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Environmental Criticality of Raw Materials

Outcomes of the OekoRess II Project



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Umwelt Bundesamt

Overview

Background

- Germany, the EU are widely dependent on imports of mineral and metals. Such dependencies are often connected with supply risks
- Criticality assessments provide a list of “critical raw materials” based on the analyses of supply risks in relation to the vulnerability of sectors or countries (economic importance)
- But, raw materials are also subject to environmental aspects. Mining & processing of minerals often have far-reaching consequences for local, regional environments which also may affect downstream users
  - corporate reputation risk for downstream manufacturing industries
  - opposition against mining, increasing mid- and long-term supply risks (e.g. closure of existing mines, no granting of new concessions)

➡ Environmental criticality complements the criticality assessment by considering the environmental dimension

Overview

1 Background

2 The OekoRess approach

3 Indicators, data & aggregation

4 Results

5 Recommendations

The OekoRess approach

- The OekoRess **raw material-related evaluation method** was developed in OekoRess I, and applied to about 50 raw materials (candidate list EU criticality study 2014) in OekoRess II
- **Scope** is on mining & processing of abiotic raw materials
  - Mining & processing are relevant steps in the value chain with regard to environmental impacts, but data on emissions and impacts are missing
  - The value chain is addressed with indicators on material & energy demand
- **Paradigm shift** from assessing environmental impacts to evaluation of Environmental Hazard Potentials (EHPs), a qualitative method
  - to screen potential impacts from mining
  - to identify most relevant abiotic raw materials in mining from an environmental point of view

The OekoRess approach

- The **method and results can be used** by decision makers and also e.g. by LCA practitioners to complement LCA results
- **Aggregated EHPs** provide an ordinal scale applicable to criticality concepts. However, disaggregated indicator results must be considered for decisions.
- For practical reasons, the actual management and possible countermeasures to avoid harmful environmental consequences are not covered by the approach
  - This is not to imply that such measures would be ineffective!
  - However, a reliable data base to include such measures is missing, and in many fields, mitigation measures can reduce but not fully eliminate environmental hazard potentials
- The **method is not suitable** for raw material comparisons or substitution recommendations (require LCA and quantitative data)

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Indicators, data & aggregation

Indicators for five main evaluation levels:

- Geology
- Technology
- Natural environment
- Value chain
- Governance

A total of 11 indicators

Evaluation based on measurement instructions

Indicators, data & aggregation

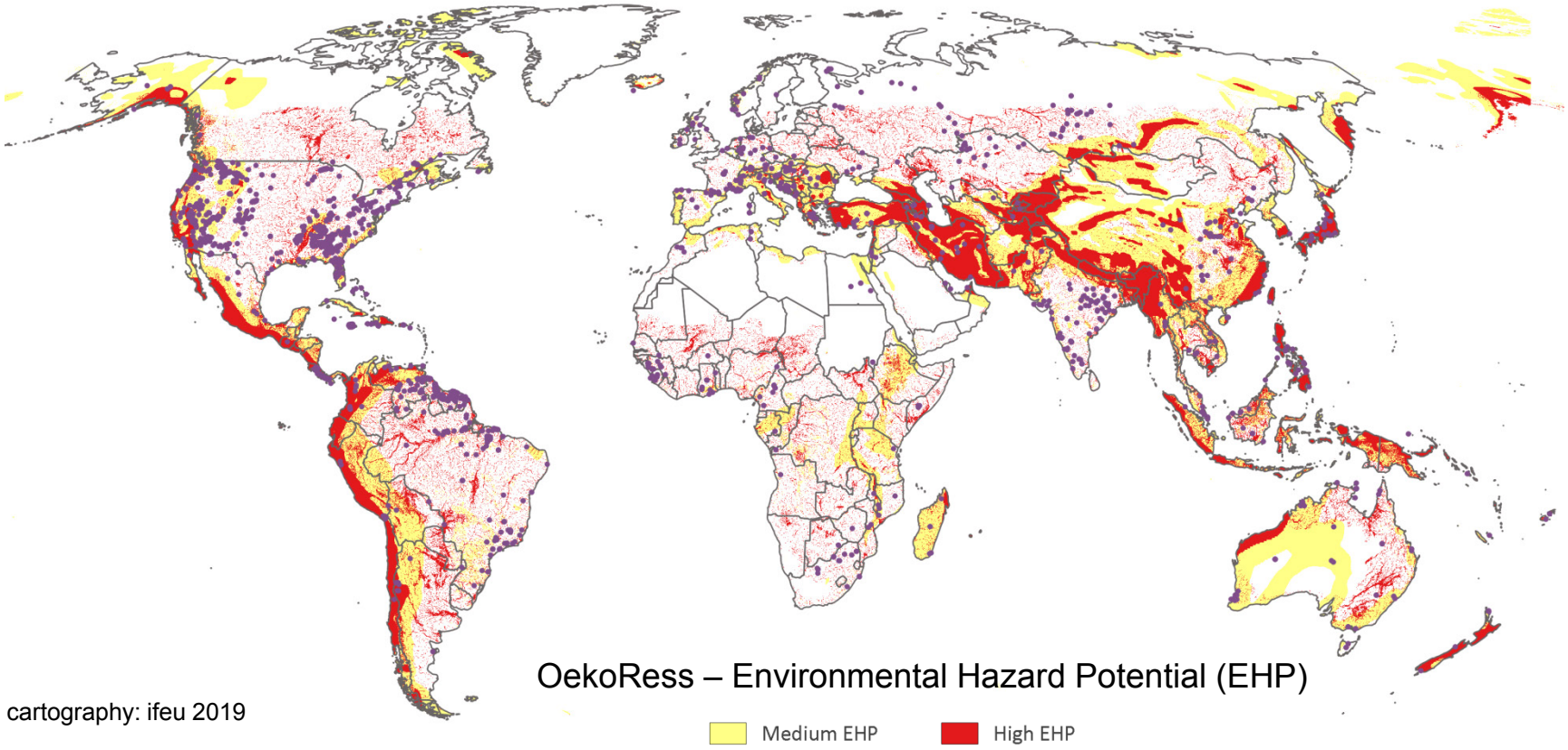
	Goal	Indicator	Environmental Hazard Potential (EHP)		
			Low	Medium	High
Geology	Avoiding pollution risks	1. Pre-conditions for AMD	Geochemical preconditions for AMD do not exist	Geochemical preconditions for AMD exist in part	Geochemical preconditions for AMD exist
		2. Paragenesis with heavy metals	The deposits usually have no elevated heavy metal concentrations	The deposits usually have slightly elevated heavy metal concentrations	The deposits usually have strongly elevated heavy metal concentrations
		3. Paragenesis with radioactive substances	The deposits usually have low uranium and/or thorium concentrations	The deposits usually have slightly elevated uranium and/or thorium concentrations	The deposits usually have elevated uranium and/or thorium concentrations
Technology	Limiting the direct impacts on eco-systems	4. Mining method	Commonly extracted in underground mines	Commonly extracted from solid rock open pit mines	Commonly extracted from alluvial or unconsolidated sediments and/or dredging in rivers
	Avoiding pollution risks	5. Use of auxiliary substances	Standard extraction & processing methods without auxiliary chemicals	Standard extraction & processing methods using auxiliary chemicals	Standard extraction & processing methods using toxic reagents and auxiliary chemicals

Indicators, data & aggregation

	Goal	Indicator	Environmental Hazard Potential (EHP)		
			Low	Medium	High
Natural environment	Avoiding natural accident hazards	6. Accident hazards due to floods, earthquakes, storms, landslides	≤ 25% quantile of the combined assessment result of the 42 raw materials with sufficient data availability	> 25% quantile and ≤ 75% quantile of the combined assessment result of the 42 raw materials with sufficient data availability	> 75% quantile of the combined assessment result of the 42 raw materials with sufficient data availability
	Avoiding competition in water usage	7. Water Stress Index (WSI) and desert areas			
	Protection of valuable ecosystems	8. Designated protected areas and AZE sites			

Indicators, data & aggregation

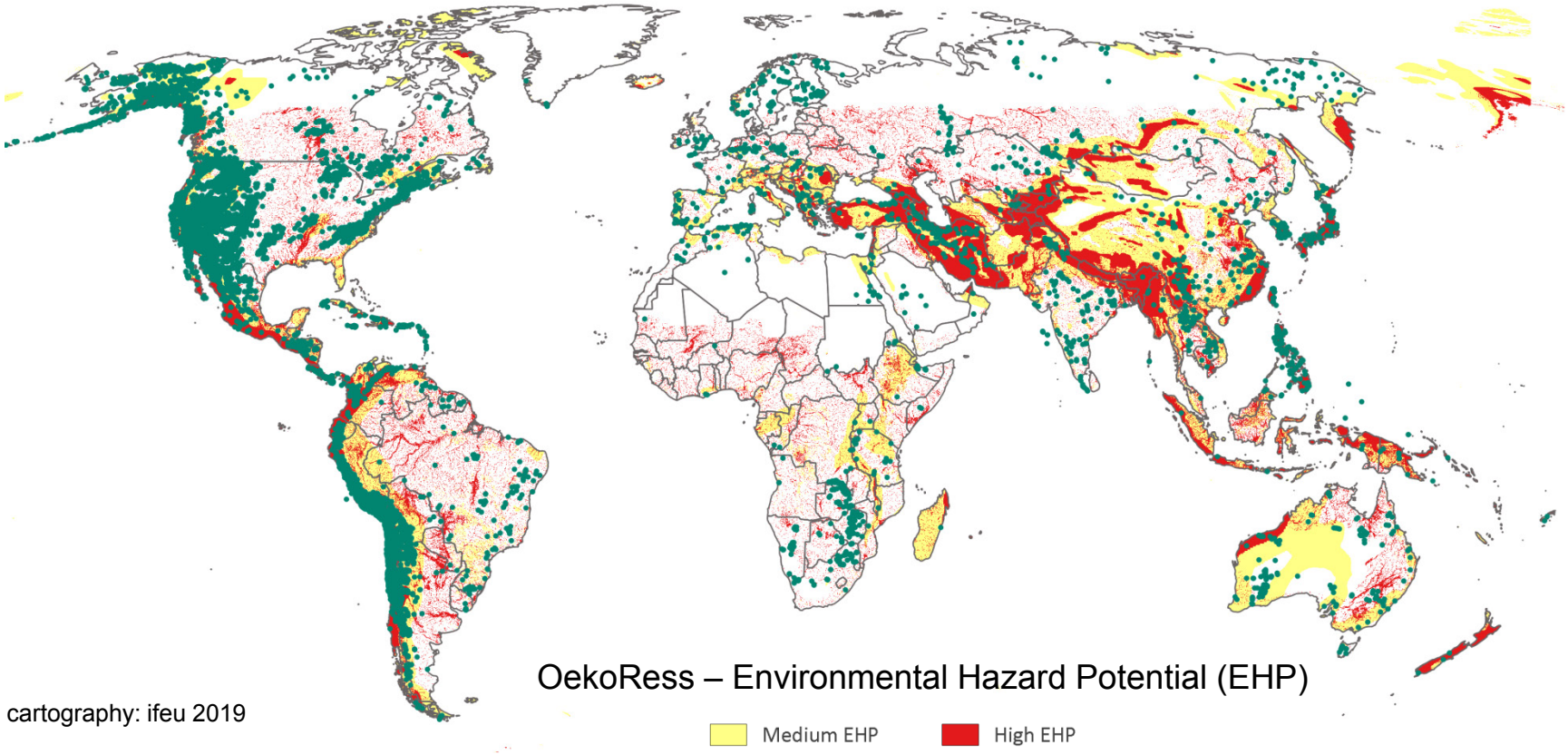
Bauxite mine sites and layer for natural accident hazards (indicator 6)



cartography: ifeu 2019

Indicators, data & aggregation

Copper mine sites and layer for natural accident hazards (indicator 6)



cartography: ifeu 2019

Indicators, data & aggregation

Class limits for the indicators of

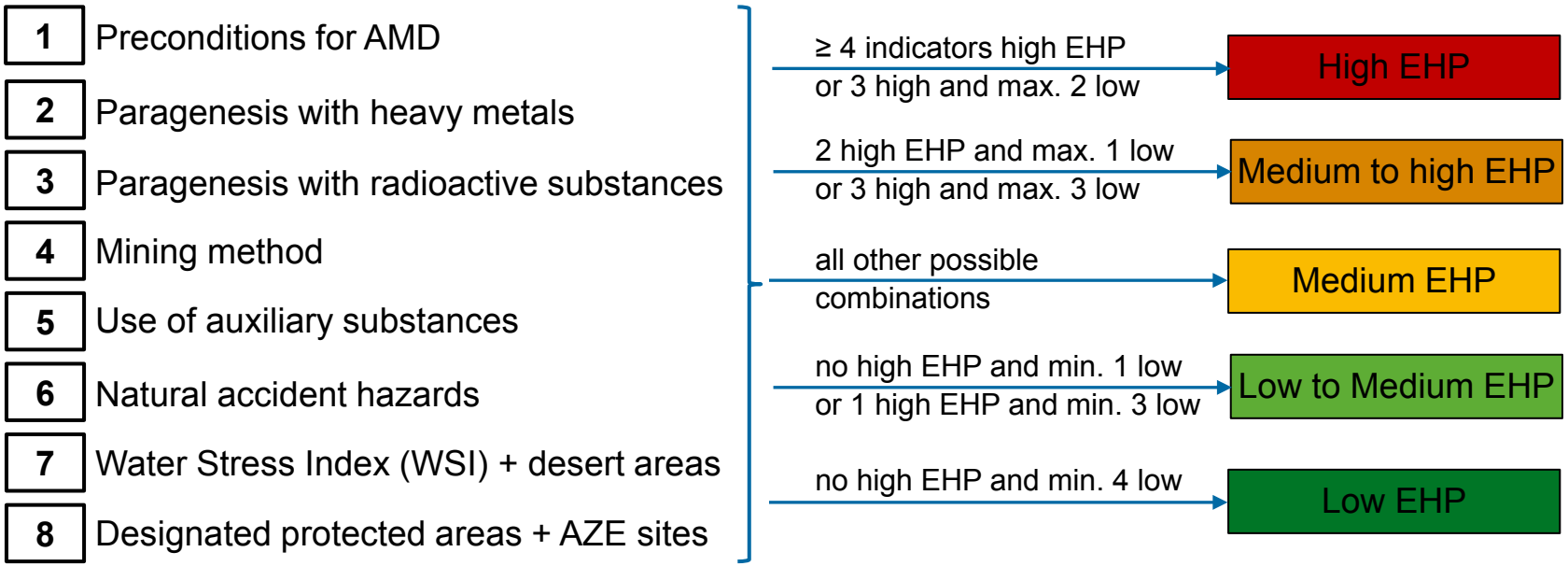
- natural environment
- value chain
- governance

are consistently set by using the 25% and 75% quantile of the results

  - For the natural environment indicators 6-8 single score results per raw material are derived by weighting the percentage of low-medium-high EHP results. The factors 0-1-5 are chosen to emphasize on the GIS assessment results with a high EHP.

Indicators, data & aggregation

Aggregation indicators 1 to 8 → aggregated EHP (aEHP)



Indicators, data & aggregation

	Goal	Indicator	Environmental Hazard Potential (EHP)		
			Low	Medium	High
Value chain	Limiting the extent of EHPs	9. Size of material flow (SMF) = Cumulated raw material demand of global production	≤ 25% quantile of the 52 raw materials with available data	> 25% quantile and ≤ 75% quantile of the 52 raw materials with available data	> 75% quantile of the 52 raw materials with available data
		10. Size of energy flows (SEF) = Cumulated energy demand of global production	≤ 25% quantile of the 52 raw materials with available data	> 25% quantile and ≤ 75% quantile of the 52 raw materials with available data	> 75% quantile of the 52 raw materials with available data

Aggregation → Global size of material and energy flows (GSMEF)

- Share [%] of total results and class limits 25% and 75% quantile
- The aggregated indicator provides information about the global dimension of raw material mining & production

Indicators, data & aggregation

Governance in major production countries (indicator 11)

- What governance indicator reflects a country's mining sector governance best (focusing on environmental aspects)?
- Eight indicators were tested on 23 case studies, covering four indicator groups:
  - General governance
  - Environmental governance
  - Sector-specific governance
  - Conflicts
- Result: Environmental Performance Index (EPI) best suited
- In addition ASM is indicated for raw materials which tend to be exploited to a significant extent by ASM

Indicators, data & aggregation

	Goal	Indicator	Environmental Hazard Potential (EHP)		
			Low	Medium	High
Governance	Compliance with standards	11. Environmental governance in major production countries = Environmental Performance Index (EPI)	Weighted EPI according to production share of producing countries ≤ 25% quantile of EPI for 180 countries	Weighted EPI according to production share of producing countries > 25% quantile and ≤ 75% quantile of EPI for 180 countries	Weighted EPI according to production share of producing countries > 75% quantile of EPI for 180 countries

The indicator on environmental governance can be used in the sense of a risk enhancing or risk reducing factor

- Good governance (low EHP) for a raw material with a high aEHP indicates that hazards are probably addressed to some extent and vice versa bad governance (high EHP) enhances EHPs

Overview

Results

Disaggregated Evaluation of Environmental Hazard Potential (EHP)

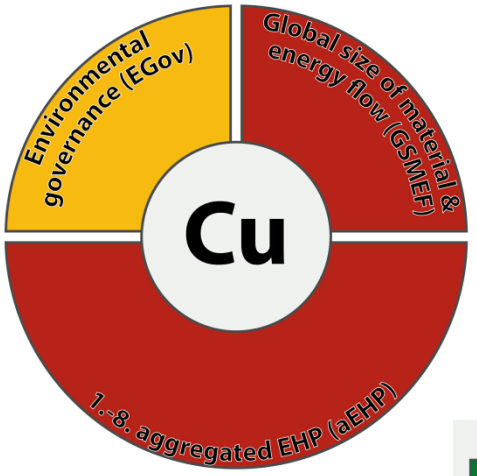
1 Preconditions for acid mine drainage (AMD)
2 Paragenesis with heavy metals
3 Paragenesis with radioactive substances
4 Mining method
5 Use of auxiliary substances
6 Accident hazards due to floods, earthquakes, storms, landslides
7 Water Stress Index (WSI) and desert areas
8 Designated protected areas and AZE sites

Global Size of Material and Energy Flows (GSMEF)

SMF Size of material flow
SEF Size of energy flow

Boundary Conditions

- Share of mining sites in the arctic region: < 5%
- Mined as main product



Disaggregated Evaluation of Environmental Hazard Potential (EHP)

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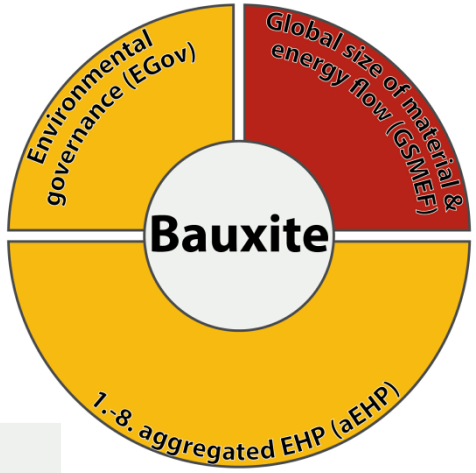
8 Designated protected areas and AZE sites

Global Size of Material and Energy Flows (GSMEF)

SMF Size of material flow
SEF Size of energy flow

Boundary Conditions

- Share of mining sites in the arctic region: < 1%
- Mined as main product



Legend

Low environmental hazard potential (EHP)
Low to medium EHP
Medium EHP
Medium to high EHP
High EHP

Inner circle colouring

Raw material mainly produced as:
- main product
- co- and/or by-product

ASM Potential artisanal and small-scale mining (ASM)

Results

EHP Indicators								GSMEF		Raw materials	Aggregated results			Supplementary information		
1.	2.	3.	4.	5.	6.	7.	8.	SMF	SEF		aEHP	EGov	GSMEF	M/B/C	ASM	AR
										Antimony				M+**B**+C	**ASM**	< 1%
										Cobalt				M+**B**	**ASM**	< 5%
										Platinum				M+B+C		< 10%
										Vanadium				M+**B**		< 5%
										Rhodium				C+B		< 20%
										Copper				M		< 5%
										Gold				M+B	**ASM**	< 5%
										Phosphate rock				M		< 5%
										Zinc				M		< 1%
										Palladium				C+B		< 30%
										Indium				B		< 1%
										Lead				M+C		< 1%
										LREE				M+C		< 5%
										Molybdenum				M+B		< 1%
										Silver				M+C+B	**ASM**	< 5%
										Bismuth				B		< 1%
										Selenium				B		< 5%
										Tellurium				B		< 5%
										Nickel				M		< 15%
										Germanium				B		< 10%
										Rhenium				B		< 5%
										HREE				M+C		< 1%
										Aluminium				M		< 1%
										Borates				M		0%
										Gallium				B		< 1%
										Scandium				B		< 10%
										Beryllium				**M**+B	**ASM**	< 5%
										Niobium				M		< 1%
										Silica sand				M		0%

Results

EHP Indicators								GSMEF		Raw materials	Aggregated results			Supplementary information		
1.	2.	3.	4.	5.	6.	7.	8.	SMF	SEF		aEHP	EGov	GSMEF	M/B/C	ASM	AR
										Chromium				M	**ASM**	0%
										Tin				M	**ASM**	< 1%
										Magnesium				M		0%
										Manganese				M	**ASM**	0%
										Bauxite				M		< 1%
										Iron				M		< 1%
										Iron ore				M		< 1%
										Titanium				M		< 1%
										Gypsum				M	**ASM**	0%
										Magnesite				M		0%
										Lithium				M		0%
										Tantalum				C	**ASM**	0%
										Fluorspar				M	**ASM**	0%
										Tungsten				M	**ASM**	< 5%
										Graphite				M	**ASM**	< 5%
										Coking coal				M		0%
										Potash				M		0%
										Kaolin clay				M		0%

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7. Water Stress Index (WSI) and desert areas
8. Designated protected areas and Alliance for Zero Extinction (AZE) sites

SMF Size of material flow
SEF Size of energy flow

aEHP aggregated environmental hazard potential
Egov Environmental governance
GSMEF Global size of material and energy flows

M/B/C Main (M), co- (C) or by- (B) product
ASM Artisanal and small scale mining
AR Share of mining sites in the arctic region

High EHP
Medium to high EHP
Medium EHP
Low to medium EHP
Low EHP

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Main recommendations are to

- link the **environmental and raw materials policy debate**
- **prioritize raw materials** with high overall environmental hazard potential in mining
- and initiate **individual raw material-specific processes**
- initiate targeted **partnerships with countries rich in raw materials** in order to improve the ecological and social conditions of primary extraction
- promote and expand **industrial partnerships and standard initiatives** aimed at achieving targeted improvements in the ecological and social conditions in mining
- support governments in implementation of **good environmental governance** in the mineral sector
- support **formalization ASGM** (Minamata convention on mercury)
- initiate studies on **Internalization and fair distribution of environmental costs** of mining along the value chain

Policy-makers

Industry

Int. Coop.

R&D

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Thank you for your attention!

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