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Finding optimal complexity in life cycle impact assessment with help of ecoinvent data

Mark A.J. Huijbregts

Department of Environmental Science, Radboud University Nijmegen, Nijmegen

In collaboration with Stefanie Hellweg, Rolf Frischknecht, Konrad Hungerbühler, Harrie Hendriks and Jan Hendriks

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Introduction

Focus on development of new impact assessment methods for LCA:

- Ecotoxicity and human toxicity (USES-LCA)
- Acidification and eutrophication (RAINS-LCA)
- Respiratory impacts (EUTREND-LCA)
- Global warming (IMAGE-LCA)

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Questions

- Many LCA methodologies available and does it matter which method to apply?
- What are the main drivers of environmental impact in production processes?

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ecoinvent…

Can help to answer these questions

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Aims of this study

- Comparison of impact methodologies with help of the ecoinvent database
- Identify the contribution of fossil energy use to the total impact of material life cycles

Method overview

Method	Abbr.	Unit	Key characteristic
Cumulative Energy Demand	CED	MJ-eq	Total energy use
Cumulative Exergy Extraction	CEENE	MJ_{ex}-eq	Total exergy use
Ecological Footprint	EF	m^2.yr	Area use
Environmental Priority Strategy	EPS	ELU	Monetarization of impacts; damage oriented
Ecological Scarcity 1997	ES	UBP	“Distance-to-political target” weighing; resource and emission oriented
Eco-Indicator 99	EI	Ecopoints	Panel weighing of impacts; damage oriented.

Data selection

Product group	Number of materials
Agricultural products	65
Construction and insulation materials	42
Glass	11
Inorganic substances	121
Organic substances	146
Plastics	33
Metals	51
Paper and cardboard	29
Total	498

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Standard and non-fossil dataset

Standard selection:

- Includes all processes relevant for the material life cycles considered

Non-fossil selection:

- excludes transport, electricity and heat production processes fuelled by fossil energy.
- Fossil feedstocks are excluded as well

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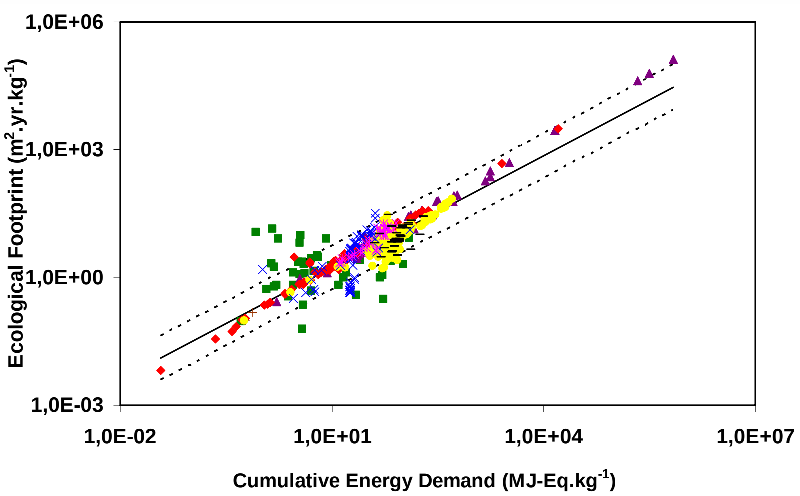
Statistical Analysis

- Univariate log-linear regression analysis with Cumulative Energy Demand (CED) as explaining variable

$$\log IS = a \cdot \log CED + b$$

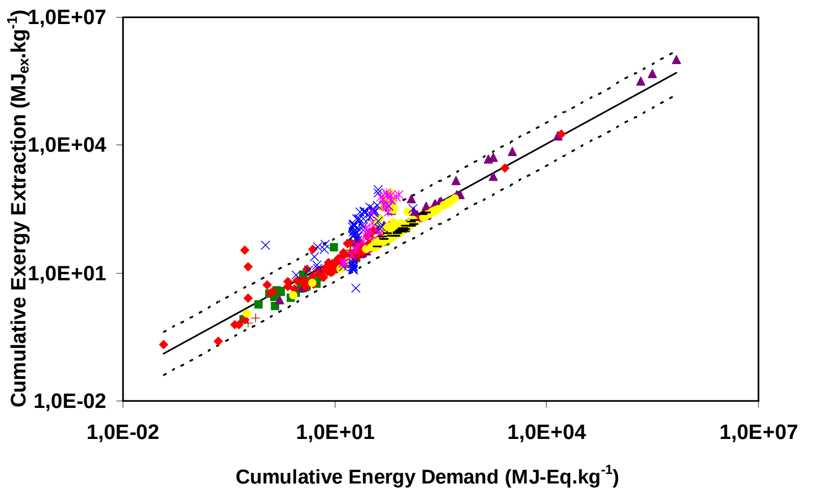
IS = Impact Score

Ecological Footprint



logEF= 0.9 logCED – 0.6
R^2 = 0.81; SE = 0.31

Cumulative Exergy Extraction



logCEENE= 0.9 logCED + 0.4

R^2 = 0.83; SE = 0.30

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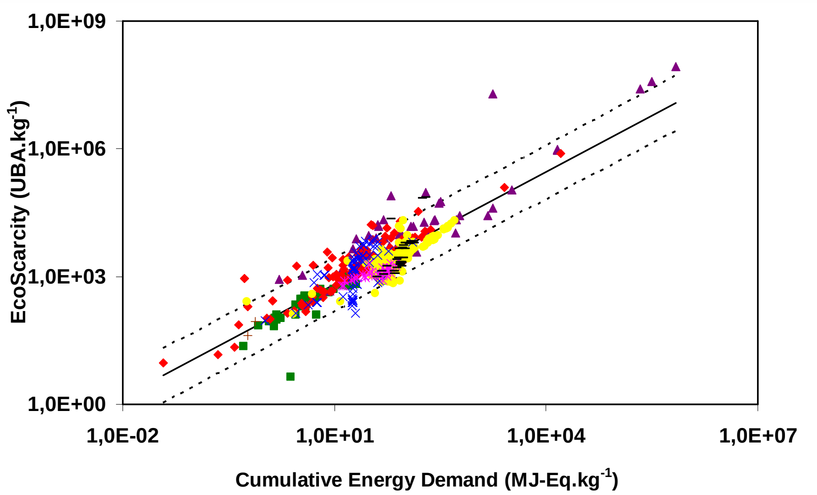
Ecoscarcity



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logES= 0.9 logCED + 1.9

R^2 = 0.75; SE = 0.38

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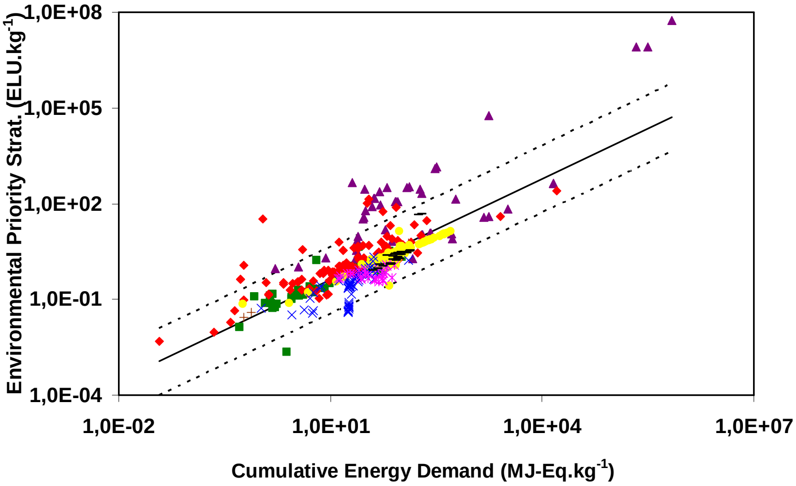
Environmental Priority System



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logEPS= 1.1 logCED – 1.4

R^2 = 0.61; SE = 0.63

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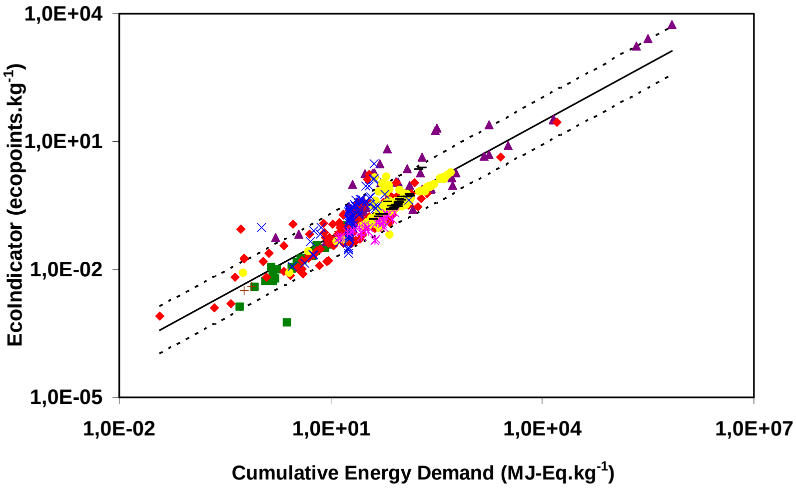
Ecoindicator



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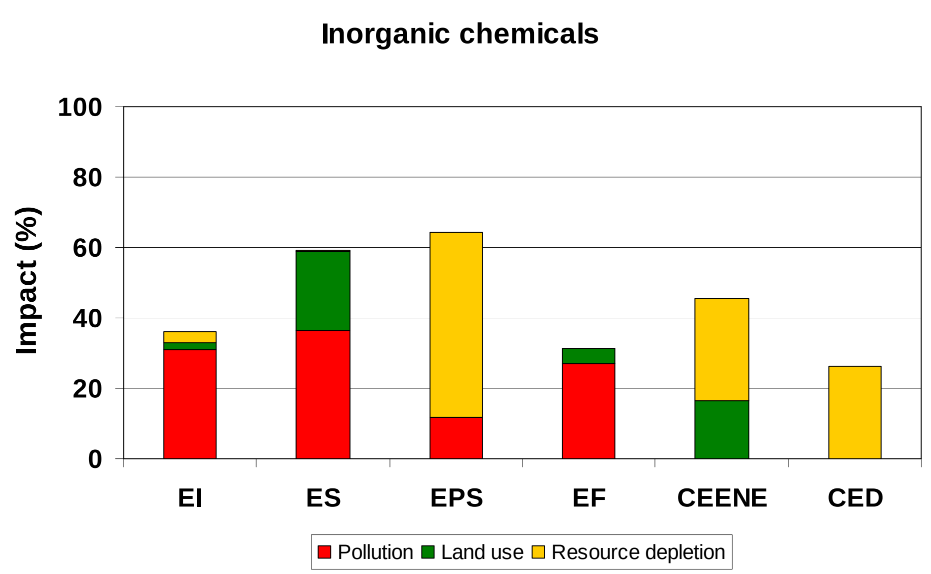
logEI= 0.9 logCED – 2.1

R^2 = 0.81; SE = 0.33

Non-fossil average contribution – Inorganic chemicals



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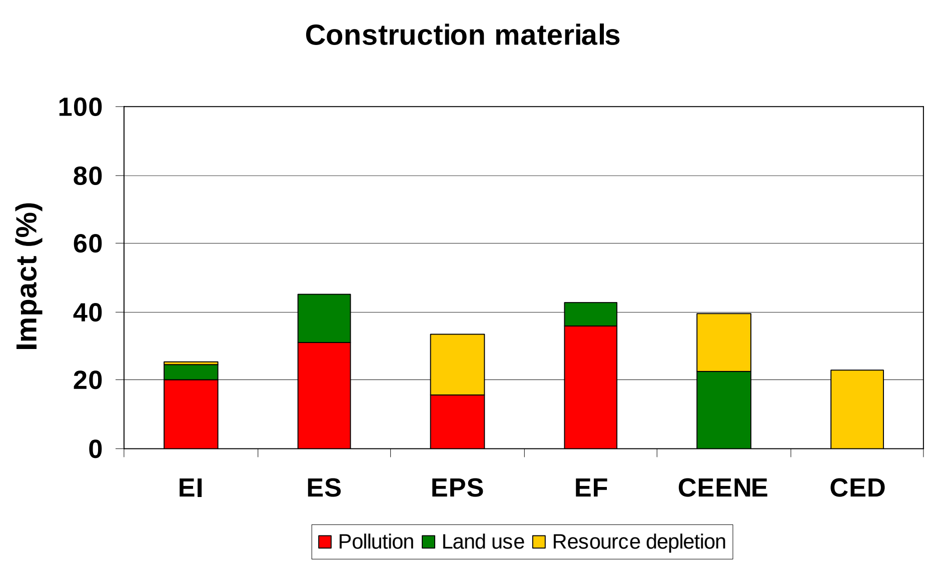
Non-fossil average contribution – Construction materials



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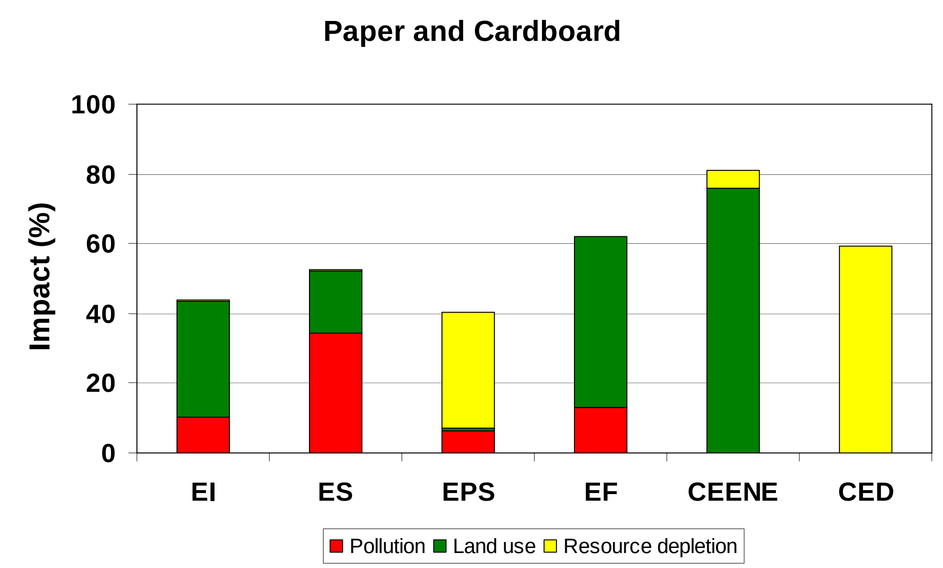
Non-fossil average contribution – Paper and cardboard



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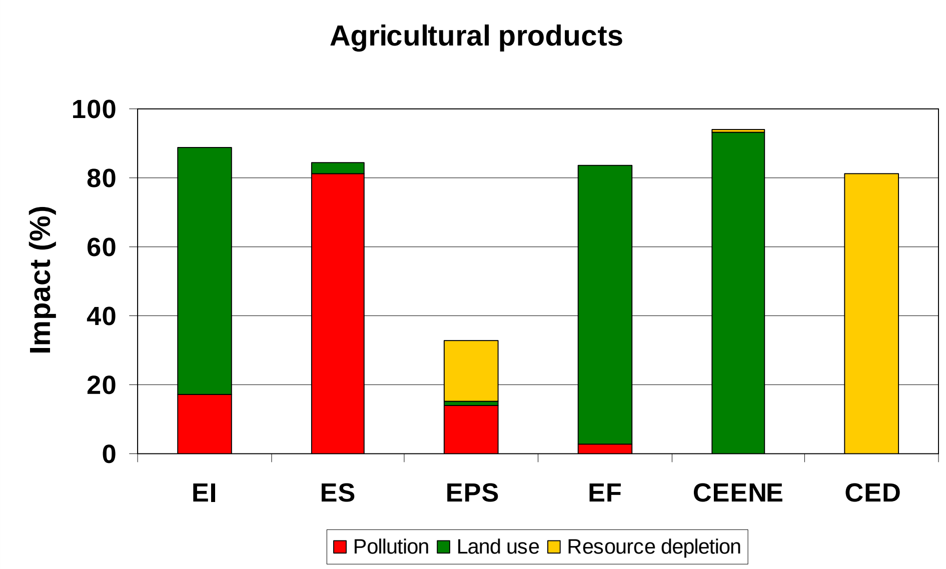
Non-fossil average contribution - Agriculture



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Conclusions

1. Cumulative Energy Demand goes in the same direction as other more detailed impact assessment methods
2. Fossil energy use has an important contribution to the environmental burden of many materials included, but with notable exceptions (e.g. biobased materials)

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Recommendations

1. Add inventory data for other methods, such as MIPS, Water footprint and Emergy (with an M)
    - Overburden of mining
    - Working hours spent
    - Region-specific water use
2. Procedure to easily split up the inventory results in e.g. fossil and non-fossil inventory flows, including aggregated datasets

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Publications

- Huijbregts et al. Is Cumulative Fossil Energy Demand a Useful Indicator for the Environmental Performance of Products? *Environ. Sci. Technol.* **2006**, 40, 641-648.
- Bösch et al. Applying Cumulative Exergy Demand (CExD) Indicators to the ecoinvent Database. *Int J LCA* **2007**, 12 (3), 181-190.
- DeWulf et al. Cumulative Exergy Extraction from the Natural Environment (CEENE): a comprehensive Life Cycle Impact Assessment method for resource accounting. *Environ. Sci. Technol.* **2007**, 41: 8477-8483.
- Huijbregts et al. Ecological Footprint Accounting in the Life Cycle Assessment of Products. *Ecol. Econ.* **2008**, in press.

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