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Introduction to Life cycle Sustainability Assessment (LCSA)

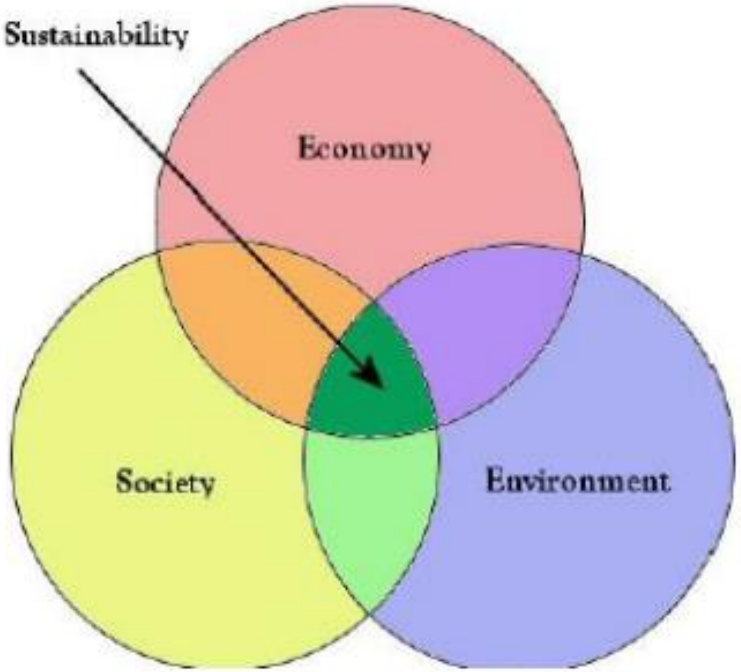
Simone Blanc

Content

- *Introduction to LCSA*
- *E-LCA*
- *LCC*
- *S-LCA*
- *Example of LCSA*

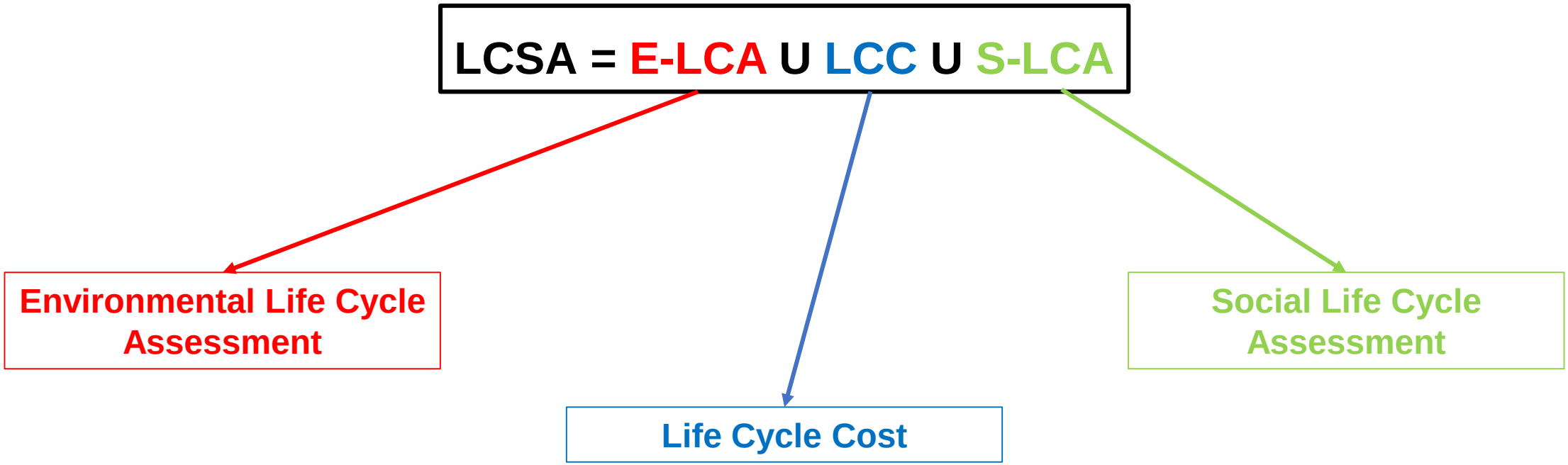
Intro to LCSA

Sustainble development is that **meets the needs of the present without compromising the ability of future generations** to meet their own needs (Brundtland Commision of the United Nations, 1987)



Intro to LCSA

LCSA refers to the evaluation of **all environmental, social and economic** negative impacts and benefits in decision-making processes towards more sustainable products throughout their life cycle



Intro to LCSA

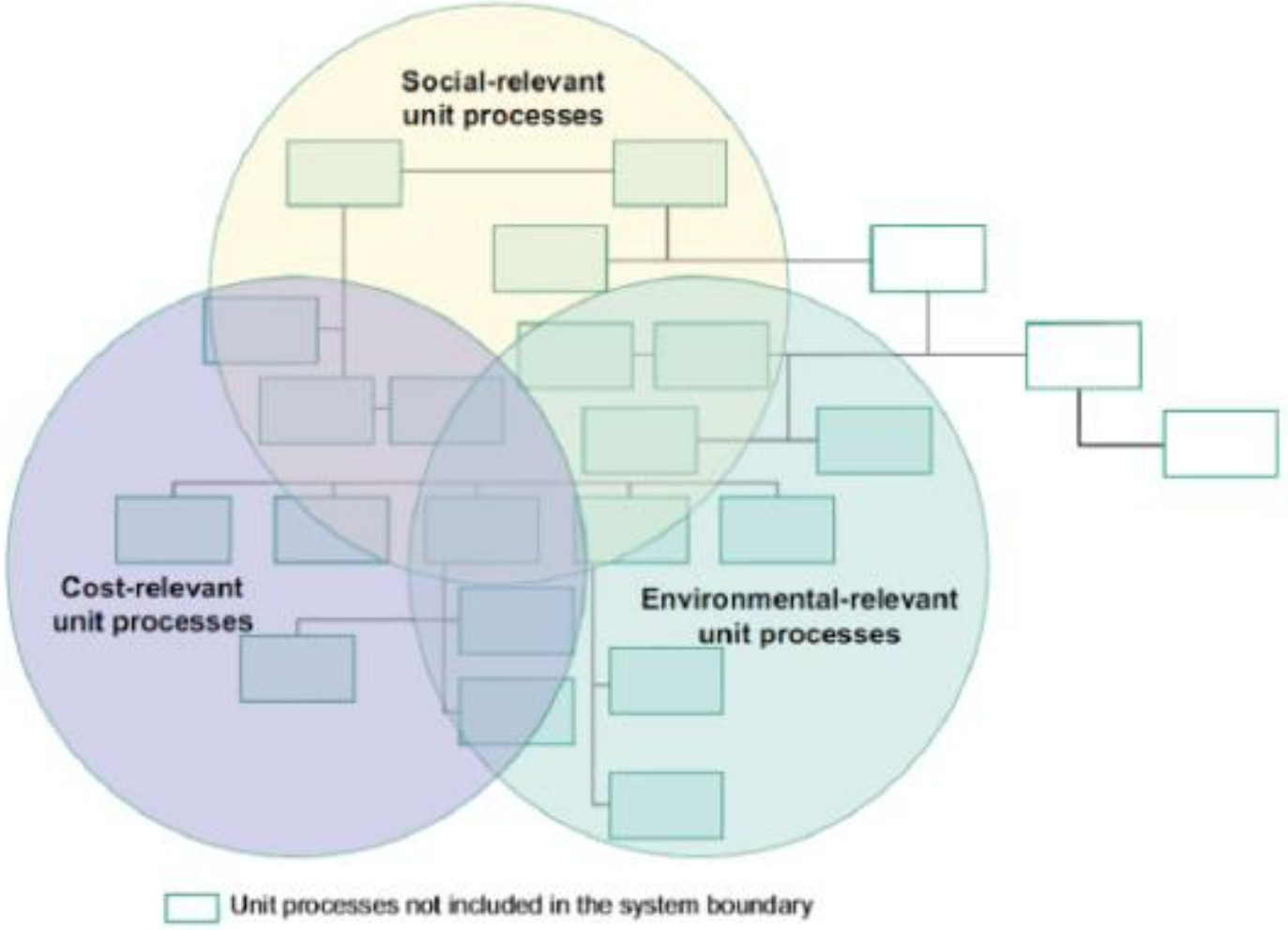
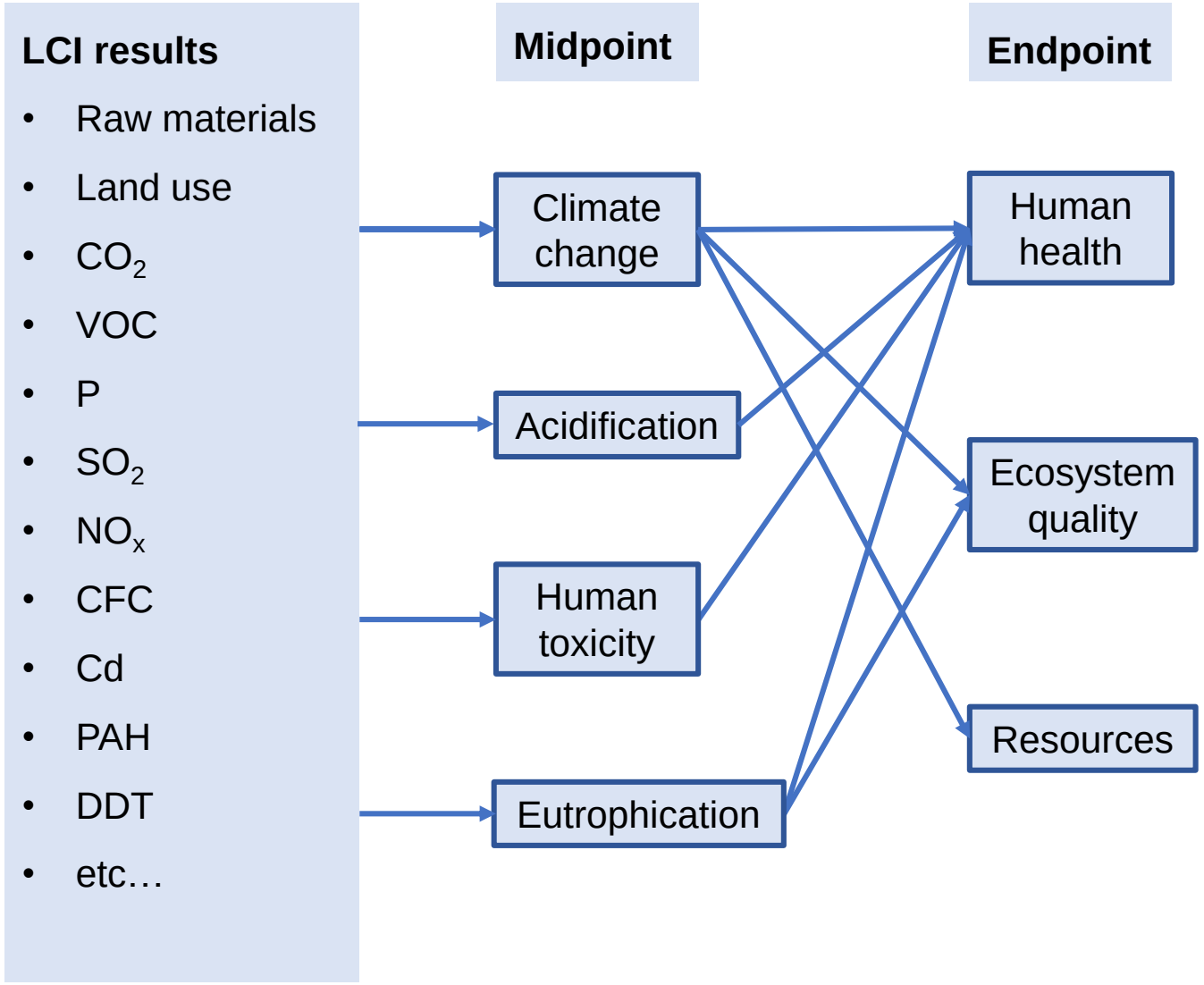


Figure 14. System boundaries of a life cycle sustainability assessment (LCSA).

Intro to LCSA

E-LCA

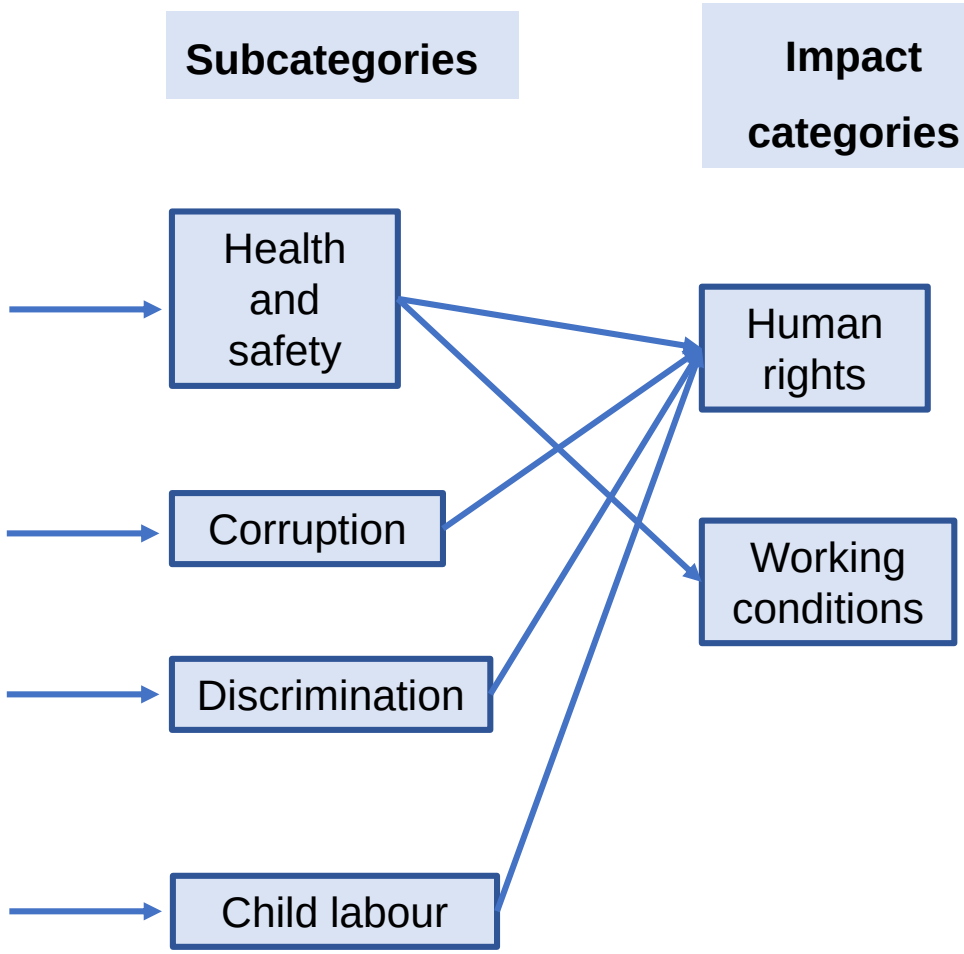


Intro to LCSA

S-LCA

LCI results

- Presence of codes of conduct in an organization
- Compliance with regulations regarding health and safety
- Annual meetings with local community representatives
- Presence of information for consumers regarding health and safety of product
- Presence of corporate policy to prevent corruption
- Number of employees
- Number of women
- Presence of children working
- Women's wages
- Men's wages
- Etc…



Intro to LCSA

Cost categories

LCI results

- Wages costs
- Material costs
- Energy costs
- Equipment costs
- Revenues
- Taxes
- Discount analysis

LCC

→ Labour costs

→ Material costs

How to evaluate the three different dimensions to decide when a system/product/process is more sustainable than others?

Life Cycle Cost (LCC)

From UNEP/SETAC – Towards a LCSA (2011)

The purchase price of a good or service is just one of the cost elements in the whole process of procuring, owning and disposing. However, when evaluating the *environmental performance* of such a good or service, it is vital to consider ***all the costs incurred during its lifetime***. This is known as the 'life-cycle costing' approach.

LCC should consider:

- Purchase and all associated costs (delivery, installation, commissioning, etc,.);
- Operating costs, including energy, spares, and maintenance;
- End-of-life costs, such as decommissioning and removal;

Life Cycle Cost (LCC)

There is no pre-defined way of conducting an LCC.

Different authors have taken different approaches

Life Cycle Cost (LCC)

UNEP-SETAC LCSA Guide

Conventional LCC incorporates private costs and benefits

Environmental LCC: life cycle costing (LCC) also takes into account external relevant costs and benefits anticipated to be privatized. Aligned with the requirements of ISO 14040 and ISO 14044

Societal LCC in which all private and external costs and benefits are monetized.

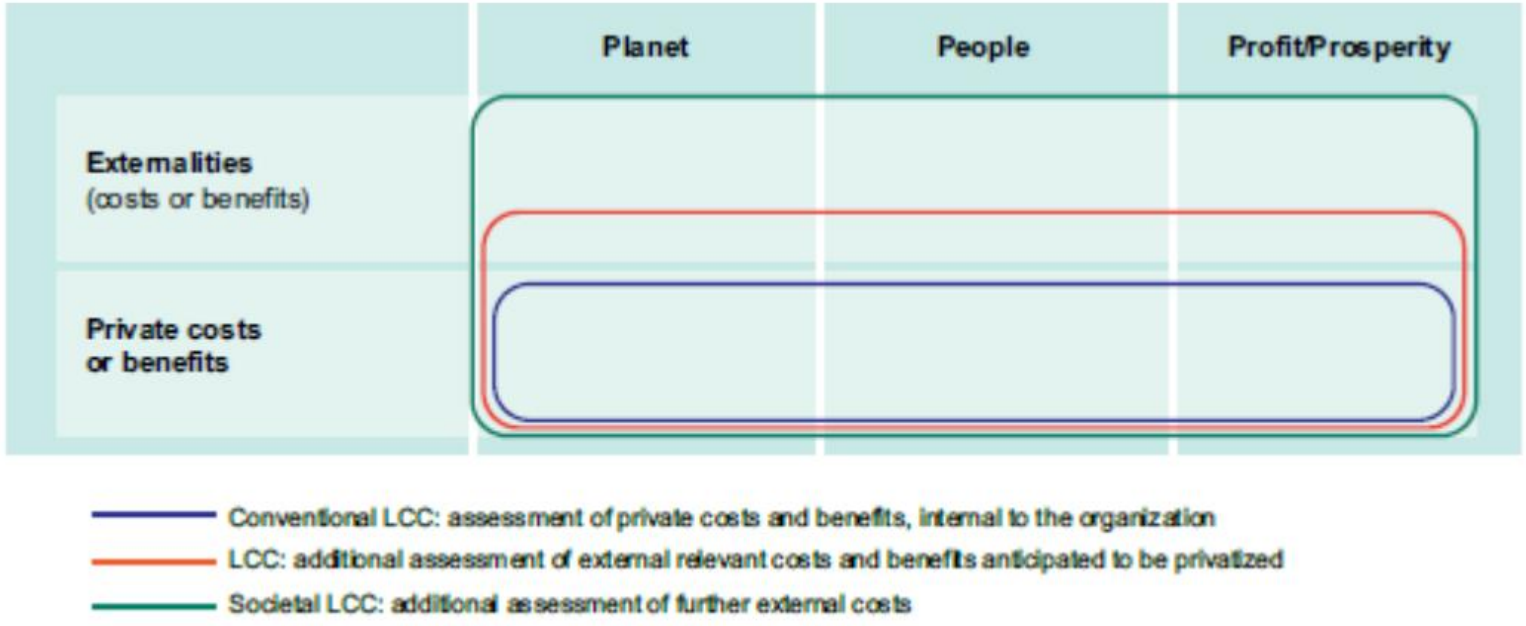


Figure 5. Scope of application of three flavours of life cycle costing.

Life Cycle Cost (LCC)

Hochschorner & Noring (2011) Practitioners' use of life cycle costing with environmental costs—a Swedish study

Another way of **defining environmental costs** is to divide them into **different types**:

- Direct (e.g. costs for a waste disposal and raw material)
- Indirect (e.g. costs for environmental management systems)
- Contingent (e.g. fines or penalties)
- Intangible (e.g. goodwill or badwill)
- External costs (costs borne by parties other than the company, e.g. the society).

Life Cycle Cost (LCC)

Peri et al. (2012) The cost of green roofs disposal in a life cycle perspective: Covering the gap. Energy 48 406-414

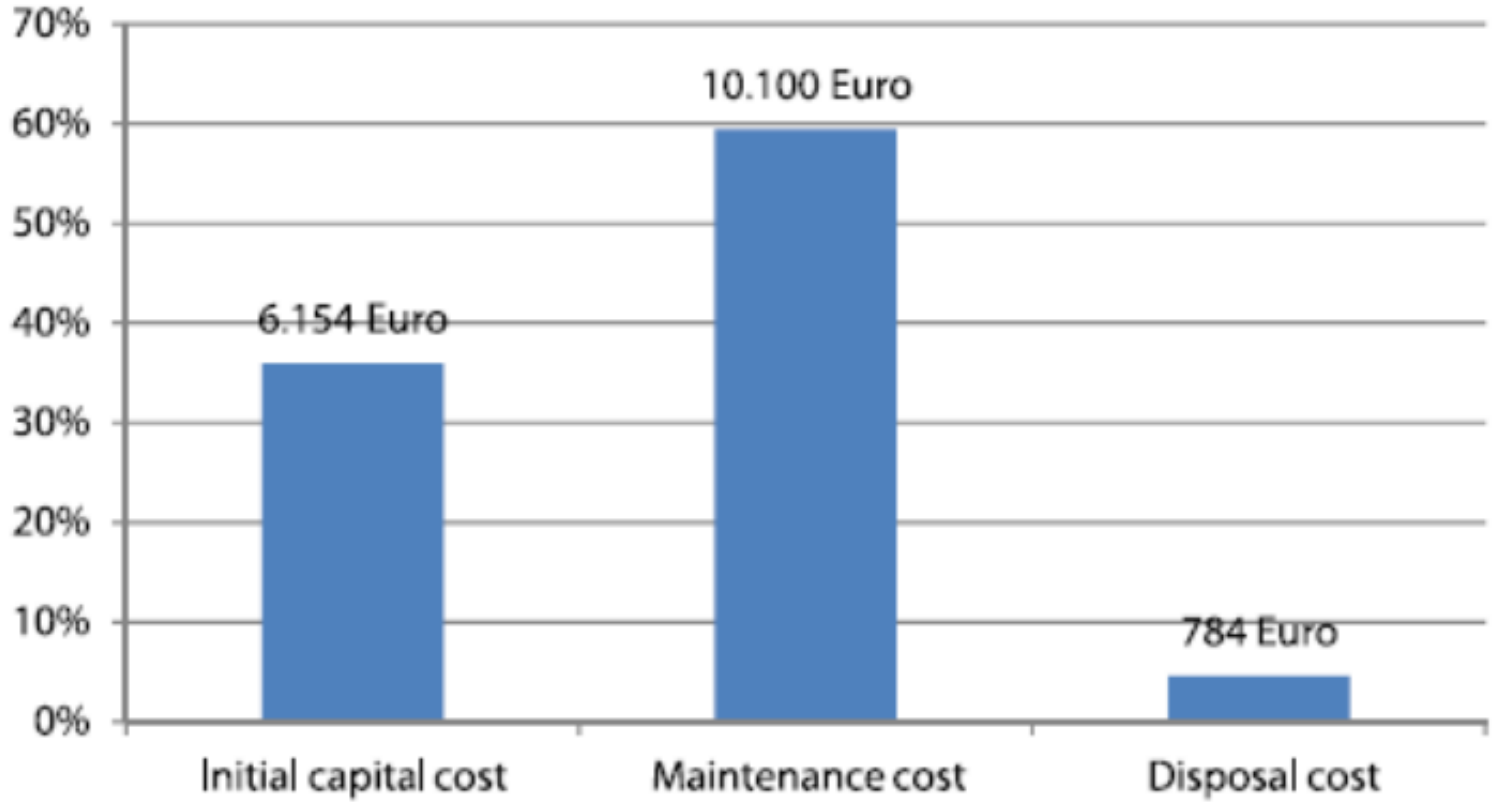


Fig. 4. Results of the life cycle costing (LCC) developed in this study. Contribution of production, maintenance and disposal to the whole life cycle cost of the case study.

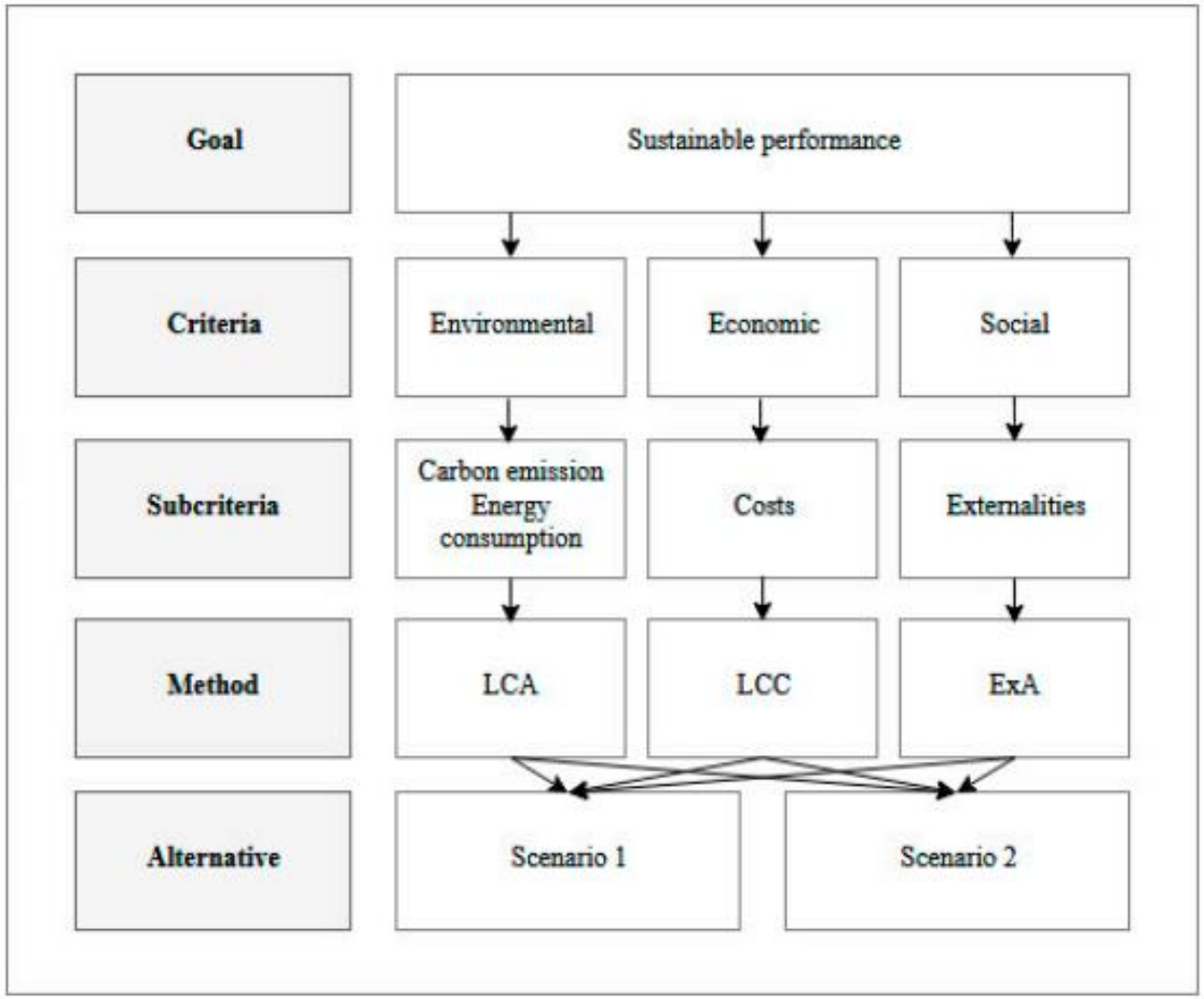
Life Cycle Cost (LCC + LCA)

POSSIBLE CONTENTS OF THE LCI OF A PRODUCT OR SERVICE

Life-cycle stage	Parameter	E-LCA	LCC
Construction/production	Design/planning/security services	Not applicable	€, $, …
	Budget and funding	Not applicable	€, $, …
	Materials	Kg/FU	€/FU
	Energy	kWh/FU	€/FU
	Labour	Not applicable	€, $, …
Operation and maintenance	Energy	kWh/FU	€/FU
	Materials	Kg/FU	€/FU
	Labour	Not applicable	€, $, …
Waste management	Transport	tkm/FU	€/FU
	Labour	Not applicable	€, $, …
	Additional inputs		

Life Cycle Cost (LCC)

Blanc et al 2019 **Use of Bio-Based Plastics in the Fruit Supply Chain: An Integrated Approach to Assess Environmental, Economic, and Social Sustainability**



Life Cycle Cost (LCC)

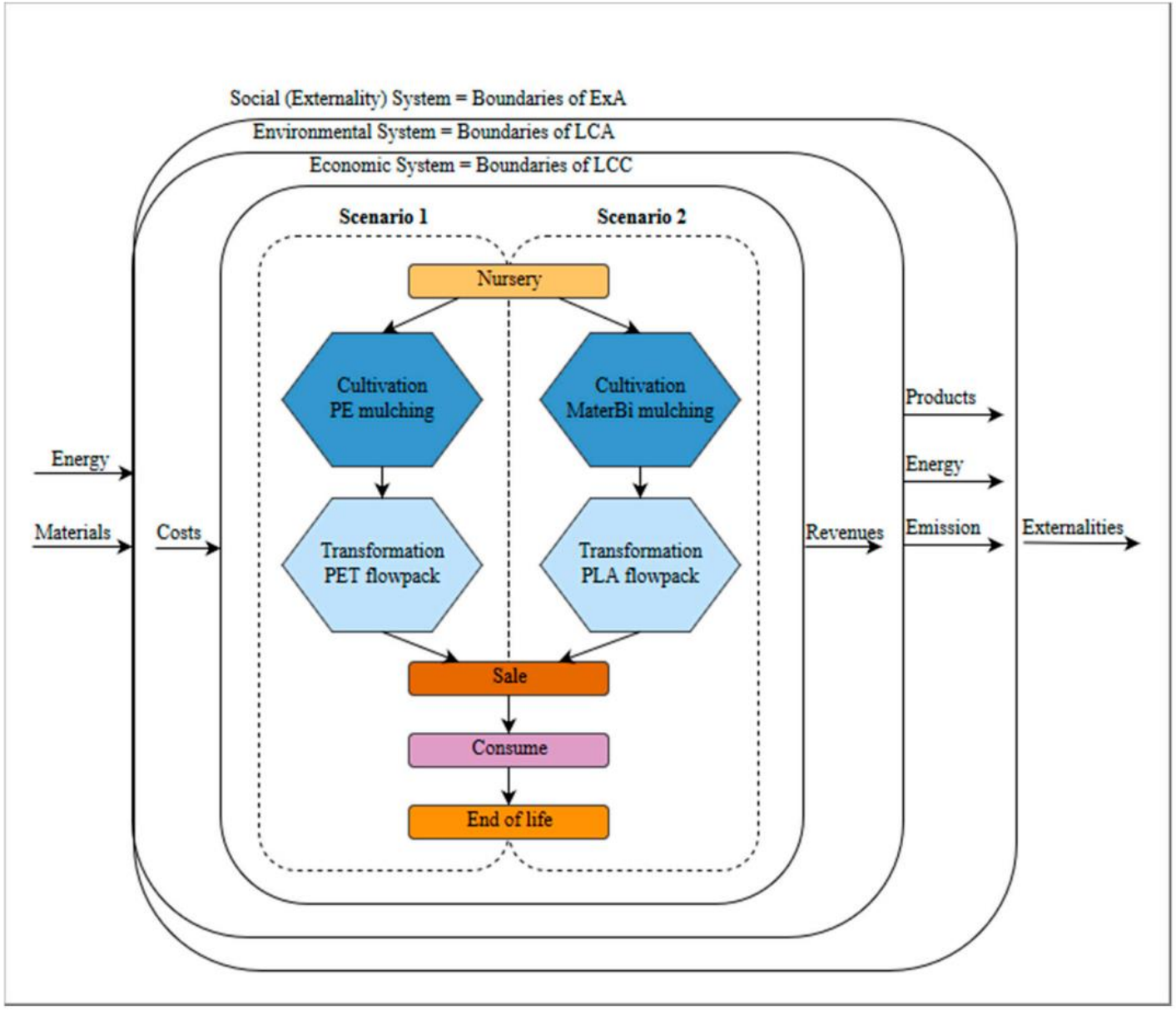


Figure 2. Context and framework.

Life Cycle Cost (LCC)

Table 2. LCA and LCC results.

	GWP		NRE		Costs		Externalities	
	kg CO_{2eq}		MJ primary		€·FU^{-1}		€·FU^{-1}	
	S1	S2	S1	S2	S1	S2	S1	S2
Nursery	0.0054	0.0054	0.4896	0.4896	0.0121	0.0121	0.00019	0.00015
Cultivation	0.1525	0.1058	3.5017	1.9637	0.5419	0.5413	0.00690	0.00554
Transformation	0.1935	0.1692	5.0854	2.9894	0.6144	0.7541	0.00622	0.00382
Sale	0.0893	0.0893	1.3260	1.3260	0.0409	0.0409	0.02243	0.01802
Consumption	0.1350	0.1350	1.8870	1.8870	0.0045	0.0045	0.04239	0.03406
End-of-life	0.0318	0.0318	0.0253	0.0253	0.0014	0.0014	0.00035	0.00028
Total	**0.6075**	**0.5366**	**12.3150**	**8.6810**	**1.2154**	**1.3545**	**0.07850**	**0.06190**

Table 3. Distribution of costs by type for the two scenarios.

	S1			S2		
Type of Cost		**€·FU^{-1}**	**%**		**€·FU^{-1}**	**%**
Machinery		0.1643	13.5%		0.1643	12.1%
Labor		0.7078	58.2%		0.7077	52.2%
Materials and services		0.2531	20.8%		0.3797	28.0%
	Mulching	0.0022	0.18%		0.0018	0.13%
	Plastic flow pack	0.0630	5.18%		0.1900	14.03%
Other expenses		0.0902	7.4%		0.1028	7.6%
Total		1.2154	100%		1.3545	100%

Life Cycle Cost (LCC)

The *ExA* model monetized the negative health effects, mortality, and morbidity, due to the major environmental pollutant (NH_3, NOx, NMVOC, PM, and SO_2) by the value of a life year (VOLY) and the social cost of carbon (SCC) for CO_2, as shown in Equation (4).

$$ExA = ECO_2 * SCCO_2 + \sum_{i=1}^{6} (EP_i * VOLYCP_i) \quad (4)$$

where *ExA* is the social cost of pollutant and CO_2 (€·FU^{-1}), ECO_2 denotes emissions of CO_2 (kg·FU^{-1}), $SCCO_2$ is the social cost of carbon (€·kg^{-1}), *EP* denotes emissions of pollutants (kg·FU^{-1}), *VOLYCP* is the monetized impact of pollutants on mortality and morbidity (€·kg^{-1}), and i denotes pollutants i_1 = NH_3, i_2 = NO_x, i_3 = NMVOC, i_4 = PM_{10}, i_5 = $PM_{2,5}$, and i_6 = SO_2.

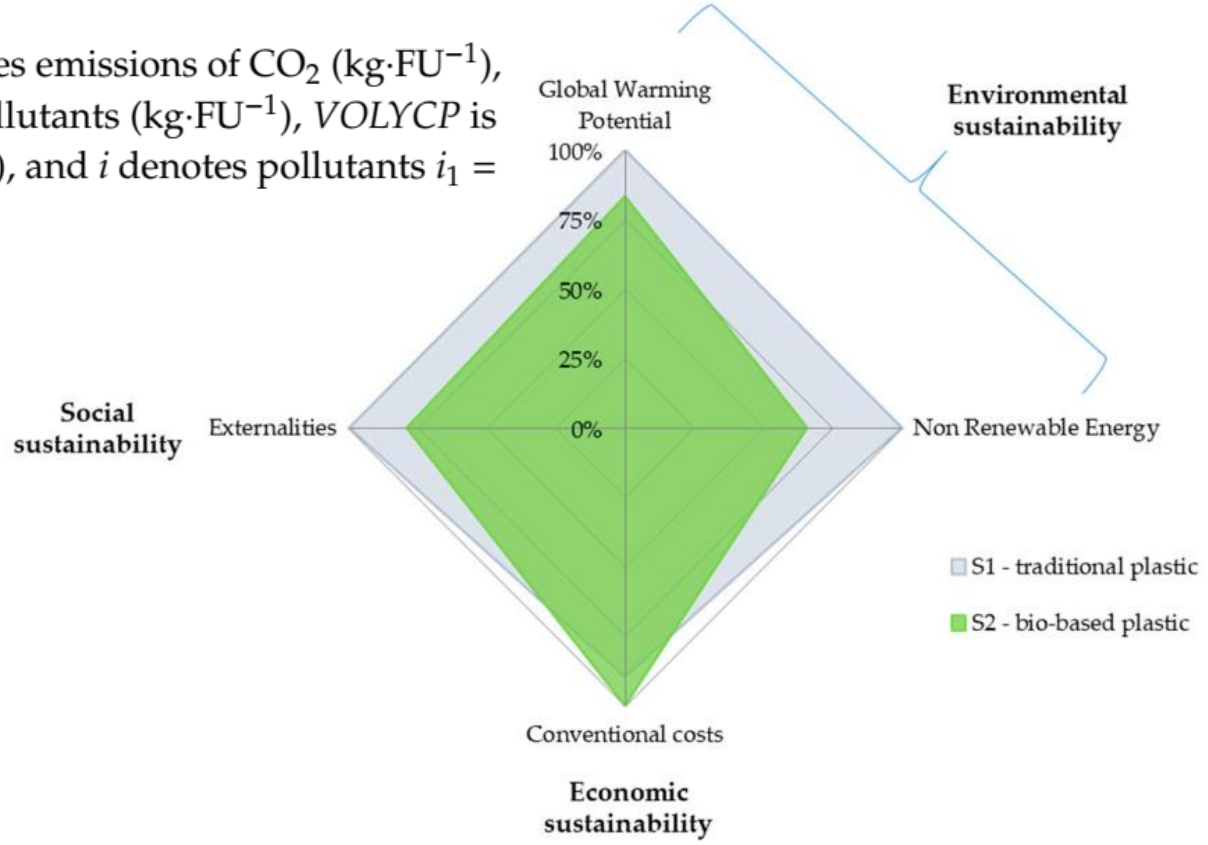
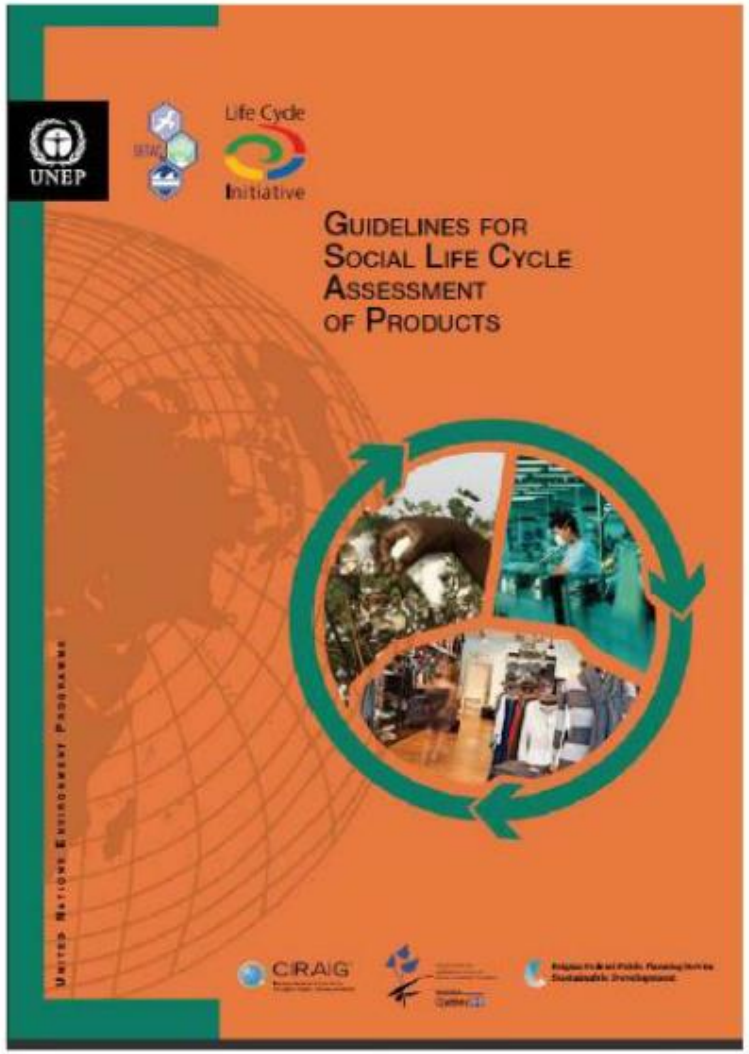


Figure 4. Sustainable performance results according to the triple bottom line (TBL) approach.

Guidelines for Social Life Cycle Assessment of Products



Guidelines for Social Life Cycle Assessment of Products

Social and socio-economic LCA guidelines complementing environmental LCA and Life Cycle Costing, contributing to the full assessment of goods and services within the context of sustainable development

http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines_sLCA.pdf

Differences between E-LCA and S-LCA

Phase of the study	Characteristics
Goal and scope	The product utility is required to be described in functionals terms, both in E-LCA and S-LCA. S-LCA goes further by also requiring that practioners consider the social impacts of the product use phase and function.
	Whereas E-LCA encourages **involvement of stakeholders** (beyond the commissioners) in the peer review of the study, S-LCA encourages that such ‘’external’’ stakeholders be involved in providing input on impacts, within the assessment itself.
	In S-LCA, **justification** needs to be presented when a subcategory is not included in the study. In E-LCA this is not a requirement.
	The subcategories are classified both by stakeholder categories and by impact categories in S-LCA. In E-LCA they are classified only by impacts categories.
	Whereas both E-LCA and S-LCA impact assessment methods may be sensitive to location no E-LCA LCIA (Life Cycle Impact Assessment Indicators) methods are site-specific, and E-LCA methods often define and use categories of location types that depend on physical factors such as geography type or population density. **S-LCA may require site-specific LCIA in some cases**, and may also need information about ‘’political’’ attributes, such as the country and its laws.

Differences between E-LCA and S-LCA

Phase of the study	Characteristics
Life Cycle Inventory	The activity variables data is collected and used more often in S-LCA than in E-LCA (e.g. number of working hours for estimating the share of each unit process in the product system). In E-LCA, activity variables are used when data about impacts is not available.
	The subjective data is sometimes in S-LCA the most appropriate information to use. Bypassing subjective data in favor of more ‘’objective” data would introduce greater uncertainty in the results, not less.
	The balance between quantitative, qualitative and semi-quantitative data will generally be different.
	The data sources will differ (coming from stakeholders).
	The data collection steps and methods vary (e.g. the irrelevance of mass balances).

Differences between E-LCA and S-LCA

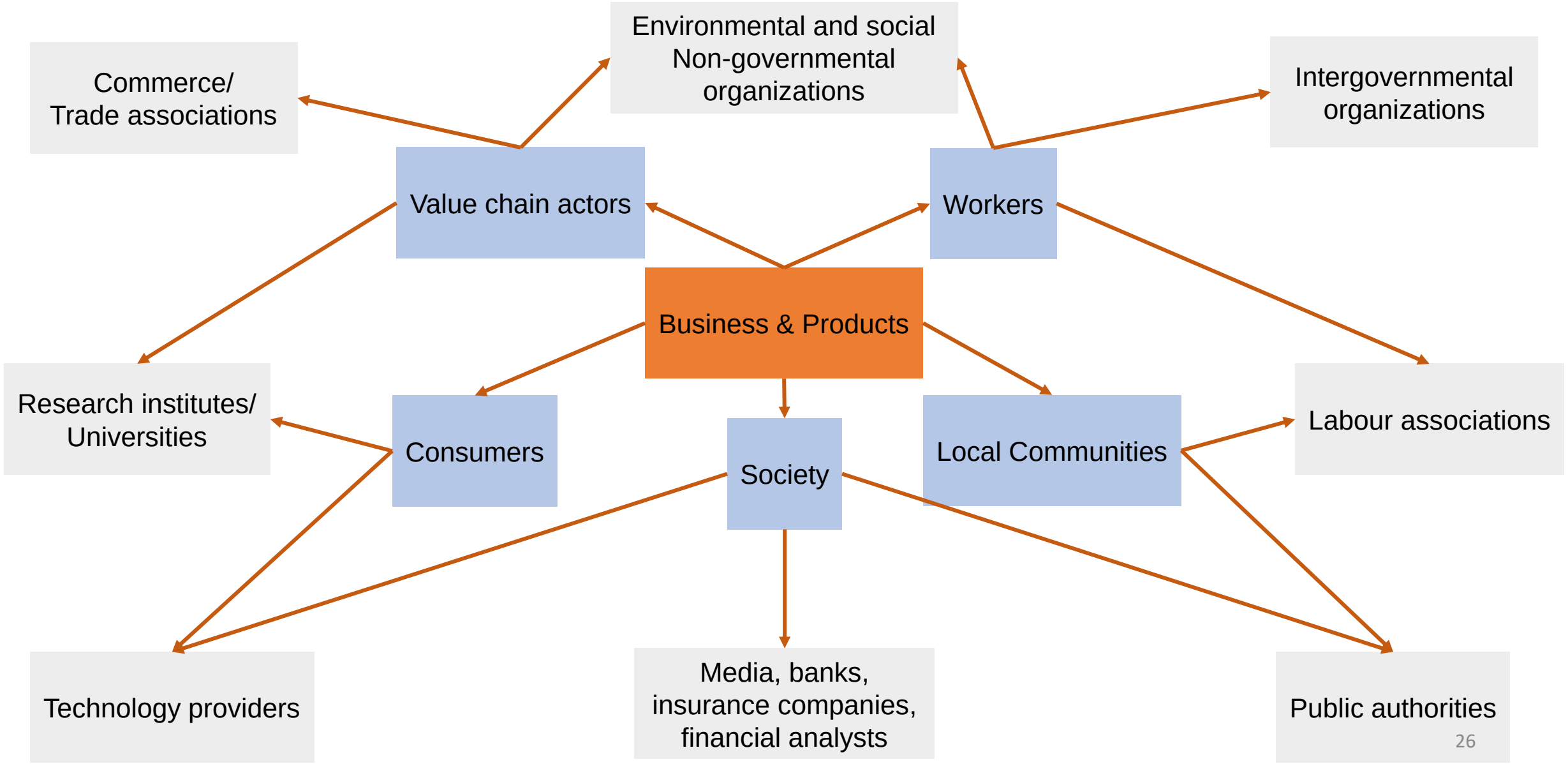
Phase of the study	Characteristics
Life Cycle Impact	The characterization models are different.
	The use of performance reference points is specific to S-LCA, e.g. **thresholds**.
	S-LCA encounters both positive and negative impacts of the product life cycle, beneficial impacts in E-LCA seldom occur.

Differences between E-LCA and S-LCA

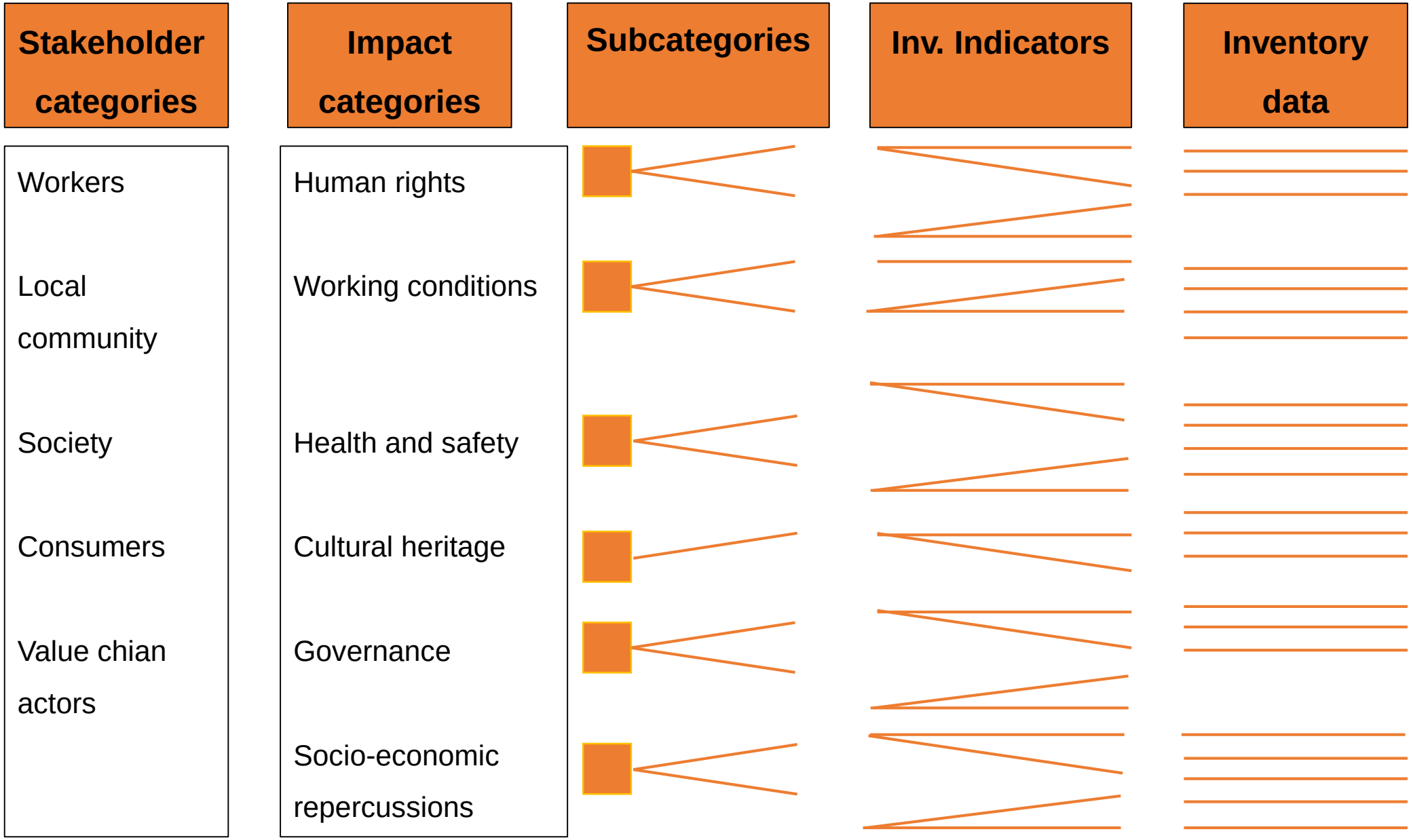
Phase of the study	Characteristics
Interpretation	The significant issues will differ.
	The addition of information on the level of engagement of **stakeholders** in S-LCA.

Differences between E-LCA and S-LCA

LIFE CYCLE STAGES = STAKEHOLDERS



S-LCA



Adapted from Benoit et al., 2007

S-LCA

Stakeholder categories	Subcategories
Stakeholder ‘’worker’’	Freedom of Association and Collective Bargaining Child Labour Fair Salary Working Hours Forced Labour Equal opportunities/Discrimination Health and safety Social Benefits / Social Security

S-LCA

Stakeholder categories	Subcategories
Stakeholder ‘’consumer”	Health & Safety Feedback Mechanism Consumer Privacy Transparency End of life responsibility

S-LCA

Stakeholder categories	Subcategories
Stakeholder "local community"	Access to material resources Access to immaterial resources Delocalitazion and Migration Cultural heritage Safe & healthy living conditions Respect of indigenous rights Community engagement Local employment Secure living conditions

S-LCA

Stakeholder categories	Subcategories
Stakeholder ‘’society’’	Pubblic commitments to sustainability issues Contribution to economic development Prevention & mitigation of armed conflicts Technology development Corruption

S-LCA

Stakeholder categories	Subcategories
Value chain actors not including consumers	Fair competition Promoting social responsibility Supplier relationships Respect of intellectual property rights

Example

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Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment

Julia Martínez-Blanco [a,b,*], Annekatrin Lehmann [a], Pere Muñoz [c], Assumpció Antón [c,d], Marzia Traverso [a], Joan Rieradevall [b,e], Matthias Finkbeiner [a]

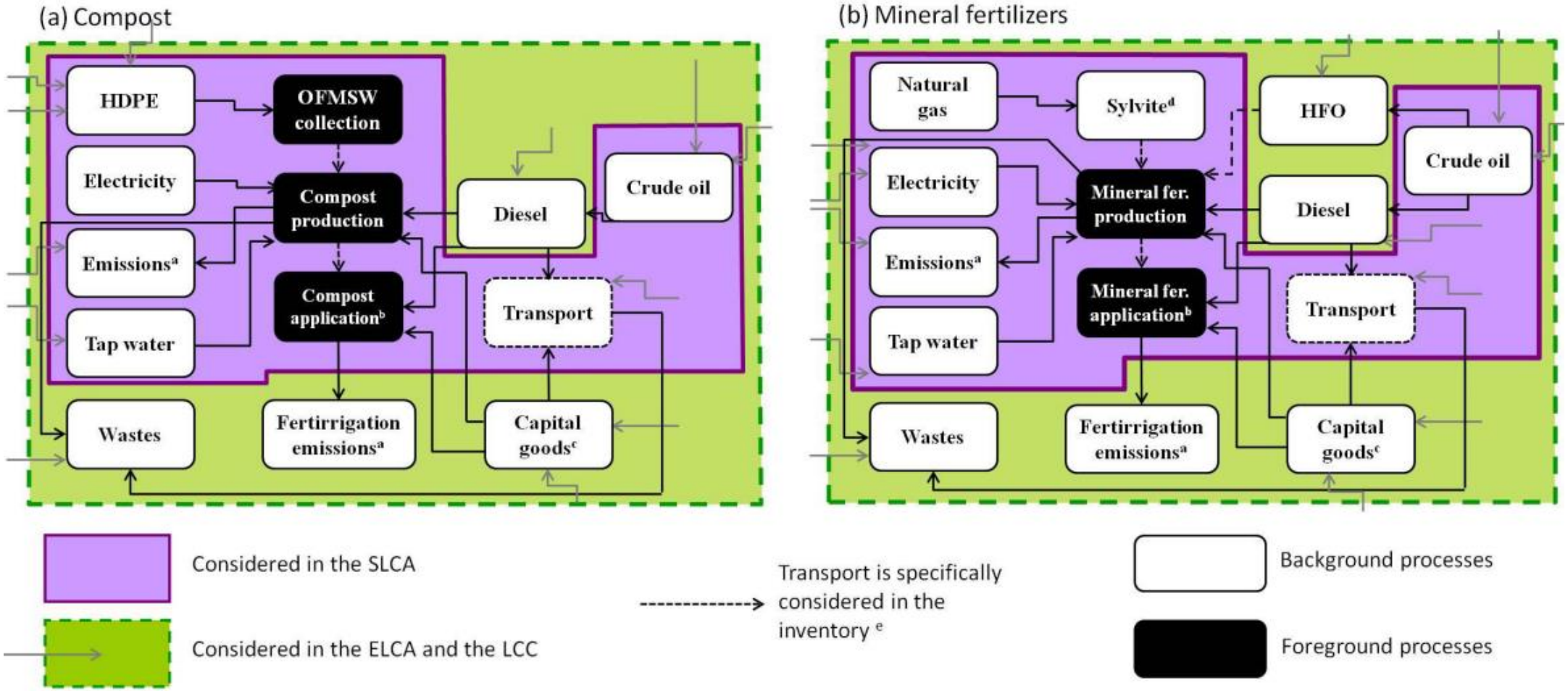
[a] Chair of Sustainable Engineering, Department of Environmental Technology, Technische Universität Berlin, 10623 Berlin, Germany
[b] Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain
[c] Institute of Research and Technology in Agrifood Sector (IRTA), Environmental Horticulture, 08348 Cabrils, Barcelona, Spain
[d] Departament d'Enginyeria Química, Universitat Rovira i Virgili (URV), 43007 Tarragona, Spain
[e] Chemical Engineering Department, Universitat Autònoma de Barcelona (UAB), 08193 Bellaterra, Barcelona, Spain

Example

Compost from OFMSW (Organic Fraction of Municipal Solid Waste) and produced in industrial plant

KNO_3 (potassium nitrate)

KNO_3 (nitric acid)



Example

Methodology	Procedure specifications	Data sources
ELCA (Environmental Life Cycle Assessment	➢ Guideline: ISO 14040:2006. ➢ Indicators: 10 midpoint impact categories from CML2001 + Cumulative Energy Demand.	Previous projects from the reasearch group.
LCC (Life Cycle Cost)	➢ Guideline: Environmental Life Cycle Costing ➢ Indicators: fertilizer market price, transport costs, and application costs.	Previous projects from the research group.
SLCA (Social Life Cycle Assessment)	➢ Guideline: Guidelines and Methodological Sheets (UNEP-SETAC). ➢ Focused on the stakeholder: worker. ➢ The whole life cycle included (foreground and background processes) at sector level. ➢ Aggregation unit: working time (seconds).	Social Hotspot Database (SHDB), Life Cycle Working Environment (LCWE) from Gabi5, national and international statics, reports, etc.
LCSA (Life Cycle Sustainability Assessment)	➢ Guideline: Towards a LCSA (UNEP-SETAC). ➢ Tool: Life Cycle Sustainability Dashboard.	Results from ELCA, LCC and SLCA.

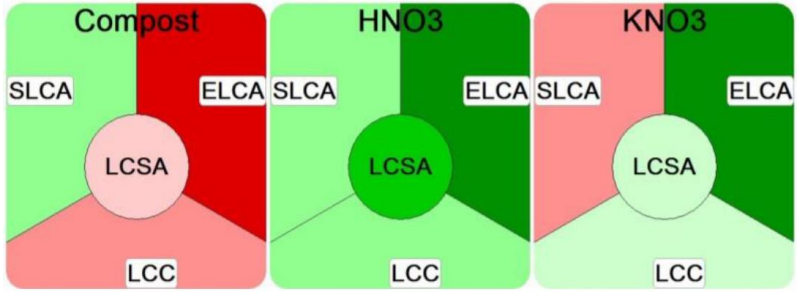
[2] Martínez-Blanco et al. (2011) [4] Hunkeler et al. (2008) [5] UNEP (2009) [6] UNEP (2010) Methodological Sheets of Sub-Categories of Impact for a Social LCA. UNEP-SETAC, France. [7] UNEP (2011) [8] Traverso et al. (2012)

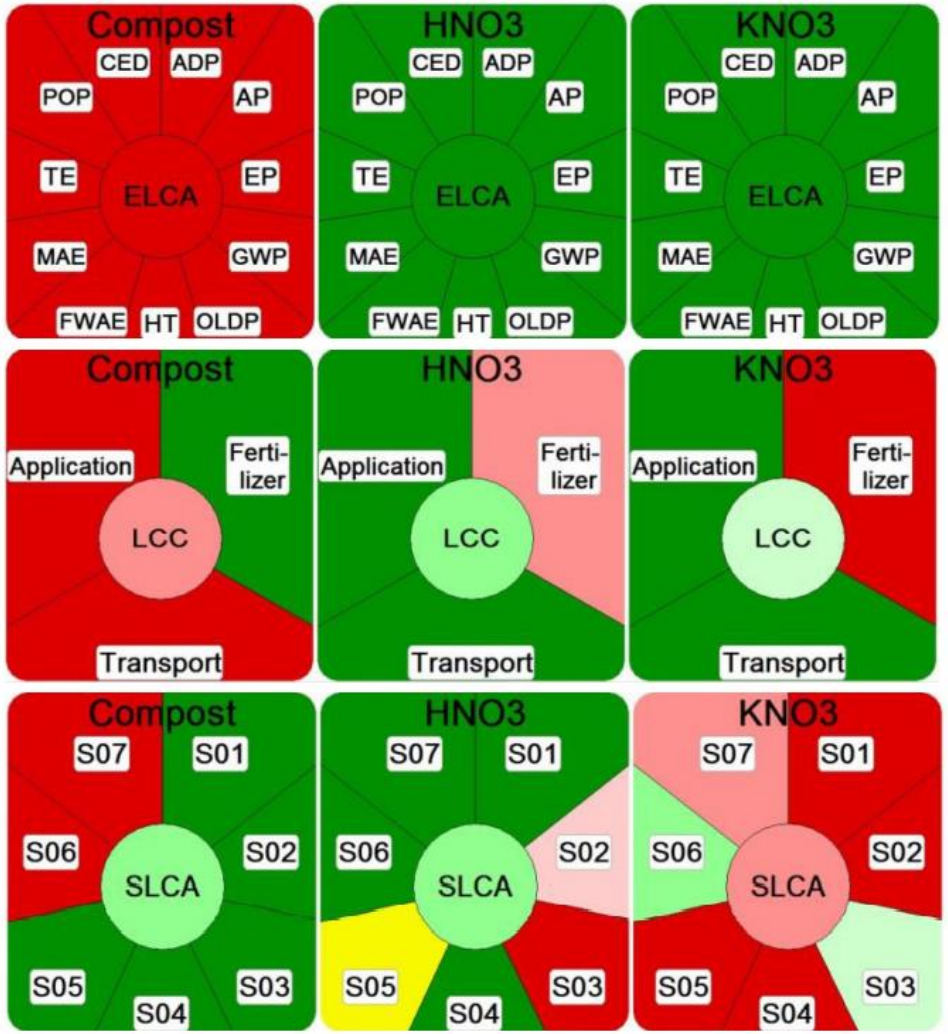
Table 3
Foreground sector scale – Comparison of social aspects and potential risks of three fertilizer alternatives involved in the production chain of fertilizers.

	Fertilizing alternatives		Compost		HNO_3 production	KNO_3 production
	Foreground processes	Data[a]	OFMSW collection	Compost production		
STAKEHOLDER >	Working time (s per ton of fertilized tomato)		5,300	23,416	394	n.d.
Subcategory (shaded)	Social indicator		Spain	Spain	Spain	Israel
WORKER						
Freedom of association and collective bargaining	Potential of sector not passing labor laws	T	B		B	W
	Potential of sector not adopting labor conventions	S	S		S	S
	Others: Risk of not having the right to strike; Risk of not having collective bargaining rights; Risk of not having freedom of association rights.					
Child labor	Risk of child labor in the sector	L	S		S	S
Working hours	Average working hours per week	T	[b]		[b]	[b]
	Others: Work-life balance situation.					
Forced labor	Risk of forced labor	L	S		S	S
Equal opportunities/ Discrimination	Overall fragility of gender equity (% women/total workers)	T	W		B	I
	Others: Ratio of basic salary of men to women by employee category; Ratio of immigrant employees (%); Ratio of basic salary of immigrants to the rest by employee category.					
Health and safety	Gaseous emissions exposure effects	T/L	[b]		[b]	[b]
	Biological agents exposure effects	L	W		B	B
	Occurrence of occupational lethal accidents	T	W		B	n.d.
	Occurrence of occupational non-lethal accidents	T	W		B	n.d.
	Others: Biological agents protection and prevention measures; Workers comfort level; Level of noise; Presence of a formal policy concerning health and safety in the sector.					
LOCAL COMMUNITY						
Safe and healthy living conditions	Odor and gaseous emissions effects	T/L	n.d.	W	B	B
	Biological agents exposure effects	T/L	n.d.	W	B	B
	Other hazards and nuisances	L	[b]		[b]	[b]
	Others: Biological agents protection and prevention measures; Level of noise; Emissions and noise records are recommended or mandatory for the company.					
Local employment	Promotion of local employment in the consumption area	S	B		B	W
	Others: Training courses for the employees; % Employees with Higher education; % Employees with Basic education; % spending on locally based suppliers.					
Community engagement	Others: rate of willingness to have the sector close to home; participation of neighbors in decisions and incomes.					
SOCIETY						
Public commitments to sustainability issues	Others: Existence of (legal) obligation on public sustainability reporting; Engagement of the sector regarding sustainability.					
Prevention and mitigation of armed conflicts	The organization is doing business in a region with ongoing conflicts	S	B		B	W
Contribution to economic development	Economic situation of the country (GDP per capita, $)	T	B		B	W
	Relevance of the considered sector for the national economy. Employees in relation to size of working population (%)	T	W		I	B
Corruption	Others: Risk of corruption in the sector.					
CONSUMER (FARMER)						
Feedback mechanism	Fertilizer production scale with regard of consumer	S	B		I	W
Health and safety	Product application dangers	L	[b]		[b]	
	Existence of health and safety measures for application of the product	L	I		B	B
Product application[c]	Extra working time for consumer to apply the product	S	W		B	
	Average prices in Catalonia (€ per ton of fertilized tomato)	T	B		I	W
	Others: Level of complexity for dosages calculation; Main consumer concerns about the product application.					
CITIZENS COLLECTING OFMSW[c]						
Education and responsibility[c]	Others: Existence of obligation of waste collection for citizens; Existence of educational campaigns for citizens engagement.					
Comfort and collecting effort for the citizens[c]	Others: Frequency of organic bin emptying; % public space used; % private space used.					
Acceptance and willingness to collect organic waste[c]	Amount of organic waste collected (%)	T	[b]		n.a.	n.a.
	% of improper materials in the organic waste	T	[b]		n.a.	n.a.

Table caption: B Best option | I Intermediate option | W Worst option | S Similar values

T Quantitative, S Semi-quantitative, L Qualitative, n.d. no sector data, n.a. not applicable.
Data sources and assumptions for Table 3 are comprehensively presented in supplementary material SM1.
[a]According to the data used in the supplementary material SM2.
[b]The inventory results are not comparable because either not enough information is found or very different type of data/units, etc.
[c]Stakeholder or subcategory proposed by the authors for the specific case study (see Sections 2.4.1. and 2.4.2).





Compost was the worst option.

Results for HNO_3 and KNO_3 were in the same order of magnitude.

The price of compost was the lowest.

Transport and application costs were higher for compost.

Compost and HNO_3 better results.

Compost better in labour rights, worst in occupational accident.

Quick guide to LCA