De l'extérieur à l'intérieur : intégrer le risque géopolitique d'approvisionnement en tant que dimension complémentaire dans l'analyse du cycle de vie des ressources abiotiques

From the outside in:

integrating the geopolitical supply risk as a complementary dimension in the life cycle assessment of abiotic resources

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Outline

1. Introduction: Motivation, Background & Objectives

2. Methods: Integrating the geopolitical supply risk in life cycle assessment
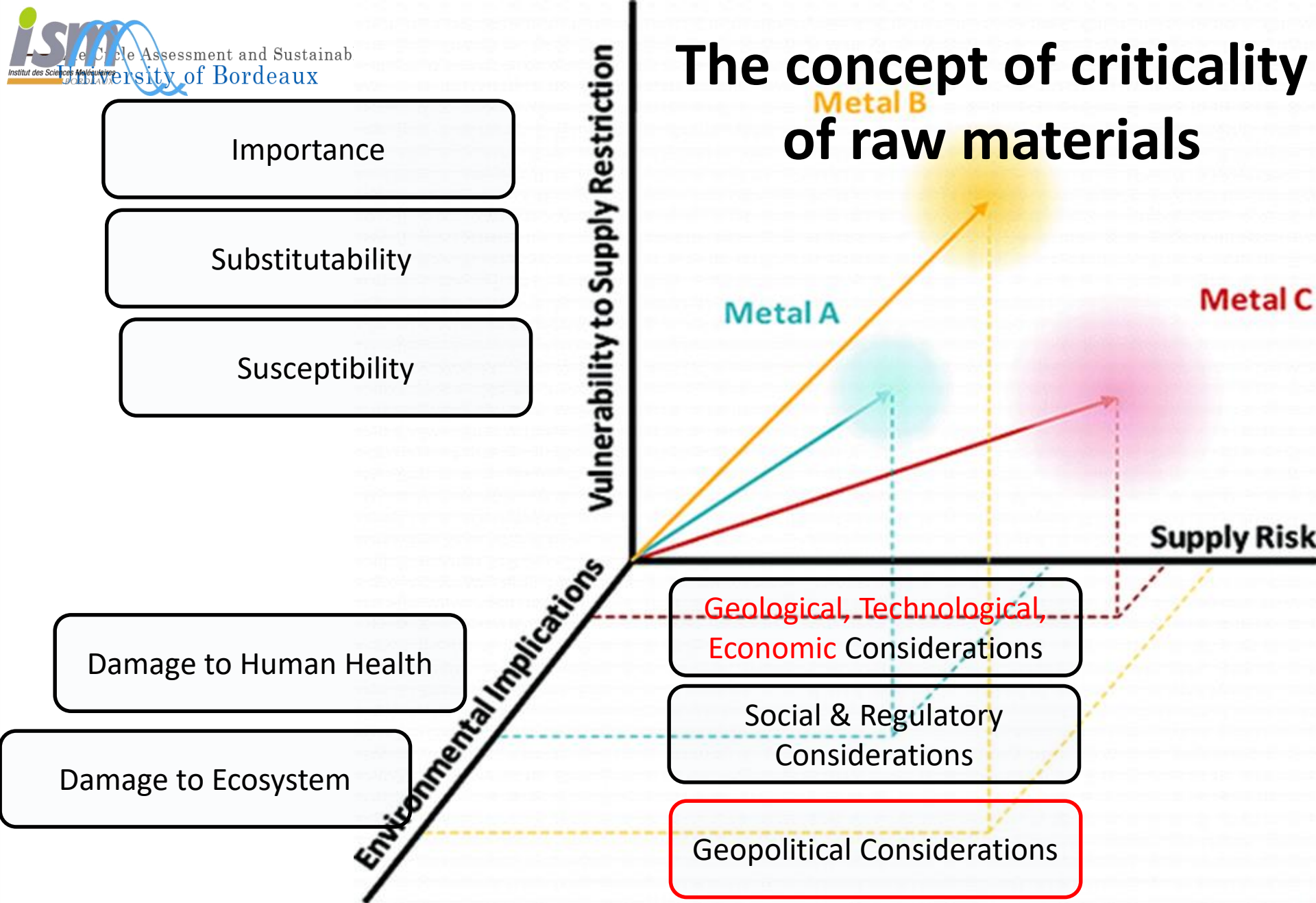
3. Case study

4. Conclusions

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1. Introduction:

Motivation, Background & Objectives

The concept of criticality of raw materials

Importance

Substitutability

Susceptibility

Damage to Human Health

Damage to Ecosystem

Vulnerability to Supply Restriction

Environmental Implications

Supply Risk

Metal A

Metal B

Metal C

Geological, Technological, Economic Considerations

Social & Regulatory Considerations

Geopolitical Considerations

Source : Graedel 2012

Introduction: Objectives

- **Explain first steps on how to integrate the geopolitical supply risk as a complementary dimension in the life cycle assessment of abiotic resources**

- **Use a case study of an electric vehicle** as an example to illustrate the value of this integration

2. Methods:

Integrating the geopolitical supply risk in life cycle assessment

LCSA – for Resource Criticality

Framework
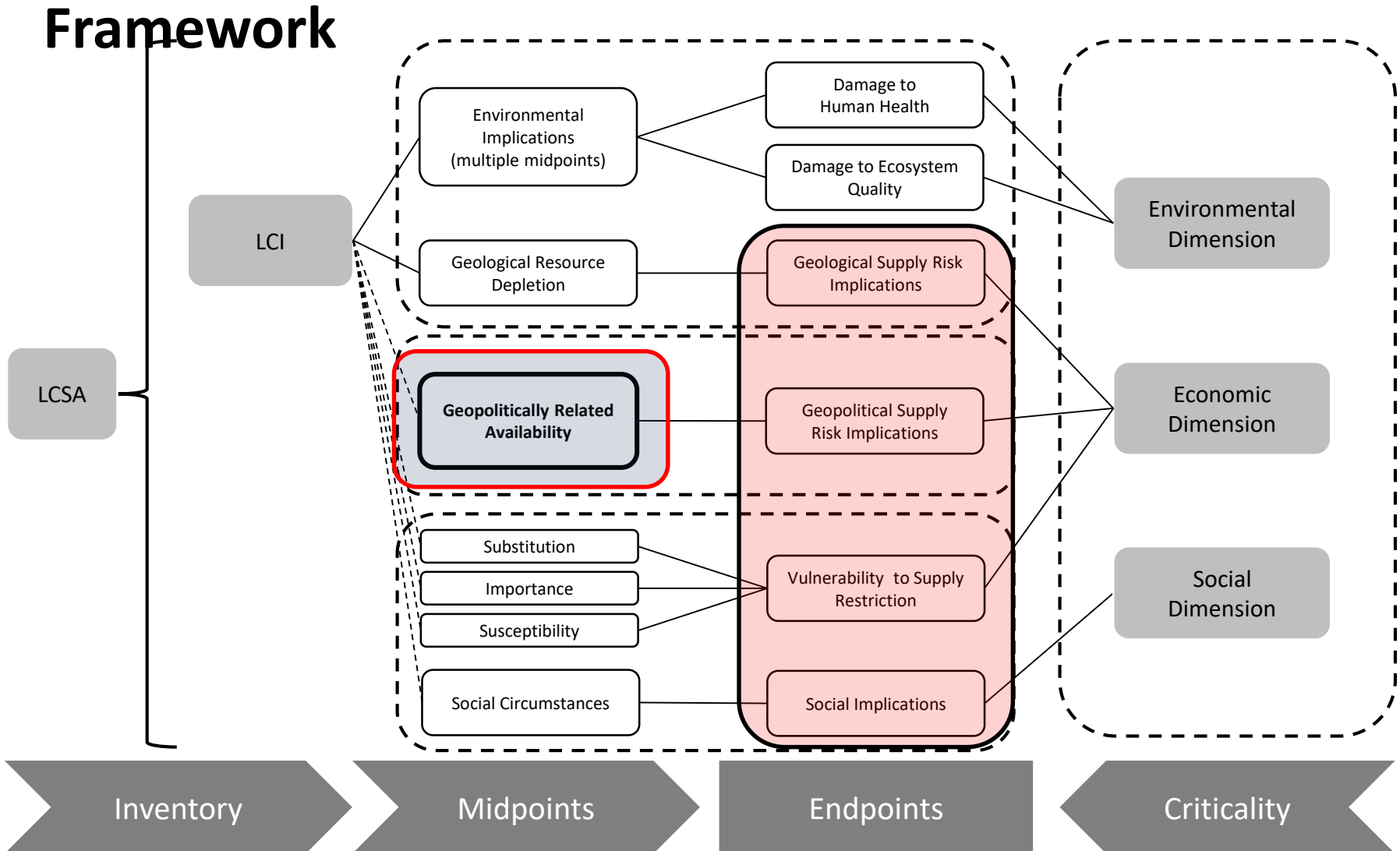
Sonnemann et al., 2015

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Integrating geopolitical supply risk in LSCA

$$SR_{c,i} = \left[\left(\sum_{k=1}^{n} s_k^2 \right) * \left(\sum_{k=1}^{n} g_k * f_{i,k} \right) \right]$$

- S_k is the share of country k in the global production (mining or refining) of the commodity c.

- g_k is the political instability indicator of country k.

- $f_{i,k}$ is the import share of country k in the supply-chain of country i.

GeoPolRisk is expressed as a socio-economic risk oriented midpoint indicator with values between 0 and 1

Gemechu et al., 2015

Resource "criticality"...

- "Supply risk" (actually probability)
- "Vulnerability" to supply disruption

$$Supply\ Risk = Probability \times Vulnerability$$

…on a product-level

Geopolitical Supply Risk (GPSR)

$$GPSR_{APc} = m_{APc} \times CF_{APc}$$

$$CF_{APc} = GeoPol_{Ac} \times Vuln_{APc}$$

Where
- $GPSR_{APc}$ = Geopolitical Supply Risk for commodity A needed to produce product P in country c
- m_{APc} = amount of commodity A needed to produce product P in country c
- $GeoPol_{Ac}$ = probability of supply disruption of commodity A in country c
- $Vuln_{APc}$ = vulnerability indicator for commodity A needed to produce product P in country c

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Geopolitical Supply Risk (GeoPol, 1-stage)

$$GeoPol_{Ac} = HHI_A \sum_i g_i \frac{f_{Aic}}{p_{Ac} + F_{Ac}}$$

Where

- HHI_A = production concentration of commodity A **→ USGS**

- g_i = political (in)stability of producing country i **→ WGI**

- f_{Aic} = imports of commodity A from country i to country c **→ UN Comtrade**

- p_{Ac} = domestic production of commodity A **→ USGS**

- F_{Ac} = total imports of commodity A to country c **→ UN Comtrade**

Geopolitical Supply Risk (GPSR)

$$Vuln_{APc} = PI_{APc} \times Sub^{-1}{}_{APc}$$

Where

- PI_{APc} = "product-level importance," $PI_{APc} = \frac{1}{m_{APc}}$

- $Sub^{-1}{}_{APc}$ = "substitutability" based on Graedel et al. 2015 (PNAS)

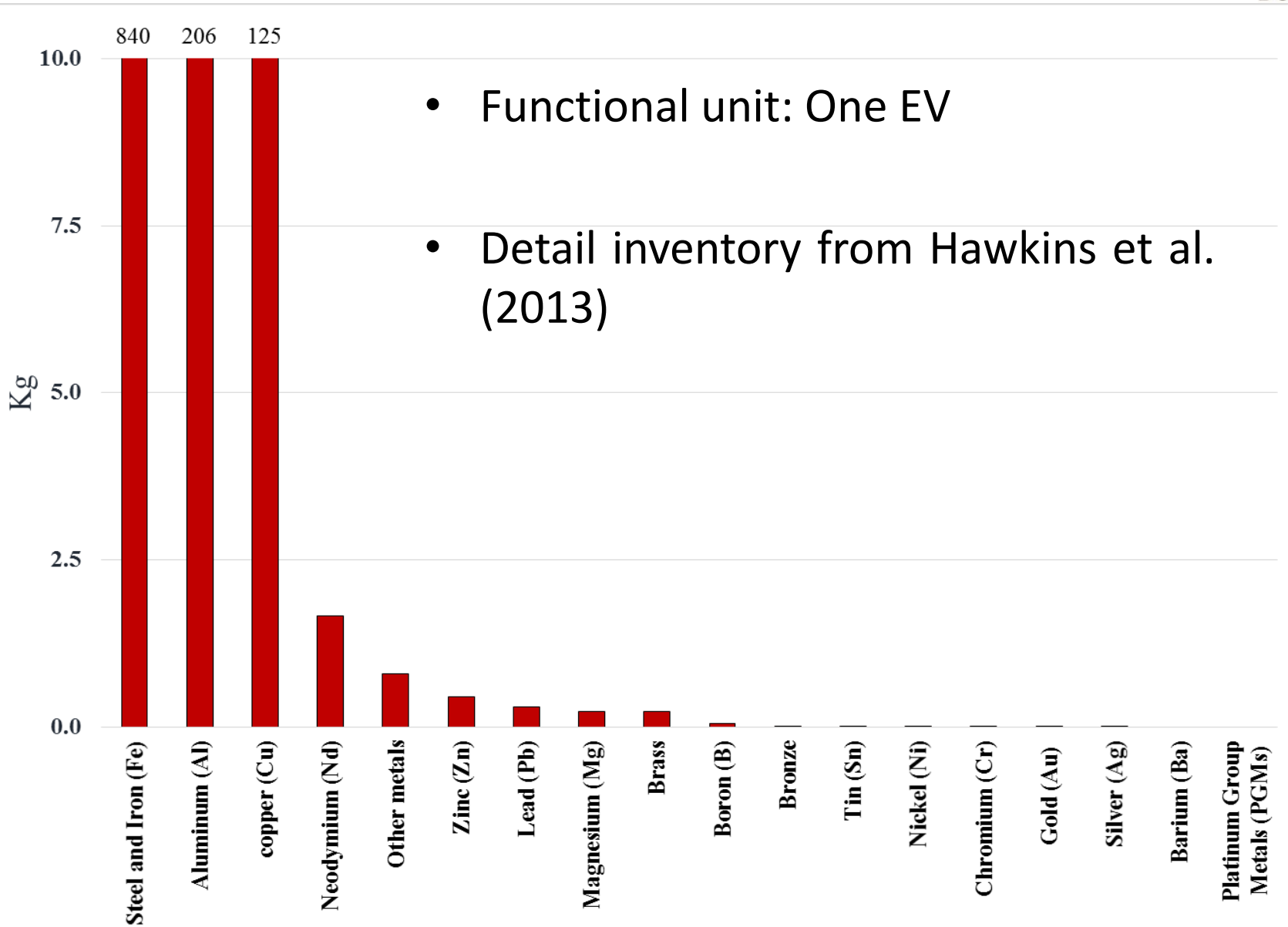***Note: "substitutability" factor not published***

3. Case study
Results of integrating criticality into LC(S)A

Critical raw materials in an electric vehicle

Mass of metals in an electric vehicle

- Functional unit: One EV

- Detail inventory from Hawkins et al. (2013)

# Methods and Materials for Environmental Impact Assessment

- LCA software: SimaPro

- LCI database: ecoinvent v3.1

- LCIA method: ReCiPe midpoint

- Impact categories
    - Global Warming Potential
    - Metal Depletion Potential
    - Human Toxicity Potential
    - Freshwater Eco-toxicity Potential

- System boundaries:

No use phase and No end-of-life

Raw Material Extraction • Material Production • Vehicle Production • Use • Disposal • Recycling

Case study published
Gemechu E., Sonnemann G., Young S.B.
Geopolitical-related supply risk assessment as a complement to environmental impact assessment: **the case of electric vehicles**, Intl. Journal of LCA 2017;
DOI:10.1007/s11367-015-0917-4

Environmental and GeoPolRisk Results
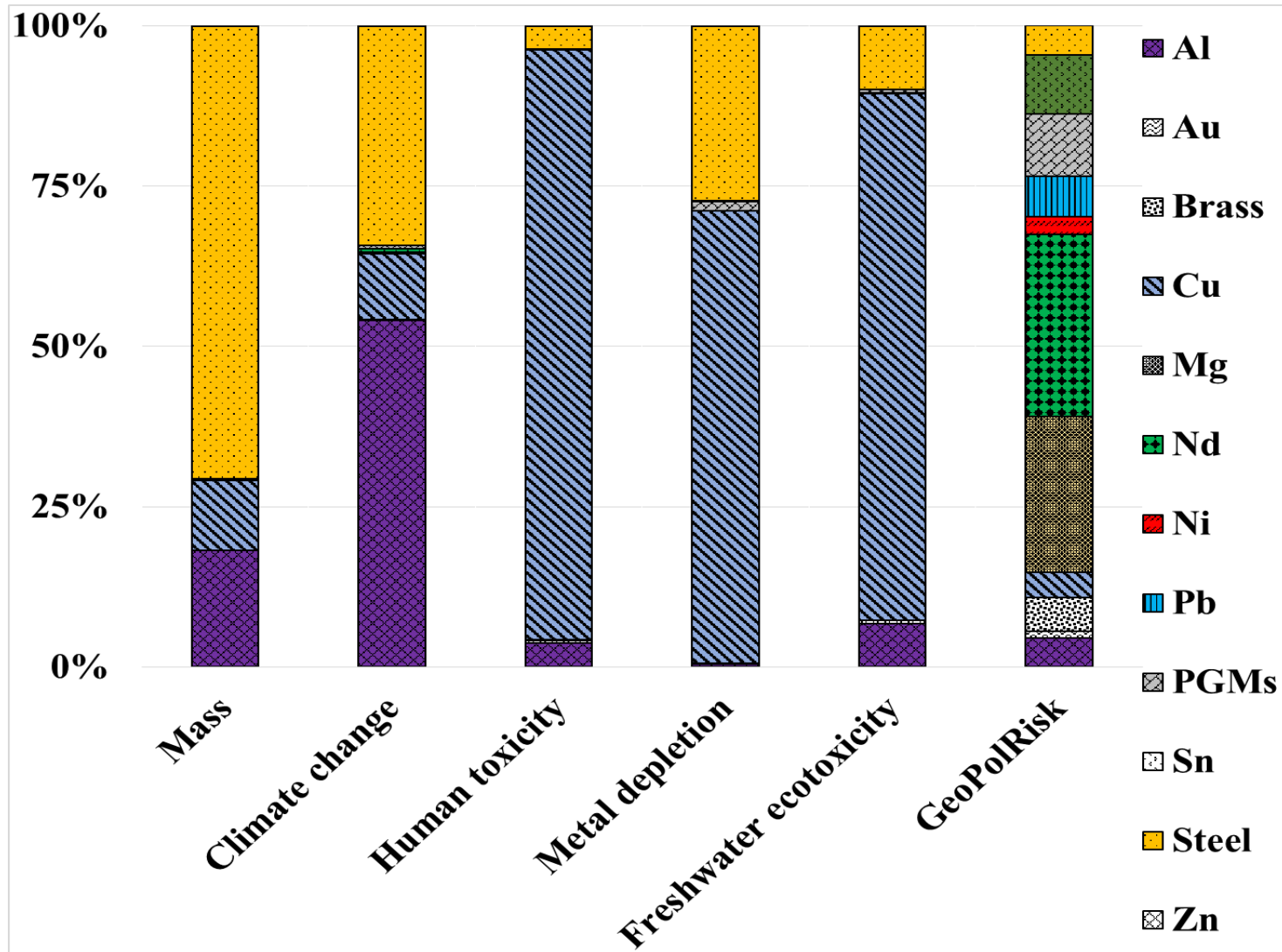
indicators selected

🪨 How can I quantify the...

Minority statement!

...changing opportunities of future generations to use resources due to a current resource use? (inside-out, LCA)					....potential resource availability issues for a product system? (outside-in, LCSA)	
...contribution of a product system to the depletion of resources?	...contribution of a product system to changing resource quality*?	...consequences of the contribution of a product system due to changing resource quality*?	...(economic) externalities of resource use?	...mineral resource use based on thermodynamics?	...potential resource availability issues for a product system related to mid-term physico-economic resource scarcity?	...potential resource availability issues for a product system related to short-term geopolitcal and socio-economic aspects?
ADPultimate reserves	OGD	ORI	Fut. wellfare loss	SED	ADP reserve base	ESP
ADP reserve base		**SOP**	**LIME2 (endpoint)**	CExD	**ADP**economic reserves	**ESSENZ**
ADP economic reserves		Eco-indicator 99		**CEENE**	Ecoscarcity	**GeoPolRisk**
Ecoscarcity		Impact2002+		TR	EDIP	
EDIP		Stepwise2006			LIME2 (midpoint)	
LIME (midpoint)		ReCiPe2008			AADP	
AADP		SCP				
		EPS				
		TR (ERC)				
Recomended		*Interim recom.*	*Interim recom.*	*Interim recom.*	*Suggested*	*Interim recommended Suggested*

Minority statement!

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Conclusions

- Criticality assessment of resources and LCA for products have a complimentary nature.

- Integrating criticality into LCSA is **useful** to compare trade-offs with environmental impact categories and **feasible** as shown with our first steps for **GeoPol and GPSR**

- Data generated for LCA provide a lot basic information on resource use that can be used in this way.

- Life Cycle Inventories need to become more geographically explicit to be more relevant (similar to water).

- The GeoPol and GPSR methods have **limitations**, some of them are currently addressed in research to cover recycling.

- More work is needed to address **all dimensions** of criticality.

Thank you for your attention!

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