SUSTAINABILITY ASSESSMENT OF CIRCULAR STRATEGIES IN AGRICULTURAL: A LCA APPROACH

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Scientific disciplinary sector: AGR/01 Economia ed Estimo Rurale

Reggio Calabria, 30 Settembre 2021

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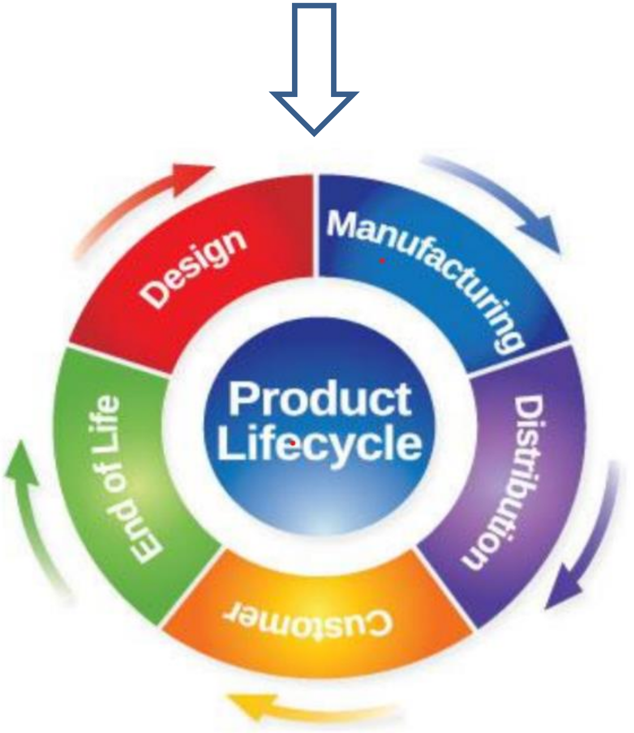
LIFE CYCLE THINKING (LCT)

Decisions made in isolation, focused on individual sustainability objectives or on one single dimension, a single aspect environmental, often give rise, so hidden, to compromise they can focus on aspects they don't they are the key to change.

This can cause decisions to create a problem slip (impacts in the others sectors or other aspects of sustainability) undesirable consequences without having them cognition and the ability to mitigate



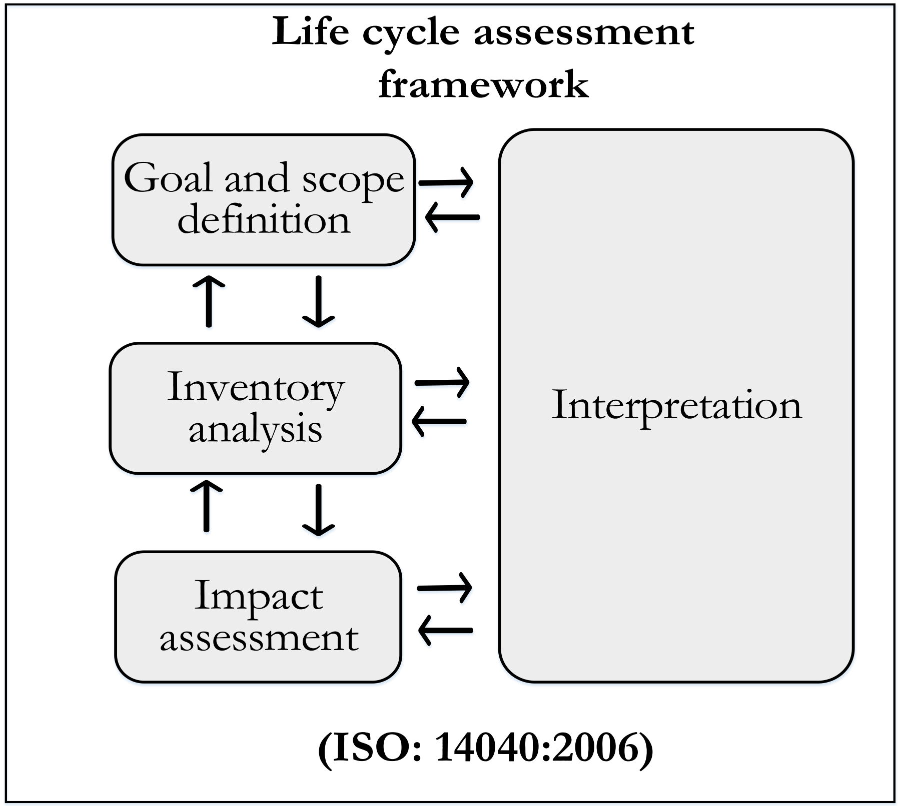
Life Cycle Assessment (LCA): this methodology represents a tool able to identify the major environmental criticalities of a production process, and to determine the potential environmental impacts.

LIFE CYCLE ASSESSMENT (LCA)

Goal and scope

• The product system under study
• Functions of the product system, or systems in the case of comparative studies.

- Functional unit (hectare, kilogram …)
- Boundaries of the product system
- Allocation procedures
- Types of impact (the definition of impact categories, category indicators)
- the quality requirements of the initial data
- Type of critical review
- Type and format of the report



LIFE CYCLE ASSESSMENT (LCA)

Inventory phase

This phase includes the collection of data (both qualitative and quantitative) and the calculation procedures to quantify the incoming and outgoing flows of a product system.

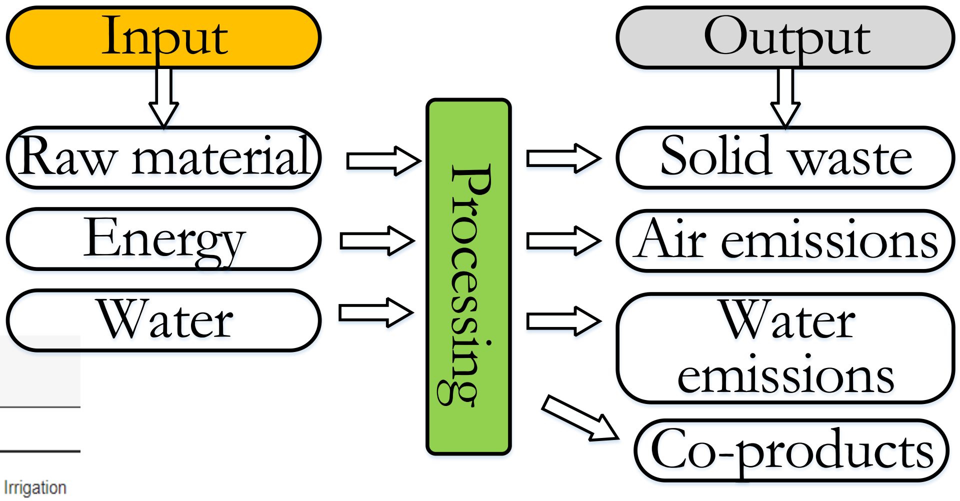


Table 2. Simplified Environmental Life Cycle Inventory (Additional data are available as supplementary material).

Life Cycle Stage			Planting								
Operation			Machinery consumption	Fertilization			Supporting structures and planting				Pest control	Irrigation
Input and output			Gasoil	Manure N 0.0031%	P_2O_5	K_2O	Iron	Wood	Concrete	Water	Glyphosate 71.7%	Water
			Unit × kg^{-1}									
Type of data	Farm	Cultivated Area (ha)	mL	kg	g	g	g	dm^3	dm^3	dm^3	mL	dm^3
Average data	OE	15.74	1.24	0.27	-	-	3.21	0.01	0.02	-	-	0.91
	OG	16.38	1.26	0.27	-	-	1.24	0.03	-	-	-	0.74
	CE	17.14	1.03	0.21	2.11	0.80	2.62	0.00	0.01	0.02	0.02	0.65
	CG	15.96	1.17	0.24	2.40	0.97	1.09	0.02	-	0.02	0.02	0.74

Falcone, G.; De Luca, A.I.; Stillitano, T.; Strano, A.; Romeo, G.; Gulisano, G. Assessment of Environmental and Economic Impacts of Vine-Growing Combining Life Cycle Assessment, Life Cycle Costing and Multicriterial Analysis. *Sustainability* **2016**

Data:

- Primary (specific, coming from direct surveys)
- Secondary (database)
- Tertiaries (generic, from literature studies)

SimaPro

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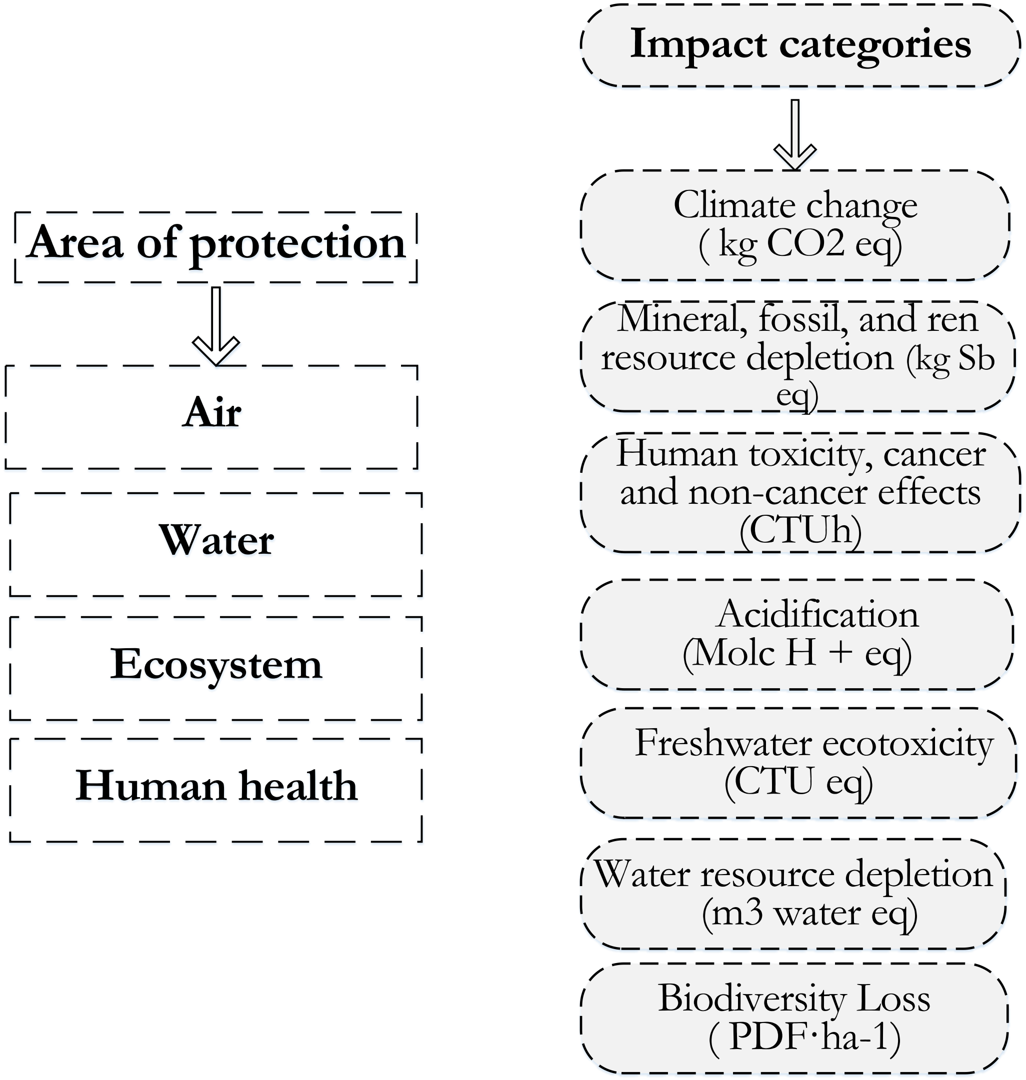
LIFE CYCLE ASSESSMENT (LCA)

Impact assessment and Interpretation of the life cycle

Impact assessment of the potential environmental impacts resulting from the inventory analysis, through the use of specific indicators for the different impact categories.

Stages:

- Selection of impact categories, category indicators and characterization models;
- Assignment of LCI results to impact categories (classification);
- Calculation of the results of the impact indicators (characterization).
- Data Aggregation
- Interpreting Results



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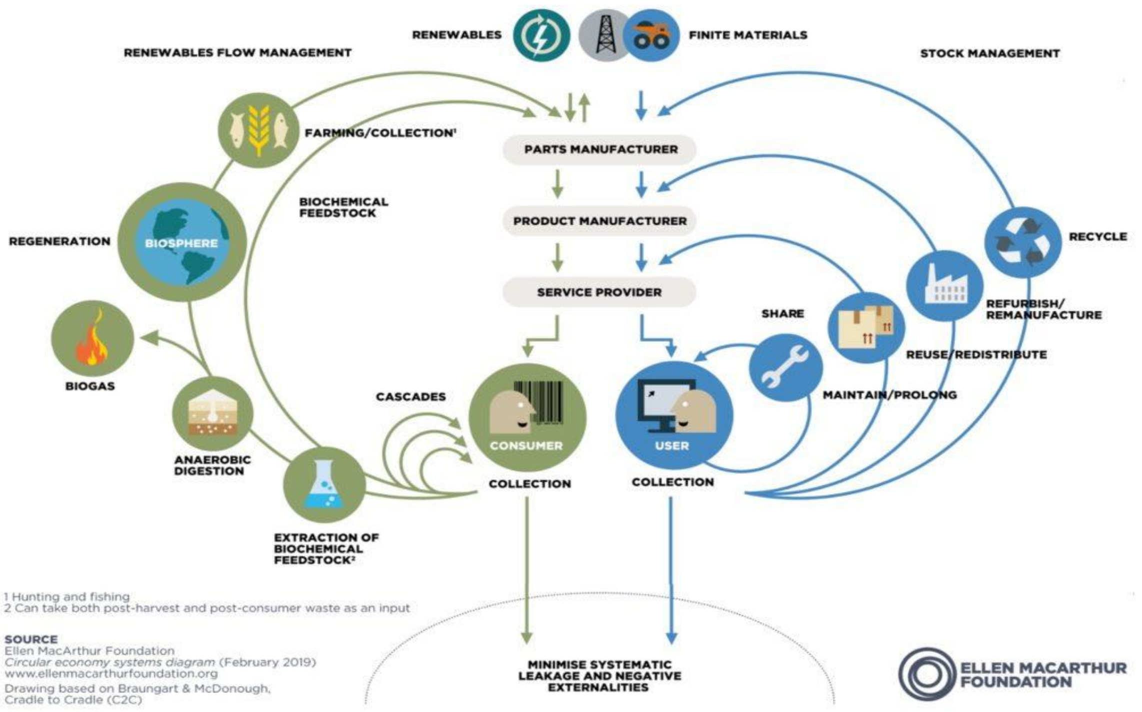
Sustainability assessment of circular strategies in Agricultural: a LCA approach

CIRCULAR ECONOMY (CE)

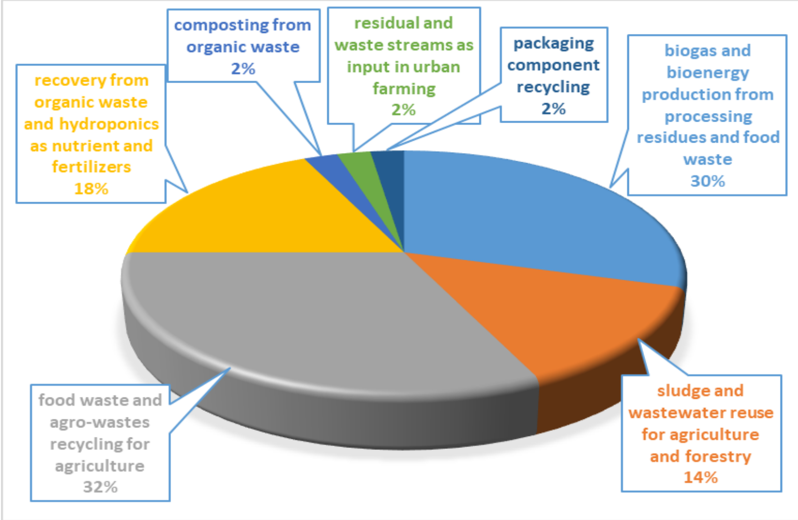
The **Ellen MacArthur Foundation** define Circular Economy:“ an industrial system that is restorative or regenerative by intention and design. It replaces the ‘end-of-life’ concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.”

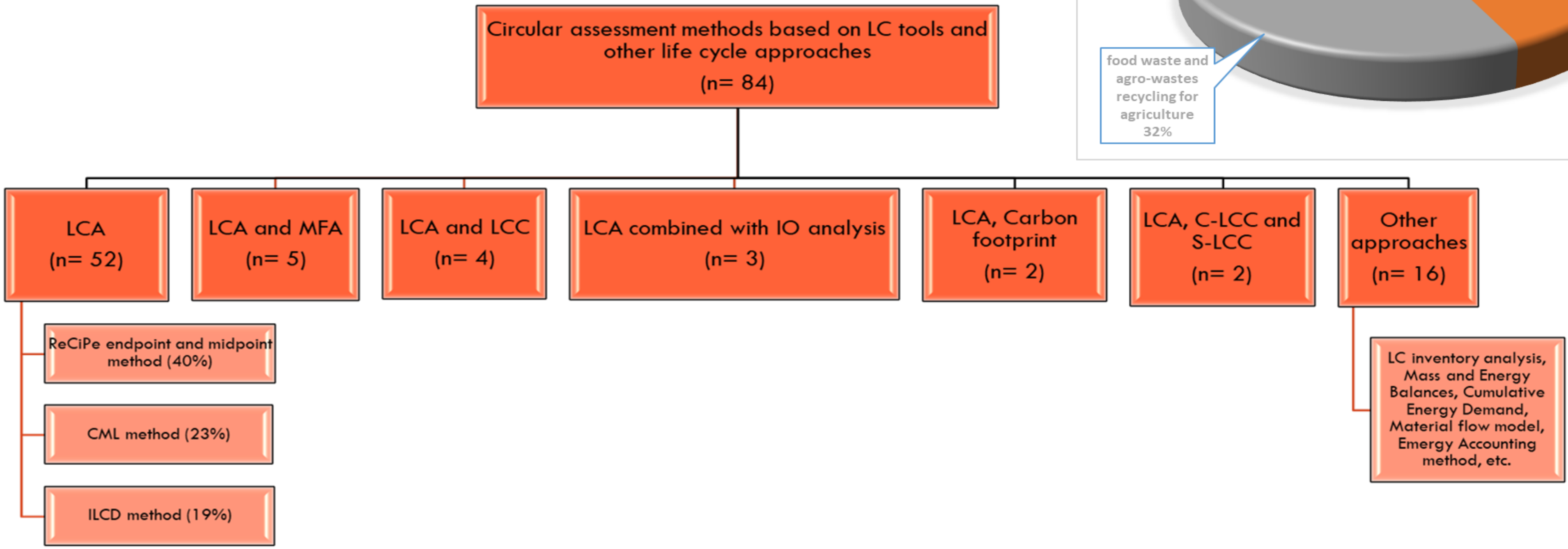


Circular economy is a relatively young field with roots in various disciplines and schools of thought (Blomsma and Brennan, 2017). Even in the academic world there is no common agreement on its definition.Kirchherr et al., (2017) identified 114 definitions of CE.

***Sustainability assessment of circular strategies in Agricultural*: a LCA approach**

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





Source: 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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# 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) Nitrogen circularity indicator (CIN) 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. 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) Material Circularity Indicator (MCI)	Climate Change, Abiotic Resource, Depletion, Acidification, 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)

Source: 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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DRiving the itAlian food SysTem Into a Circular economy model

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.

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MIUR
Ministero dell'Istruzione, dell'Università e della Ricerca

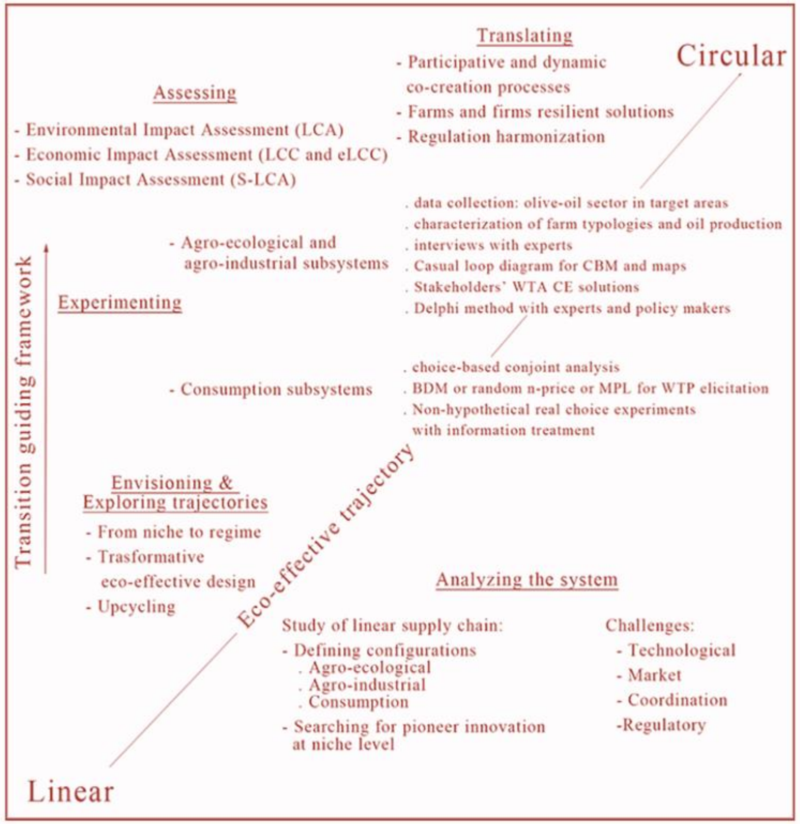
Project partners

Università degli Studi di Napoli Federico II

Università degli Studi di Bari Aldo Moro

Università degli Studi di Catania

Università degli Studi di Reggio Calabria Mediterranea



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

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MIUR

WP4 "IMPACT ASSESSMENT" WITHIN THE DRASTIC PROJECT FRAMEWORK

WP4.Impact assessment

Task 4.1 Environmental Impact Assessment (LCA)
Life Cycle Assessment (LCA), ReCiPe 2016 method (endpoint/midpoint)

Task 4.2. Economic Impact Assessment (LCC and eLCC)
Life Cycle Costing (LCC), conventional LLC, Environmental LCC-EPS2015, profitability and financial indicators, sensitivity analysis.

Task 4.3 Social Impact Assessment (S-LCA)
Social Life Cycle Assessment (S-LCA), UNEP/SETAC appriach, Social Impact Matrix SIM), impact pathways method, Psychosocial Risk Factors (PRF)

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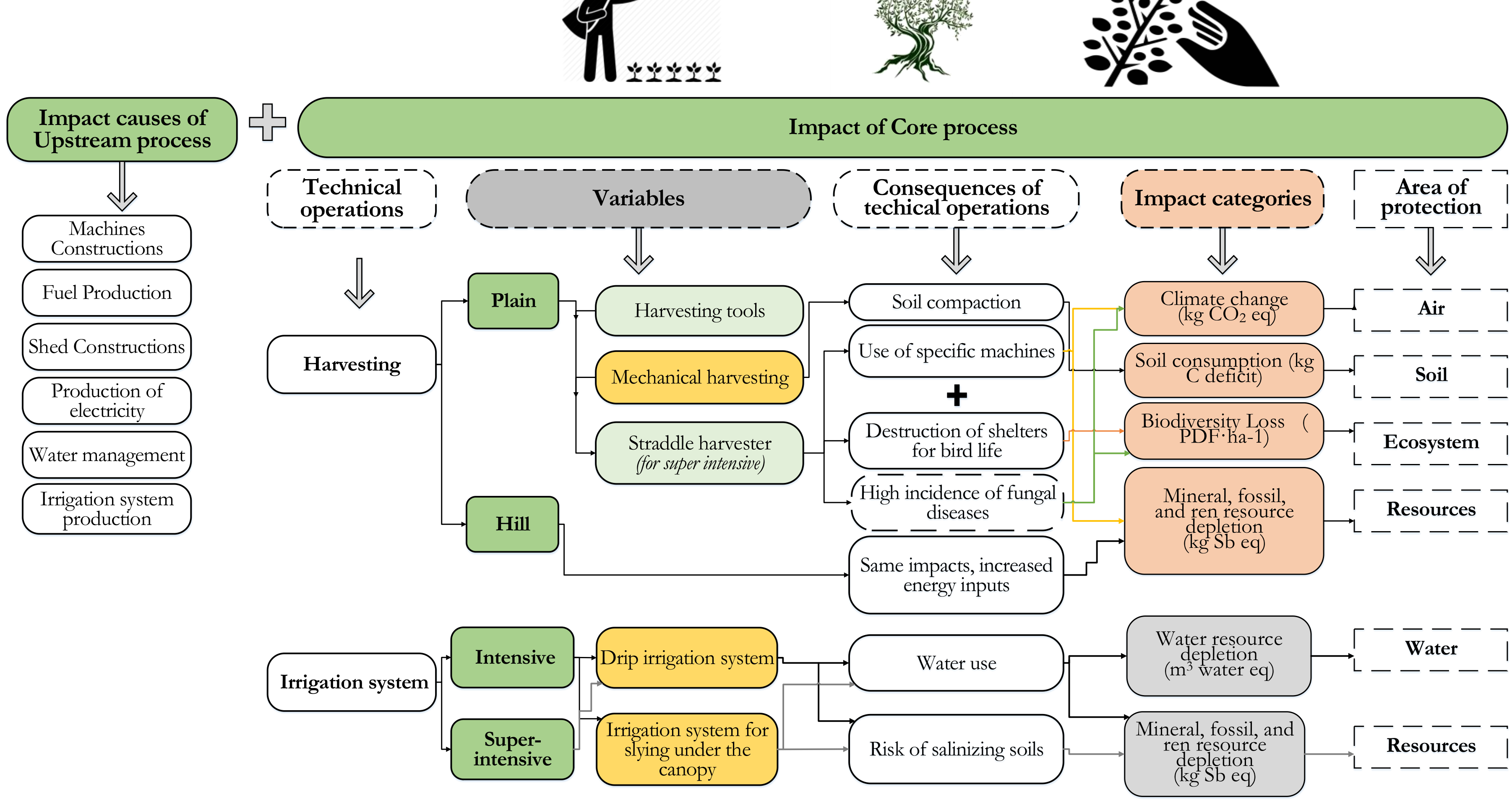
ENVIRONMENTAL CONCERNS OF SOME AGRICULTURAL OPERATIONS IN THE OIL CHAIN



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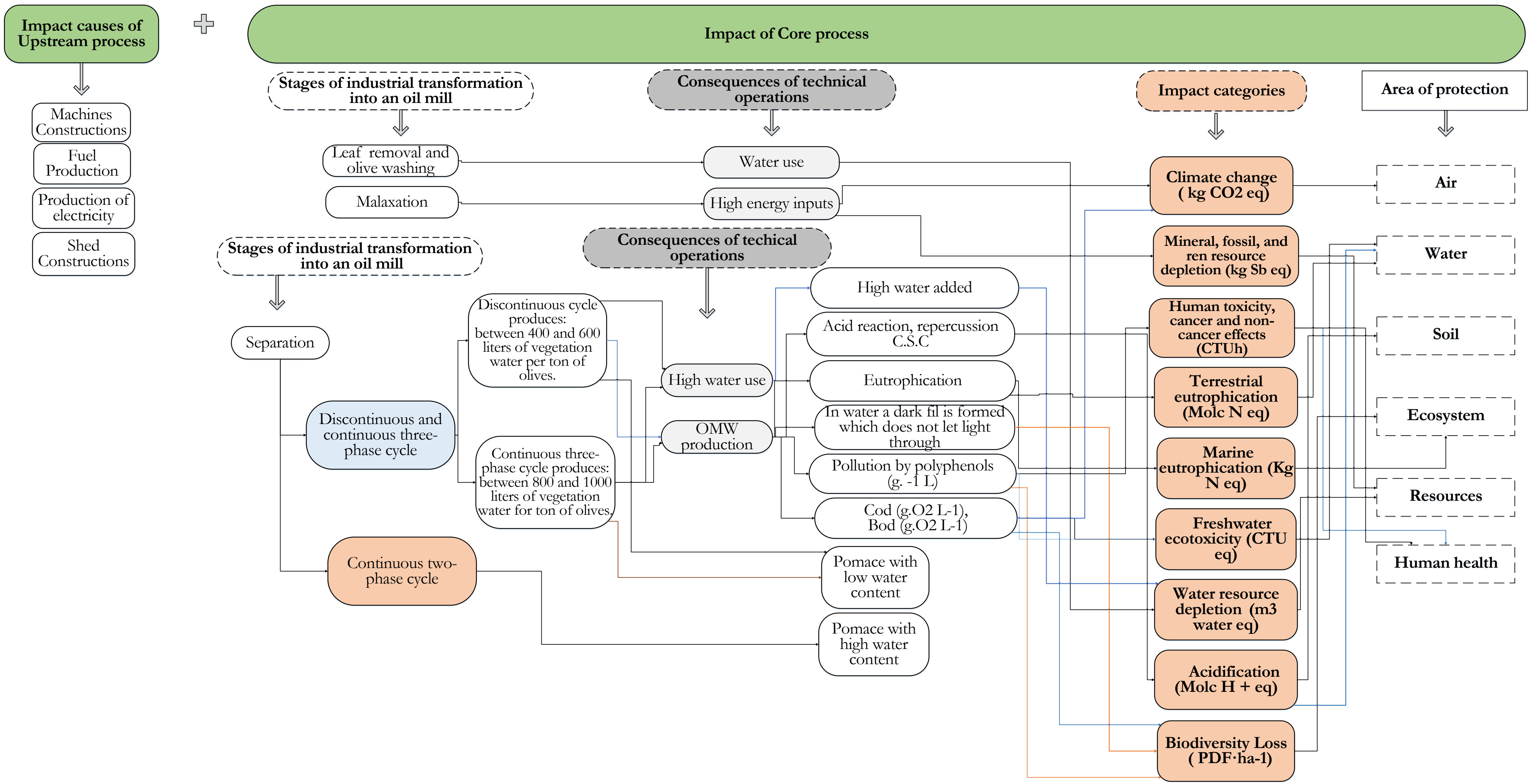
ENVIRONMENTAL CONCERNS OF THE INDUSTRIAL PHASE IN THE OLIVE OIL



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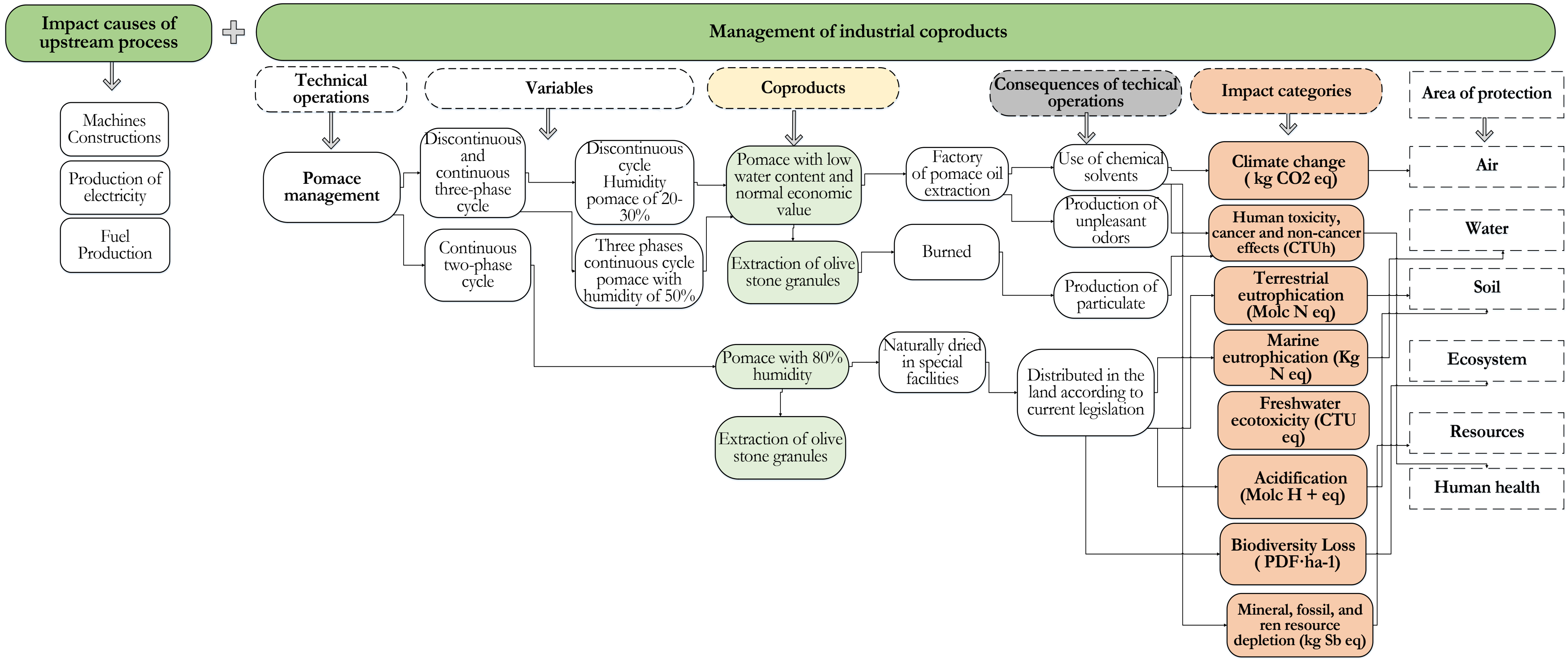
ENVIRONMENTAL CONCERNS OF THE OLIVE-OIL COPRODUCT MANAGEMENT



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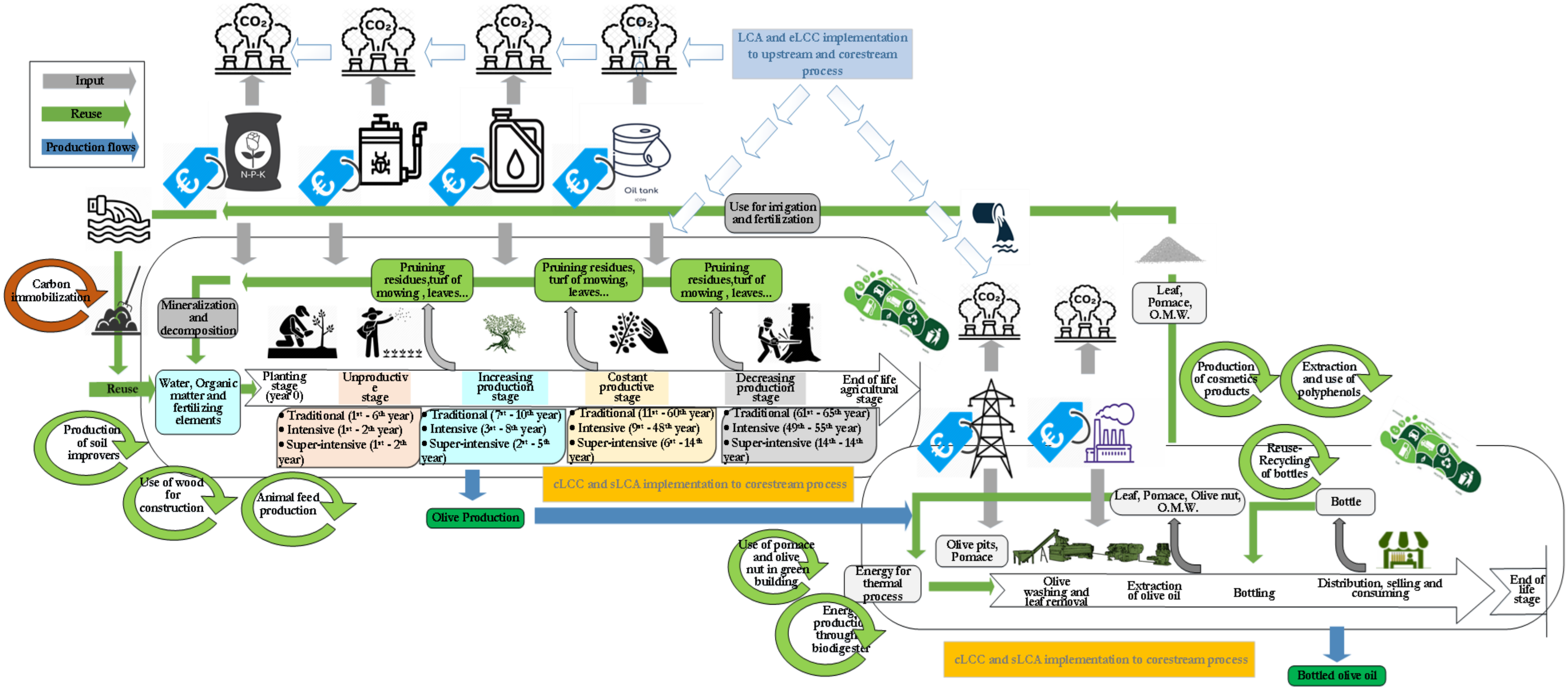
DESIGN OF LIFE CYCLE-BASED MODEL TO ASSESS CIRCULARITY PATHWAYS IN OLIVE-OIL CHAIN



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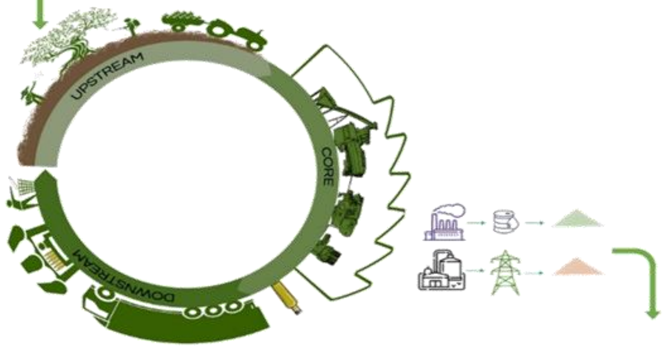
DESIGN OF LIFE CYCLE-BASED MODEL TO ASSESS CIRCULARITY PATHWAYS IN OLIVE-OIL CHAIN

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).

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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.

THANKS FOR THE ATTENTION!

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