STRADE

Draft concept for a data and knowledge information system on mineral mining and trade and related environmental and socio-economic issues (Part I)

Andreas Manhart, Stefanie Degreif,
Peter Dolega, Doris Schueler

Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

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Coordinator: Oeko-Institut e.V.

Contact: Dr. Doris Schüler, d.schueler@oeko.de , +49 6151 8191-127

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Project Partners:

OEKO-INSTITUT E.V. – INSTITUT FUER ANGEWANDTE OEKOLOGIE (Oeko-Institut)
Merzhauser Strasse 173, Freiburg 79100, Germany

SNL Financial AB (SNL AB)
Olof Palmes gata 13, 4st, SE-11137, Sweden

UNIVERSITY OF DUNDEE (UNIVDUN)
Nethergate, DD1 4HN Dundee, United Kingdom

PROJEKT-CONSULT BERATUNG IN ENTWICKLUNGS- LAENDERN GMBH (Projekt-Consult)
Laechenstrasse 12, Bad Vilbel 61118, Germany

GEORANGE IDEELLA FORENING (GEORANGE)
Box 43, Mala 93070, Sweden

UNIVERSITY OF WITWATERSRAND JOHANNESBURG (WITS)
Jan Smuts Avenue 1, Johannesburg 2001, South Africa

DMT-Kai Batla (PTY) Ltd
P.O Box 41955, Craighall, 2024, South Africa

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List of Abbreviations

Abbreviation	Description
AMD	Acid mine drainage
ASM	Artisanal and small-scale mining
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources Germany)
BGS	British Geological Survey
BRGM	Bureau de Recherches Géologiques et Minières
CED	Cumulative energy demand
COMEXT	Community External Trade Statistics (EU database on external TRADE)
DMC	Domestic material consumption
DMI	Direct material input
EIP	European Innovation Partnership on Raw Materials
EITI	Extractive Industries Transparency Initiative
EU	European Union
EURMKB	European Union Raw Materials Knowledge Base
GHG	Greenhouse gas emissions
ICMM	International Council on Mining and Metals
ILO	International Labour Organization
ILZSG	International Lead and Zinc Study Group
JRC	Joint Research Centre
LCA	Life-cycle assessment
LCI	Life-cycle inventory
MCI	Mining Contribution Index
OECD	Organisation for Economic Co-operation and Development
PRODCOM	Production Communautaire (EU database on production)
RGI	Resource Governance Index
RMC	Raw material consumption
RME	Raw material equivalents
RMI	Responsible Mining Index
RMIS	Raw Material Information System
UNDP	United Nations Development Programme
USGS	United States Geological Survey
WGI	World Governance Indicators

1. Introduction

This paper, Part I of two sections, examines the necessity and feasibility of a data and knowledge information system on mineral mining and trade and related environmental and socio-economic issues. Chapter 2 here summarises drivers for raw-material-related data demand; chapters 3 and 4 present initiatives and data sources that already create and publish data and information relevant for raw-material-related policy- development. This analysis is completed in chapter 5, which summarises country-specific data that can be used to complete raw-material-related information on a country level. Based on this summary, chapter 6 provides general considerations for a data and knowledge platform on mineral mining and trade.

The data is broadly structured into:

- Part I – Raw-material-specific information
- Part II – Country-specific information

While users might typically start their analysis with raw-material-specific information, this data architecture allows coupling this information with mining-country-specific data and indices. One possible way of compiling the identified raw material information is presented in Annex I. A concrete example of compiling country-specific information can be found for Brazil in the supplementary document *Draft concept for a data and knowledge information system on mineral mining and trade and related environmental and socio-economic issues (Part II)*.

This paper contributes towards the development of a holistic European raw material information system that combines mining and trade data with information on environmental and socio-economic aspects. Although the system primarily aims at supporting the EU's raw material policy, it has a global scope reflecting Europe's import dependency for many commodities.

2. Background

Raw-material-related policy development has always relied on sound data about geological reserves, mining and the uses of mineral commodities. While this information has traditionally been provided by national geological surveys such as BRGM, BGS, BGR and USGS, the focus of raw-material-related policies has widened over the last decade and increased the need for additional types of material-related information and analysis. This additional demand is mostly linked to the following developments:

- Sudden changes in demand and supply caused quite pronounced and unexpected price hikes for some commodities such as tantalum in 2000 and rare earth elements in 2010/11. This led to a widespread fear of comparable development for other commodities and stimulated political and scientific debates on *critical raw materials*. Subsequently, various research groups developed and proposed methodologies to assess and compare supply risks of raw materials and the vulnerability of industries and economies to these risks [1–3].

- Mining can yield significant socio-economic benefits and is one of the few economic sectors with the potential to stimulate lasting economic growth in many regions. This is reflected in a number of policy processes and documents aiming to harness the sector for sustainable economic development and poverty alleviation [4,5]. However, many developing countries' experiences reflect poor economic development performance from mining revenues and their inability to meet high expectations. There is an urgent need to learn from past failures and develop new approaches that consider the interests of resource-rich and resource-consuming countries.

- The general increase in environmental awareness in the last decades has led to the development of life-cycle assessment methodologies (LCA), which assess the environmental impact of products and processes over their entire life cycle, from primary production to end-of-life. As all physical products and infrastructure require raw materials, this has created a demand for life-cycle inventory datasets on raw materials covering environmental impacts such as greenhouse gas emissions (GHG) and cumulative energy demand (CED) per defined unit of used raw material.

- A series of quite recent mining dam failures with disastrous consequences for ecosystems and local residents has increased the public's general awareness that mining is often associated with quite severe impacts on the environment that are not fully covered in existing life-cycle inventory datasets (see above about LCA). This also includes environmental impacts relate to land-use and ecosystem degradation, as well as various other impacts such as pollution caused by acid mine drainage (AMD), mobilisation of heavy metals and elevated levels of radioactive substances in ores and tailings [6].

- Starting with a series of reports addressing the role of mineral mining and trade in financing armed groups in the eastern DR Congo, international attention has shifted to human rights issues in mining within war- and post-war zones as well as in some other developing countries and emerging economies. Today, social issues in mining are widely seen as major challenges in international supply-chains [7,8].

While these developments have led to the creation of new assessment methodologies and raw-material and country-specific information systems, many of these initiatives mainly focus on their specific sphere of issues. As a consequence, there is now a wealth of high quality data and information tools on raw materials and mining available, but this knowledge is distributed over a rather broad variety of publications and datasets. For interested stakeholders from governments, industry, civil society and media, this diversity can be a major obstacle in finding the appropriate information, particularly information on responsible mining and human right issues.

To overcome this problem, establishing a common data and knowledge information system where data and information from the various existing sources are hosted in a structured and easy accessible manner is considered and presented. This paper lays out initial considerations for such an information system and aims to stimulate related networking and developments.

3. Review of current activities in collection and provision of raw-material-related data

The following table provides an initial summary of European and global institutions and their activities in the field of data collection and provision with the focus on global and EU raw material flows and responsible mining issues.

Table 1: Selected institutions' activities related to data on global and EU raw material flows and responsible mining issues

Institution	Type of activity	Name
Eurostat	International trade and production statistics	COMEXT, PRODCOM [9] [10]
Eurostat	Raw material indicators	Indicators DMC, RMC, DMI, RME [11]

Institution	Type of activity	Name
	related to EU raw material consumption and material flows along the supply chain based on environmental-economic accounting	
European Innovation Partnership on Raw Materials (EIP)	24 indicators on EU raw materials (5 related to imports)	Raw materials score board [12]
European Innovation Partnership on Raw Materials (EIP)	Provision of EU-level data and information on raw materials from different sources in a harmonised and standardised way	European Union Raw Materials Knowledge Base (EURMKB) [13]
European Commission	Criticality analysis of raw materials	Critical material list and background reports [2,14,15]
Joint Research Centre	Raw material information systems (advanced RMIS 2.0 under development);	RMIS [16]
UN	Database on global trade	COMTRADE [17]
OECD	Information on human rights issues for companies' due diligence activities (under development)	Minerals Risk Handbook
UNEP	Platform and information for stakeholders in the extractives sector (under development)	MAP-X [18]
Responsible Mining Foundation	Independent ranking of large mining companies in responsible mining practice (under development)	Responsible Mining Index (RMI) [19]
Mining companies	Sustainability reporting	Sustainability reports
World Bank	Evaluation of countries' governance (cross-sectoral) and provision of economic data	World Governance Indicators (WGI) [20]
Natural Resource Governance Institute	Evaluation of countries' resource governance	Resource Governance Index (RGI) [21] [22]
Civil Society and Research (e.g. Environmental Justice Atlas)	Mapping of mining conflicts	Web based information on environmental and social conflicts, e.g. [23]

Institution	Type of activity	Name
International Council on Mining & Metals (ICMM)	Evaluation of mining countries' contribution to national economies	Mining Contribution Index (MCI) [24]
Ilostat (ILO labour statistics)	Country-specific data on labour issues	Data on mining employment and working conditions

Source: Oeko-Institut compilation

This large number of institutions already working on specific aspects of data compilation (see Table 1) is discussed in more depth in the next two chapters within the context of raw-material and country-specific subject areas.

4. Review of raw-material-specific data sources

4.1. Data on primary production, trade and use

Information on primary production volumes and trends are compiled by various national geological surveys, with the most widely used data regularly published and updated by USGS [25,26] and BGS [27]. Data on commodity trade can be retrieved from statistical data agencies such as Eurostat and the UN Statistic Commission. Data on commodity prices are available from service providers (e.g. Metal pages [28] or Asian Metal [29]). Stock exchanges that trade raw materials publish information on current price developments [30].

While data on raw material use per sector are partly included in USGS publications, the data is mostly limited to the US economy. Information on sector- and application-specific uses can often be found in publications from industry associations and raw-material-related research groups such as the International Lead and Zinc Study Group (ILZSG) and the World Gold Council.

4.2. Data on recycling and substitution

Data on global and country-specific recycling rates, volumes and recycling content are not available in a uniform and regularly updated format. European data are provided by Eurostat, and further individual data are sometimes provided by industry associations and raw material related research groups (see section 4.1), UNEP Resource Panel published global average data on end-of-life recycling rates and recycled-content rates [32].

There is little systematic information on the substitutability of raw materials. Nevertheless, some studies have attempted to assess the substitutability of raw materials using simplified clusters such as low, medium and high [2,33,34]. These studies have mostly been conducted in relation to criticality assessments (see section 4.3).

4.3. Methods and data on raw material supply risks

In the last decade, price hikes for some technology metals has stimulated a broad debate on the *criticality* of raw materials. To support this debate and to facilitate political and economic decision-making, various European and international research groups have developed related assessment methodologies [2,3,34–39]. Raw material criticality is commonly determined by two dimensions: supply risks and vulnerability. While vulnerability entirely depends on the level to which an economy, an industry or a company relies on a certain material, supply risk assessments follow a more universal approach and mostly use indicators and data such as country and company concentration of production, the political and regulatory situation in producing reserve-holding countries, recycling and substitutability.

While most studies yield a comparative assessment of raw material criticality, individual indicator values are also available and can be of interest to decision-makers.

4.4. Life-cycle inventory (LCI) datasets

To support live-cycle assessments (LCA), a variety of life-cycle inventory databases such as ProBas (German Environment Agency), EcoInvent (Swiss not-for-profit association) and EPLCA (European Platform on Life Cycle Assessment) have been established. These databases contain quantitative data on environmental impacts such as greenhouse gas emissions (GHG), cumulative energy demand (CED), acidification potential (AP) and water use for industrial processes and can also be used quantify such impacts for a defined unit of raw material (e.g. 1 metric tonne). Although such assessments have been carried-out to compare various types of commodities [40], data gaps have been found to be significant [41]; LCA-based assessments of raw material related environmental impacts are currently only reliable for greenhouse gas emissions (GHG) and cumulative energy demand (CED).

4.5. Methods and data on environmental issues beyond LCI data

Since life-cycle inventory (LCI) data is currently still insufficient to cover all aspects of environmental impacts from mining, additional types of information can help to sharpen the view on potential environmental consequences of mining and beneficiation. In the ongoing ÖkoRess project led by the German Umweltbundesamt, a team of scientists is currently developing a methodology to assess the environmental hazard potential of mineral resources [42]. While the methodology uses many of the data sources listed in sections 4.4 and 5.4, it also considers characteristic geochemical properties of deposits and ores (associated heavy metals, radioactive substances, potential for acid mine drainage), commonly applied extraction (open pit or underground mining) and beneficiation practices (use of process chemicals). Once the level of raw materials is evaluated, the results can be used to complement criticality assessments (see section 4.3) with an environmental dimension.

5. Review of country specific data sources

5.1. Economic indicators

Economic indicators and a wealth of other important socio-economic data are provided by the World Bank [43] and UNDP [44]. Both organisations use statistics from various sources, including government statistics and data from other UN bodies; both sources are the major entry point for country-based economic and socio-economic data.

Further evaluations of the role that mining plays in national economies are published by the International Council on Mining & Metals (ICMM) [45].

5.2. Governance indicators

The quality of governance has far reaching influence on mining-related issues, including understanding how mineral wealth is used to stimulate socio-economic development and growth. The organisation Revenue

Watch created and published the Resource Governance Index for 58 countries in 2013 [46], which will be updated by the Natural Resource Governance Institute in the near future. Although not specifically tailored to natural-resource-related governance, the World Bank provides comparative data on various country governance aspects [47]. Further data sources for governance on a national level include the Corruption Perception Index by Transparency International [48], as well as the EITI process that, amongst others, requires member countries to report on financial flows from the mining sector to government bodies.

5.3. Data on production and trade

In addition to the data available on an international level (see section 4.1), national statistics often provide more detailed country-specific data that frequently contain information on individual production sites, activities of mining and trading companies, as well as trends over time.

5.4. Methods and data on country and site-specific environmental risks

One major type of environmental impact is related to tailing dam bursts [6], for which some datasets allow an analysis of past incidents, including their location and the type of mineral being mined [49,50]. To assess potential future disaster risks, geospatial information on risks for strong storms, floods and earthquakes can be used [51,52]. This data can either be displayed in country maps to give a graphical orientation of areas where mining might be subject to extreme events or it can be combined with the geographic coordinates of mining sites to assess whether or not an individual mine is located within a high-risk area. Comparable approaches can also be taken for water stress, protected areas, land-cover and land-use.

5.5. Methods and data on human rights risks in mining areas

With the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas [53], as well as the UN Guiding Principles on Business and Human Rights [54], upstream and downstream companies in mineral supply chains are increasingly requested to conduct human rights due diligence, including an assessment of potential human rights risks in mining areas. Originally it was seen that supply-chain-related activities were widely related to tin, tantalum, tungsten and gold from the African Great Lakes Region; however, the OECD Guidance subsequently recommends addressing human rights issues in the supply chains of *all* minerals sourced from any conflict-affected and high-risk area [53]. To implement these recommendations, companies are now challenged with conducting human-rights-related risk assessments of their various mineral supply-chains. While there are no perfect information sources to provide a full insight into the realities of mining areas on the ground, various sources exist that allow first risk screenings and prioritisations. This includes country rankings related to child labour [55] and forced labour [56], as well as evaluations of ongoing conflicts [57,58].

Another means to assess potential human rights issues of mining is the evaluation of artisanal and small-scale mining (ASM) activities. Although artisanal mining is not necessarily related to human rights abuses, ASM activities are often carried out in areas with weak government control. In addition, many artisanal mining activities are carried out with little or no health and safety measures, making severe health impacts and fatal accidents significantly more common than in most regular mining projects. There are various studies on the challenges and opportunities of artisanal mining in certain economies and for individual minerals [59–61]. A recent project by the World Bank and the non-profit international development organization PACT aims at further improving data on artisanal mining [62].

6. Considerations for a data and knowledge information system on minerals and related socio-economic and environmental issues

The analysis in the previous chapters yielded a plethora of raw-material and country-specific data sources and information systems. While some of this data is quite closely linked to raw material production and trade, others (such as country indicators on various socio-economic aspects) were originally designed for multiple purposes but can also be utilised to gain insights into relevant framework conditions affecting the mining sector. Although, many of the reviewed information systems and data sources have quite specific foci, some recent developments aim at establishing a more holistic platform for raw-materials-related information: amongst others, the Raw Material Information System (RMIS) by JRC and the efforts of OECD for a Mineral Risk Handbook. Both efforts are still in development, but both have the potential to serve as major raw-materials-related data and knowledge information systems. STRADE suggests that such information systems have the following characteristics and target groups:

- The information system should offer a wide range of reliable data and data-sources on raw material production, trade and related socio-economic and environmental issues. This should also encompass topics and data around development perspectives from mining, as well as existing initiatives aiming for environmentally and socially responsible development of the minerals sector.
- Due to the wealth of existing data sources, the information system should mainly strive for integrating existing data into one information system. Development of new indicators and data-sets might partly be relevant for socio-economic and environmental issues where existing data sources are still fragmentary.
- While such a system should have a global perspective, an EU-led system (such as the RMIS currently being developed by JRC) should be able to combine global information with European demand and trade data.
- The use of the system should be free of charge and target use by policy-makers, analysts and decision-makers from industry, civil society organizations and academia.
- Due to the different data types and information references, data can be grouped into two major levels: Raw-material-specific information and country-specific information. Country-specific information can then be attributed to raw material information by using either global production distribution (raw material a is mined in countries u, v, w) or trade data (raw material a is imported into the EU from country x, y, z).
- The information system has to be updated regularly and should also consider new developments in data availability. Thus, hosting such a knowledge platform requires stable financing and institutional set-up. For a European knowledge platform, JRC appears most suitable taking over these tasks.

Beyond these general principles Annex I and II provide first concepts on how the existing data can be compiled and grouped into raw-material and country-specific information levels. The concept for the raw-material-specific information (raw material profiles) uses iron as an example. The concept for the country-specific information (country profiles) offers Brazil as the example. The data collection for these examples does not claim completeness but builds on easily available data to illustrate the underlying concept and serve as a basis for a general discussion of the structure of the information system. Further data collection will be necessary to elaborate comprehensive raw material and country profiles if the STRADE team and the requested stakeholders agreed upon their principal architecture.

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[45] ICMM. The role of mining in national economies [Internet]. London; 2012 [cited 2017 Apr 13]. Available from: http://www.icmm.com/website/publications/pdfs/4440.pdf.

[46] Revenue Watch. The 2013 Resource Governance Index [Internet]. New York; 2013 [cited 2017 Apr 13]. Available from: http://www.resourcegovernance.org/sites/default/files/rgi_2013_Eng.pdf.

[47] World Bank. Worldwide Governance Indicators [Internet]. Washington D.C.; 2017 [cited 2017 Apr 13]. Available from: http://info.worldbank.org/governance/wgi/#home.

[48] Transparency International. Corruption Perception Index 2016 [Internet]. Berlin; 2017 [cited 2017 Apr 13]. Available from: http://files.transparency.org/content/download/2089/13368/file/2016_CPIReport_EN.pdf.

[49] World Information Service on Energy. Chronology of major tailings dam failures [Internet]. Arnsdorf; 2017 [cited 2017 Apr 13]. Available from: http://www.wise-uranium.org/mdaf.html.

[50] International Committee on Large Dams. Tailings Dams Risk of Dangerous Occurences - Lessons learnt from practical experiences: Bulletin 121. Paris; 2001.

[51] United Nations Office for Disaster Risk Reduction. Global Assessment Report on Disaster Risk Reduction. Geneva; 2015.

[52] Shedlock KM, Giardini D, Grünthal G, et al. The GSHAP Global Seismic Hazard Map. Seismological Research Letters. 2000;71:679–689.

[53] OECD. OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas: Third Edition [Internet]. [place unknown]; 2016 [cited 2016 Dec 19]. Available from: http://www.oecd.org/daf/inv/mne/OECD-Due-Diligence-Guidance-Minerals-Edition3.pdf.

[54] United Nations. Guiding Principles on Business and Human Rights [Internet]. Geneva; 2011 [cited 2016 Dec 9]. Available from: http://www.ohchr.org/Documents/Publications/GuidingPrinciplesBusinessHR_EN.pdf.

[55] UNICEF. Child Labour Database [Internet]. New York; 2016 [cited 2017 Apr 13]. Available from: http://data.unicef.org/topic/child-protection/child-labour/.

[56] Walk Free Foundation. The Global Slavery Index [Internet]. Broadway Nedlands; 2016 [cited 2017 Apr 13]. Available from: http://www.globalslaveryindex.org/findings/.

[57] Heidelberg Institute for International Conflict Research. Conflict Barometer 2016 [Internet]. Heidelberg; 2017 [cited 2017 Apr 13]. Available from: http://hiik.de/de/konfliktbarometer/pdf/ConflictBarometer_2016.pdf.

[58] International Crises Group. CrisesWatch [Internet]. Brussels; 2017 [cited 2017 Apr 13]. Available from: https://www.crisisgroup.org/crisiswatch/database.

[59] Dorner U, Franken G, Liedtke M, et al. Artisanal and Small-Scale Mining (ASM): POLINARES working paper no. 19 [Internet]. Hannover; 2012 [cited 2017 Apr 13]. Available from: http://pratclif.com/2015/mines-ressources/polinares/chapter7.pdf.

[60] Hentschel T, Hruschka F, Priester M. Artisanal and Small-Scale Mining [Internet]. London; 2003 [cited 2017 Apr 13]. Available from: http://pubs.iied.org/pdfs/9268IIED.pdf.

[61] Wagner M, Franken G, Martin N, et al. Zertifizierte Handelsketten im Bereich mineralischer Rohstoffe [Internet]. Hannover; 2007 [cited 2017 Apr 13]. Available from: http://www.bgr.bund.de/DE/Themen/Min_rohstoffe/Downloads/Studie_Zertifizierte_Handelsketten.pdf?__blob=publicationFile&v=2.

[62] PACT & World Bank. DELVE - a global platform for artisanal & small scale mining data [Internet]. [place unknown]; 2017 [cited 2017 Apr 13]. Available from: http://www.pactworld.org/delve/contact.

STRADE

Annex I

Draft concept of raw material profiles

Iron

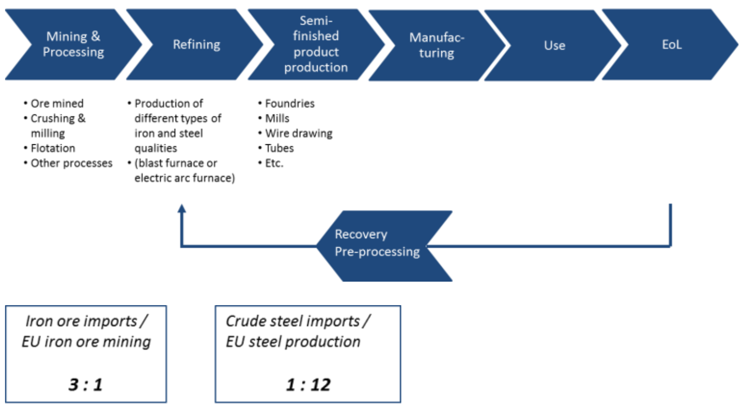
Darmstadt,
10 May 2017

Öko-Institut e.V. Institut für angewandte Ökologie Institute for Applied Ecology
SNL Financial
University of Dundee
projekt consult Member of GFA Consulting Group
GEORANGE www.georange.se
University of the Witwatersrand Johannesburg
DMT DMT Kai Batla (Pty) Ltd

Preface

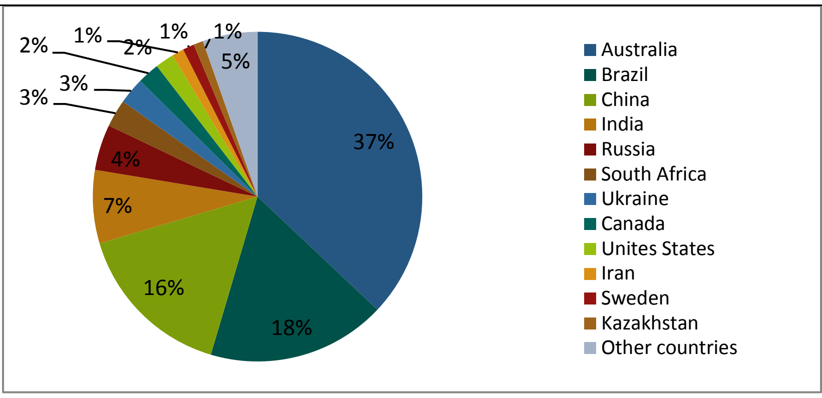
This document is a draft concept for raw material profiles as one pillar of a raw material information system. It proposes a structure how to provide raw-material specific data in a useful and compiled framework. For the purpose of illustration existing data for the raw material iron ore are included. These raw material profiles should be considered together with the country profiles found in Annex II.

Raw material profile (draft, at the example of iron)

	DATA	SOURCE
INTRODUCTION		
Iron (Fe) is the fourth most abundant element in the Earth's crust, with a concentration of 4.7%.[1] Iron has the highest production volume of all metals globally – in 2016 2.2 billion tonnes iron ore (usable) were mined.[2] Almost every industrial sector depends on iron; moreover Europe is the second largest manufacturer of steel and iron globally.		
SUPPLY CHAIN OVERVIEW		
Supply chain map	 Detailed information on the main production processes are available on www.eurofer.eu	Used source for mining data: BGS Used source for import iron ore data: COMTRADE Further source: Eurostat Used source for crude steel import and production: eurofer.eu
GLOBAL PRODUCTION AND RESERVES		
Global primary productio n and **reserves** per country	**Global primary mine production 2016** (usable iron ore): Total 2,230 million metric tonnes	Used data source: USGS 2017 (*https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf*) *Other data*

[1] European Commission. Report on Critical Raw Materials for the EU - Non-Critical Raw Materials Profiles [Internet] [cited 2016 Nov 15]. Available from: http://ec.europa.eu/DocsRoom/documents/7422/attachments/1/translations/en/renditions/pdf.

[2] *USGS 2017: US Geological Survey. Mineral Commodity Summaries 2017* *https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf*



sources: BGS

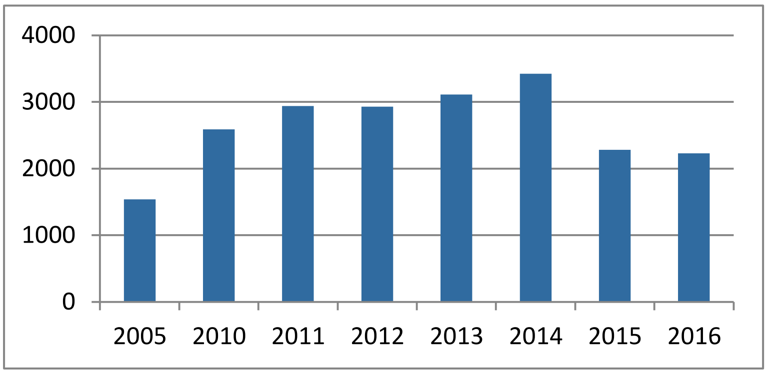
Country concentration of iron ore primary production:

Used source: VDI standard 4800

Herfindahl-Hirschman Index country production[3]	1

Used source: USGS
Other data: BGS

Historical development of primary production (usable iron ore) in million metric tonnes: The decrease in 2015 is a result of new data from China (since 2015 China with usable ore data; before China included with crude ore data – till 2015 China with around 1,300 mio. tonnes in China; as usable ore ca 375 mio. tonnes)



Largest iron ore producers in 2014

Used data:

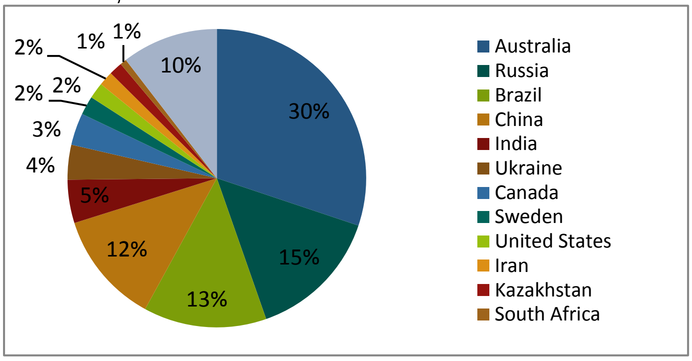
Comtois C, Slack B. Dynamic Determinants in Global Iron Ore Supply Chain [Internet] [cited 2017 Mar 13]. Available from: https://www.cirrelt.ca/DocumentsTravail/CIRRELT-

[3] The Herfindahl-Hirschman index (HHI) is a key figure for measuring concentrations. In this case the concentration of iron ore producing countries. 1 = high concentration of production

Corporation	ICMM member	Country	Capacity (Mt)	Capacity (%)
Vale Group	No	Brazil	451,7	17,17
Rio Tinto Group	Yes	UK	378,7	14,39
BHP Billiton	Yes	Australia	310,3	11,79
Fortescue Metals	No	Australia	81,5	3,10
Arcelor Mittal Group	No	UK	79,6	3,03
AnBenGroup	No	China	55,7	2,12
Anglo American Group	Yes	South Africa	50,8	1,93
Metalloinvest	No	Russia	46,8	1,78
Evrazholding Group	No	Russia	46,4	1,76
LKAB Group	No	Sweden	45,2	1,72
Metinvest Holding Group	No	Ukraine	44,7	1,70
Cliffs Natural Resources		USA	42,9	1,63

2016-06.pdf.

Global reserves of crude iron ore:
Total 170,000 million metric tonnes



Used data source USGS 2017 (*https://minerals.usgs.gov/minerals/pubs/mcs/2017/mcs2017.pdf*). *Other data sources: BGS*

Country concentration of iron ore reserves:

Herfindahl-Hirschman Index reserves[4]	0.3

Used data: VDI standard 4800

Ore as main-product / by-product

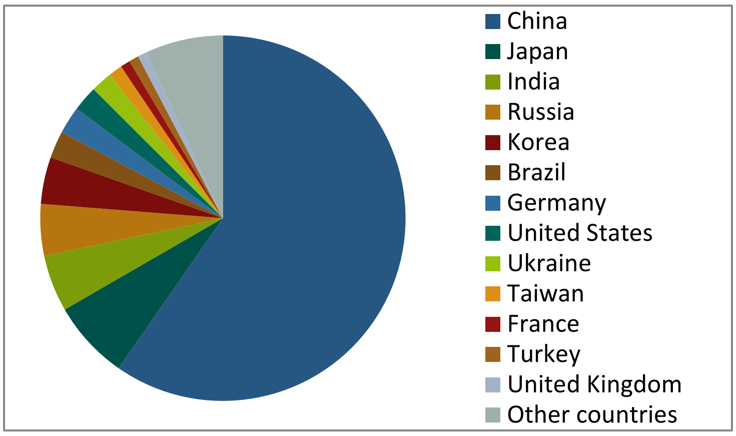
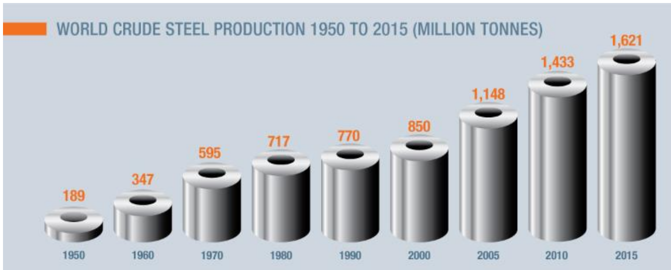
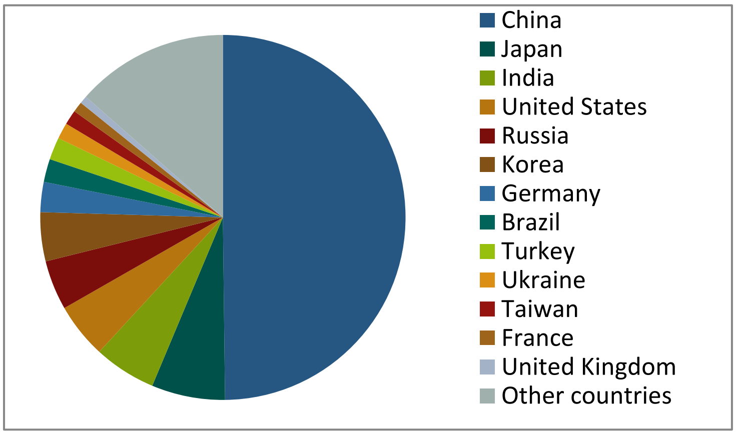
- Iron ore is mainly mined as **main-product**.
- **Frequent by-products** in iron ore mining are: TiO2, S, Ni, Cu, V

The **principal iron-bearing minerals** of commercial importance are hematite, magnetite, and goethite/limonite (59, 60). Others include siderite, ilmenite, chamosite, and pyrite; in the case of ilmenite, Fe is recovered as a companion of TiO2, while pyrite is roasted to recover S with Fe oxide being recovered as a companion (60). Fe from ilmenite (and siderite) is used on a local basis, while pyrite and chamosite are virtually no longer important for iron production (59). Similarly, Fe may have previously been recovered from Ni-Cu deposits such as the Inco Sudbury deposit in Canada (38). Fe from magnetite was recovered as a co-product of V from the Mapoch mine and Cu from the Palabora mine, both in South

Science Advances 2015 (www.advances.sciencemag.org/cgi/content/full/1/3/e1400180/DC1)

Other sources: e.g. The Metal-Wheel by Reuter and van Schaik (http://eco3e.eu/wp-content/uploads/2011/01/29-metal_wheel.jpg)

[4] The Herfindahl-Hirschman index (HHI) is a key figure for measuring concentrations. In this case the concentration of iron ore reserves. 0.3 = low concentration of reserves

	Africa. Quantities of Fe produced as a companion are estimated to be a very small percentage of overall global production (38, 61).	
Inter-mediate products productio n	**Pig iron global production 2015 (World total around 1,160 million metric tonnes of metal)**  	USGS 2017
	Historical development of worldwide crude steel production 1950 to 2015:  	Used source: WORLDSTEEL (https://www.worldsteel.org/en/dam/jcr:f9a336d7-8903-4bdf-9ed6-83b27d0ff807/WSiF+2016.pdf) Other sources: EUROFER
	Crude steel producing countries 2015 (World total around 1,610 million metric tonnes of metal)  	USGS 2017

	EU28	Global
Pig iron production		
Crude Steel production (2016)	162 mio. t [1]	1,628.5 mio. t [3]
Stainless Crude production (2015)	7,2 mio.t [2]	n.a.

[1] (http://www.eurofer.org/Facts%26Figures/Crude%20Steel%20Production/All%20Qualities.fhtml)

[2] (http://www.eurofer.org/Facts%26Figures/Crude%20Steel%20Production/Stainless.fhtml)

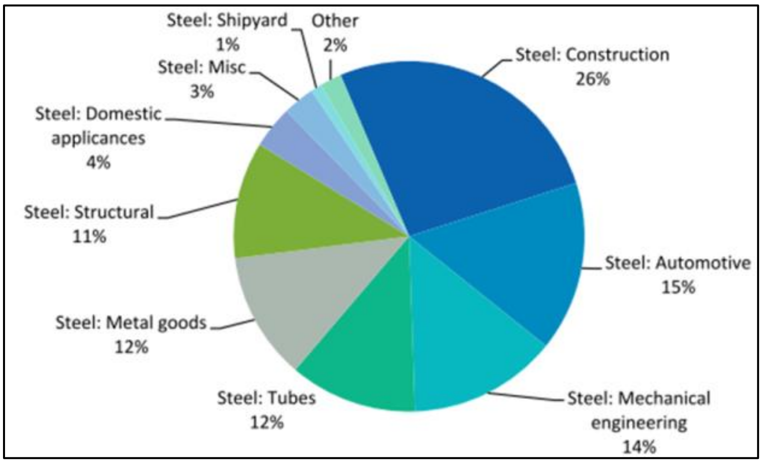
[3] https://www.worldsteel.org/media-centre/about-steel.html

GLOBAL DEMAND

Applications / End-use

The **main application** of iron ore is steel.

End-use of iron ore in Europe in 2010

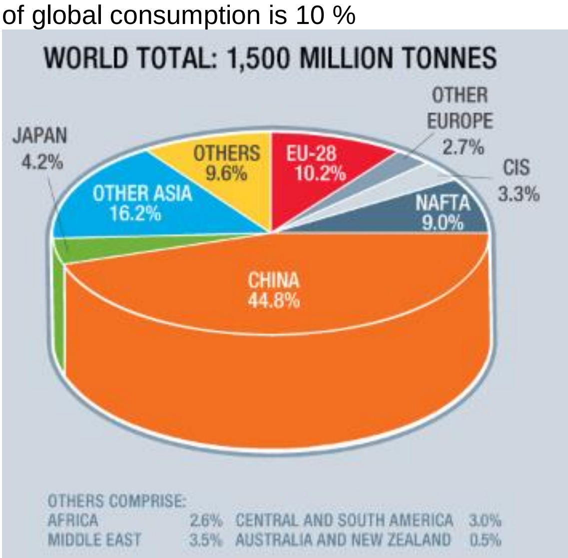


Used source: EC 2014 (Report on Critical Raw Materials for the EU - Non-Critical Raw Materials Profiles) https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_de

Other sources: e.g. The World Steel Association (www.worldsteel.org)

Global versus EU demand / consumption

Worldwide Steel use in 2015 (finished steel products): European share of global consumption is 10 %



Used source: World Steel in Figures 2016: https://www.worldsteel.org/en/dam/jcr:f9a336d7-8903-4bdf-9ed6-83b27d0ff807/WSiF+2016.pdf

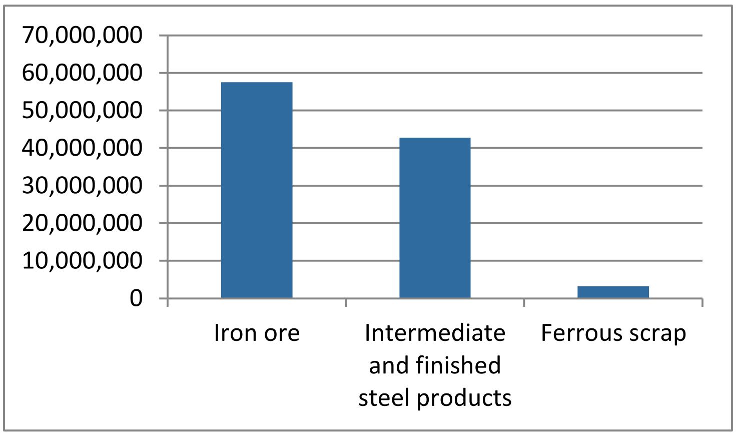
Other sources: EUROFER 2017: The European Steel Association (www.eurofer.org)

Worldsteel 2017: The World Steel Association (www.worldsteel.org)

EU TRADE

Extra-EU imports (primary products, intermediate products)

Specific EU iron gross imports: ores and intermediate products for EU processing industry; (rough estimation; intra-EU imports excluded; data refer to metal content)



Source: STRADE Policy Brief – Oeko-Institut rough estimation [xxx]

Used source: COMTRADE (https://comtrade.un.org/data/) and estimates for iron content
Other sources: Eurostat, Comext

EU28 import of iron ores and concentrates (HS 2601) in 2015 (Official trade data; no metal content estimated)

Import iron ore from major countries	Million tonnes in brackets share of total)	Million USD (in brackets share of total)
Brazil	54.5 (47%)	3.4 billion (48%)
Canada	19.0 (17%)	1.3 billion (17%)
Ukraine	16.3 (14%)	1.0 billion (14%)
Total	115.1 (100 %)	7.2 billion (100 %)

Used data source: COMTRADE

Other data sources: Eurostat, Comext

EU28 imports of selected intermediate products:

- **EU28 import of stainless steel in primary forms, semi-finished product** (HS 7218) in 2015 (Official trade data; no metal content estimated)

Major EU stainless steel imports (steel in primary forms, semi-finished product) from:	tonnes (in brackets share of total)	

Used data source: COMTRADE

Other data sources: Eurostat, Comext

<table>
<tr>
<td></td>
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<table>
<tr><td>Russian Federation</td><td>13 844 (52%)</td><td>24 million (31%)</td></tr>
<tr><td>USA</td><td>4 387 (16%)</td><td>29 million (37%)</td></tr>
<tr><td>India</td><td>2 071 (8%)</td><td>5 million (7%)</td></tr>
<tr><td>Worldwide</td><td>26 795 (100 %)</td><td>79 million (100 %)</td></tr>
</table>

• Further product groups ….

Scrap import is detailed in parameter recycling.
</td>
<td></td>
</tr>
<tr>
<td>EXTRA-EU exports (primary products, intermediate products)</td>
<td>Note: The detailed concept for this section on extra EU exports should be elaborated in other projects / research; this issue is not in the STRADE focus.

Possible data sources are: COMTRADE or Associations e.g. Worldsteel (https://www.worldsteel.org/en/dam/jcr:37ad1117-fefc-4df3-b84f-6295478ae460/Steel+Statistical+Yearbook+2016.pdf)</td>
<td>COMTRADE, Associations</td>
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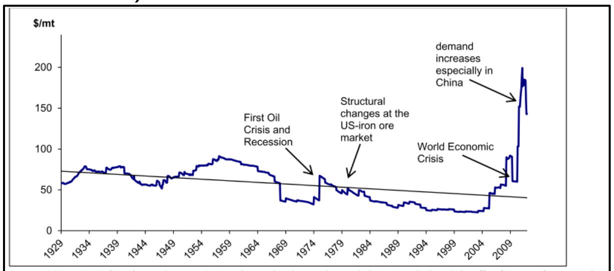
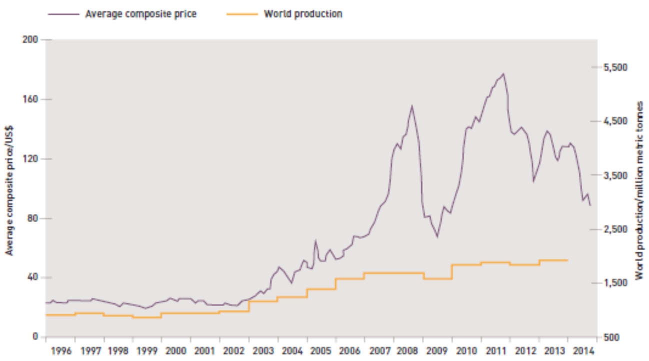
<tr>
<td>Prices</td>
<td>Price history: Development of real iron ore prices (Prices are deflated, 2011 = 100)


Source: DERA, HWWI (2013) Ursachen von Preispeaks, -einbrüchen und –trends bei mineralischen Rohstoffen (Causes of price peaks, collapses and trends of mineral raw materials), Hamburg Institute of International Economics (HWWI) in contract for Deutsche Rohstoffagentur (DERA). April 2013, trend line and translation to English by Fraunhofer ISI

Figure 15: Iron ore prices and production volumes


Source: Raw Materials Data, Stockholm 2014.

Source: Raw Materials Group “The role of mining in national economies”, October 2014</td>
<td>Used data source: EC 2014 (Report on Critical Raw Materials for the EU - Non-Critical Raw Materials Profiles) https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_de
Other data sources: asianmetal.com; metalpages.com

Used source:</td>
</tr>
</table>

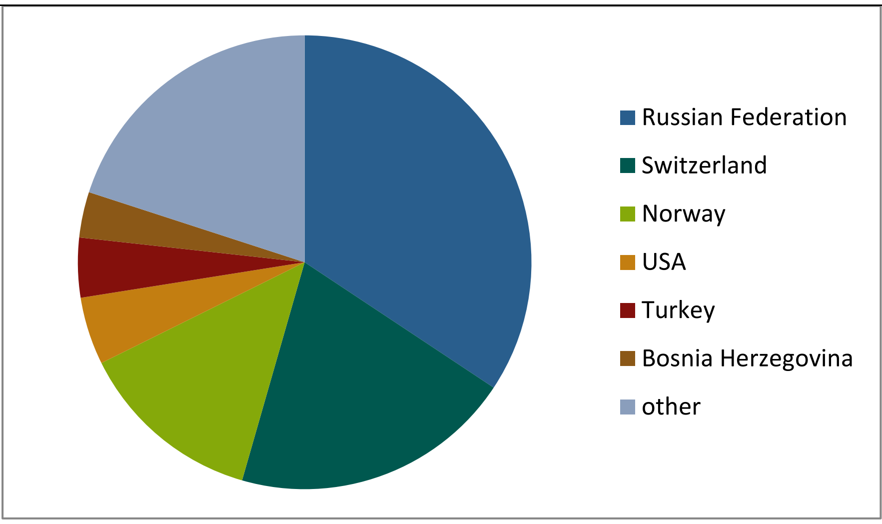
	Average ore price, Jan-Dec 2016 / Price Iron ore USD/t (100% Fe)[5]: 93	Marketindex (http://www.marketindex.com.au/iron-ore)
RECYCLING / SUBSTITUTION / MATERIAL EFFICIENCY		
Recycling	**Note:** The detailed concept for the section on recycling should be elaborated in other projects / research since the STRADE project focuses on primary production. Nevertheless some key data are proposed: - Iron: The end-of-life recycling rate (**EoL-RR**)[6] of iron is between 52 % (USGS 2004) and 90 % (Steel Recycling Institute 2007) in UNEP 2011 and Bowyer et al 2015 (http://www.dovetailinc.org/report_pdfs/2015/dovetailsteelrecycling0315.pdf) - Iron: The recycled content (**RC**)[7] content of iron is > 25 – 50% (UNEP 2011) **EoL-RR and RC for selected product groups:** (see table below) **Ferrous scraps import to the EU-28 in 2014**, main countries [in weight % iron]	UNEP 2011 http://wedocs.unep.org/bitstream/handle/20.500.11822/8702/-Recycling%20rates%20of%20metals%3a%20A%20status%20report-2011Recycling_Rates.pdf?sequence=3&isAllowed=y Other data sources: Associations, research BIO by Deloitte. Study on Data for a Raw Material System Analysis: Roadmap and Test of the Fully Operational MSA for Raw Materials Final Report [Internet] [cited 2017 Feb 15]. Available from: http://c.ymcdn.com/sites/www.intlmag.org/resource/resmgr/docs/membership_central/newsletter/2016/February/MSA_Final_Report_02.pdf. [5] http://www.worldstainless.org/Files/issf/Animations/Recycling/Flash.html COMTRADE

Product Group	EU28		Global	
	EoL	RC	EoL	RC
Stainless steel	n.a.	n.a.	80-90% [5]	60% [5]
…				
…				

[5] marketindex 2017; Iron Ore Fines 62% FE spot (CFR Tianjin port), US dollars per metric ton

[6] Definition EoL RR; The EOL-RR is a measure of the extent to which ferrous metal contained in end – of - life steel products is actually recycled Bowyer et al 2015 (http://www.dovetailinc.org/report_pdfs/2015/dovetailsteelrecycling0315.pdf

[7] Recycled Content (RC): The RC indicates the extent to which end – of - life scrap is actually used in making new steel products. Note that this is the same formula, though expressed in slightly different terms, as that for post-consumer recycled content Bowyer et al 2015 (http://www.dovetailinc.org/report_pdfs/2015/dovetailsteelrecycling0315.pdf



Substitutability

Substitutability scores for applications (1 = low substitutability)

Application	Substitutability score
Steel: Construction	1
Steel: Metal goods	1
Other	0.5
Steel: Automotive	0.7
Steel: Shipyard	1
Steel: Domestic appliances	0.7
Steel: Mechanical engineering	0.7
Steel: Structural	1
Steel: Tubes	0.7

Substitutability and effects of increased material efficiency are difficult to express in one indicator. With the above indicator estimation on substitutability is given. Specific research and expert estimation is necessary for substitutability in each application and in material efficiency potential.

Material efficiency: Data sources / analysis needed

EC 2014 (Report on Critical Raw Materials for the EU - Non-Critical Raw Materials Profiles) https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_de Further literature e.g. report for JRC Petten xxx

MINING & DEVELOPMENT

Economic contribution

Note: Detailed information on economic contribution of mining in the primary producing countries is elaborated in the countries profiles (Part II). See also Part II for further country-specific information and indicators (e.g. EITI-membership, control of corruption, political stability and absence of violence, job creation, revenues, etc.).

ASM

Information on artisanal mining of iron ore:

Used sources:

<table>
<tr><td></td><td><table><tr><td>Share of artisanal mining</td><td>> 4 % [6]</td></tr><tr><td>Countries where artisanal mining is practiced</td><td>China, DRC [7]</td></tr></table></td><td>[6] Dorner et al. 2012 (http://www.polinares.eu/docs/d2-1/polinares_wp2_chapter7.pdf)

[7] Gunson & Jian 2001 (http://pubs.iied.org/pdfs/G00719.pdf)

Further sources: BGR (https://www.bgr.bund.de/DE/Themen/Min_rohstoffe/Downloads/Studie_Zertifizierte_Handelsketten.pdf?__blob=publicationFile&v=2; https://www.bgr.bund.de/EN/Themen/Min_rohstoffe/CTC/Concept_MC/ASM-great-lakes/ASM_node_en.html)</td></tr>
<tr><td colspan="3">HUMAN RIGHTS</td></tr>
<tr><td>Conflicts related to iron</td><td>Detailed information on conflicts related to mining see Part II country profiles.</td><td></td></tr>
<tr><td>Child labour and forced labour</td><td>See Part II country profiles for detailed information in child labour and forced labour in producing countries.

Case studies are provided in BGR study „Human Rights Risks in Mining“ (https://www.bgr.bund.de/DE/Themen/Zusammenarbeit/TechnZusammenarbeit/Downloads/human_rights_risks_in_mining.pdf?__blob=publicationFile&v=2)</td><td></td></tr>
<tr><td colspan="3">ENVIRONMENTAL ISSUES</td></tr>
<tr><td>LCA data</td><td>Data LCA analysis
<table><tr><th></th><th>Iron ore
[iron ore 46%]</th><th>Iron</th><th>Steel
[Steel]</th></tr><tr><td>Cumulative Energy Demand (CED)[8]</td><td>63 (MJ/t)</td><td>21,1 (MJ/t)</td><td>25,6 (MJ/t)</td></tr></table></td><td>Used source: UBA 2012; (https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/4237.pdf)</td></tr>
</table>

[8] The consumption of energy resources is represented by the cumulative energy demand (CED). CED is a measure of the total amount of energy resources used to make a product or provide a service. It also includes the energy contained in the product itself. The CED identifies all non-renewable and renewable energy resources as primary energy values, with the higher heating value (HHV) of the various fuels used in the calculations. No characterization factors are used. This means that the consumption of energy resources is not an impact category based on different impact factors, but a life cycle inventory parameter.

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<tr><td>Cumulative Raw Material demand (CRD)[9]</td><td>1,0 (kg/t)</td><td>4,1 (kg/t)</td><td>10,0 (kg/t)</td></tr>
</table>
</td>
<td>Further sources : Ecoinvent www.ecoinvent.ch

PROBAS http://www.probas.umweltbundesamt.de/php/index.php

JRC (http://eplca.jrc.ec.europa.eu/)</td>
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<tr>
<td>Association with radioactive substances</td>
<td>
Environmental hazard potential:
<table>
<tr><th>Category</th><th>Environmental hazard potential according to ÖkoRess methodology</th></tr>
<tr><td>Association with radioactive substances</td><td>medium</td></tr>
</table>
Data from Chinese iron ore deposits show average activity concentrations of 0.068 Bq/g for Thorium and 0.27 Bq/kg for Uranium (Hua 2011). According to the ÖkoRess methodology, this leads to a medium environmental hazard potential related to association with radioactive substances. (China produces 16 % of global primary mine production)
The risks varies highly between different mining sites and can be mitigated by various technological and management measures. The successful implementation highly depends on the local governance and mining companies’ responsible mining practice.
</td>
<td>Hua, L. (2011): The Situation of NORM in Non-Uranium Mining in China. China National Nuclear safety Administration. (http://www.icrp.org/docs/Liu%20Hua%20NORM%20in%20Non-Uranium%20Mining%20in%20China.pdf).

ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-oekoress</td>
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<tr>
<td>Association with heavy metals</td>
<td>
Environmental hazard potential:
<table>
<tr><th>Category</th><th>Environmental hazard potential according to ÖkoRess methodology</th></tr>
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<td>ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/</td>
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[9] The cumulative raw material demand (CRD) is defined as the sum of all used raw material – except of water and air – in weight unit.

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<tr><td>Association with heavy metals</td><td>Medium</td></tr>
</table>
While iron is not a heavy metal itself, ores are commonly associated with elevated concentrations of heavy metals.

The risks varies highly between different mining sites and can be mitigated by various technological and management measures. The successful implementation highly depends on the local governance and mining companies’ responsible mining practice.
</td>
<td>umweltfragen-oekoress</td>
</tr>
<tr>
<td>Acid mine drainage</td>
<td>
Environmental hazard potential:
<table>
<tr><th>Category</th><th>Environmental hazard potential according to ÖkoRess methodology</th></tr>
<tr><td>Acid Mine Drainage</td><td>Medium</td></tr>
</table>
Iron ore is commonly mined from silica-rock deposits. While such formations usually contain sulfidic minerals, iron ore is mainly mined in oxidised form (iron oxides) and therefore from strata where sulfidic minerals have mostly been oxidised and depleted. According to the ÖkoRess methodology, this leads to a medium environmental hazard potential.

The risk varies highly between different mining sites can be mitigated by various technological and management measures. The successful implementation highly depends on the local governance and mining companies’ responsible mining practice.
</td>
<td>ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-oekoress</td>
</tr>
<tr>
<td>Chemical use</td>
<td>
Environmental hazard potential:
<table>
<tr><th>Category</th><th>Environmental hazard potential according to ÖkoRess methodology</th></tr>
<tr><td>Use of additives in extraction and benefication</td><td>Medium</td></tr>
</table>
Iron ores are commonly treated by flotation with the use of chemical additives.
</td>
<td>ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-oekoress</td>
</tr>
<tr>
<td>Open pit mining or underground mining</td>
<td>
<table>
<tr><th>Category</th><th>Environmental hazard potential according to ÖkoRess methodology</th></tr>
<tr><td>Mining type</td><td>medium</td></tr>
</table>
Iron ore is commonly mined from open pits from solid rock formations.
</td>
<td>ÖkoRess Project Report (forthcoming): https://www.umweltbundesamt.de/umweltfragen-</td>
</tr>
</table>

	Explanatory note: While underground mining has comparably little impacts in terms of land use and conversion of local ecosystems, open pit mining is much more relevant in this regard. Mining activities on loose material such as alluvial deposits (e.g. dredging in rivers) often has very high impacts on local environments.	oekoress
Dam bursts / flooding	Number of incidents since 2000 | | **EU-28** | **Global, without EU-28** | | Dam bursts / flooding | … | … |	Xxx Research necessary
Mining waste	| Average ore grade | 10-50% | | Submarine / riverine tailings disposal [if yes, include countries] | No |	Priester, Dolega (2015) (https://www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/oekoress_-_teilbericht_bergbauliche_reststoffe.pdf)
Sites-specific environmental risks	Site-specific environmental risk are detailed in the country profiles (water stress, protected areas, earth quake, mining accidents, Heavy rain/flooding)	
INITIATIVES		
Initiatives	**Initiatives:** | **Type of initiative** | **Iron ore / Steel** | | Specific iron and steel initiatives related to sustainable primary and secondary production | Responsible Steel Stewardship[10] (Australia; global initiative under development) | | Initiatives across the whole range of raw materials, including iron and steel: | ICMM[11] (LSM) IRMA[12] (draft) IFC[13] |	

[10] RSS = Responsible Steel Stewardship (http://steelstewardship.com/steel-stewardship-forum-update/) in Australia; as global initiative under development (http://www.responsiblesteel.org/)

[11] ICMM = International Council on Mining and Metals (https://www.icmm.com/)

[12] IRMA = Initiative for Responsible Mining Assurance (http://www.responsiblemining.net/)

	TSM[14] (Canada; Finland) GARD[15]

Please see sources for detailed information on the initiatives.

Global market share of raw materials from different schemes:

Initiative	**Focus**	**Contribubtion of initiative to global production**
Responsible Steel Stewardship	LSM (large scale mining)	n.a.%
Towards Sustainable Mining	LSM	n.a.%
ICMM	LSM	3 of the 12 largest iron ore producers are ICMM members (see above)

13 IFC = International Finance Corporation (http://www.ifc.org/wps/wcm/connect/corp_ext_content/ifc_external_corporate_site/about+ifc_new)

14 TSM = Towards Sustainable Mining (http://mining.ca/towards-sustainable-mining); Finnish adoption see www.kaivosvastuu

15 GARD = Global Acid Rock Drainage Guide (http://www.gardguide.com/images/5/5f/TheGlobalAcidRockDrainageGuide.pdf)