Ore grade decrease as a basis for modeling impact assessment for mineral scarcity

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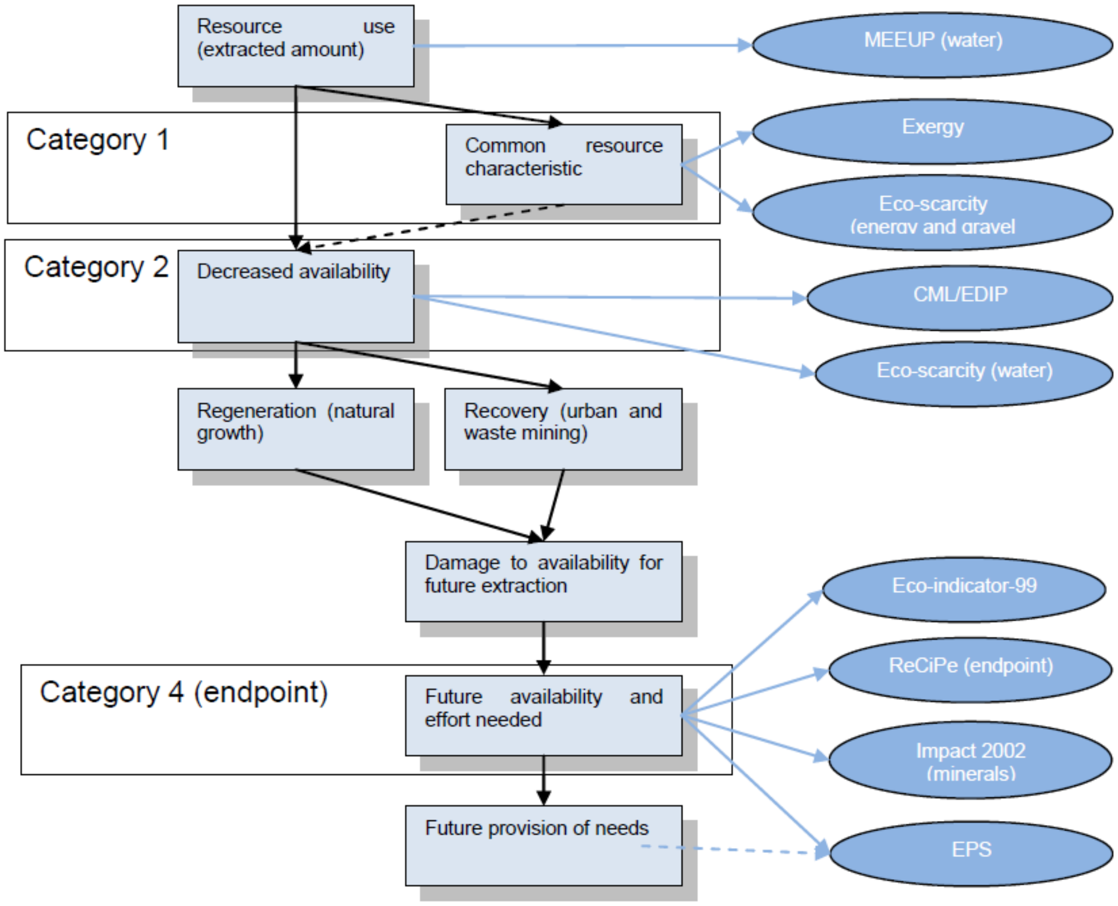
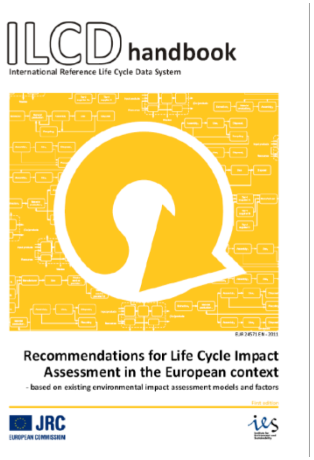
LCIA methods address mineral scarcity in a preliminary way





ILCD handbook

International Reference Life Cycle Data System

EUR 24571 EN - 2011

Recommendations for Life Cycle Impact Assessment in the European context

- based on existing environmental impact assessment models and factors

First edition

JRC
EUROPEAN COMMISSION

LC-IMPACT

Presentation outline

1. Stakeholder consultation to bring clarity
2. Explanation of the chosen cause-effect chain
3. Modelling example worked out for copper
4. Resulting characterisation factors and normalisation
5. Pros and cons of the method

We initiated a stakeholder consultation to bring clarity

- **Clarity on issue of concern** regarding the use of abiotic resources
- 20 participants in total representing policy, industry and experts

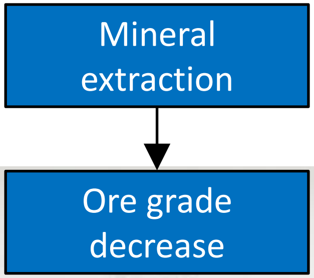
- Identification of issue of concern for different time frames:
  - ❑ **short term** (< 5 years): availability of resources constrained by geopolitical factors
  - ❑ **midterm** (5-20 years): increase in extraction efforts
  - ❑ **long term:** overall availability/depletion

Vieira M, Storm P, Goedkoop M. 2011. Stakeholder Consultation: What do Decision Makers in Public Policy and Industry Want to Know Regarding Abiotic Resource Use? In M. Finkbeiner, *Towards Life Cycle Management* (pp. 27-34). Springer Science+Business Media B.V.

Explanation of the chosen cause-effect chain

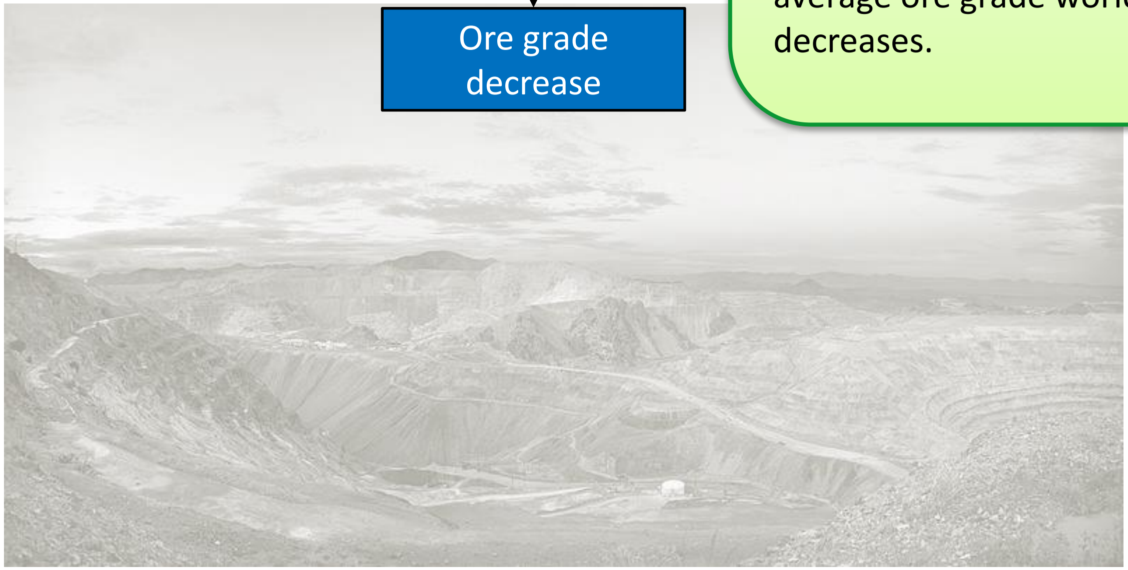
Photo: *TJBlackwell at Wikimedia Commons*

1. Worldwide metal ore grades are decreasing



Mineral extraction

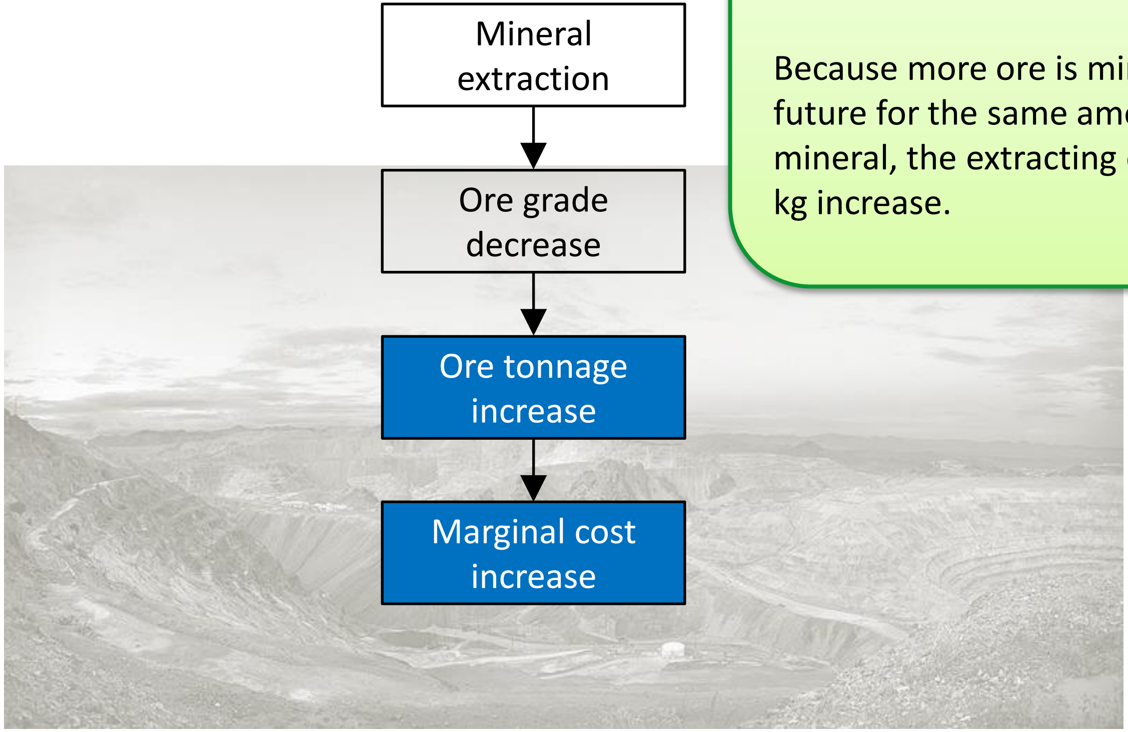
Ore grade decrease



The mineral concentration within an ore - ore grade - is a quality property of the mineral.

Assuming that mines with higher grades are explored first, its average ore grade worldwide decreases.

2. Ore grade decrease results in increased mining costs



Mineral extraction

Ore grade decrease

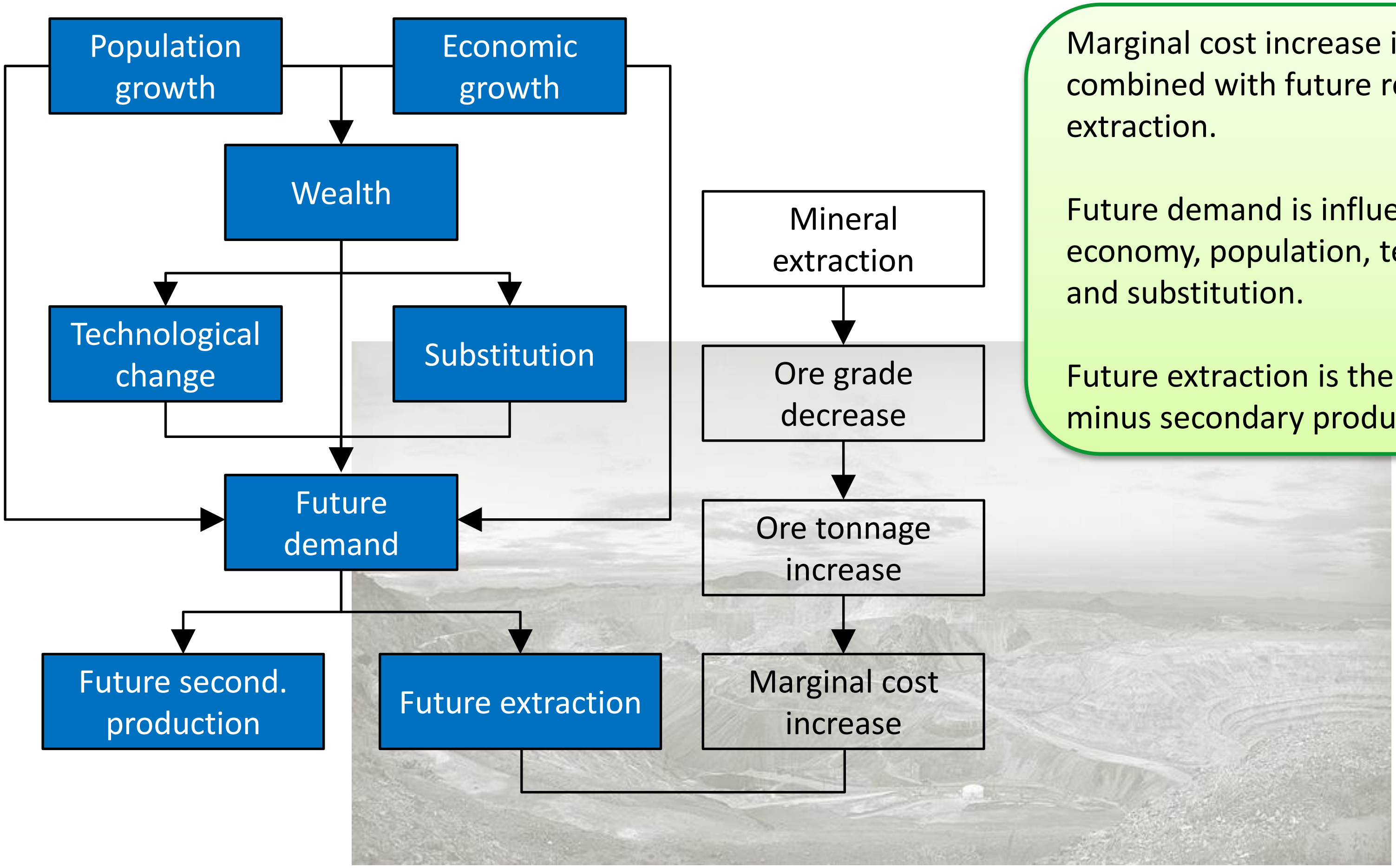
Ore tonnage increase

Marginal cost increase

The lower the ore grade, the smaller the mineral volume extracted per ore mined.

Because more ore is mined in the future for the same amount of mineral, the extracting costs per kg increase.

3. Future extraction depends on many factors



Population growth

Economic growth

Wealth

Technological change

Substitution

Future demand

Future second. production

Future extraction

Mineral extraction

Ore grade decrease

Ore tonnage increase

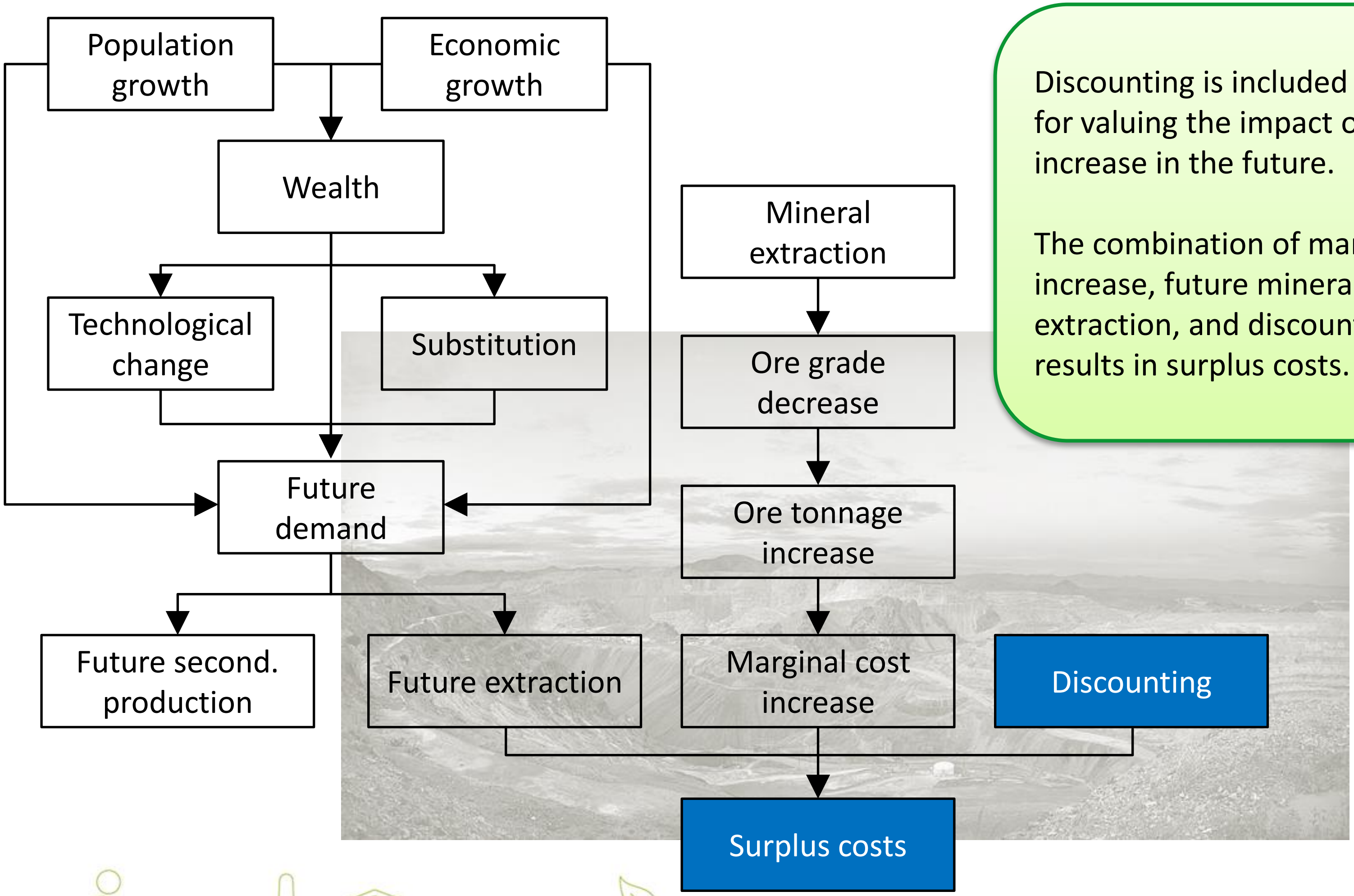
Marginal cost increase

Marginal cost increase is combined with future resource extraction.

Future demand is influenced by economy, population, technology and substitution.

Future extraction is the demand minus secondary production.

4. Combined with discounting surplus cost can be calculated



Discounting is included to account for valuing the impact of cost increase in the future.

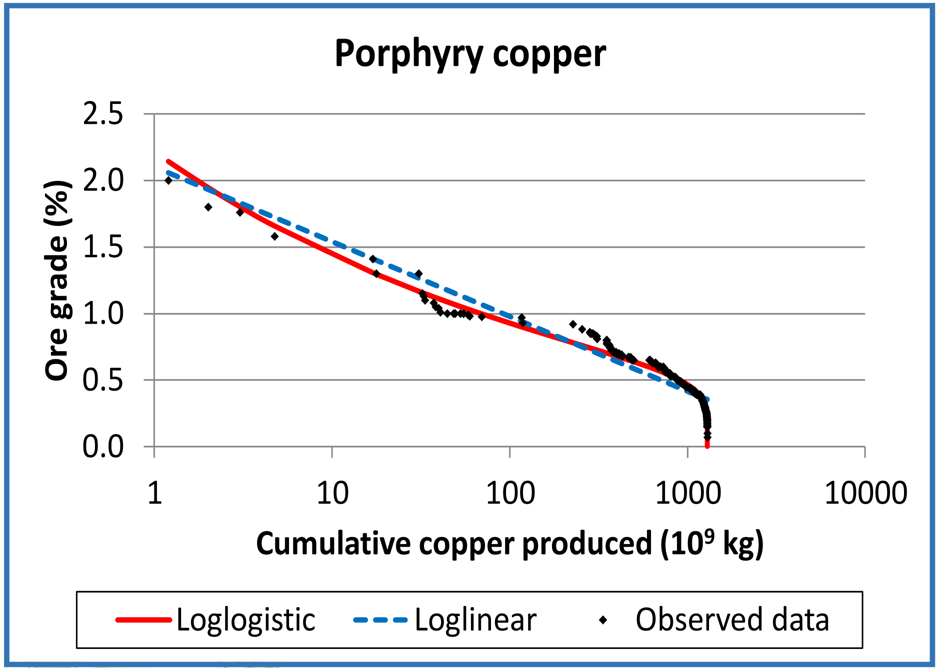
The combination of marginal cost increase, future mineral extraction, and discounting results in surplus costs.

Modelling example worked out for copper

Photo: Jonathan Zander at Wikimedia Commons

The ore grade decrease of copper can be calculated in different ways

- Use of cumulative grade-tonnage relationships per deposit type
  - **Marginal** or average modeling
  - **Loglinear** or loglogistic regression
- Characterization factor calculated as symmetric of the derivative of these relationships
- Data source: U.S. Geological Survey



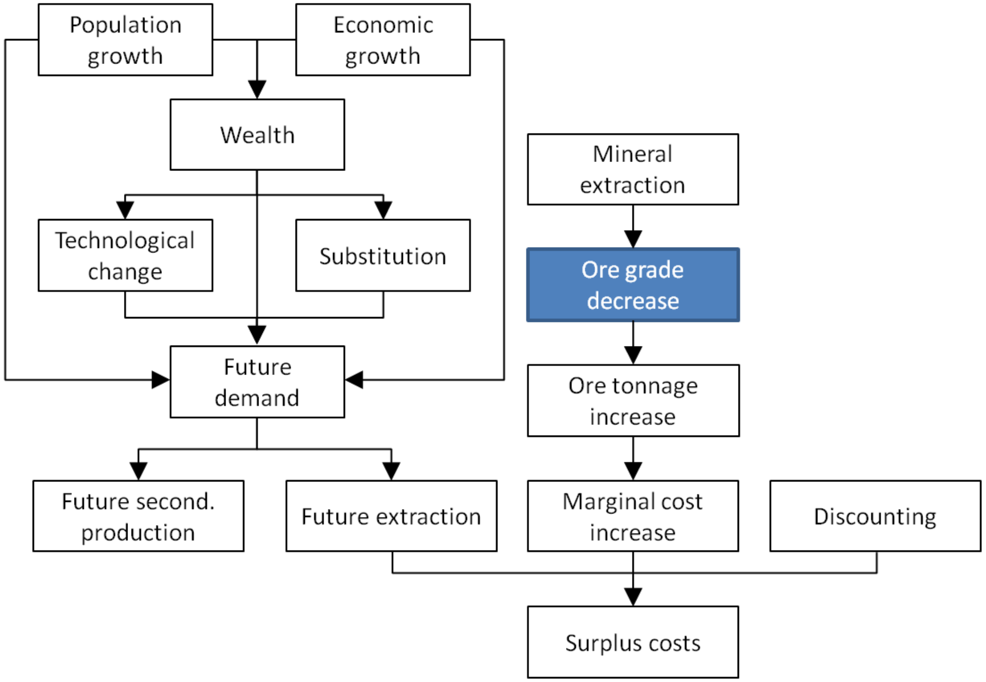
The ore grade decrease factor was proposed as a impact indicator at midpoint

Ore grade characterization factor:

$$CF_{mid,x} = \frac{\partial g_x}{\partial CMT_x}$$

in %/kg where:

- g_x is the grade of a specific resource *x* and
- CMT_x is the cumulative mineral *x* extracted.



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Marginal cost increase

Discounting

Surplus costs

Vieira MDM, Goedkoop MJ, Storm P, Huijbregts MAJ. 2012. *Ore Grade Decrease As Life Cycle Impact Indicator for Metal Scarcity: The Case of Copper*. Environ. Sci. Technol. 46(23): 12772-12778.

The surplus cost indicator was calculated by multiplying several parameters for each year in the future

Endpoint characterization factor (US$/kg):

$$CF_x = \sum_{t=0}^{\infty} \left(\underset{\uparrow \; \boxed{1.0E-10}}{\frac{\partial OT_x}{\partial CMT_x}} \times \underset{\nwarrow \; \boxed{0.00218}}{\frac{\partial Cx}{\partial O_{Tx}}} \times MT_{x,t} \times \frac{1}{(1+d)^t} \right)$$

where

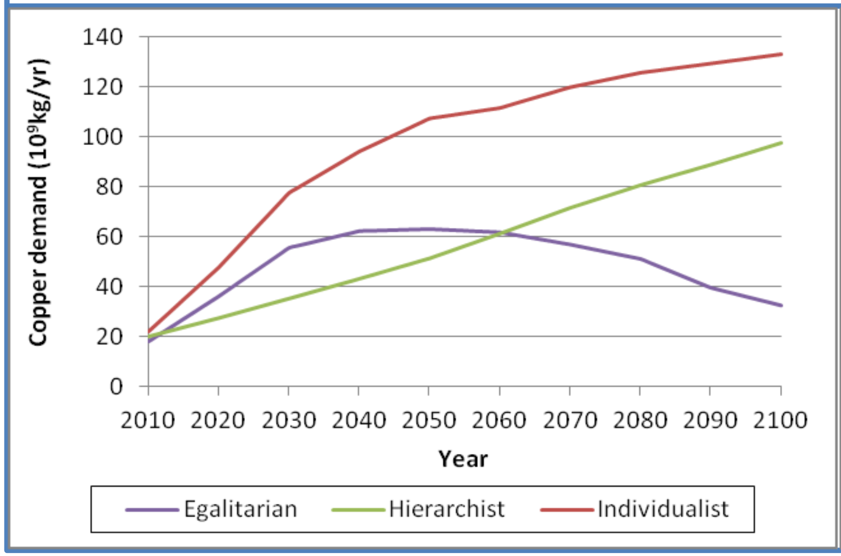
- OT_x is the ore extracted per mineral x extracted,
- C_x are the operating costs per ore mined,
- $MT_{x,t}$ is the annual mineral x extraction in year t,
- d is the discount rate.

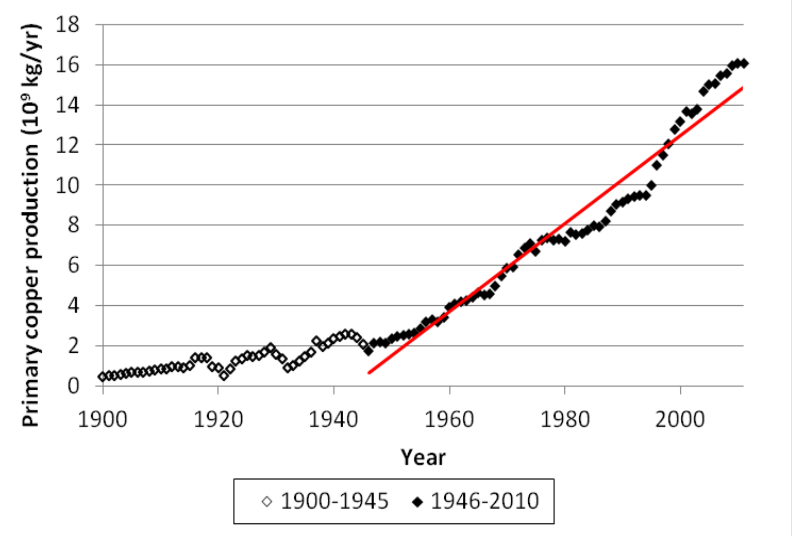
Future production can be modelled in different ways

Future demand scenarios can be estimated using two approaches:

- Bottom-up: from demand per sector
- Top-down: using the intensity of use hypothesis

Future production estimates can also be derived using historical trends.



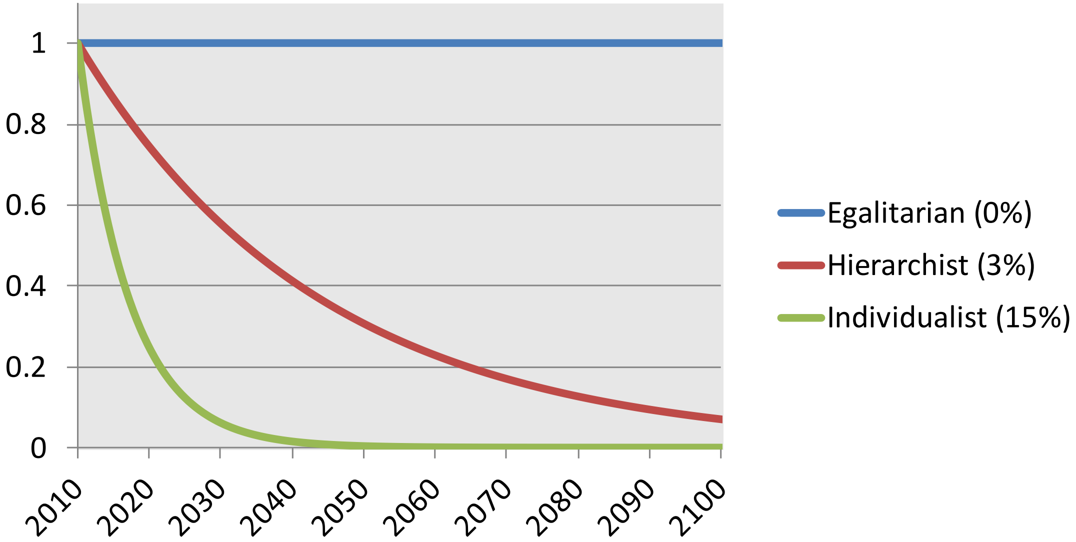


We chose to use future extraction based on historic trends until reserve base is reached (940 10^9 kg for copper)

An important difference between the perspectives is discount rate

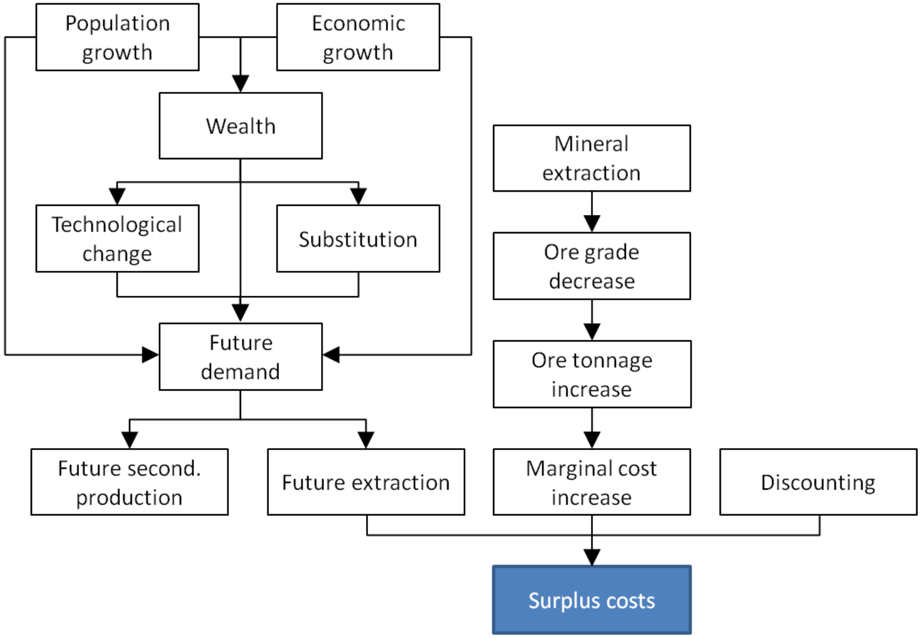
The discount rate

- of the individualist perspective is based on short term thinking,
- of the hierarchist on medium term and
- of the egalitarian on infinite effects:



The surplus cost of copper was then calculated

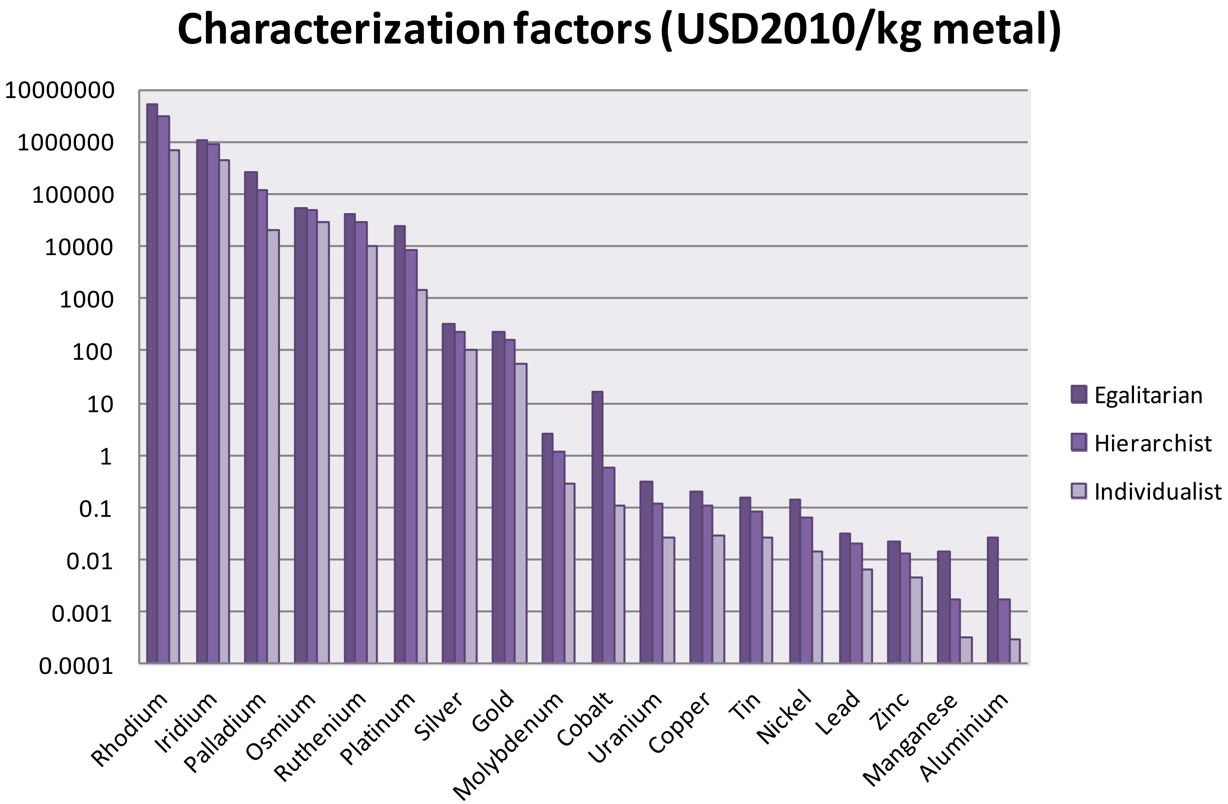
Perspective	Surplus cost of copper (US$/kg)
Egalitarian	0.21
Hierarchist	0.11
Individualist	0.03



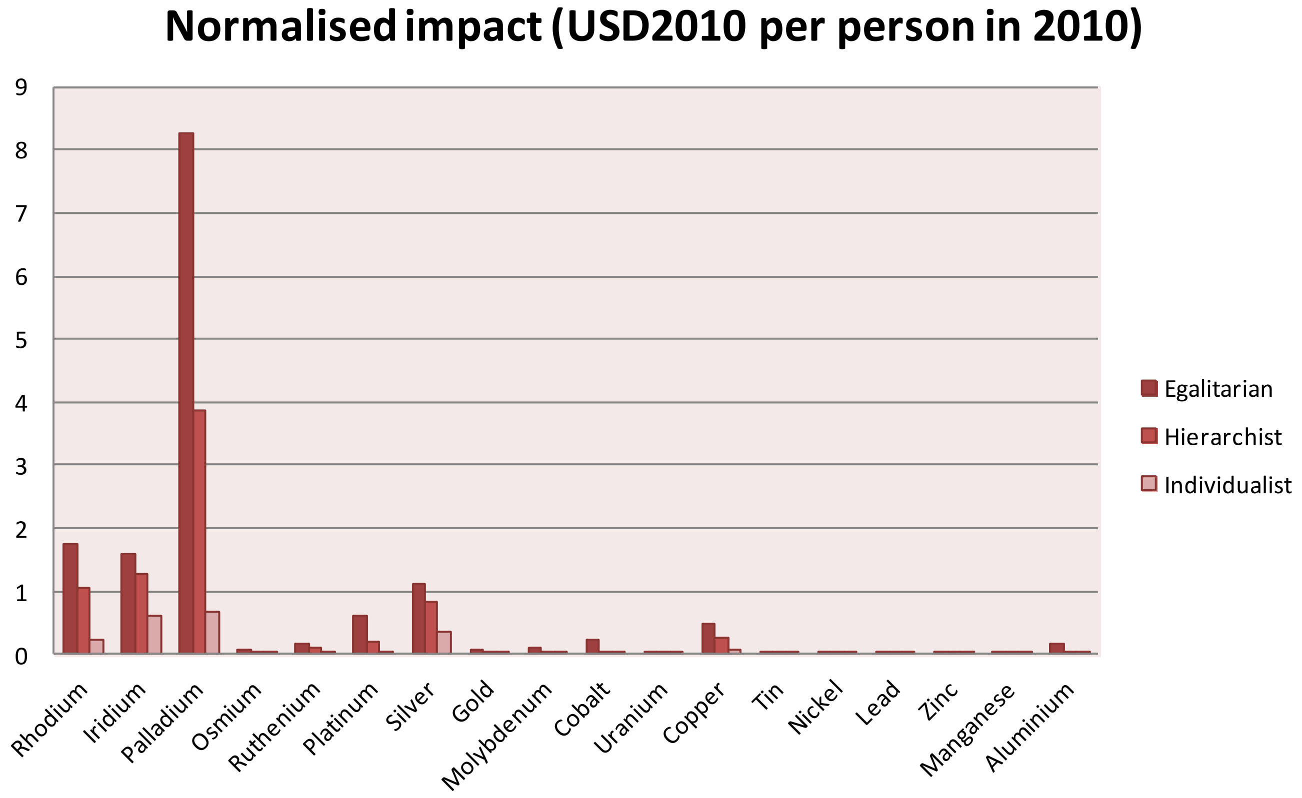
Resulting characterisation factors and normalisation

Photo: DerFussi at wikivoyage shared

Platinum group metals have the highest factors, followed by gold and silver – differences between Al and Rh are a factor 9



The normalised impact in 2010 is about 15 (E), 8 (H) and 2 (I) USD, which is mainly due to PGMs, silver and a bit to copper



Pros and cons of the method

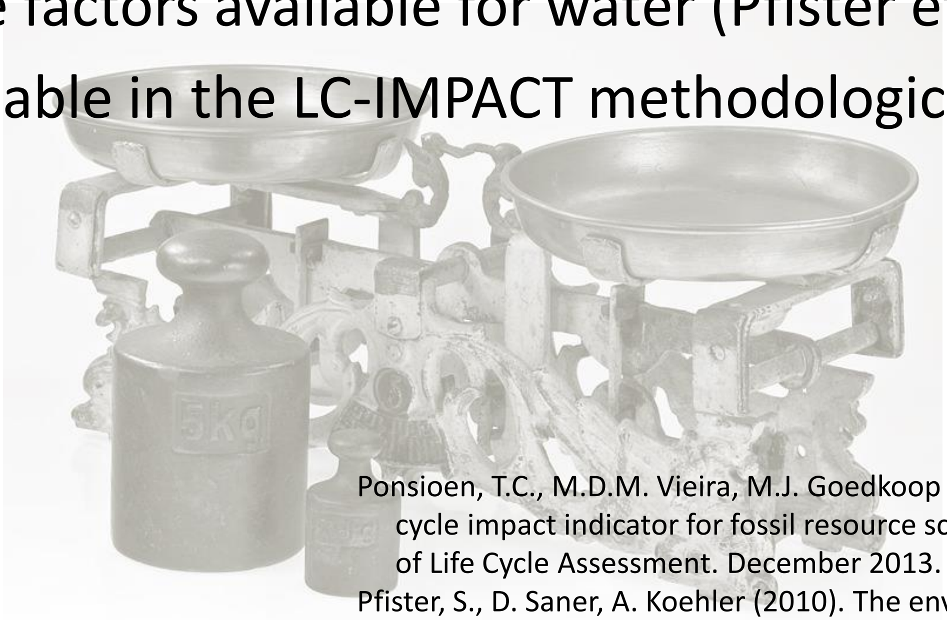
Photo: Nikodem Nijaki at Wikimedia Commons

Contras of the surplus cost method for mineral scarcity

- we could only calculate the factors of 18 metals
- it is difficult to identify a related midpoint indicator
- regional differences of scarcity are not taken into account

Pros of the surplus cost method for mineral scarcity

- we were able to calculate factors for at least 18 metals!
- scientific shortcomings in the ILCD handbook addressed
- comparable factors available for fossils (Ponsioen et al, 2013)
- comparable factors available for water (Pfister et al, 2010)
- will be available in the LC-IMPACT methodological framework



Ponsioen, T.C., M.D.M. Vieira, M.J. Goedkoop (2013). Surplus cost as a life cycle impact indicator for fossil resource scarcity. The International Journal of Life Cycle Assessment. December 2013.

Pfister, S., D. Saner, A. Koehler (2010). The environmental relevance of freshwater consumption in global power production. The International Journal of Life Cycle Assessment 2011, 16, 580-591

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