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

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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

Part I

1. Introduction

This paper contributes towards the development of a holistic raw material information system that combines global and EU mining and trade data with information on environmental and socio-economic aspects. The proposed concept used as a foundation companies' and policy makers' need for better knowledge on the relationship between issues addressing raw materials and responsible mining that will support their measures to mitigate negative impacts and to support socio-economic development in non-EU mining areas. Available data in this sector is fragmented and scattered, although some European and international institutions globally generate data and provide information. The current major challenge is consolidating the available data and filling in only selected missing information in this data set. With this objective, the authors suggest generating a raw material information system that broadly structures the data into:

- Raw-material-specific information and
- Country-specific information.

The proposed raw material information system has a global scope reflecting Europe's import dependency for many commodities and the global interrelationship of resource production and consumption. In the first stage, the proposed concept has a strong focus on non-EU raw material flows and non-EU mining countries in view of the fact that currently many parallel research projects, e.g. within the Horizon 2020 programme, already work on EU data collection and EU data harmonization. Their results are expected to importantly contribute to the suggested information system. In order not to duplicate other's work, the STRADE project, with its work packages on cooperation with resource-rich non-EU countries, focuses this draft concept on the global material flows, EU import flows and the related challenges in non-EU mining countries.

The analysis for developing this concept starts here in Part I with chapter 2, which 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.

A proposal for compiling the identified raw material and country-specific information is presented in more detail in Part II (raw material profiles) and Part III (country profiles). This data architecture allows coupling general and global raw-material specific information with mining-country-specific data and indices.

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 successes and reengineer 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 related to EU raw material consumption and material flows along the supply chain based on environmental-economic accounting	Indicators DMC and DMI (domestic material consumption and input) Indicators RMC and RME (raw material consumption and equivalents [11]
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]

Institution	Type of activity	Name
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]
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

The 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 WTO or from statistical data agencies such as Eurostat and the UN Statistic Commission (with a temporal offset of several months). Data on commodity prices are available from UNCTADstat [28], IMF [30] (base metals only) or from service providers (e.g. Metal pages [29] or Asian Metal [31]). Stock exchanges that trade raw materials publish information on current price developments [32].

While data on raw material use per sector are partly included in USGS publications, the data is mostly limited to the US economy. Comprehensive data on iron ore are available from UNCTAD [28]. Further 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 Copper Study Group (ICSG), the International Lead and Zinc Study Group (ILZSG), the International Aluminium Institute, the World Steel Association, the International Molybdenum Association 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 [33].

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 [2,34–36]. 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 have 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 [2,3,35,37–41]. 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 life-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; various industry associations also provide LCA data. 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 [42], data gaps have been found to be significant [43]; 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 benefication. 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 [44]. 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 benefication 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 [45] and UNDP [46]. 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) [47].

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 [48], 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 [49]. Further data sources for governance on a national level include the Corruption Perception Index by Transparency International [50], 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 [51,52]. To assess potential future disaster risks, geospatial information on risks for strong storms, floods and earthquakes can be used. Geospatial information is available from national geological surveys or data sources with global scope [53,54]. 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. The overall geological comparable approaches can also be taken for water stress, protected areas, land-cover and land-use.

In 2018, the Responsible Mining Index is expected to publish environment indicators on the performance of approximately 150 mining operations from 30 of the world's largest mining companies, with regular biennial updates. The indicators deal with the topics environmental stewardship, tailings management, air, water, noise and vibration, biodiversity, GHG emissions, energy efficiency, hazardous materials management, emergency preparedness and lifecycle management.

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

With the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas [55], as well as the UN Guiding Principles on Business and Human Rights [56], 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 [55]. 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 [57] and forced labour [58], as well as evaluations of ongoing conflicts [59,60]. In addition, information on human rights situations on a country level can be taken from the country profiles compiled by Amnesty International [61], Human Rights Watch [62] and the U.S. Secretary of State [63].

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 [64–66]. A recent project by the World Bank and the non-profit international development organization PACT aims at further improving data on artisanal mining [67].

Country data on labour standards are compiled in the ILO Information System on International Labour Standards NORMLEX [68], while the International Trade Union Confederation provides a country-based overview on violations of trade union rights [69]. Detailed information and country indicators on various social and human development aspects are annually published in the UNDP Human Development Report [46]. Further development-related indicators are provided by the World Bank [45].

While reports on individual human rights abuses and social tensions on a community-level can also be integrated into such an information system, awareness is needed that such types of information require highly careful and neutral editing for presenting the differing views and standpoints. Political views or biases might otherwise influence the reporting, showing a one-sided image and questioning the credibility of the information system.

The current draft Responsible Mining Index methodology foresees detailed data collection on company and mine-site levels as data foundation for a set of 35 indicators related to human rights and social issues (first publically available ranking is scheduled in 2018). In workshops in June 2017, STRADE will discuss to which extent these extensive indicators might be integrated in country profiles as part of a raw material information system. In any case, the proposed information system might benefit substantially from RMI's futures experiences in their challenging data collection process.

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 proposed raw material information system is supposed to be implemented in several stages. It is suggested to begin implementation with those minerals having good data availability (e.g. copper, zinc, nickel, lead, iron ore, gold). In the next step, minerals and metals with less data availability, such as bauxite, molybdenum, and rare-earths, can be addressed. Those minerals where the demand for information is high, e.g. conflict minerals, should be particularly emphasized. The data depth should also increase stepwise, with data gaps being closed gradually.

- The information system should offer a wide range of reliable data, information 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. Although the approach slightly defers from this proposed information system for mineral and metals, the FAO database FAOSTAT on agricultural, forestry and fishery resources can be used as a good example of how such data integration can occur [70].

- 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.

- Such a system should have a global perspective and might be implemented and maintained by a global player, for example by UNEP's International Resource Panel or a future global resource forum. Faster implementation is to be expected from an EU-led system, such as the RMIS that is currently being developed by JRC. Such an EU-led system should further be able to combine global information with EU demand and trade data and allow a steady exchange and cooperation with other international and national institutions.

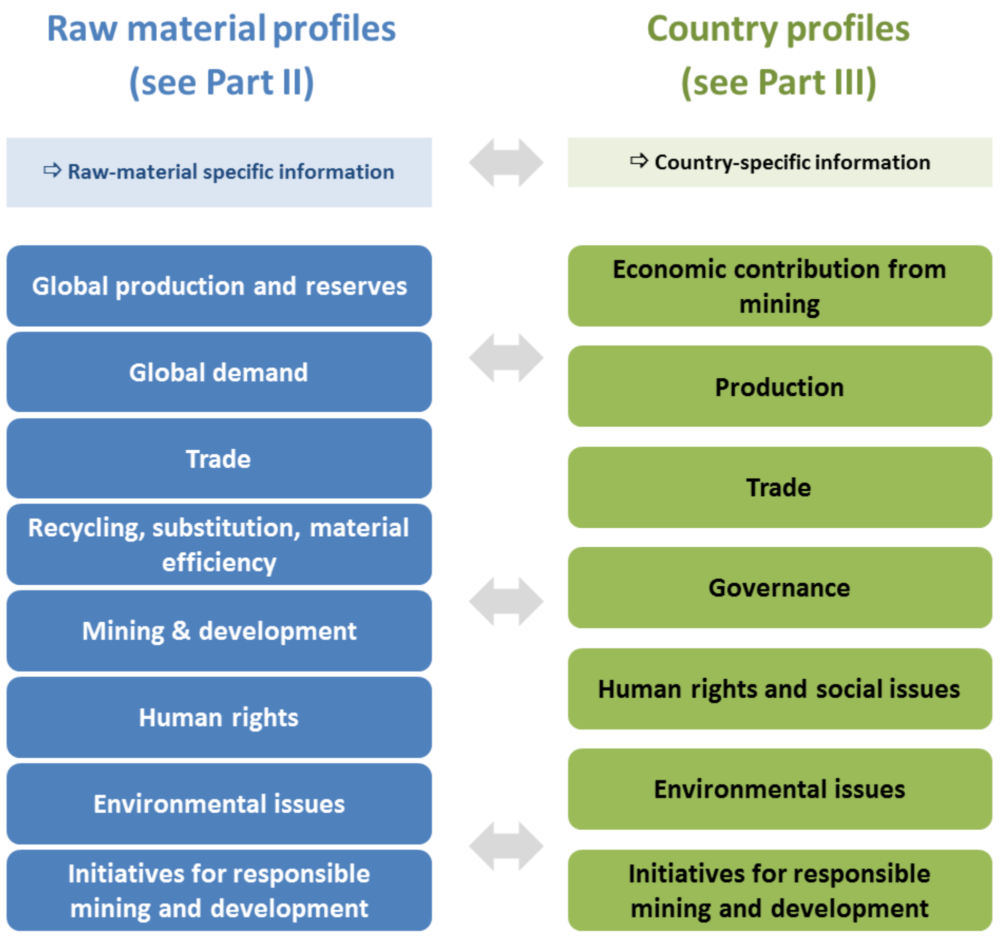
- The use of the system should be free of charge and target use by policy-makers, analysts and decision-makers from industry (upstream and downstream companies), civil society organizations and academia.

- 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 or 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.
- The amount of work to be done to implement and maintain the information system will surely be high and would require contribution from many experts. However, the poorer alternative to one central information tool is the widely scattered and duplicated research from a large number of stakeholders. Currently, an increasing number of upstream and downstream companies and private and public institutions make great efforts to collect the proposed data individually. Societies' and companies' rising interest in supply chain due diligence for a wide range of raw materials will reinforce the related information demand in the coming years. The overall working load would be significantly reduced if one information tool could provide basic information to a wide range of users. Consequently, the information system also supports EU companies' competitiveness by assisting them to gain basic knowledge of all three sustainability dimensions related to global raw material flows.

Figure 1 illustrates the proposed structure for complementary raw-material-specific and country-specific information in a joint information system and lists the major topics to be covered. It underlines the strong overlaps between raw-material-specific and country-specific topics.

Figure 1 Concept and structure of raw material profiles and country profiles



Part II presents a more detailed structure for the raw-material-specific information (raw material profiles). It uses iron ore as an example and provides draft concepts on how the existing data can be compiled and grouped.

Part III provides a draft concept on how the existing country-specific data can be compiled and grouped (country profiles), with Brazil as the example.

The data collection for these examples in Part II and III 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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