European Commission

Assessing resource depletion in LCA: a review of methods and methodological issues

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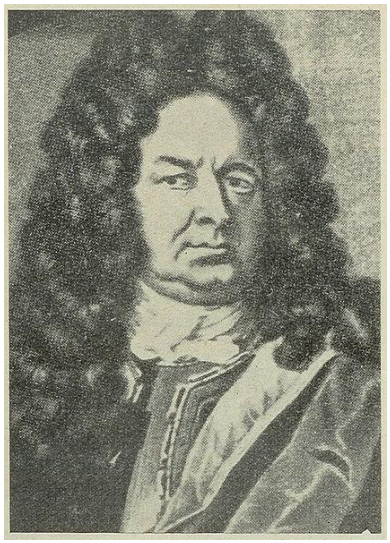
Outline

- Sustainability and resources
- Key concepts and perspectives
- Review on current impact assessment methodologies for Resources

Resources and sustainability -1



One of the father of the definition of "sustainability" was Hans Carl von Carlowitz.

The concept was founded in **forestry** and was strictly **resource-based** and stayed so for centuries (Carlowitz 1713, Cotta 1828).

The concept was developed by foresters because timber had been excessively overused and become a very scarce resource in the process of the industrial revolution and urbanisation.

Carlowitz HC (1713)Sylvicultura oeconomica, oder haußwirthliche Nachricht und Naturmäßige Anweisung zur wilden Baum-Zucht

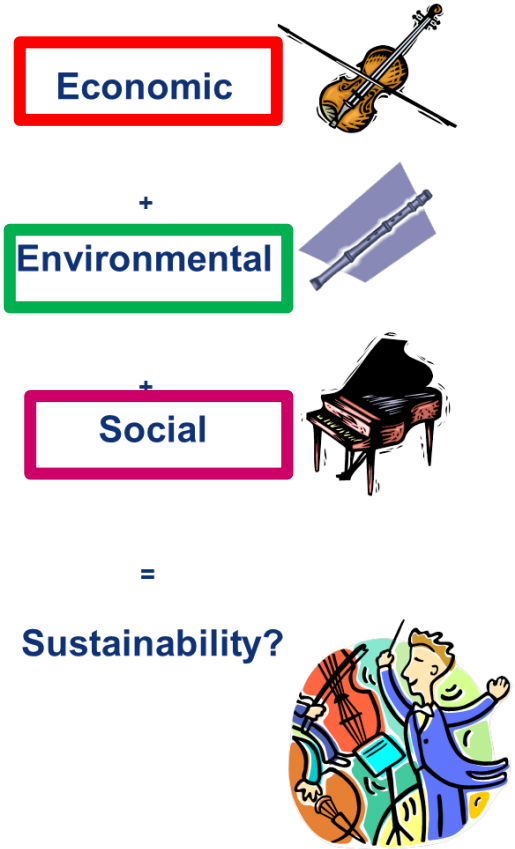
Resources and sustainability _2

Around 1700, the **mining industry** and livelihood of thousands was threatened in **Saxony**.
It was not that the mines had been exhausted of their **ores**, the problem was an acute scarcity of **timber.**

The mining industry and smelting of ores had consumed whole forests. In the vicinity of places of mining activity the old growth forests had disappeared completely. **Trees had been cut at unsustainable rates** for decades without efforts to restore the forests.

First, the river systems in the Erzgebirge was engineered, so logs could be transported from ever more distant forest areas, but these measures only postponed the crisis.

The **prices for timber** rose ever more, which led to bankruptcy and **closure of parts of the mining industry**.



Resources and sustainability _3

- Environmental as well as economic and social dimension
- Interplay between socio-economic drivers, environmental and socio economic impacts

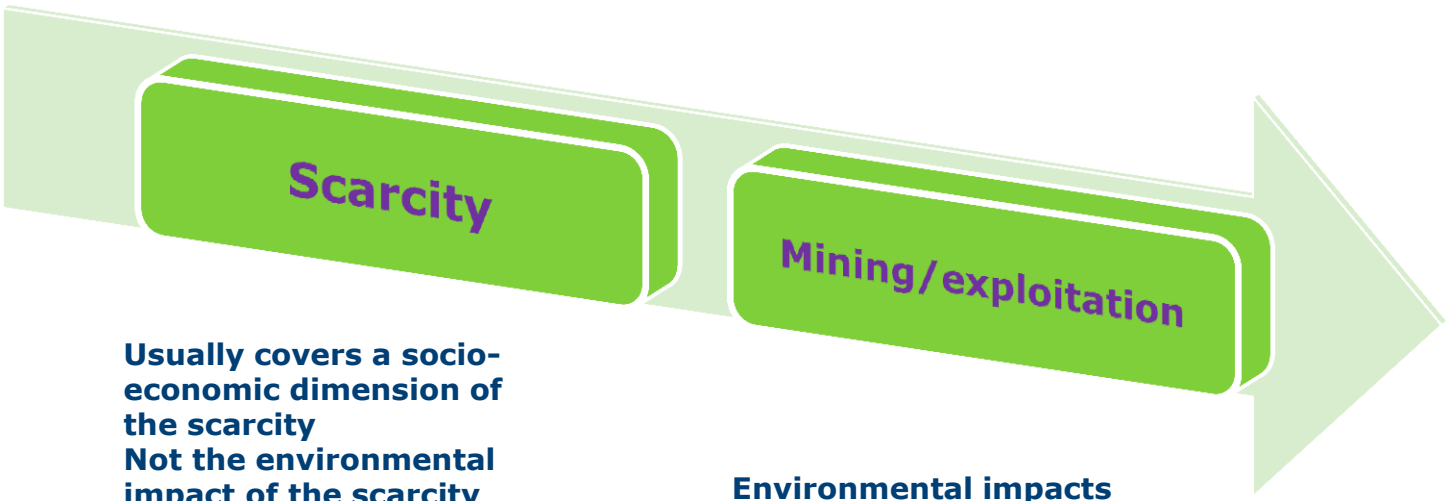
Should resources be included in LCIA?

Scientific debate

For sure they should be part of the impact assessment in LCSA….

However…

Environmental impact of resources



Usually covers a socio-economic dimension of the scarcity
Not the environmental impact of the scarcity itself

Environmental impacts due to mining process, modelled in other impact category, such as climate change, acidification etc

Scarcity and criticality

Environmental dimension and impacts

Abiotic resources

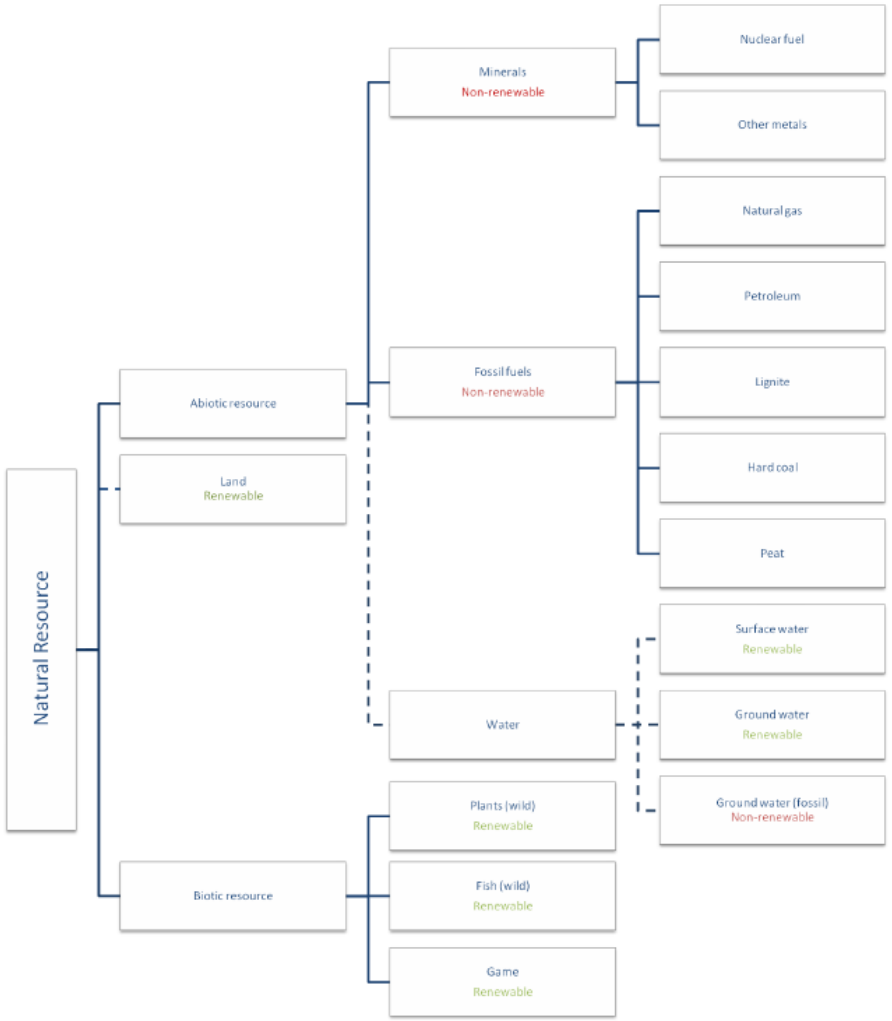
- **Part of biogeochemical cycles**
- **Ecological niche/habitat**
- Almost inert- e.g. impact associated to their extraction but not to their scarcity…

Biotic resource

- **Habitat**
- **Ecosystems service and function**

Socio- economic and geopolitical aspects

Classification of resources



Dewulf *et al.* (2007):

- atmospheric resources
- land
- water
- minerals
- metal ores
- nuclear energy
- fossil fuels
- renewables

Finnveden (1998):

- deposits
- funds
- flows

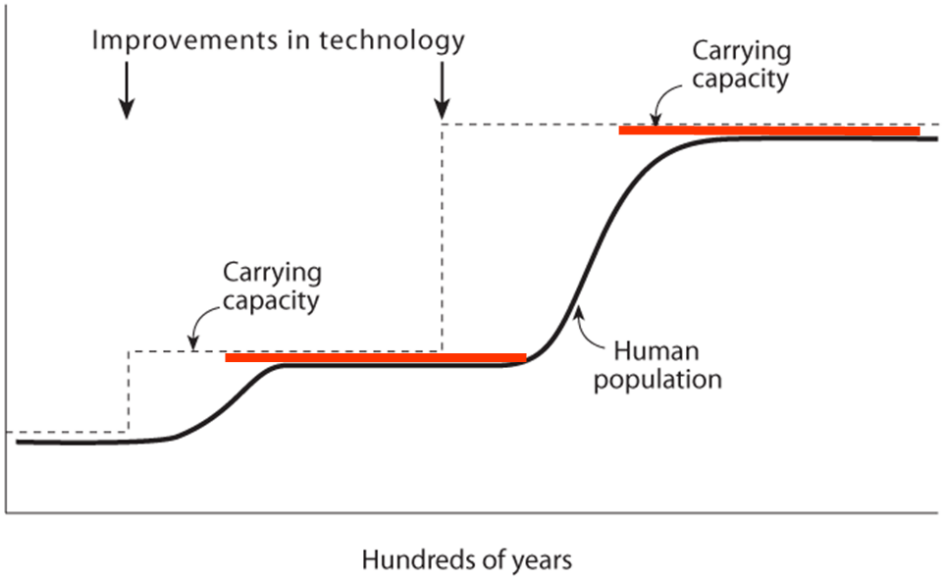
Guinée *et al.* (2002):

- biotic
- abiotic

All these are commonly aggregated into one indicator

Current impact assessment methods for resources in LCIA

- Carrying capacity
- Environmental impact associated with scarcity itself
- Role of technology



Current Impact Assessment Methodologies for Resources

ILCD

- **Scarcity/mass based: CML** (Guinee/Heijungs 1995; van Oers et al. 2002) and **EDIP** methods (Hauschild/Wenzel 1998)
- **Anthropogenic stock extended Abiotic Depletion Potential (AADP):** (Schneider et al. 2011)
- **Exergy**: (Dewulf et al. 2007)
- **Surplus energy**: **Eco-Indicator 99** (Goedkoop/Spriensma 2001) and **IMPACT 2002+** (Jolliet et al. 2003)
- **Marginal cost**: **ReCiPe** methodology (Goedkoop et al. 2009)
- **Willingness-to-pay: EPS 2000** (Steen 1999)
- **Distance to target**: **EcoPoints** method (Frischknecht et al. 2008)

Impact assessment methodologies

	Exergy	AADP	CML 2002	EI99	Ecopoints 2006	EDIP 97	EPS 2000	IMPACT 2002+	ReCiPe 2008
Minerals	57	10	48	12	1	29	67	13	19
Fossil fuels	6		4	4	4	4	3	5	4
Nuclear fuels	1		1		1	1	1	1	1
Biotic	5				1		2	1	0
CRM	0	2	13	1	0	8	28	1	7

Source: Kinglmair et al. (2012) *Assessing resource depletion in LCA: a review of methods and methodological issues* (submitted paper)

Coverage of CRM (scarcity focus)

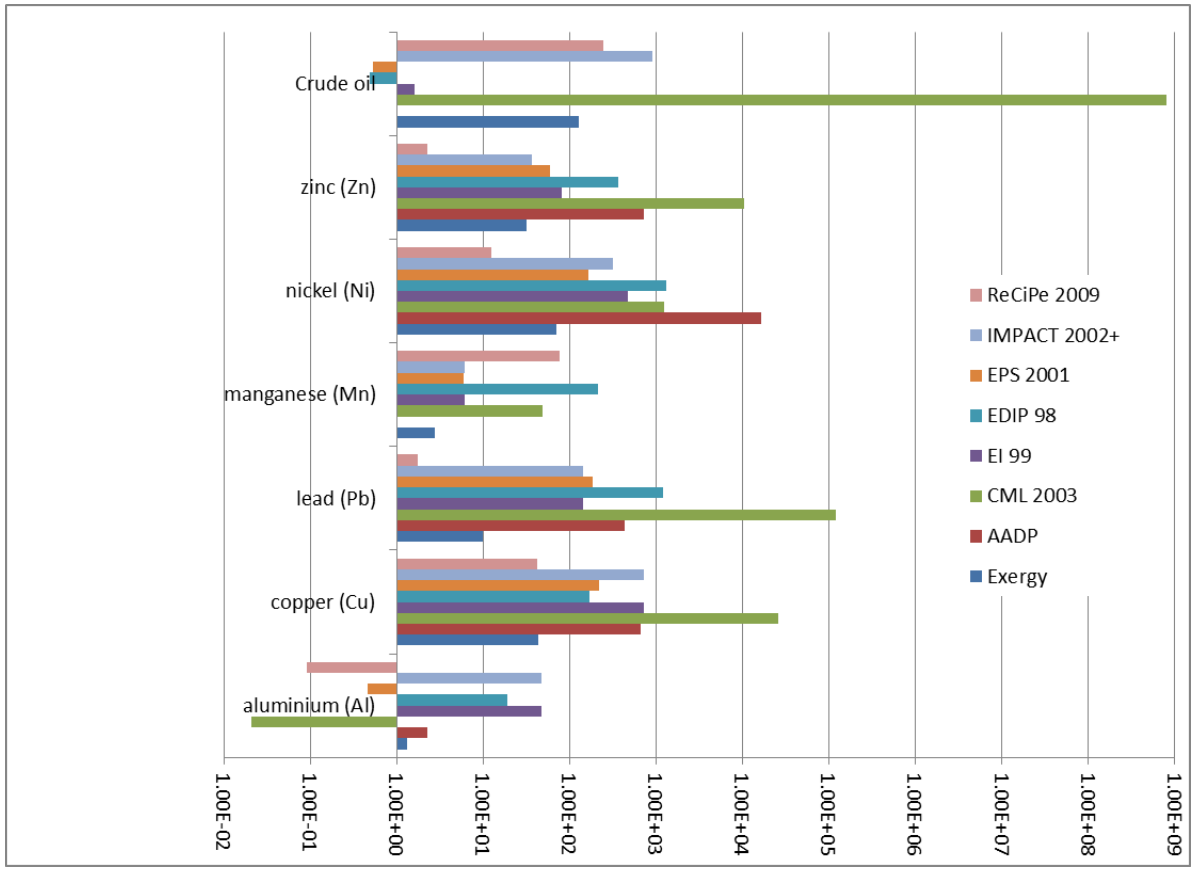
CRM	Number of methods covering the resource	CRM	Number of methods covering the resource
Antinomy	4	Indium	2
Beryllium	3	Magnesium	1
Cobalt	4	Niobium	2
Fluospar*	-	Platinum group metals	Platinum 2 Palladium 2
Gallium	2	Rare earths	Yttrium 3
Germanium	2	Tantalum	3
Graphite*	-	Tungsten	4

Source: our elaboration

* Not included in the method recommended by ILCD

Relative ranking of the different methods

- Relative ranking considering iron as reference
- Several orders of magnitude of difference in CFs



Thank you for your attention

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natural resources as — "*those elements that are extracted for human use. They comprise both abiotic resources, such as fossil fuels and mineral ores, and biotic resources, such as wood and fish. They have predominantly a functional value for society.*" Udo de Haes *et al.* (1999)

Reserve based

Indicators based on total reserves directly assess the extracted mass of a given resource, usually in relation to its deposits. Both the CML (Guinee/Heijungs 1995; van Oers et al. 2002) and EDIP methods (Hauschild/Wenzel 1998)

Exergy

Exergy has been described as “the upper limit of the portion of a resource that can be converted into work” (Dewulf et al. 2007). Conversely, exergy extraction represents extracted potential for entropy production from the natural environment, since a resource is usually concentrated following extraction; the amount of energy necessary to bring the resource back into the state before extraction can be described exergy loss (Lindeijer et al 2002)

Surplus energy

The surplus energy approach, as adopted in the Eco-Indicator 99 (Goedkoop/Spriensma 2001) and IMPACT 2002+ (Jolliet et al 2003), is based on the assumption that as more of a resource is extracted over time, quality of deposits still available tends to decrease. Each extraction of a certain amount of a resource from a deposit in the present will require an earlier move to more energy-intensive extraction from lower-quality, less accessible deposits in the future.

Marginal cost

It may be argued that as energy demand increases if a resource is to be extracted from less concentrated, lower-quality deposits over time, extraction costs increase as well. A case has been made from an **economic perspective for measuring resource depletion as energy demand for extraction or concentration** (e.g. Roma/Perino 2009). Monetizing the energy requirements of resource extraction, as in the ReCiPe methodology (Goedkoop et al 2009), provides a more universally applicable indicator; in principle, marginal extraction costs can be utilized as a metric for renewable resource extraction.

Willingness to pay

Willingness-to-pay models aim to capture the costs of an environmental intervention that stakeholders are willing to accept. The EPS 2000 method (Steen 1999) assesses resource depletion using this approach. A market model is used for abiotic resource depletion, assumptions differing depending on the substance or material (different groups of metals and minerals, fossil oil, coal, natural gas): the cost of substituting a substance by a sustainable alternative is used as a WTP value for future generations affected by present-day depletion. In case of biotic resources or ecosystem capacity, including fish, meat, wood, and land use, a survey-based contingent valuation method is used to determine WTP, i.e. the value of a resource to stakeholders.

Distance to target

Distance-to-target approaches set environmental impacts against predefined targets.

For resource depletion, such a target may be defined as a critical resource flow. The Swiss EcoPoints method (Frischknecht et al 2008) only incorporates gravel, energy resources, land and water use. Wood, as fuel, and uranium, as a nuclear energy carrier, are included. The model chooses a distance-to-target approach, characterizing depletion of resources in environmental load points (*Umweltbelastungspunkte* UBP). In the method documentation, scarcity ratios and environmental load points are given for Switzerland only.

In principle, a ratio of critical to actual flows can be established for any natural resource or other impact categories; e.g. in the case of renewable resources, the **critical flow corresponds to the carrying capacity** of woods or fisheries, while high recycling rates may be viewed as diminishing the actual flow of a given resource.

Eco-LCA

Zhang et al (2010) propose a more holistic approach to ecological issues resulting from resource depletion. They propose a differentiated, hierarchical Ecologically-based LCA (Eco-LCA) approach to account for ecosystem services as ecological resources, exceeding the relatively narrow definition of availability of a natural resource for human use considered by the other models in this review. From a set of individual resource flows, aggregated midpoint indicators are established using mass, exergy or energy metrics.