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Resource efficiency and sustainable management of natural resources and raw materials: the need for a common understanding of the terminology in policy making

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1. Introduction

The JRC inside the European Commission

European Commission,

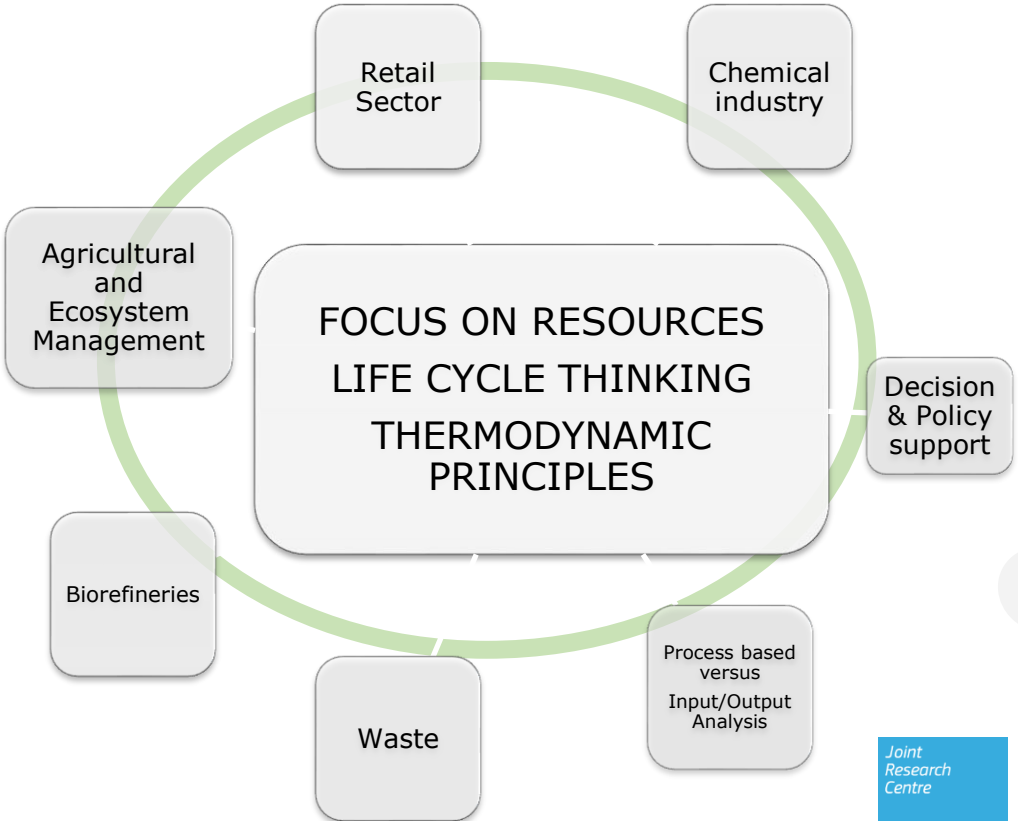
Joint Research Centre (JRC),

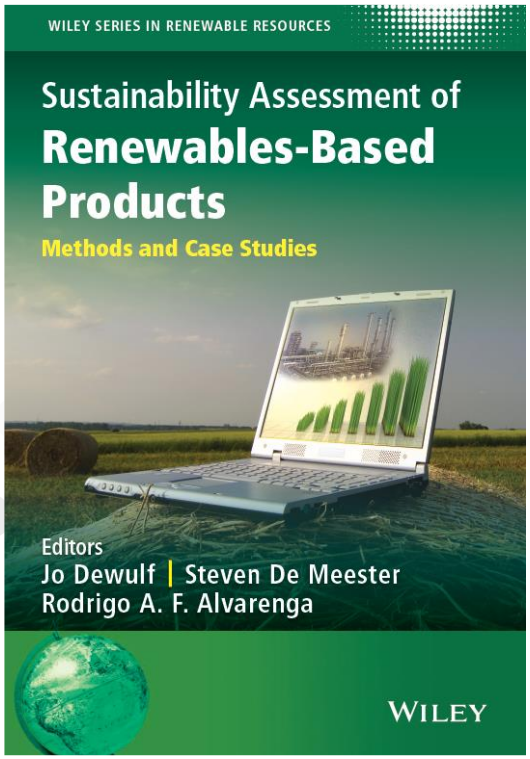
Institute for Environment and Sustainability (IES)

"The mission of the IES is to provide scientific-technical support to the European Union's policies for the protection and sustainable development of the European and global environment"

Ghent University:

Sustainable and Clean Technology





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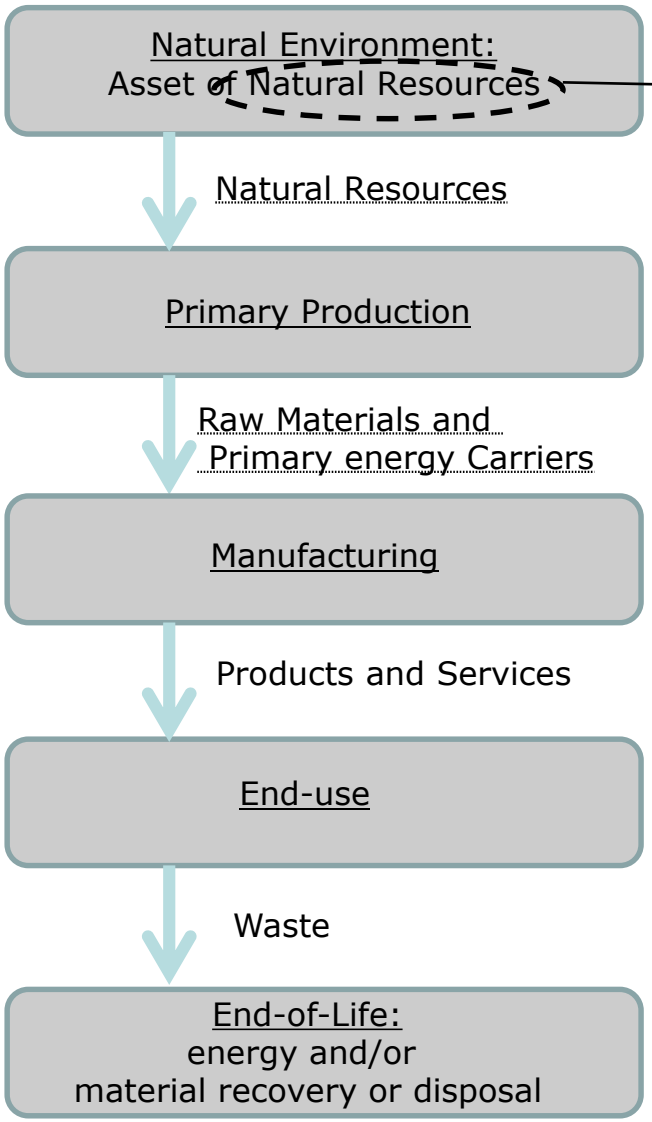
2. Natural resources versus Raw Materials



Natural Resources:

Heterogeneous definitions:

- OECD:
  - -asset in nature,
  - -starting point econ. production
- EC 2005:
  - - Source and sink functions (incl.ecosystem services)

Consequences of definition on:

→ 'Resource' efficiency

→ 'Natural Resources' as 'Area of Protection' or 'safeguard subject' in Life Cycle Assessment (LCA)

Sources: Dewulf et al., J. Ind. Ecol., 2015

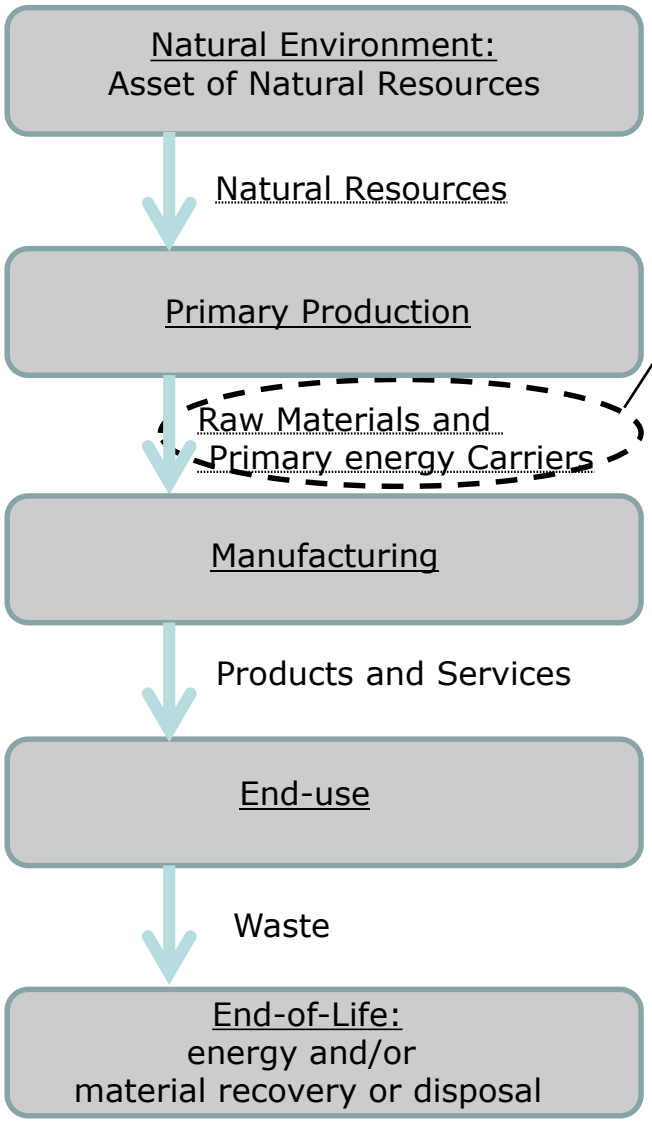
Asset of 3D Natural Resources:

lithosphere	soil and sediments	minerals and materials
		metal ores (incl. nuclear)
		fossil fuels (conventional, unconventional)
		geothermal
hydrosphere	freshwater	rain water
		fresh underground water
		fresh surface water (bulk)
		freshwater biota (natural)
		freshwater currents
	seawater	marine water (bulk)
		marine biota (natural)
		marine elements (salts...)
		marine currents
atmosphere	air	atmospheric gases (He, CO_2...)
		wind

Asset of 2D Natural Resources:

terrestrial	land surface[a]	residential/industrial/Transport infrastructure land
		agricultural land
		forestry land
		natural land[b]
		solar irradiation[c]
		terrestrial biota (natural)
aquatic	freshwater surface	rivers and estuaries[b]
		lakes and wetlands[b]
		solar irradiation[c]
	seawater surface	sea surface (coastal, shelf, deep sea)[b]
		solar irradiation[c]

Source: Dewulf et al., ES&T, 2015



Raw Materials:

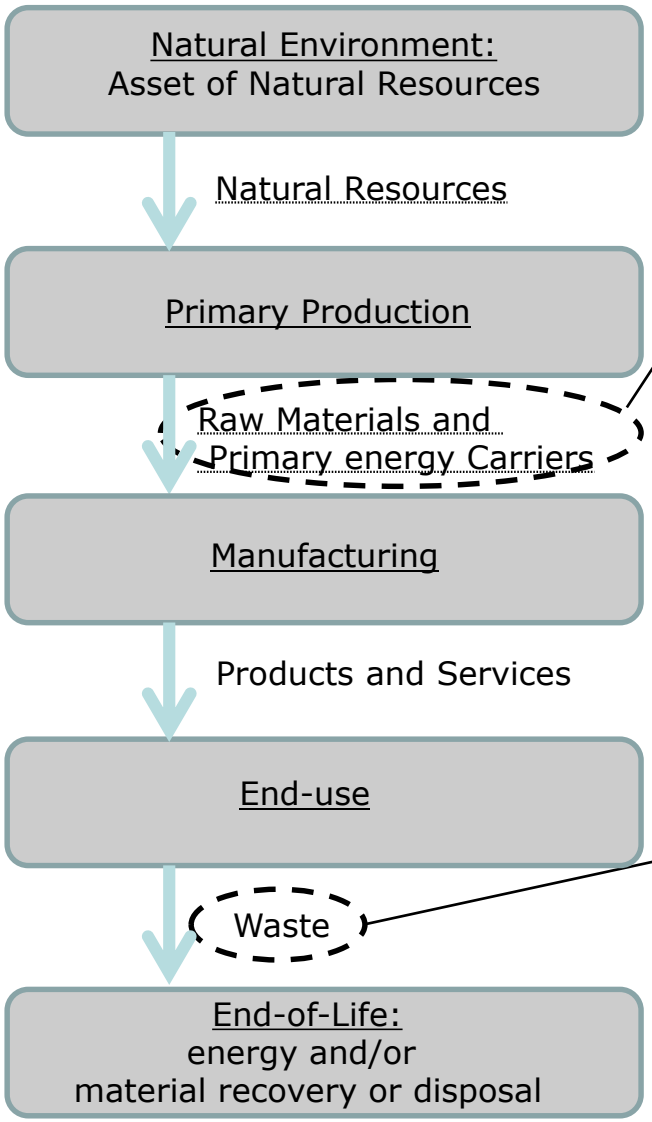
Heterogeneous definitions:

- As they occur in the natural environment, next to flow resources (EC 2005)

- Partially processed natural resources (e.g., chemical, high-tech raw materials), also even processed waste (e.g., scrap: so-called secondary raw materials) (EC 2008)

→ Need for common scope and understanding

Source: Dewulf et al., J. Ind. Ecol., 2015



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Proposed definitions:

Primary:

- Raw Materials are result from primary production processes:
  - Mining
  - Growing
  - Harvesting
  - Refining
- Raw Materials are typical first market commodities
- Depending on future applications:
  - [Primary] [nonenergy] Raw Mat.
  - Primary energy carriers

Secondary: Waste:

- Source of secondary materials or of energy
- Enters operations like:
  - Recycling/Downcycling
  - Incineration

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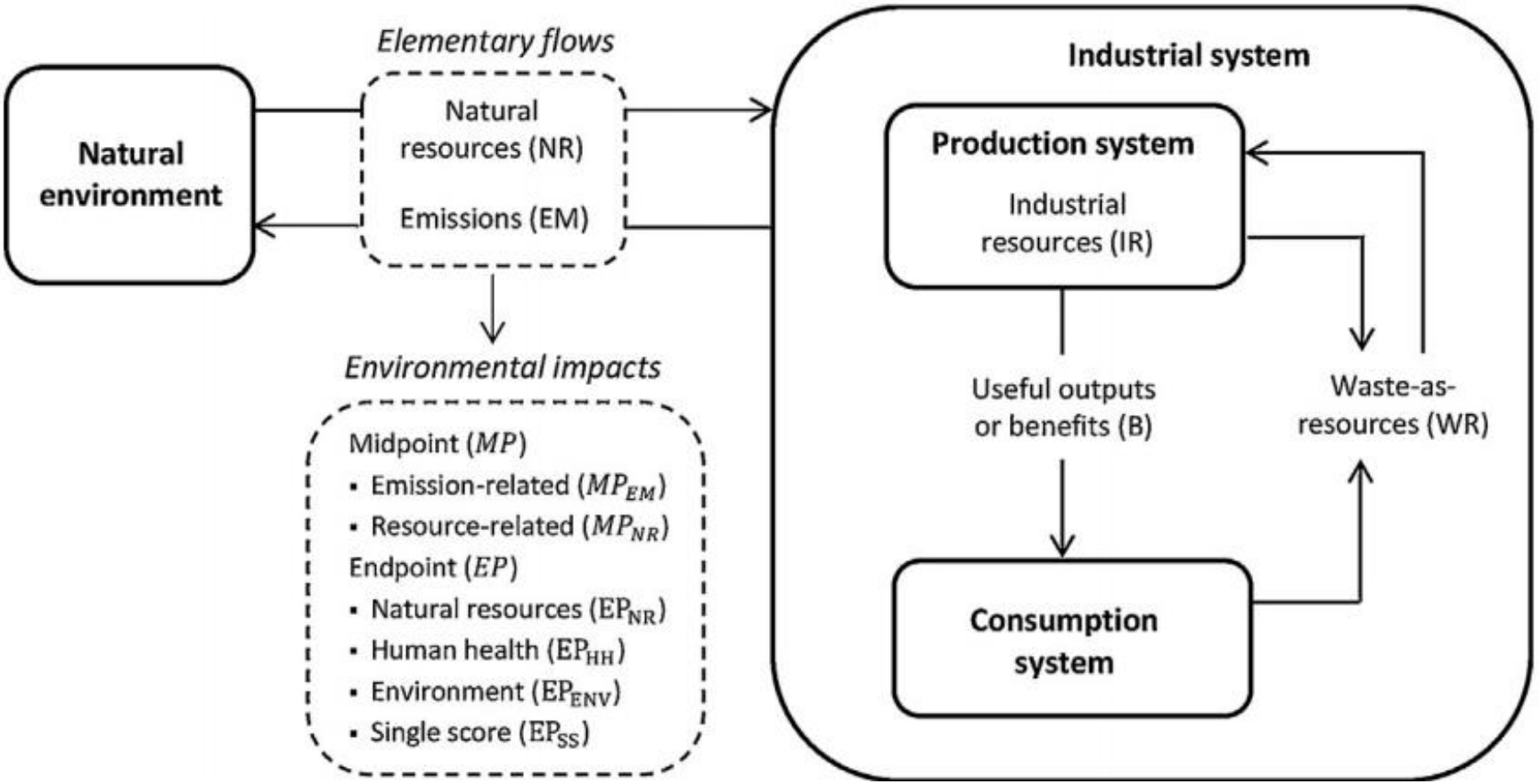
Source: Dewulf et al., J. Ind. Ecol., 2015

Classification of primary raw materials:

ORIGIN OF RAW MATERIALS	RAW MATERIAL GROUP	#
Terrestrial biomass (for material applications)	Agricultural raw materials	8
	Forestry raw materials	12
Aquatic biomass for food and material applications	Aquaculture raw materials	2
Water (components)	Freshwater raw materials	3
	Raw materials from seawater	3
Atmosphere	Raw Materials from atmosphere	3
Fossil fuels (for material applications)	Petroleum raw materials	5
	Raw Materials from natural gas	3
	Raw materials from non-convential fossil fuels (shale gas, oil sands, methane hydrates, coal bed methane ...)	3
Metallic ores	Ferrous metals raw materials	8
	Non-Ferrous bulk/traditional metal raw materials	6
	Non-Ferrous rare metal raw materials	5
	Non-ferrous precious/high tech metal raw materials	5
	Alkali metal raw materials	3
Natural deposits of industrial minerals and construction materials	Construction minerals and mineral materials	4
	Industrial minerals and mineral materials	11
	Other	1
ORIGIN OF PRIMARY ENERGY CARRIERS	**PRIMARY ENERGY CARRIER GROUP**	
Terrestrial biomass (for energy applications)	Energy crops	4
	Forestry products (for energy)	1
	Soil products	1
Aquatic biomass (for energy applications)	Aquaculture energy products	1
Flow resources (solar, water, wind and geothermal)	Solar based energy carriers	3
	hydropower based energy carriers	2
	Wind energy based energy carriers	2
	Tidal energy based energy carriers	1
	Geothermal based energy carriers	1
Fossils for energy applications	Coal and lignite energy carriers	3
	Petroleum based energy carriers	7
	Natural gas based energy carriers	1
	Non-convential fossil based energy carriers (shale gas)	1
Nuclear energy metal ores	Nuclear energy based energy carriers	2

3. Resource efficiency indicators



$$\text{Resource efficiency} = \frac{\text{Benefits}}{\text{Inputs/Burden/Impact}}$$

- Benefits: €? Kg? MJ?
- Inputs/Burden/Impact:
  What? From where?

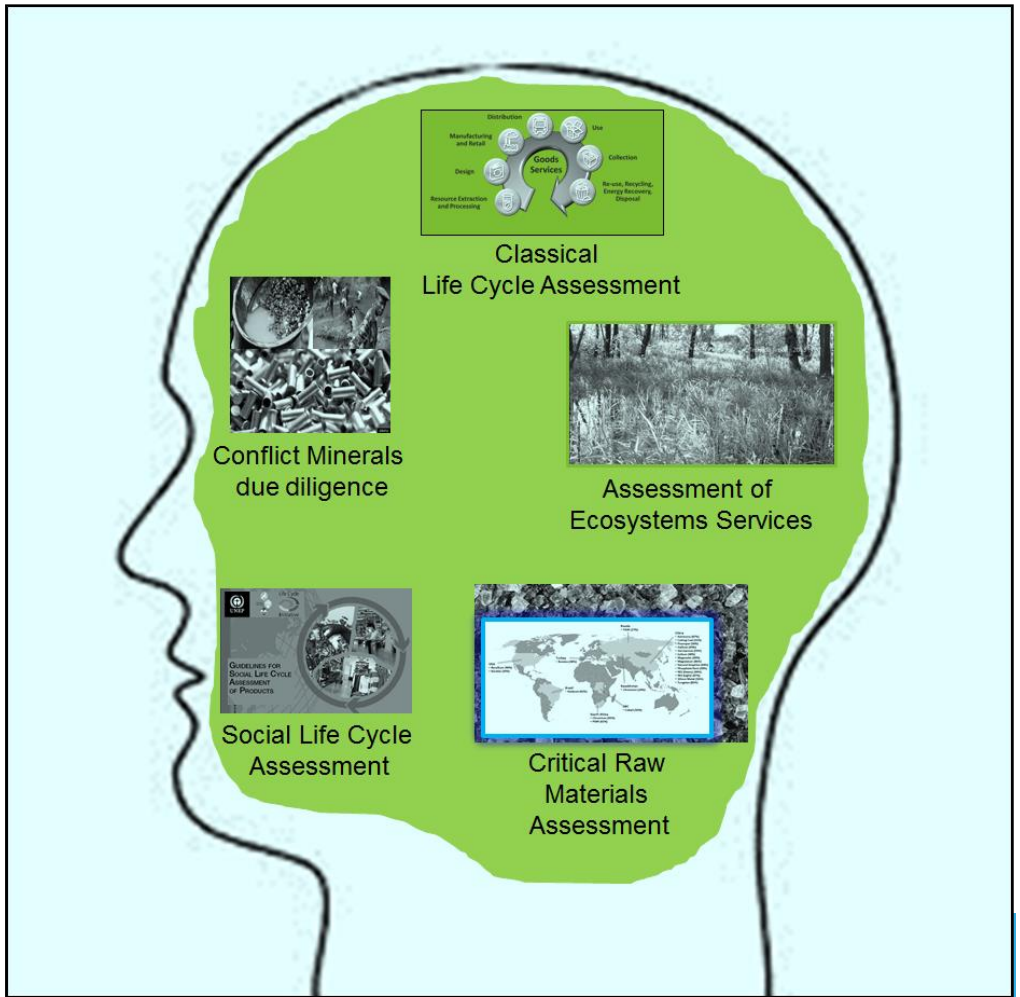
A framework for Resource efficiency metrics:

Fields of study: environmental science and engineering versus environmental policy		Level 1		Level 2 (Eco-efficiency)		
		Resource efficiency at flow level (RE-FL) Benefits over resource flows (natural, waste or industrial)	**Emission efficiency at flow level (EM-FL)** Benefits over emission flows (often the reciprocal is used)	**Resource efficiency at impact level (RE-IMP)** Benefits over impacts derived from the resource flows	**Emission efficiency at impact level (EM-IMP)** Benefits over impacts derived from the emission flows	**Overall efficiency at impact level (OE-IMP)** Benefits over impacts from both resource and emission flows
Micro-scale ↓ Macro-scale	Gate-to-gate perspective	*benefits over (kg) resources*	*benefits over (kg) emissions*	*benefits over (ADP) impact*	*benefits over (GWP) impact*	*benefits over single score impact*
	Life cycle Perspective	*benefits over (kg) resources in life cycle*	*benefits over (kg) emissions in life cycle*	*benefits over (ADP) impact in life cycle*	*benefits over (GWP) impact in life cycle*	*benefits over single score impact in life cycle*
	Domestic perspective	*GDP over (kg) domestic extracted resources*	*GDP over (kg) domestic emissions*	*GDP over domestic (ADP) impact*	*GDP over domestic (GWP) impact*	*GDP over domestic single score impact*
	Global Perspective	*GDP over (kg) global extracted resources*	*GDP over (kg) global emissions*	*GDP over global (ADP) impact*	*GDP over global (GWP) impact*	*GDP over global single score impact*

Source: Huysman et al., RCR, 2015

4. Concerns to develop sustainable management of raw materials

Different concepts as a base for sustainable management:



Different concepts/frameworks:

- They cover different aspects
- They partially overlap
- Need for a consistent base
- Anthropogenic focus

Different concepts may lead to different prioritisation of the policy interventions for resource efficiency

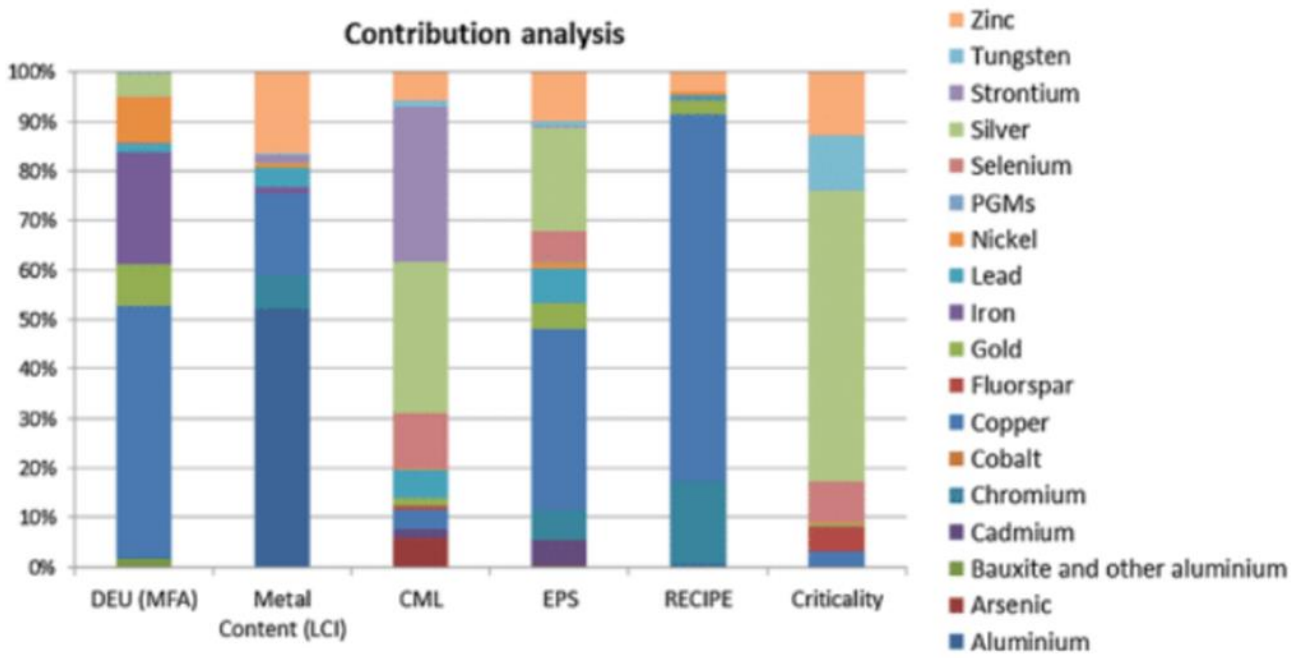


Fig. 5. Contribution analysis of metal and mineral resources using different approaches: mass based accounting (in DEU) and in the life cycle inventory (considering metal content); different LCIA methods (CML, EPS, RECIPE) and applying criticality assessment factors (CRM) (year 2010).

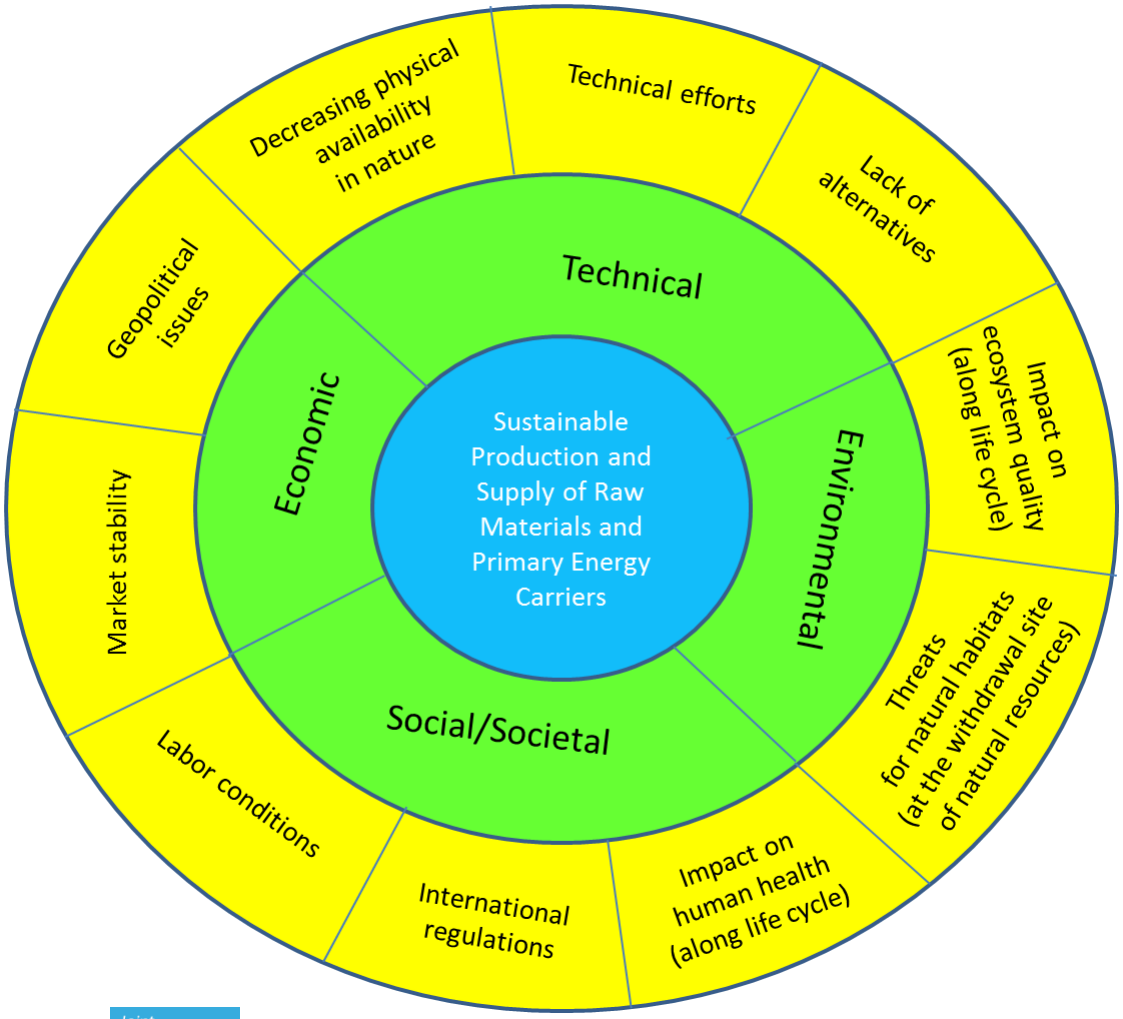
Differences in the relative importance of the resouces extracted in Europe over the overall «impact» assessed (being economic/ strategic etc)

Source: Mancini et al. Env. Sci. Pol. , 2015

An underlying framework for sustainable management of raw materials:

- Based on 10 sustainability concerns

- Organised into 4 Areas of Concern:
  - Economic
  - Technical
  - Environmental
  - Social/societal



Source: Dewulf et al., J. Ind. Ecol., 2015

5. Conclusions

- Need for all stakeholders to have a common understanding:
  - Governmental organisations
    e.g. '*Resource Efficient Europe'* flagship
  - Non-Governmental organisations
    e.g. Factor 10 institute: *energy and resource productivity*
  - Business sector
    e.g. WBSCD: '*Enhancing energy and resource efficiency*'

- Dialogue could take advantage of:
  - Internationally agreed definitions
    e.g. Natural Resources, Raw Materials, Resource efficiency
  - Internationally agreed assessment methods

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