



CALIMERO
IMPROVING BIO-BASED INDUSTRIES LIFE CYCLE SUSTAINABILITY



Funded by
the European Union

Et si la bioéconomie n'échappait pas aux risques de criticité ?



welc**o**p

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Industry case studies analysis to improve environmental performance and sustainability of bio-based industrial processes

Main aim and context

Advancing the transition to a sustainable European bio-economy by enhancing the sustainability of key industrial processes across five bio-based sectors:

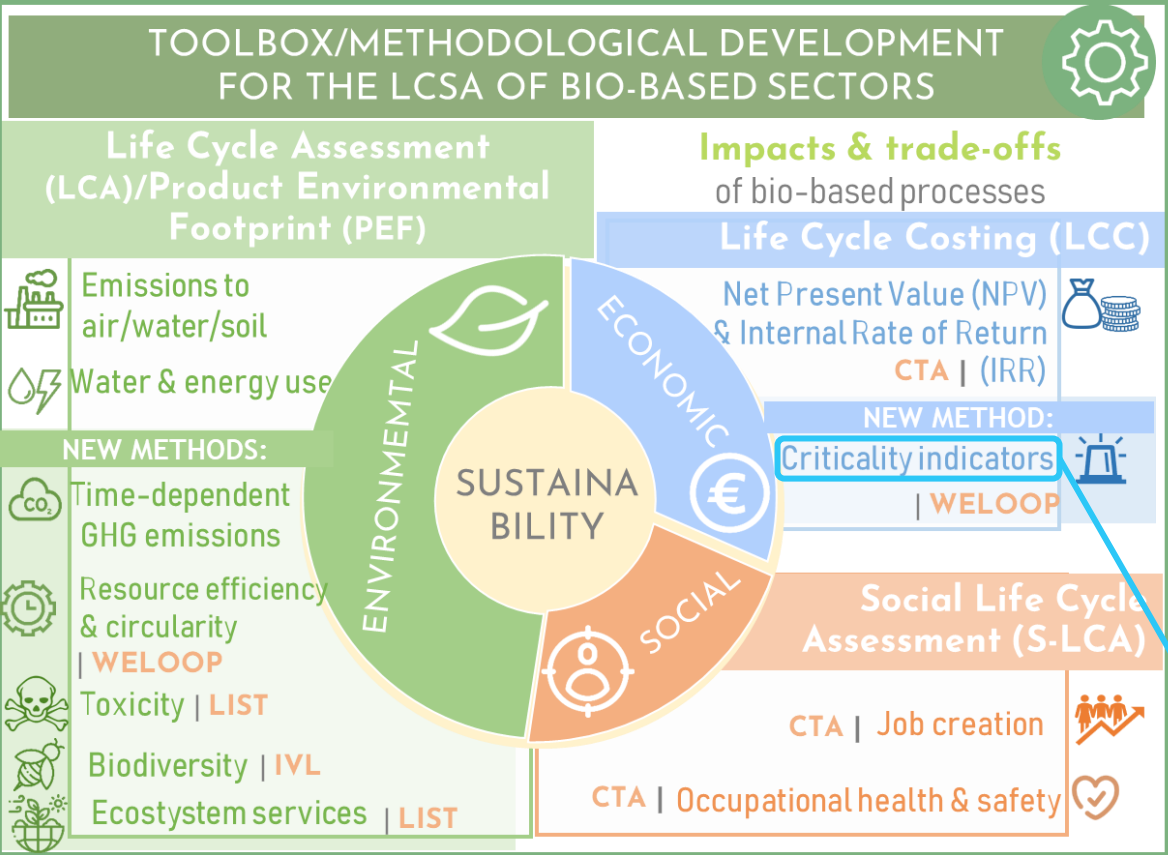
- Construction
- Woodworking
- Textiles
- Pulp and paper
- Biochemicals



Project partners



CALIMERO's toolbox/ methodological developments



Enhancement of existing environmental indicators and development of new ones to broaden the study's scope

Tailoring the approach to specific bio-based industries to enhance result quality

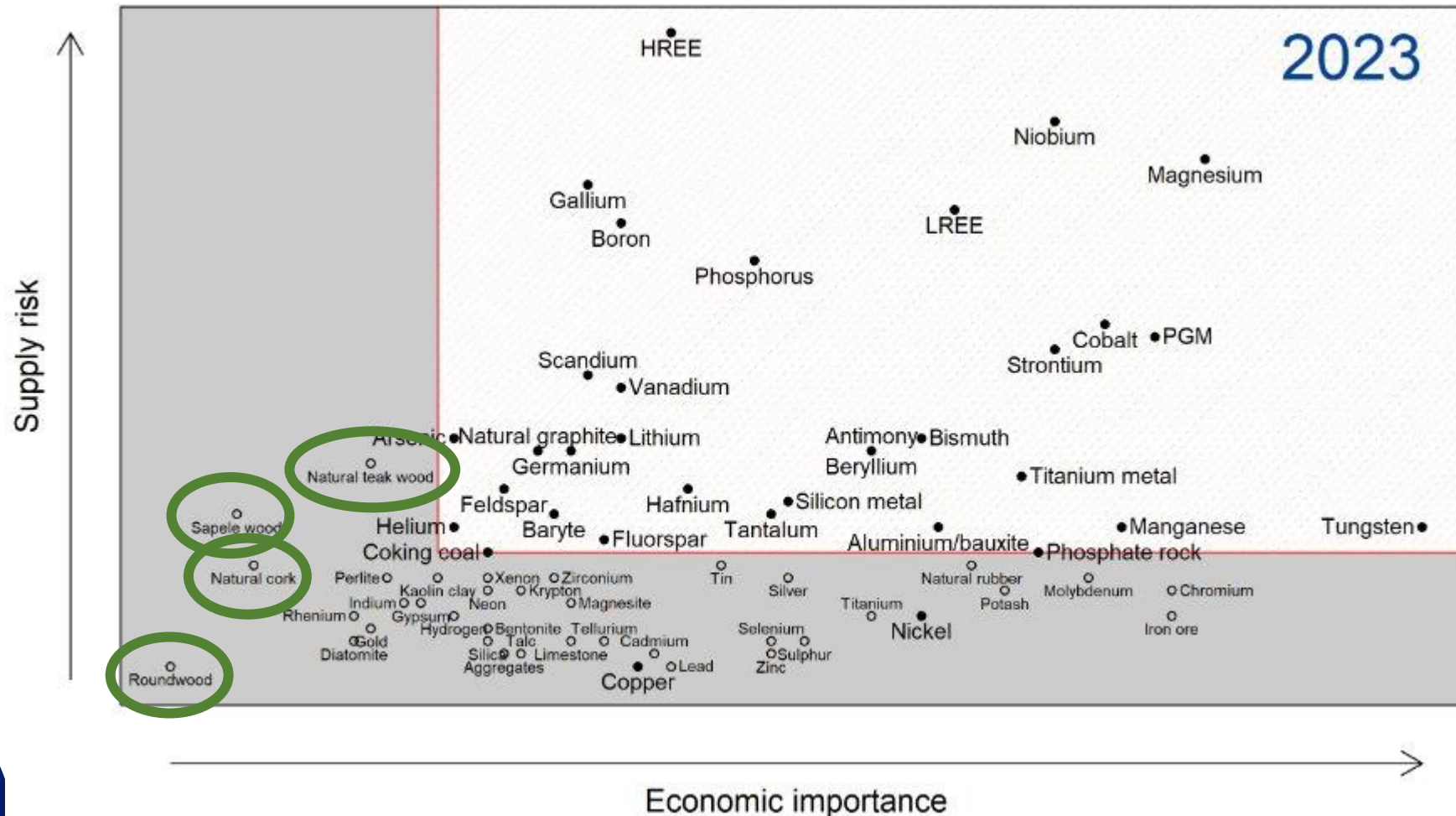
Incorporating social and economic dimensions to enable comprehensive sustainability analysis

Inclusion of criticality aspects for bio-based products in LCSA

Introduction

Critical raw materials

- High **probability of a disruption of supply**
- High **vulnerability of a system** to such a supply disruption (« importance »)



Luis Tercero, based on study on the Critical Raw Materials for the EU (2023)

Introduction

Is raw material criticality less relevant for the bio-based sector?

Or does 'criticality' have a different meaning for bio-based materials compared to metals?



Ancient forests (500–1000+ years old) are non-renewable and at risk of depletion



Deforestation for bio-based materials harms biodiversity and ecosystems



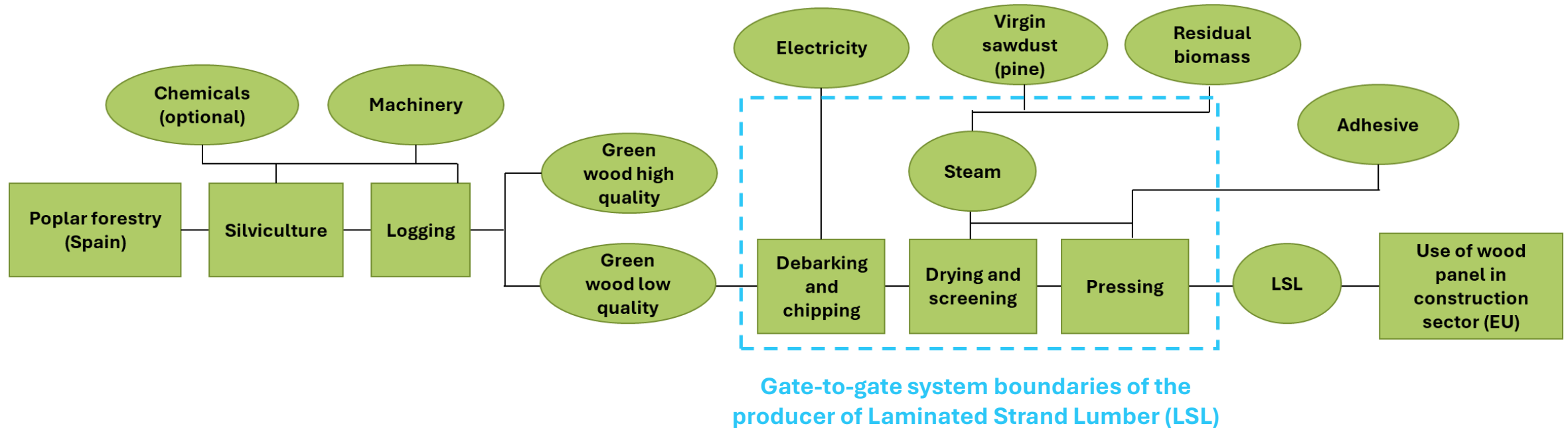
Land competition between agriculture, land access, and geopolitical tensions



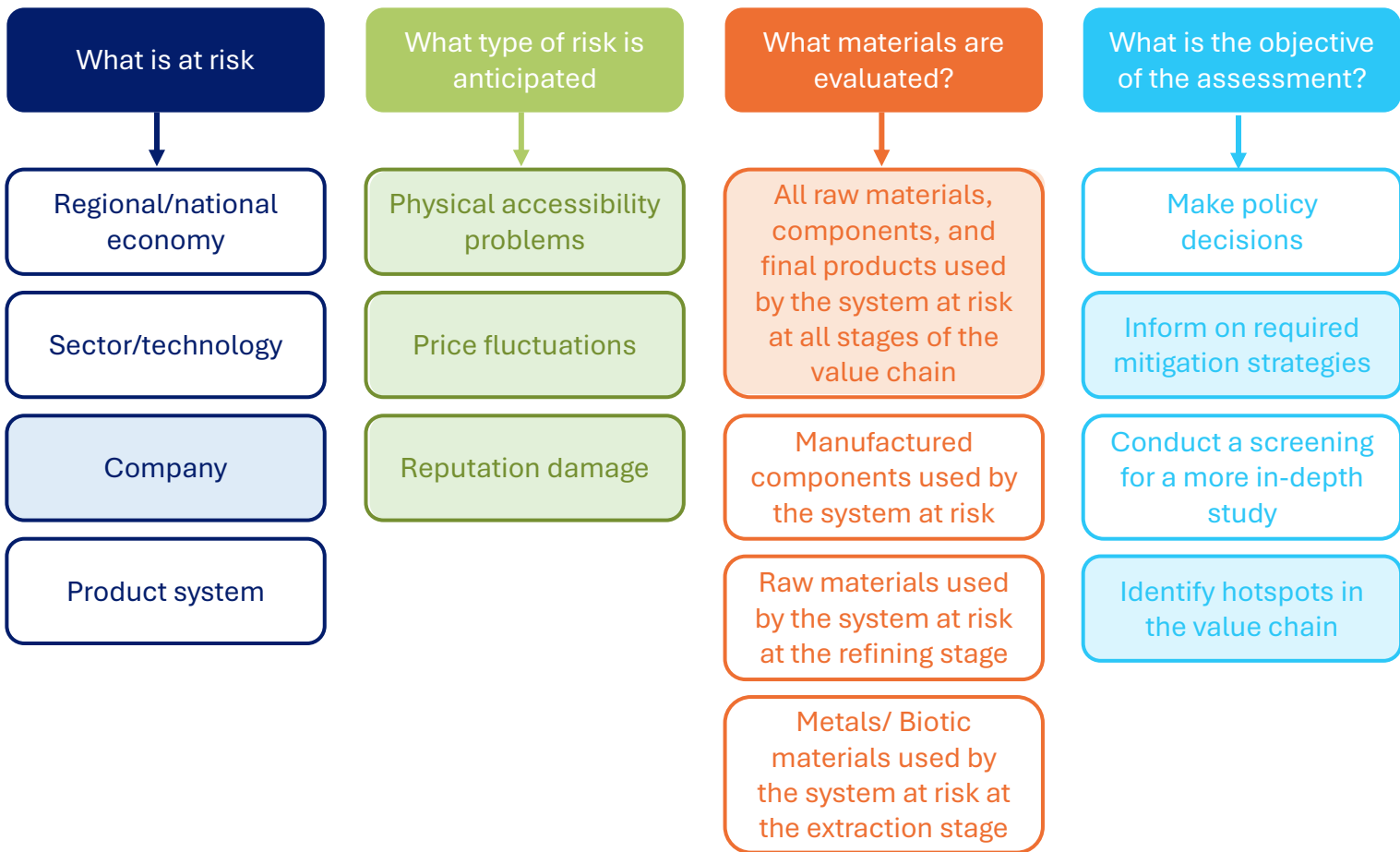
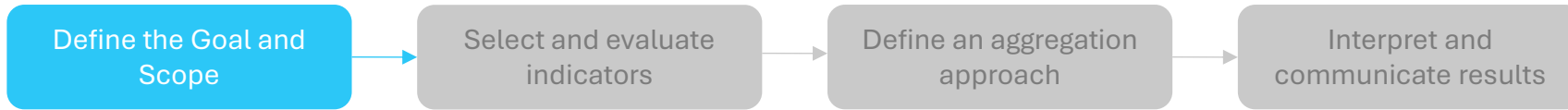
Resource demand conflict (e.g., food vs fuel) with limited supply

(Bach et al. 2017)

Laminated Strand Lumber (LSL) - case study



- Production of Laminated Strand Lumber (LSL) in the Spanish woodworking sector
- Produced from low-quality wood scraps from the poplar forestry sector
- Steam used during drying and screening of the chipped wood is provided from incineration of biomass, including both virgin sawdust and waste biomass



From the perspective of the producer of LSL, these flow may be subject to disruptions in the supply chain:

- Low-quality green wood
- Virgin sawdust (pine and beech wood)
- Waste biomass (discarded chips, dust, trimmings, and board waste)
- Adhesive material

Define the Goal and Scope

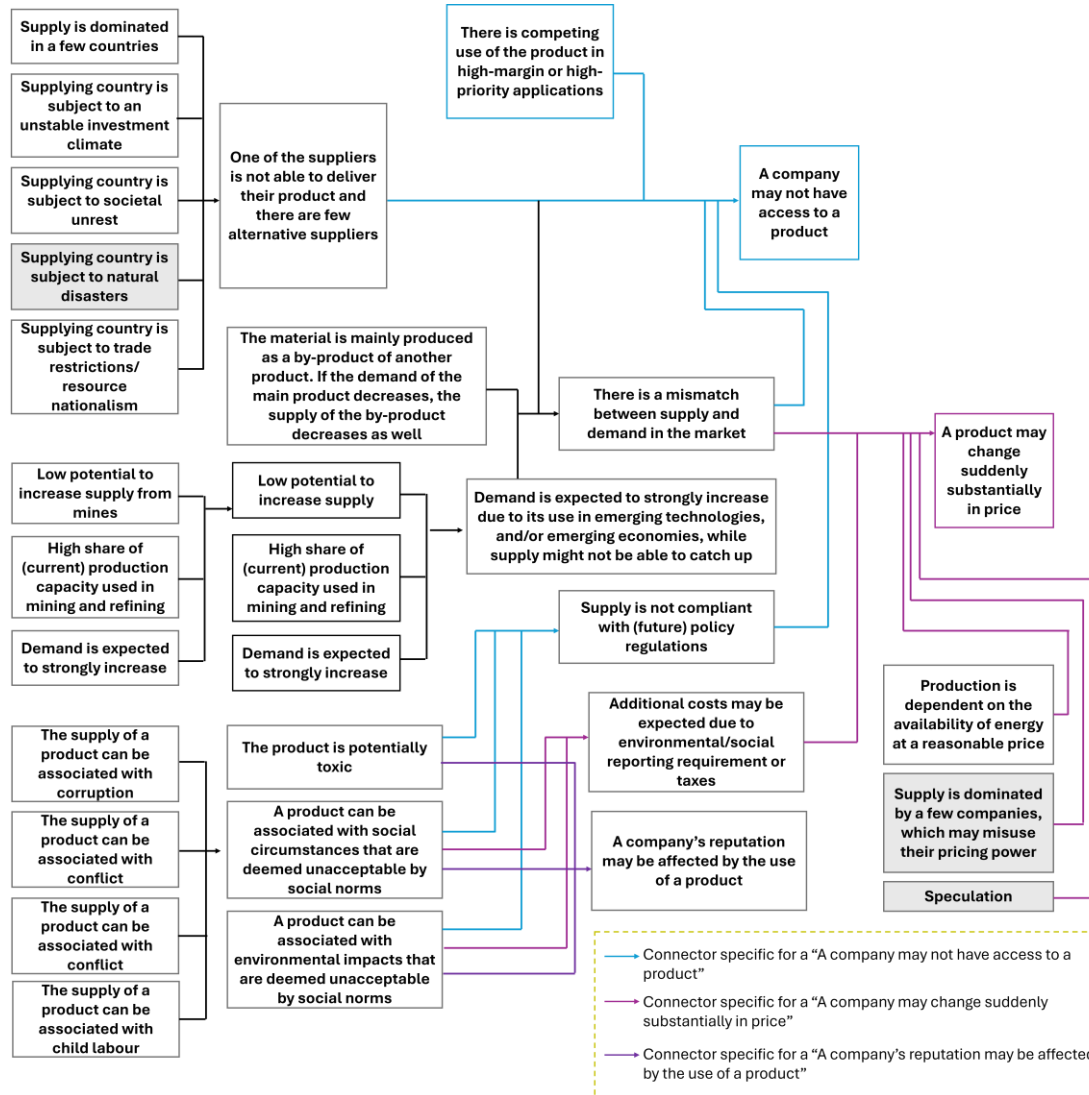
Select and evaluate indicators

Define an aggregation approach

Interpret and communicate results



IRTC framework



<https://www.irtc-decision-tool.welooop.org/tools>

Indicator selection based on the anticipated risks identified/selected by method developers

Impact pathways that link commonly used criticality indicators with the anticipated risks is done by the creation of "storylines"

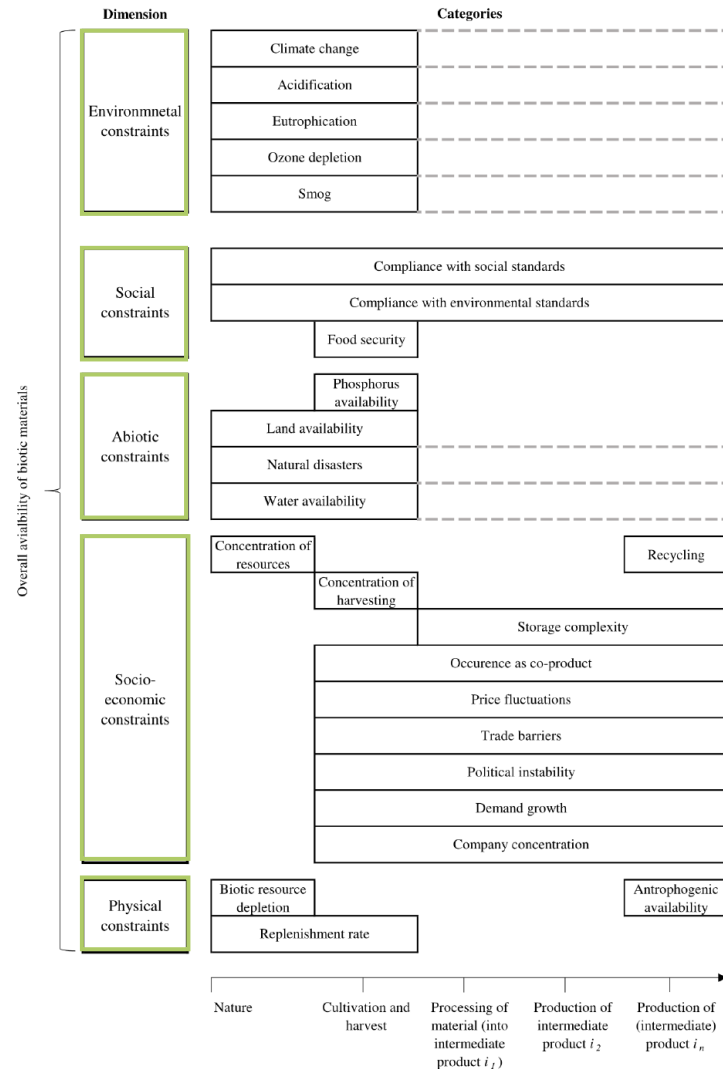
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BIRD framework



- No cause-and-effect mechanisms are developed within the framework
- Criticality indicators are only categorized based on their indicator type, but not on the type of risk they may pose on the company conducting the study

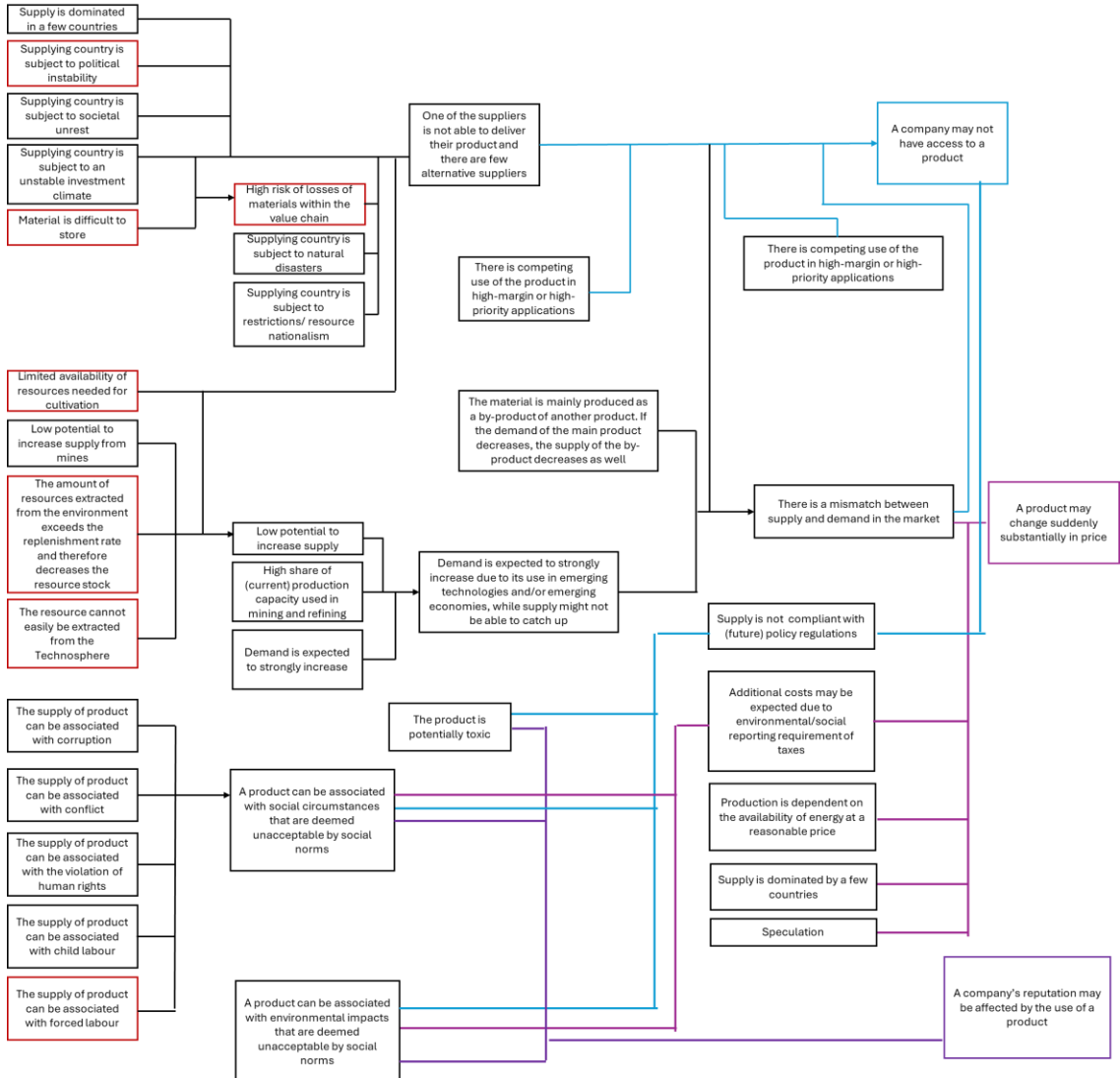
(Bach et al. 2017)

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Indicator evaluation based on combination of two criticality frameworks:

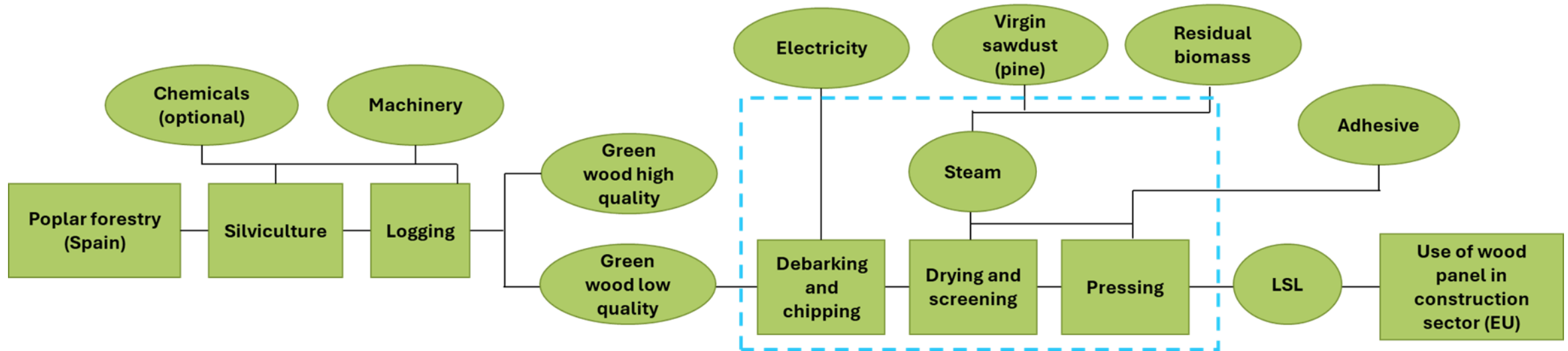
- IRTC framework (Schrijvers et al. 2023)
 - Cause-and-effect mechanisms of indicators and anticipated risks
 - Focus on metals
- BIRD framework (Bach et al. 2017)
 - Indicators for bio-based materials
 - Do not consider cause-and-effect mechanisms

 Supply-risk aspects relevant for biobased materials added

Indicator scoring using the developed criticality Excel tool

1 Defining the intermediate flows consumed by the system at risk

Intermediate flow consumed by the system at risk	Value-chain step	Supplying countries
Low-quality green wood	Processed raw material	Spain (100%)
Electricity	Final product	NA
Virgin sawdust (pine and beech wood)	Processed raw material	Spain (100%)
Waste biomass (discarded chips, dust, trimmings, and board waste)	Processed raw material	Spain (100%)
Adhesive material (in this case a polymeric methylene diphenyl diisocyanate glue, in some other cases formaldehyde-based adhesive is used)	Final product	China (50%), Germany (25%), USA (15%), Brazil (7%), Saudi Arabia (3%)



Gate-to-gate system boundaries of the producer of Laminated Strand Lumber (LSL)

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2 Identification of the value-chain step

- Availability of reserves (for minerals/metals) or natural growth (of biotic resources)
- Supply from mines (for minerals/metals) or cultivation and harvesting (for biotic resources)
- Production of refined or processed raw materials
- Production of intermediate products
- Production of final products

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3 Identification of the countries supplying each intermediate flow

Intermediate flow consumed by the system at risk	Value-chain step	Supplying countries
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Electricity	Final product	NA
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4 In the Excel tool:

The shares of supplying countries are multiplied with country-specific indicator values in the novel Excel template, to calculate a weighted average of country-specific indicator scores

Aggregated scoring of country-level indicators	Total HHI % of market represented	Production of final product	China	Germany	United States	Brazil	Saudi Arabia
	3408	100% Share	50,0%	25,0%	15,0%	7,0%	3,0%
54,05660412		0% Export restrictions between 2017-2020					
24,0961541		WGI - Political stability & absence of					
33,48076851		100% Violence/terrorism (2020)	31,13207626	7,78302	8,06604	4,7547171	2,32075
32,28365299		100% WGI - Government effectiveness (2020)	13,70192337	2,76442	1,94711	4,44230782	1,24038
32,40384586		100% WGI - Regulatory Quality (2020)	25	1,68269	1,875	3,76923073	1,15385
58,97584578		100% WGI - Rule of law (2020)	23,55769157	2,16346	1,73077	3,63461536	1,19712
45,46916667		100% WGI - Control of corruption (2020)	23,55769157	1,20192	2,59615	3,9375	1,11058
37,4987		100% WGI - Voice and Accountability (2020)	47,58454108	1,44928	4,05797	3,0434782	2,84058
36,67666667		100% Fragile State Index (2022)	29,625	5,14583	4,75	4,18833333	1,76
46,751		72% Policy Perception Index (2021)	27,775	#VALUE!	6,0585	3,6652	#VALUE!
0,378		100% Enabling trade index (2016)	20,91666667	6,29167	4,4	3,73333333	1,335
26,11875		100% Environmental Performance Index (2020)	31,35	5,7	4,605	3,416	1,68
43,2		7% Child labour (% ages 5-17) (2010-2019)	#VALUE!	#VALUE!	#VALUE!	0,378	#VALUE!
16,468		100% Global Peace Index (2022)	14,575	3,0875	4,90125	2,47275	1,08225
		100% Corruption Perceptions Index CPI (2021)	27,5	5	4,95	4,34	1,41
		100% Human Development Index HDI (2019)	11,95	1,325	1,11	1,645	0,438

Low-q green wood Residual biomass Virgin sawdust Adhesive

Criticality indicator scoring is calculated per intermediary flow

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Normalized values	Low-quality green wood	Virgin sawdust	Residual biomass	Adhesive	Cobalt	Lithium
Supply is dominated in a few countries (bottleneck)	100%	100%	100%	81%	88%	84%
WGI - Political stability & absence of violence/terrorism (2020)	34%	34%	34%	69%	100%	72%
WGI - Government effectiveness (2020)	29%	29%	29%	31%	100%	34%
WGI - Regulatory Quality (2020)	34%	34%	34%	43%	100%	46%
WGI - Rule of law (2020)	27%	27%	27%	40%	100%	41%
WGI - Control of corruption (2020)	30%	30%	30%	41%	100%	40%
WGI - Voice and Accountability (2020)	27%	27%	27%	81%	100%	69%
Fragile State Index (2022)	45%	45%	45%	60%	100%	57%
Policy Perception Index (2021)	85%	85%	85%	77%	100%	72%
Enabling trade index (2016)	52%	52%	52%	67%	100%	67%
Environmental Performance Index (2024)	64%	64%	64%	89%	100%	92%
Child labour (% ages 5-17) (2010-2019)				3%	100%	25%
Global Peace Index (2022)	39%	39%	39%	57%	100%	55%
Corruption Perceptions Index CPI (2021)	56%	56%	56%	62%	100%	65%
Human Development Index HDI (2019)	23%	23%	23%	39%	100%	43%
Natural disaster Index (NDI) (2013)	17%	17%	17%	100%		
Economic Vulnerability Index (2024)				100%		
Economic Vulnerability Index - Share of agriculture, forestry and fisheries (2024)				100%		
Economic Vulnerability Index - Remoteness and landlockedness (2024)				100%		
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Economic Vulnerability Index - Agricultural instability (2024)				100%		
Economic Vulnerability Index - Victims of disasters (%) (2024)				100%		
Water Depletion Index (WDI) (2018)	100%	100%	100%	46%		
EPI Species Habitat Index (2024)	51%	51%	51%	100%		
EPI Protected Area Representativeness Index (2024)	57%	57%	57%	100%		
Total subjected to export restrictions				19%	100%	14%
Potential to recycle	50%	100%	100%	100%		
Amount of phosphorous applied (kg) in a product system						
Amount of land used (h/year) in a product system						
Cradle-to-gate LCA (single score)					100%	58%
Climate change						
Acidification						
Eutrophication						
Ozone Depletion						
Photochemical ozone formation						
Cumulative energy demand					100%	98%
Threatened Species Index (TSI)						
Primary material use (%)	100%			100%		
Biotic resource depletion						
Replenishment rate (man-made biotic materials)	100%					
Substance of very high concern for Authorisation (REACH framework)				100%		
% supply as by-product	100%	100%	100%		98%	52%
% expected demand growth				24%	51%	100%

Key observations:

Biobased materials are compared to lithium and cobalt to facilitate the interpretation of results

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Replenishment rate (man-made biotic materials)	100%					
Substance of very high concern for Authorisation (REACH framework)				100%		
% supply as by-product	100%	100%	100%		98%	52%
% expected demand growth				24%	51%	100%

Key observations:

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- Adhesive material in LSL potentially restricted / potential reputation damage due to toxicity

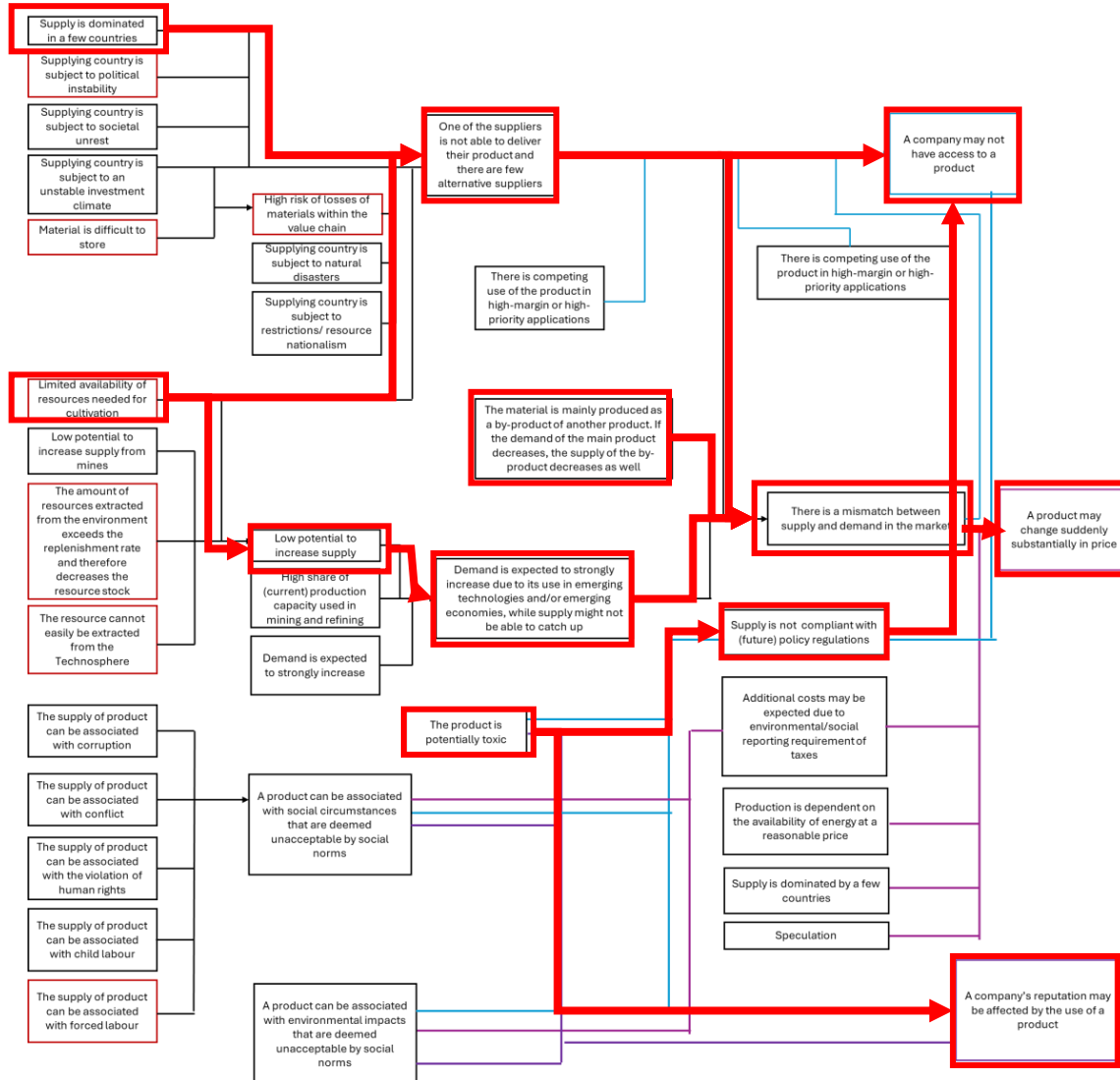
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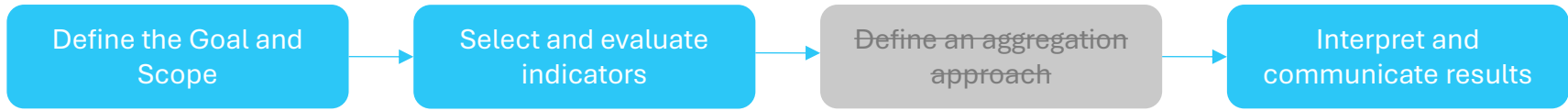
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WGI - Political stability & absence of Violence/terrorism (2020)	54%	54%	54%	69%	100%	72%
WGI - Government effectiveness (2020)	29%	29%	29%	31%	100%	34%
WGI - Regulatory Quality (2020)	34%	34%	34%	43%	100%	46%
WGI - Rule of law (2020)	27%	27%	27%	40%	100%	41%
WGI - Control of corruption (2020)	30%	30%	30%	41%	100%	40%
WGI - Voice and Accountability (2020)	27%	27%	27%	81%	100%	69%
Fragile State Index (2022)	45%	45%	45%	60%	100%	67%
Policy Perception Index (2021)	85%	85%	85%	77%	100%	72%
Enabling trade index (2016)	52%	52%	52%	67%	100%	67%
Environmental Performance Index (2024)	64%	64%	64%	89%	100%	92%
Child labour (% ages 5-17) (2010-2019)				3%	100%	25%
Global Peace Index (2022)	39%	39%	39%	57%	100%	55%
Corruption Perceptions Index CPI (2021)	56%	56%	56%	62%	100%	65%
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Economic Vulnerability Index - Agricultural instability (2024)				100%		
Economic Vulnerability Index - Victims of disasters (%) (2024)				100%		
Water Depletion Index (WDI) (2018)	100%	100%	100%	46%		
EPI Species Habitat Index (2024)	51%	51%	51%	100%		
EPI Protected Area Representativeness Index (2024)	57%	57%	57%	100%		
Total subjected to export restrictions				19%	100%	14%
Potential to recycle	50%	100%	100%	100%		
Amount of phosphorous applied (kg) in a product system						
Amount of land used (h/year) in a product system						
Cradle-to-gate LCA (single score)					100%	58%
Climate change						
Acidification						
Eutrophication						
Ozone Depletion						
Photochemical ozone formation						
Cumulative energy demand					100%	98%
Threatened Species Index (TSI)						
Primary material use (%)	100%			100%		
Biotic resource depletion						
Replenishment rate (man-made biotic materials)	100%					
Substance of very high concern for Authorisation (REACH framework)				100%		
% supply as by-product	100%	100%	100%		98%	52%
% expected demand growth				24%	51%	100%

Discussion

- Some indicators are less relevant for biobased material than for metals (e.g. Policy Perception Index)

Biobased materials are compared to lithium and cobalt to facilitate the interpretation of results

Define the Goal and Scope

Select and evaluate indicators

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Discussion

- Some indicators are less relevant for biobased material than for metals (e.g. Policy Perception Index)
- Spain does not have a score on Economic Vulnerability Indices. The results of adhesives can therefore not be put in perspective

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Discussion

- Some indicators are less relevant for biobased material than for metals (e.g. Policy Perception Index)
- Spain does not have a score on Economic Vulnerability Indices. The results of adhesives can therefore not be put in perspective
- Not all material-specific indicators are quantified, this study applied only basic assumptions for illustrative purposes.

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Discussion

The assessment of intermediate flows based on a few data points (including the supplying countries) already provides information on relevant criticality hotspots.

Awareness of data gaps and/or excluded indicators is important to be conscious of potential supply risks that are not quantified.

Conclusions and recommendations

This new criticality assessment framework and tool for biobased materials can be applied as:

- an initial checklist of value-chain attributes that may affect the stability of the “system at risk”
- a contextualization of indicator scoring, in which different material flows can be compared with each other
- an interpretation tool to understand the relevance of indicators
- a guidance framework to formulate mitigation strategies



Thank you !

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