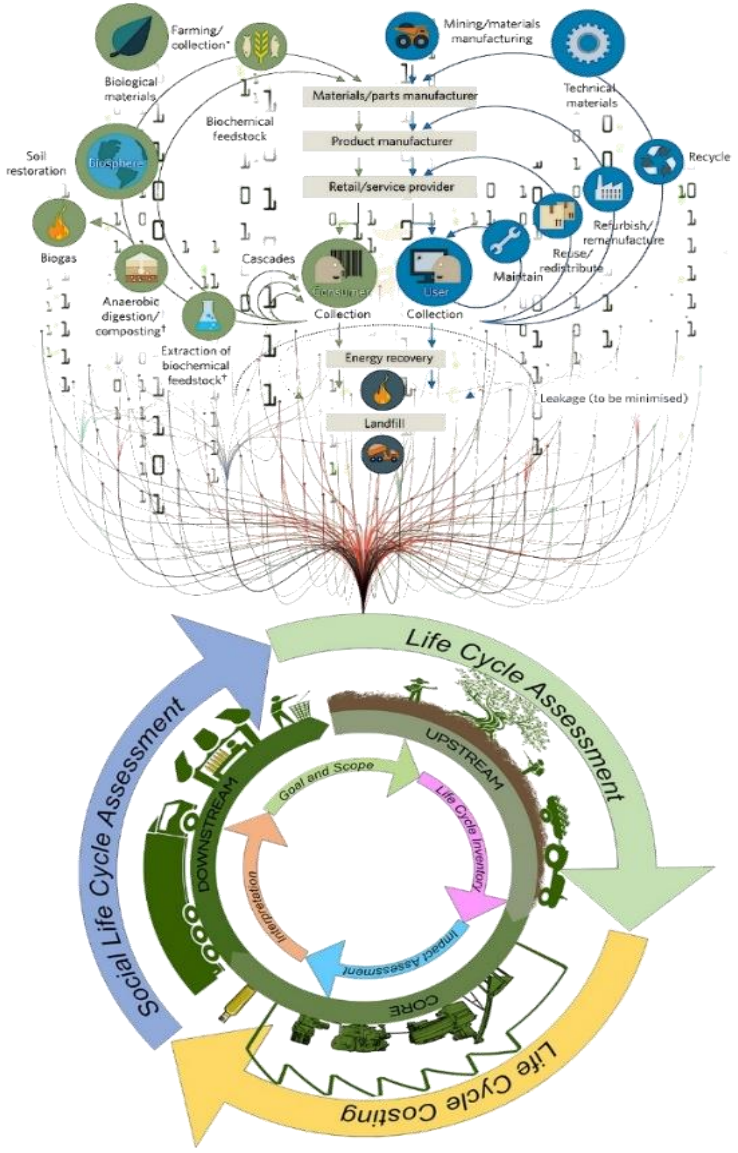
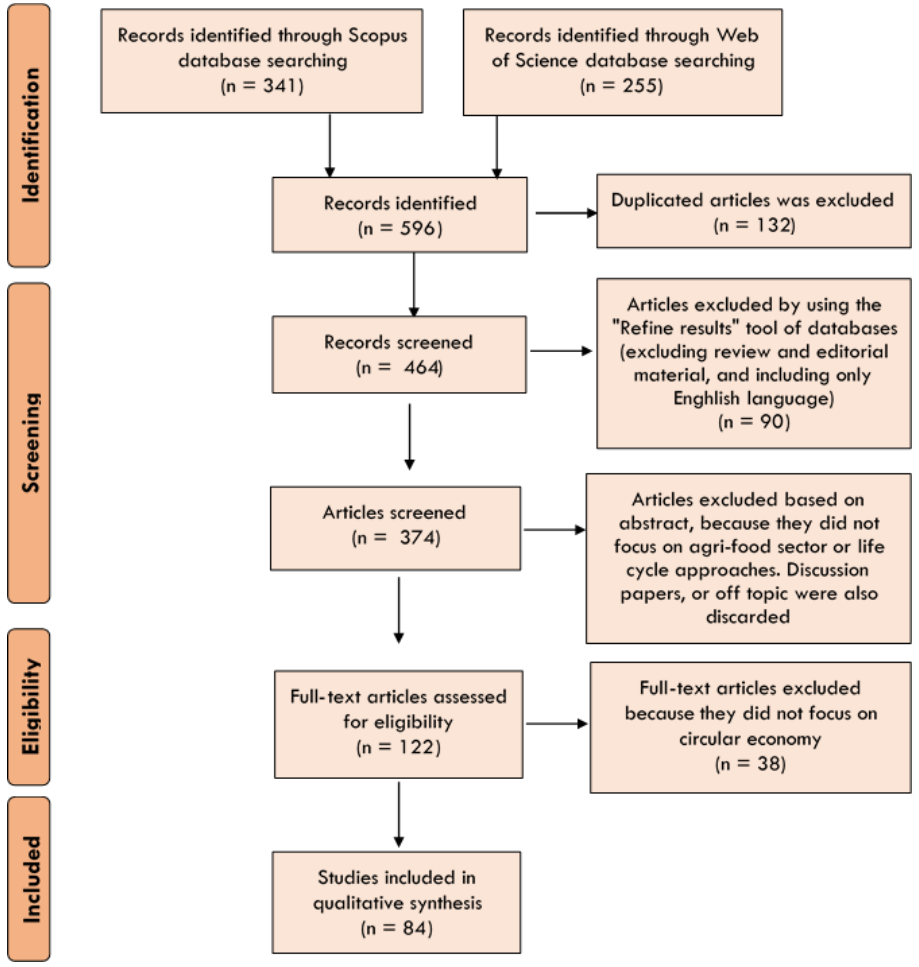
Query used in database searching.

| | Search strings |
|---|---|
| **Scopus** | (TITLE-ABS-KEY ("circular economy") AND TITLE-ABS-KEY ("life cycle assessment" OR "life cycle analysis" OR "life cycle costing" OR "social life cycle assessment" OR "life cycle sustainability assessment" OR lca OR lcc OR "s-lca" OR slca OR "social-lca" OR lcsa) AND ALL (agr* OR food)) |
| **Web of Science** | TOPIC: ("circular economy") AND TOPIC: ("life cycle assessment" OR "life cycle analysis" OR "life cycle costing" OR "social life cycle assessment" OR "life cycle sustainability assessment" OR lca OR lcc OR s-lca OR slca OR "social-lca" OR lcsa) AND ALL FIELDS: (agr* OR food) |




Methodological steps of the literature search process using the PRISMA flow diagram (Moher et al. 2009).




*Fonte: Stillitano, T.; Spada, E.; Iofrida, N.; Falcone, G.; De Luca, A.I. Sustainable Agri-Food Processes and Circular Economy Pathways in a Life Cycle Perspective: State of the Art of Applicative Research. Sustainability 2021, 13, 2472.*

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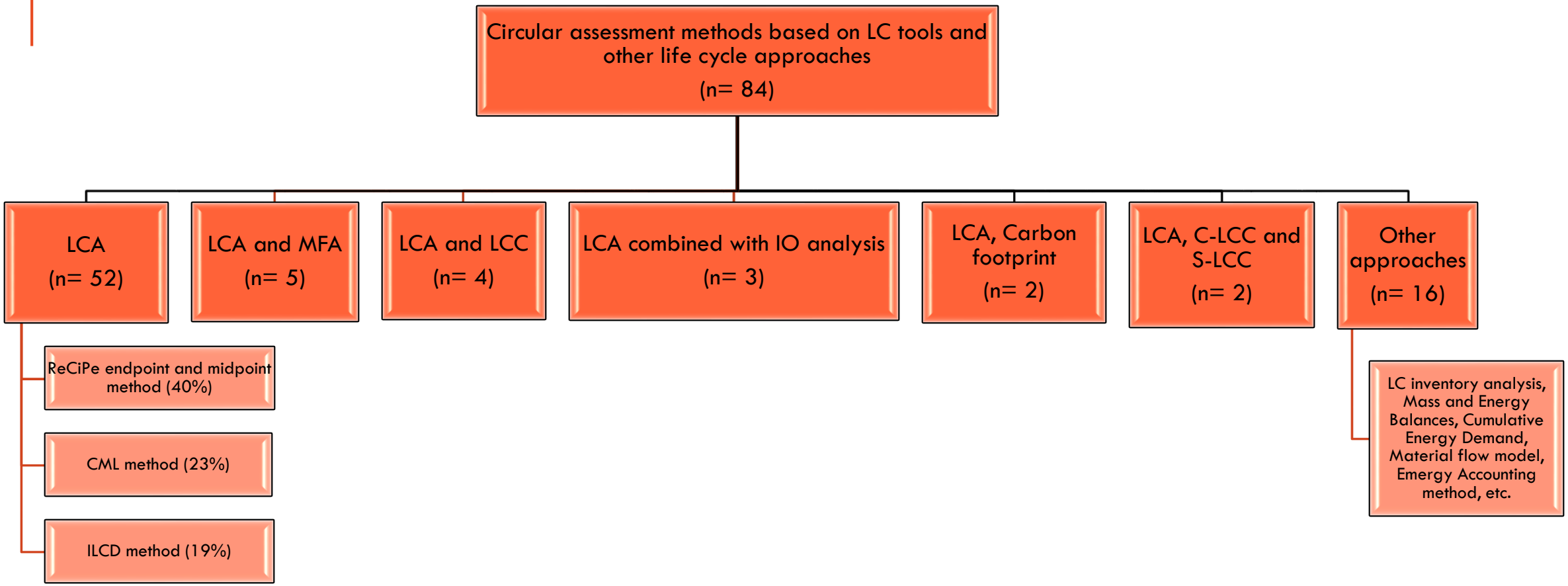


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| # ID Paper | Authors | Circularity assessment method | Circularity indices (measuring the circular degree of a system) | CE assessment indicators (assessing the effects of circularity) |
|---|---|---|---|---|
| | | | | Life cycle based-indicators |
| 1 | Cobo et al. 2018 | LCA and MFA | Carbon circularity indicator (CIC)<br>Nitrogen circularity indicator (CIN)<br>Phosphorus circularity indicator (CIP) | Global warming, Marine eutrophication, Freshwater eutrophication |
| 2 | Hoehn et al. 2019 | LCA, MFA, Energy flow analysis | Energy return on investment -circular economy index (EROIce) | Primary Energy Demand (PED) |
| 3 | Laso et al. 2018 | LCA and LCC | - | Global Warming Potential, Acidification Potential, Eutrophication Potential, ReCIPE Single Score (SS), Value-added (VA) indicator, Eco-efficiency index (EEI) |
| 4 | Lokesh et al. 2020 | LCA | - | Global warming potential, Respiratory inorganics, Human toxicity, Cancer, Acidification, Terrestrial and freshwater, Freshwater eutrophication, Water scarcity, Fossil resource depletion.<br>Hazardous chemical use, Circular-process feedstock intensity (CPFI), Circular-process waste factor (CPWF), Process material circularity (PMC), Product renewability (PR), Circular-process energy intensity (CPEI). |
| 5 | Niero and Kalbar, 2019 | LCA | Material Reutilization Score (MRS)<br>Material Circularity Indicator (MCI) | Climate Change, Abiotic Resource, Depletion, Acidification,<br>Particulate Matter, Water Consumption |
| 6 | Schmidt Rivera et al. 2019 | LCA | Amount of material, Mono or multi-components, Recycling content, Reuse rate, Current waste management, Current recycling rate, Potential recyclability, Use of renewable materials, Use of renewable energy | Climate change, Depletion of fossil fuels, Depletion of metals, Primary energy demand (PED) |
| 7 | Stanchev et al. 2020 | LCA and MFA | Material circularity performance indicator (MCPI) | Environmental circularity performance indicator (ECPI) |

*Fonte: Stillitano, T.; Spada, E.; Iofrida, N.; Falcone, G.; De Luca, A.I. Sustainable Agri-Food Processes and Circular Economy Pathways in a Life Cycle Perspective: State of the Art of Applicative Research. Sustainability 2021, 13, 2472.*

# FINDINGS OF A SYSTEMATIC AND CRITICAL REVIEW OF LIFE CYCLE APPROACHES TO ASSESS CIRCULAR ECONOMY PATHWAYS IN THE AGRI-FOOD SECTOR

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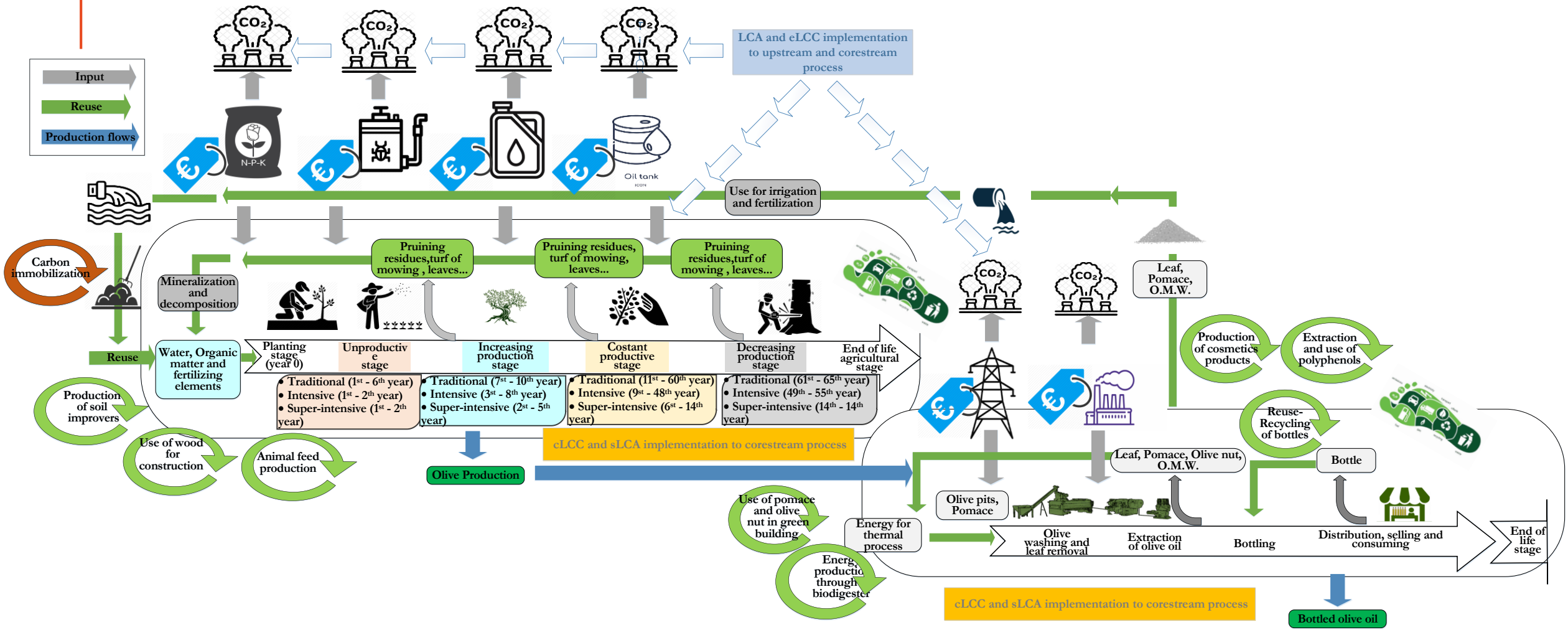
- The **problem** also stays in the different views of the **life cycle:**
  - in the case of impact evaluation, it is **limited to cradle-to-gate or cradle-to-grave** analyses;
  - the **circularity evaluation** would **require** an extension of the system boundaries to more life cycles, in a **cradle-to-cradle perspective.**
- Then, **an LCA** complementary to a circularity assessment framework **should always assess the whole life cycle** of a product **and should consider its possible extensions,** expanding also the time boundaries of the study **by considering at least more than one life cycle.**
- Despite these limitations, it is evident how LC methodologies allow an improved understanding of the sustainability implications of CE strategies: they are not fully implemented or exploited to provide a circularity measure in a life cycle perspective; however, they allow evaluating environmental, economic and social impacts of circular strategies.

*Fonte: Stillitano, T.; Spada, E.; Iofrida, N.; Falcone, G.; De Luca, A.I. Sustainable Agri-Food Processes and Circular Economy Pathways in a Life Cycle Perspective: State of the Art of Applicative Research. Sustainability 2021, 13, 2472.*

# DESIGN OF LIFE CYCLE-BASED MODEL TO ASSESS CIRCULARITY PATHWAYS IN OLIVE-OIL CHAIN



# CONVENTIONAL LIFE CYCLE MODELLING

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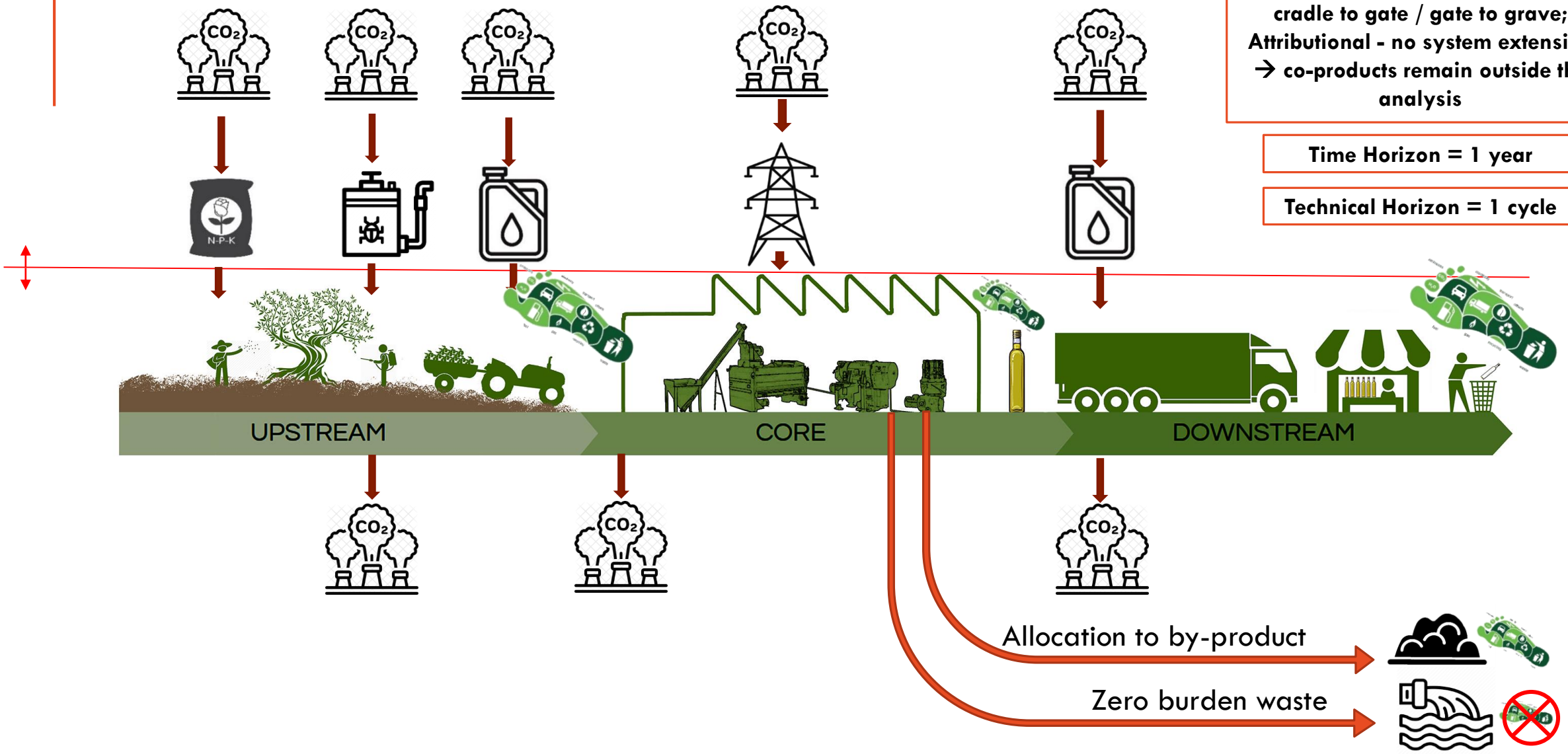
Background processes

Foreground processes



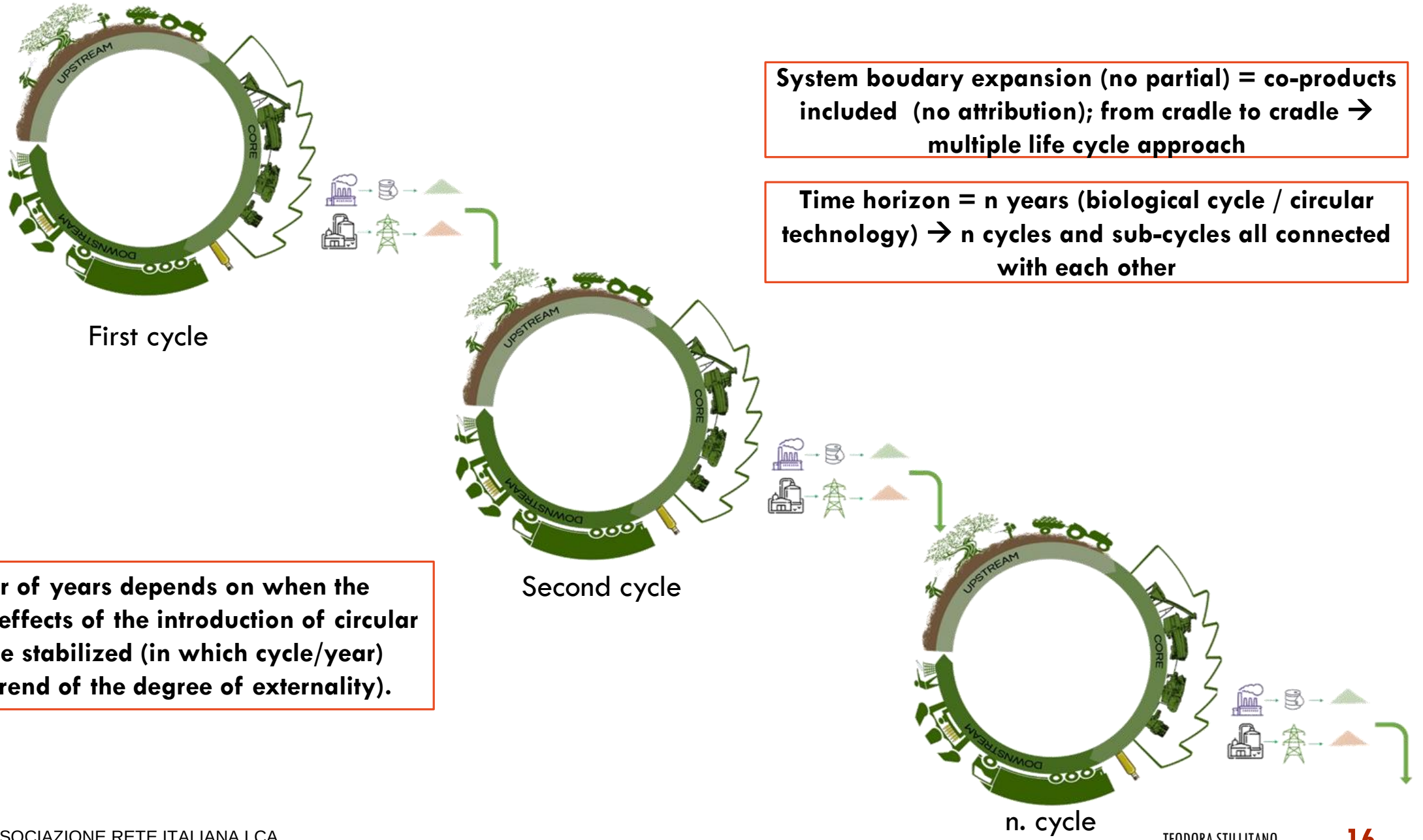

**Partial system boundaries = cradle to gate / gate to grave; Attributional - no system extension → co-products remain outside the analysis**

**Time Horizon = 1 year**

**Technical Horizon = 1 cycle**

# PROPOSAL APPROACH FOR MULTIPLE LIFE CYCLE MODELLING






**System boudary expansion (no partial) = co-products included (no attribution); from cradle to cradle → multiple life cycle approach**

**Time horizon = n years (biological cycle / circular technology) → n cycles and sub-cycles all connected with each other**

**The number of years depends on when the environmental effects of the introduction of circular strategies are stabilized (in which cycle/year) (decreasing trend of the degree of externality).**

# CONCLUSIONS

- The methodological development of the life cycle approaches in the circularity assessment of processes and products is constantly evolving and new tools are increasingly being tested by the scientific community to identify the most effective ones.
- Experts in life cycle methodologies must strive to adopt some key elements to ensure that the results obtained fit perfectly with the measurements of circularity and that these can even be largely based on a common basis.
- The effort must also go in the direction of operability of the framework for measuring circularity and sustainability, so that it does not have the opposite effect of an assessment structure that is so complex that it is hardly usable, thus thwarting efforts to create new models of sustainable agri-food production and consumption.

# GRAZIE PER L'ATTENZIONE!

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