Harmonizing the LCIA of mineral resource use

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Background

Mineral resources are of great relevance for industry and society now and in the future. Environmental impacts caused by emissions from mining and refining are analyzed in various impact categories. However, consensus on how the use of resources as such should be considered in LCIA is currently lacking. Within the Life Cycle Initiative's flagship project "Global guidance on environmental Life Cycle Impact Assessment Indicators", a task force has been evaluating the state of the art and recommends best practices for assessing mineral resource use in LCA.

Methodology

Based on discussions between various stakeholders, the safeguard subject with regard to mineral resources has been defined as:

Within the area of protection "natural resources", the safeguard subject for "mineral resources" is the potential to make use of the value that mineral resources, as embedded in a natural or anthropogenic stock, can hold for humans in the technosphere. The damage is quantified as the reduction or loss of this potential caused by human activity. Mineral resources are chemical elements (e.g. copper) or minerals (e.g. gypsum) or aggregates (e.g. sand).

In a literature review, 29 methods assessing impacts of resource use in LCA have been identified. Depending on the impact pathway (Figure 1), methods have been clustered into four categories, assessing:

- Depletion of stocks
- Future efforts resulting from an (assumed) ore grade decline
- Thermodynamics (exergy/emergy)
- Supply risk of raw materials

Within the four clusters, key axioms and methodological choices have been discussed and all methods have been analyzed using an evaluation scheme comprising criteria like scientific robustness or applicability.

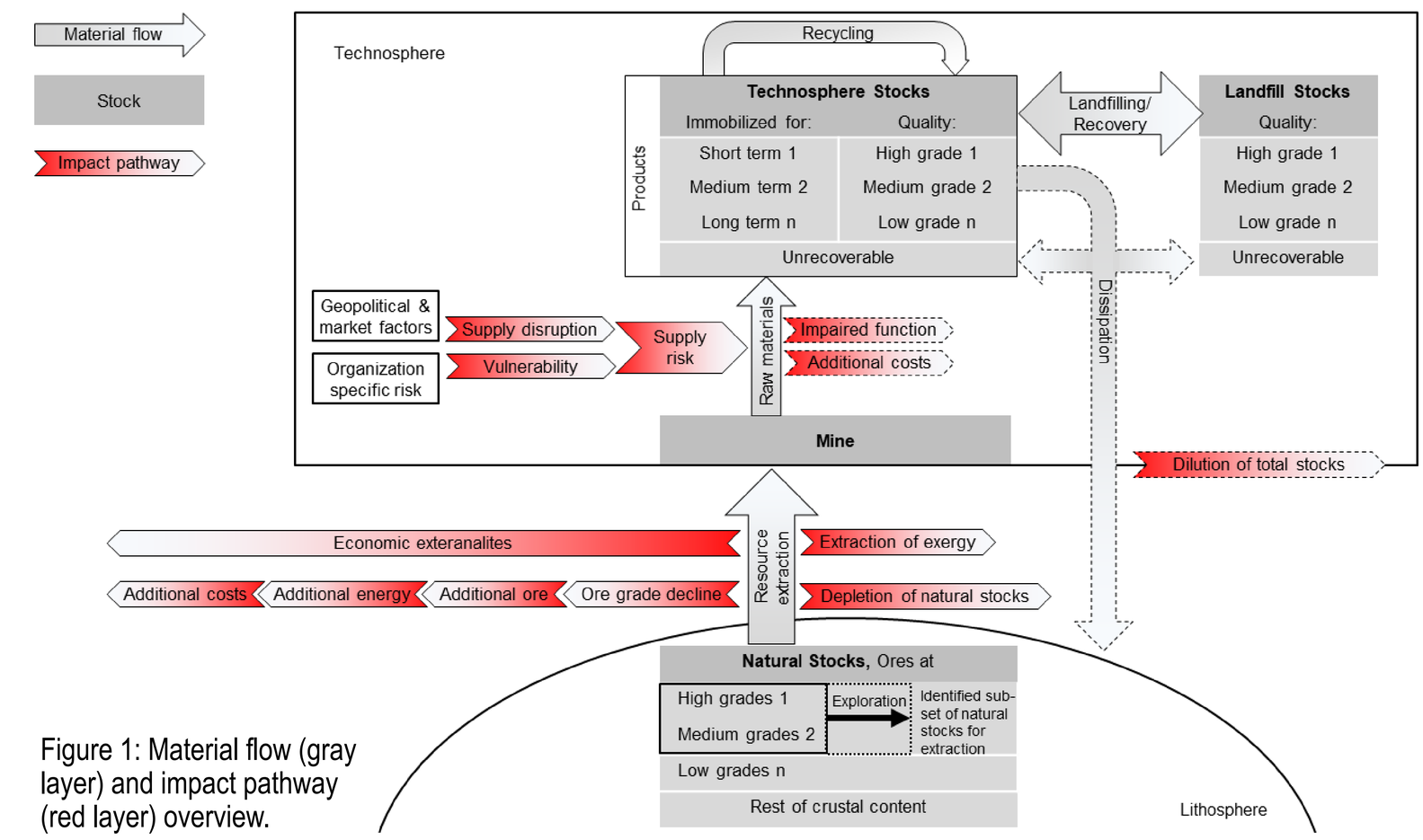

Figure 1: Material flow (gray layer) and impact pathway (red layer) overview.

All methods have been tested in an LCA study of an electric vehicle. During the Pellston workshop®, held in Valencia in June 2018, key questions an LC(S)A practitioner could be interested in when assessing impacts of resource use was established (Table 1). While the first group of questions focused on how a product system's resource use can affect opportunities of future generations (inside-out), the second group of questions focused on how the environment/society can affect a product system (outside-in).

Recommendations

Existing LCIA methods have been assigned to the question(s) they answer and (if possible) one method has been recommended based on the modelling approach, underlying data and applicability.

Table 1: Questions related to the impacts of mineral resource use, suitable methods, **recommended methods (bold)** and *level of recommendation (italic)*

How can I quantify the…						
…changing opportunities of future generations to use resources due to a current resource use? (inside-out)					**….potential resource availability issues for a product system? (outside-in)**	
…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?
$ADP_{ultimate\ reserves}$	Ore grade decline	Ore requirement ind.	Future wellfare loss	Solar energy demand	$ADP_{reserve\ base}$	Economic scarcity pot.
$ADP_{reserve\ base}$		**Surplus ore potential**	**LIME2 (endpoint)**	CExD	**$ADP_{economic\ reserves}$**	**ESSENZ**
$ADP_{economic\ reserves}$		Surplus cost potential		**CEENE**	Ecoscarcity	**GeoPolRisk**
Ecoscarcity		Eco-indicator 99		Thermodynamic rarity	EDIP	
EDIP		Impact2002+			LIME2 (midpoint)	
LIME2 (midpoint)		Stepwise2006			AADP	
AADP		ReCiPe2008				
		EPS, TR (ERC)				*Interim recommended*
Recomended		*Interim recommended*	*Interim recommended*	*Interim recommended*	*Suggested*	*Suggested*

Future method developments should update and increase the number of characterization factors and consider secondary resource use as well as anthropogenic stocks. Further, dissipative resource use should be defined and implemented in characterization models.

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