Optimizing quality of information in RAw MAterial data collection across Europe

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Report on the datasets available relating to social and environmental dimensions of extraction

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Publishable abstract

The extraction of minerals is an essential part of the global economy and fundamental to the development of living standards for all societies. The extractives sector provides the raw materials that are needed to build homes, schools, hospitals and all other buildings or structures. The sector also provides the essential materials that ensure modern technology works or to enable the transition to green forms of energy. Nevertheless, mineral extraction also has the potential to cause negative impacts as well as positive ones and, particularly in the past, these negative impacts have been substantial. It is often the legacy of past mining and quarrying that creates a negative perception of the sector in the minds of ordinary citizens.

Most European countries have systems in place for recording and monitoring the quantities of raw materials produced and in recent years, efforts have been made to improve the consistency and comparability of these datasets. Work continues to expand these efforts to include resources and reserves of minerals, in addition to the production of and trade in minerals.

The importance of the extractives sector for economic development has been recognised by the EU and EU funded projects such as ProMine, Minventory, Minerals4EU and MICA. These projects have added much to knowledge on raw materials data and its reporting and harmonisation across Europe.

However, there has been much less consideration of the availability of datasets relating to the environmental and social aspects of mineral extraction, i.e. is it possible to measure the environmental and social impacts of mining and quarrying (both negative and positive)? If the datasets were available, would the publication of easily understandable metrics have an effect on public perceptions?

This report aims to give a first pass overview of some of the datasets that are available, or that could be developed, for a series of thematic topics related to the environmental and social impacts of mineral extraction. For each theme, the interactions between the mineral extractive sector and the environment or human population are presented and discussed. The level of harmonised data that are available on a pan-European scale is examined along with recommendations of how data and harmonisation of data can be improved.

In many respects, this report is a ‘scoping study’ that considers what is currently possible. For many themes identified in this report, additional research or development of metrics is required in order to portray the full picture of the impacts of mining and quarrying. It is hoped that examples given in this report of available datasets that clearly show both the positive and negative impacts of mineral extraction activities can be taken, further developed and used in future editions of the ‘European Minerals Yearbook’ to improve environmental reporting for primary raw materials across Europe.

For many of the thematic subject areas discussed in this report either no data are available, or much of the available data cannot be related to specific impacts of mineral extraction. If extraction sector specific datasets, relating to these topics, are required at a European level, further disaggregation by industrial sector may be required when collecting data. This would be a significant undertaking and a strong need for particular datasets would need to be proven to make such disaggregation worthwhile, it is hoped that this report highlights what may be possible.

One finding of particular relevance from this review of European datasets is that although the many European funded projects in recent years have enhanced our knowledge on many issues regarding raw materials, they are often lacking harmonisation and interoperability. Their quality

is also highly variable, as they seem to take only information readily available from project partners and stakeholders rather than provide an integrated picture of raw materials issues in Europe. This highlights the need for an exercise of harmonisation to enable a single data model and procedure ensuring data interoperability is established.

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1 Introduction

Overall, the ORAMA project aims to evaluate raw materials data collection throughout Europe, focused on how data can be harmonised between different European countries to facilitate the provision of better raw materials information on a pan-European scale. Such data are important because they are required to inform long-term raw materials policies and strategies.

This report provides the results of Task 1.4, of the ORAMA project, "Data relating to environmental and social dimensions of extraction", which considers the available datasets relating to environmental and social impacts of mineral extraction and how relevant characteristics are measured and recorded, i.e. what data are generated. These are illustrated by using examples from within selected countries or if available, for pan-European data. Where possible, this report also includes a comparison between selected countries to identify where standardisation or harmonisation might be possible, identifies examples of good practice and provides a set of recommendations to take this work forward.

To date, most of the work relating to statistical data for primary raw materials within Europe has been connected to production, trade and resources. Very little work has been undertaken on the availability of environmental and social data to measure the impact of mineral extraction. Consequently, knowledge was limited with regard to: a) what datasets are available, b) what are the common data standards and levels of interoperability within Europe for these data types and c) how can these data be displayed. This knowledge gap is something this report aims to begin to address.

Information such as this is key to assess how the extractive industry is performing against key indicators, such as the UN's Sustainable Development Goals[2]. Although none of the sustainable development goals specifically relate to the extractive sector, the effects of mining and quarrying can feed into almost all 17 of the goals in some form, in many cases both positively and negatively. Some of the goals with strong links to the extractive sector[3] include good health and well-being, clean water, clean energy, decent work and economic growth, infrastructure, sustainable cities, responsible production and consumption, life in water and life on land (goals 3, 6, 7, 8, 9, 10, 11, 14 and 15).

[2] https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[3] Mancini, L; Vidal Legaz, B; Vizzarri M.Wittmer, D.; Grassi G.and Pennington, D. 2018. Mapping the role of Raw Materials in Sustainable Development Goals. JRC. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC112892/jrc112892_sustainable_development_goals_final_08_01_19_pubsy.pdf

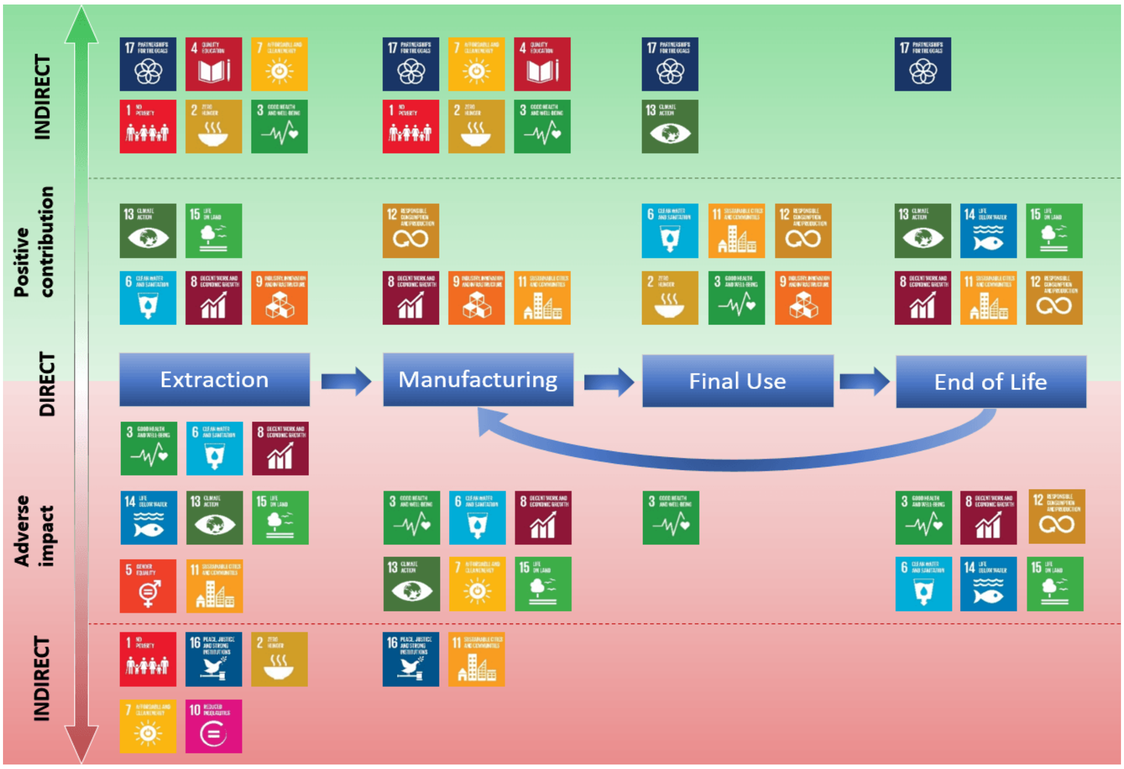

Figure 1: The link of Sustainable Development Goals to the extractive sector. Source: Mancini et al., 2018. https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/mapping-role-raw-materials-sustainable-development-goals

Although the extractive sector can be strongly linked to the Sustainable Development Goals without adequate data, it is difficult to assess the scale of either the positive or the negative impacts of mineral extraction without data.

It is important to understand these impacts, which can be used to aid the sector in terms of the positive aspects or to understand and mitigate the negative impacts. Such metrics are key to forming a coherent industrial strategy.

This report is split into two main sections, the environmental aspects of mineral extraction and the social aspects of mineral extraction. Within these sections, different thematic topics have been identified that may be relevant to the extractive sector, these are:

Environmental aspects

- Greenhouse gas emissions
- Waste (solid)
- Nuisance, including noise, visual appearance and traffic
- Water use
- Biodiversity
- Human health
- Soils
- Recycling and re-use of materials
- Energy use
- Land use

Social aspects

- Employment
- Health and safety
- Social acceptance
- Cultural heritage and archaeology
- Human/indigenous rights

It is hoped that the results of this report can lead to new data regarding the environmental and social aspects of mineral extraction being added to future editions of the European Minerals Yearbook[4]. This requires data to follow consistent standards and definitions across national and regional boundaries which will allow them to be simply mapped into the existing INSPIRE data model for the creation of pan-European datasets. Recommendations for extra data that can be included in new editions for the European Minerals Yearbook can be found in Section 4. Work package 3 of the ORAMA project, Task 3.4, aims to take a selection of the datasets identified in this report to test whether it is possible to produce high quality statistical data aggregated at national level for expert use and policy evaluation.

This report discusses the potential for data harmonisation to achieve reliable pan-European datasets, harmonisation in this context refers to ensuring data is interoperable and that consistent standards and definitions are used. It is not suggested that data is collected, managed and stored the same way across national boundaries, how this is done is the decision of individual Member States.

Many different datasets have been analysed and discussed in this report however a common theme running through all the chapters is the use of Eurostat data, perhaps unsurprisingly due to the fact it is already harmonised at a European level and has pan-European coverage. Eurostat is the official statistics office of the European Commission and has the responsibility for the provision of statistical information and the harmonisation of statistical methods. Eurostat publishes a wide range of statistical data, much of which member states are required to provide to the Commission by law. All Eurostat data is available from within various on-line tables and databases from their website (https://ec.europa.eu/eurostat).

All the statistical data identified within Eurostat used in this report is reported according to the NACE classification scheme (Nomenclature Statistique des Activités Économiques dans la Communauté Européenne). NACE is the industry standard classification system used in the European Union. The current version is revision 2 and this was established by Regulation (EC) No 1893/2006. It is a classification system designed for collecting and presenting a large range of statistical data according to economic activity. Further information can be found regarding the use of the NACE classification system from Eurostat[5].

[4] http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html
[5] http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)

2 Data regarding environmental aspects of extraction

2.1 *Greenhouse gas emissions*

2.1.1 Background and definitions

The minerals sector can be a significant emitter of greenhouse gas (GHG), especially CO_2. It emits also air pollutants responsible for ground-level ozone formation such as Non-Methane Volatile Organic Compounds (NMVOCs), acidifying substances such as and sulphur dioxide (SO_2), particulate matter (e.g. PM_{10}, $PM_{2.5}$), and other substances, which are not considered here.

In order to provide an example on data availability, this chapter focuses on major GHG emissions. Conclusions on harmonisation would be similar for data on other air pollutants. Yet, it needs to be noted that in order to measure the total amount of pollutant emissions one has to account not only for the primary release of pollutants from mining facilities but also for the formation of pollutants in the atmosphere due to the interaction of particles (secondary formation of pollutants). Moreover, while the ultimate impact of GHG emissions (global warming potential) can be estimated in a relatively straightforward manner, it is much more complex to estimate the ultimate impact (in human health and ecosystems) of air pollutants.

GHG emissions from mineral extraction originate from fuel combustion, where mineral extraction can be a very energy intensive activity. GHG also originate from other activities such as mineral processing, which can take place also onsite, or from waste management. Beyond direct GHG emissions at mining facilities, mining activities have also associated indirect GHG emissions, such as those from the production of electricity, fuels, chemicals, equipment, etc., that are used at the mining facilities and whose associated GHG are not emitted onsite.

In order to assess the climate performance of the extractive sector, it is necessary to follow up on GHG emission trends in absolute terms, which relates to the ultimate impact of the sector on the climate. Also, data on emission intensity are needed, i.e. emissions related to the production volumes, which gives insight about changes in the efficiency of extractive activities. The latter data is very relevant to understand the climate performance of different typologies of extractive activities and varied management and extraction practices.

Direct GHG emissions from mining have decreased in the EU in the last decades (European Commission, 2018), due to the shift of mining to other countries outside Europe and to efficiency improvements. The latter has been particularly related to changes in the fuel mix (e.g. moving from the use of coal to gas or renewable sources).

GHG emissions accounts usually consider major GHGs such as CO_2, NH_4 and N_2O. They can also account for other gases such as hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), Non-Methane Organic Volatile Compounds (NMVOC), NOx, CO and SO_2. Indeed, the United Nations Framework Convention on Climate Change (UNFCCC) considers the gases shown in Table 1, which slightly differs for energy-related and process-based GHG emissions.

<table>
<tr><td colspan="12">For energy (combustion-related emissions)</td></tr>
<tr><td colspan="2">CO_2</td><td colspan="2">CH_4</td><td colspan="2">N_2O</td><td colspan="2">NO_X</td><td colspan="1">CO</td><td colspan="2">NMVOC</td><td colspan="1">SO_2</td></tr>
<tr><td colspan="12">For industrial processes and product use (process-emissions)</td></tr>
<tr><td>CO_2</td><td>CH_4</td><td>N_2O</td><td>HFCs</td><td>PFCs</td><td>Unspecified mix of HFCs and PFCs</td><td>SF_6</td><td>NF_3</td><td>NO_x</td><td>CO</td><td>NMVOC</td><td>SO_2</td></tr>
</table>

Table 1: Gases covered under UNFCCC

GHG emissions are expressed in global warming potential (GWP) units, using as reference the GWP of CO_2 (the so-called CO_2 equivalents).

2.1.2 Policy background and relevance of GHG from extractive activities in Europe

The Paris Agreement sets out a global action plan to limit global warming to well below 2°C, aiming to limit the increase to 1.5°C, and towards climate neutrality before the end of the century. Goal 13 of Sustainable Development Goals calls countries to take urgent action to combat climate change and its impacts.

In this context, the EU is already taking action: the 2030 climate and energy policy framework (European Commission, 2019(a)) contains a binding target to cut emissions in EU territory by at least 40% below 1990 levels by 2030, and the 2050 low-carbon economy roadmap (European Commission, 2019(b)) announces 80% cuts by 2050 also compared to 1990 levels. As a result of the decarbonisation of the EU economy, considering the 2030 and 2050 targets, all sectors need to cut emissions.

The EU Emissions Trading System (EU ETS) (European Commission, 2019(c)), a cornerstone of the EU policy to combat climate change, was created with the idea of fostering emission reduction where it results more cost-effective. The EU ETS, now in its phase 3 (2013-2020), allows free GHG emission allocation (European Commission, 2019(d)) to the best performing installations, while installations not meeting the best performers' benchmarks (European Commission, 2019(e)) have to cut emissions and/or buy carbon credits (also called emission permits). In addition to emission allowances, the climate policy also gives facilities the possibility of buying a limited amount of international credits (European Commission, 2019(f)) from emission-saving projects around the world.

The EU ETS scheme considers that some industries that are competing in the global market could be more exposed to the so-called carbon leakage (European Commission, 2019(g)), i.e. shifting industries to other countries outside the EU with laxer GHG emission constraints. With the aim of avoiding this leakage, industries included in the official list of sectors possibly exposed to carbon leakage (European Commission, 2014) might be entitled to higher shares of free emission allowances. The mining typologies in Table 2 are considered within this list.

NACE code	Name
0710	Mining of iron ores
0729	Mining of other non-ferrous metal ores
0891	Mining of chemical and fertiliser minerals
0893	Extraction of salt
0899	Other mining and quarrying not elsewhere classified

Table 2: Mining typologies used in the ETS scheme

2.1.3 Available data on GHG emissions in the extractive sector in Europe

Relevant GHG emissions data consist of official GHG emission inventories and research databases.

Official GHG emissions inventories

Eurostat provides GHG emissions data by source sector[6], compiled by the European Environment Agency, following the reporting to the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 2006).

GHG emission estimates are based on emission factors[7] and activity data[8]. Emission factors estimate the amount of emissions to air relative to the activity of the sector. The activity of the sector refers to fuel combustion for energy-related emissions and to material produced for process-emissions. Data accuracy for emission factors and activity data can significantly vary across economic sectors and among countries since they can be based on the assumption at different *tiers* (country, region, facility, etc.).

The UNFCCC scheme differentiates between energy-related and process-based emissions. According to this classification, energy-related GHG emissions can be disaggregated by fuel type. On the other hand, process-based emissions estimate process-related emissions resulting from the use of carbonate raw materials in the production and use of a variety of mineral industry products.

Energy-related GHG emissions of extractive activities and mineral production are covered under UNFCCC's sector *1.A.2.g iii) Mining (excluding fuels) and Quarrying*. Process-emissions from the mineral industry fall under sector *2A Mineral industry*. See sectors highlighted in bold in Table 3.

[6] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en
[7] Average emission rate of a given GHG for a given source, relative to units of activity.
[8] Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time (e.g. fuel consumption, production volume).

1 Energy
1.A Fuel combustion
1.A.2 Manufacturing industries and construction
1.A.2 g *Other*
iii. Mining (excluding fuels) and quarrying
Liquid fuels
Solid fuels
Gaseous fuels
Other fossil fuels(4)
Peat(5)
Biomass(6)
2 Industrial processes and product use
2.A. Mineral industry
1. Cement production
2. Lime production
3. Glass production
4. Other process uses of carbonates
a. Ceramics
b. Other uses of soda ash
c. Non-metallurgical magnesium production
d. Other

Table 3: Sectors covered by the UNFCCC

These data should provide insight into the GHG emission trends of the raw materials industries over the last decades. However, there are two relevant limitations. First, Eurostat and EEA databases do not show any record for sector *1.A.2.g iii) Mining* (energy-related emissions). Then, process-based emissions are reported under categories for which is unclear whether emissions refer to processing at mining facilities or elsewhere (see table above).

Apart from these official data on absolute emissions, Eurostat provides also the Eurostat Air Emission Accounts (AEA) (Eurostat, 2019). There, GHG emissions data are mapped to the NACE classification for economic activities. This dataset covers time series since 2007/2008. Based on the AEA, Eurostat also estimates GHG emission intensities[9] (emissions per unit of economic output of the sector). These data presents limited sector disaggregation, with data available for B *Mining and quarrying*, which covers also the mining of energy commodities. The AEA differ methodologically from the GHG inventories in the context of the UNFCCC since AEA consider emissions belonging to an economic activity even when it takes place outside a country's territory, given the activity of economically based in one country (for instance, transport activities).

Scientific database EDGAR

Apart from these data sources, GHG emissions data are also provided by the scientific database Emissions Database for Global Atmospheric Research (EDGAR) (JRC, 2019). The last update of EDGAR estimates on GHG emissions covers a comprehensive set of substances and the industrial sectors cited in the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC, 2006). EDGAR provides time series data since 1970 and its emission estimates are based (as it is the case for official GHG inventories) on emission factor and activity data. Similarly to official GHG inventories, the activity of the sector as used by EDGAR

[9] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_aeint_r2&lang=en

refers to fuel combustion for energy-related emissions and to material produced for process-emissions. Activity data comes from trustworthy producer associations and the United States Geological Survey (USGS), while emission factors[10] mostly come from the International Energy Agency (IEA) (who take into account several factors, such as technology and fuel mixes used in production) and IPCC.

While for official inventories data accuracy for emission factors and activity data can significantly vary across economic sectors and among countries, EDGAR tries to use data with a similar level of resolution (tiers) for, at least, countries in the EU region. In addition, differently from the AEA described above, the activity data used by EDGAR is based on physical units and is often not available due to confidentiality.

The way in which EDGAR data are organized and modelled provide absolute emissions data and allows also the computation of implied emission factors, i.e. average emission factors by sector for each country.

Non-energy mining is covered in EDGAR by a data series embodying (only) energy-related emissions from NACE divisions B07 Mining of metals ores, B08 Other mining and quarrying. The latter covers quarrying of stone, sand and clay and mining and quarrying not elsewhere classified and B099 Support activities for other mining and quarrying. No data are provided for process-emissions of this sector.

2.1.4 Additional datasets

Other data sources exist that, although not providing data with comprehensive coverage and regular updates, it is worth to mention, since they tackle some of the limitations of the data described above.

European pollutant release and transfer register (E-PRTR)

E-PRTR is the Europe-wide register that provides data on pollutant releases to air (plus water and soil) for the major EU industrial facilities, covering also GHG emissions. Data from this registry are reported annually, publicly available and validated; covers time series since 2007 and all EU Member States plus European Free Trade Association (Stockholm Convention) (EFTA) countries.

The registry covers industrial facilities that produce emissions above certain sector-specific thresholds, which generally depend on the production capacity or on the area under extractive operation for some mining-related activities. For some specific activities, pollutants have to be reported regardless of the facility production capacity (e.g. underground mining, metal ore roasting/sintering, etc.). E-PRTR provides pollutant-release data by facility, which can be aggregated by economic sectors (an own classification) and adapted to the NACE classification. Differently, from the official data sources described above, reporting is done at the facility level, which allows zooming in more in detail in the different mining activities. Yet E-PRTR has not full coverage since it considers only the major EU industrial facilities.

E-PRTR covers mining activities such as mining of iron ores, mining of clays and kaolin, mining of non-ferrous metal ores, other mining and quarrying not elsewhere classified (n.e.c.), quarrying of limestone, gypsum and chalk, quarrying of ornamental and building stone, limestone, gypsum, chalk and slate and operation of gravel and sand pits.

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[10] Emission factors are representative values to relate substance emissions to the atmosphere with an activity.

Although industrial facilities are asked to report their activity data, the completeness of these data is very limited. Therefore, a sound estimation of GHG emissions intensity is not possible. An additional limitation is the soundness of data belonging to different years, where significant limitations prevent from using the data for accurate time trend analysis.

Environmentally-extended input-output tables

The official data sources mentioned above only account for GHG emission linked to direct onsite activities without considering emissions from energy generation that takes place off-site, from the production of the auxiliary inputs, or from products transport and delivery. Data from environmentally-extended input-output (EE-IO) tables covers this gaps: they EE-IO tables follow the flows through the economy and estimate the inputs to production as well as emissions (e.g. air emissions) associated with a given sector, accounting for all the upstream value chains. Thus, they include both direct onsite GHG emissions and indirect emissions.

Research projects such as Exiopol (Exiopol, 2011) and then CREEA (CREEA, 2019) have developed subsequent versions of the EE-IO table Exiobase (Exiobase, 2019), which provide data on GHG emissions among the environmental extensions they developed. The World Input-Output Database (WIOD) (WIOD, 2019) is another example of EE-IO table that covers GHG emissions within their environmental extensions.

Exiobase version 3 covers the following extractive sectors:

- mining of iron ores,
- mining of copper ores and concentrates,
- mining of nickel ores and concentrates,
- mining of aluminium ores and concentrates,
- mining of precious metal ores and concentrates,
- mining of lead, zinc and tin ores and concentrates,
- mining of other non-ferrous metal ores and concentrates,
- quarrying of stone and quarrying of sand and clay.

It is important to mention that the continuity of the developments of these EE-IO is not always granted, plus the sector classification is often not fully harmonized with official data, making it more difficult to assess the data processing.

Life Cycle Assessment

Life cycle assessment (LCA) is not a data source as such, but a method used to quantify the potential environmental impacts of products and services along the whole production chain and beyond (use and end-of-life). GHG emissions and their impact on the climate is included among the impact categories analysed by LCA, which allows accounting for GHG emissions associated to all relevant production processes. Therefore, LCA allows identifying where *hotspots* of GHG emissions are located in the production chain, and compare the climate performance of different ways of extraction and processing materials. However, the raw data underlying this methodology are limited and not systematically reported over time.

2.1.5 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Eurostat - Greenhouse gas emissions by source sector (source: EEA) (data reported to the United Nations Framework Convention on Climate Change (UNFCCC))	Greenhouse gas (GHG) emissions by source sector (data for the mineral industry and for the production of specific materials). Emissions of single GHGs and GHGs sums reported in CO_2 equivalents (Thousand tonnes, million tonnes)	EU and EFTA countries for the Eurostat database (World coverage when accessing the United Nations Framework Convention on Climate Change (UNFCCC) data)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en Viewer of these data in the EEA site: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer
Eurostat – Air emissions accounts by NACE Rev. 2 activity (env_ac_ainah_r2)	GHG emissions by economic sector (sector B mining and quarrying according to the NACE Rev. 2 classification). Emissions of single GHGs and GHGs sums reported in CO_2 equivalents (Grams per capita, kg per capita, tonne and thousand tonnes)	EU and EFTA countries	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_ainah_r2&lang=en
Eurostat - Air emissions intensities by NACE Rev. 2 activity	GHG emissions intensities (emissions related to production volume) by economic sector (sector B mining and quarrying according to the NACE Rev. 2 classification). Emissions of single GHGs and GHGs sums reported in CO_2 equivalents (Grams and kg per euro – current prices –, grams and kg per euro – price corrected referring to 2010)	EU and EFTA countries	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_aeint_r2&lang=en
Emissions Database for Global Atmospheric Research (EDGAR) - Global Greenhouse Gases Emissions v4.3.2	GHG emissions by economic sector and by country, covering also the mineral mining sector. Emissions of single GHGs and GHGs sums reported in CO_2 equivalents (Thousand tonnes) Possible also to estimate GHG implied emission factors (emissions intensity)	World (all countries)	http://edgar.jrc.ec.europa.eu/overview.php?v=432_GHG (dataset for CO_2 up to year 2017) http://edgar.jrc.ec.europa.eu/overview.php?v=booklet2018

Table 4: Key datasets for greenhouse gas emission data in Europe

2.1.6 Recommendations for harmonisation and standardisation of GHG data

Very relevant harmonization efforts have been done in the sector classification and methodologies to estimate GHG emissions, especially those in the context of the UNFCCC. However, this reference classification follows a sector classification that does not allow discriminating different types of mining activities. These data covers energy-related emissions from mining activities, yet data reported for the EU does not show record for this sector. On the other hand, process-emissions fall under the mineral industry sectors, which usually refer to production processes beyond extraction.

EDGAR data does provide figures for the mineral industry. However, similarly to official inventories, it does not allow the disaggregation of different mining activities.

Other approaches such as the EE-IO table Exiobase provide more disaggregated data than the two sources above, yet its continuity and regular update is not granted.

Regarding the relevance of GHG emissions data, it is important to note that the estimate of the global warming potential of GHG emission is among the most straightforward ways to translate an environmental pressure (emissions) in their potential impact (global warming potential).

A relevant limitation of these data is the limited availability of production data, which could allow following up on changes not only on absolute emissions but also on emissions intensity (which informs about changes in emissions efficiency). An advantage of EDGAR in comparison to official inventories is the possibility to estimate emission intensity based on activity data measured in physical units.

Another relevant consideration is the fact that both official inventories and EDGAR do no account for indirect emissions, which can be a relevant contributor to the total climate footprint of the extractive sector. EE-IO tables can bridge this gap.

Finally, all approaches above are based on estimates that can lack accuracy for some specific sectors. E-PRTR data might cover this gap since it is based on facility data, which are also often estimated but are usually based on more accurate methodologies. However, not all facilities are covered by this data source.

2.1.7 References

CREEA. 2019. Compiling and refining environmental accounts. http://www.creea.eu/

European Commission. 2019(a). 2030 climate & energy framework. https://ec.europa.eu/clima/policies/strategies/2030_en

European Commission. 2019(b). 2050 long-term strategy. https://ec.europa.eu/clima/policies/strategies/2050_en

European Commission. 2019(c) EU Emissions Trading System (EU ETS). https://ec.europa.eu/clima/policies/ets_en

European Commission. 2019(d). Free allocation. https://ec.europa.eu/clima/policies/ets/allowances_en

European Commission. 2019(e). 2011/278/EU: Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (notified under document C(2011) 2772). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011D0278

European Commission. 2019(f). Use of international credits. https://ec.europa.eu/clima/policies/ets/credits_en.

European Commission. 2014. 2014/746/EU: Commission Decision of 27 October 2014 determining, pursuant to Directive 2003/87/EC of the European Parliament and of the Council, a list of sectors and subsectors which are deemed to be exposed to a significant risk

of carbon leakage, for the period 2015 to 2019.
https://ec.europa.eu/clima/policies/ets/credits_en

https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32014D0746.

European Commission, EIP on Raw Materials (2018), “Raw Materials Scoreboard 2018", Publications Office of the European Union.

Eurostat. 2019. What are AEA and what are they for? https://ec.europa.eu/eurostat/web/environment/emissions-of-greenhouse-gases-and-air-pollutants/air-emissions-accounts

JRC. 2019. EDGAR. http://edgar.jrc.ec.europa.eu/index.php

Exiobase. 2019. Exiobase project. https://www.exiobase.eu/

Exiopol. 2011. Exiopol project. http://www.feem-project.net/exiopol/

IPCC, 2006. IPCC guidelines for national greenhouse gas inventories – volume 1: General guidance and reporting’, Annex 8.A2 reporting tables, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8x_Ch8_An2_ReportingTables.pdf.

WIOD. 2019. World input-output database. http://www.wiod.org/home.

UNFCCC. 2006. National reports. http://unfccc.int/files/national_reports/annex_i_ghg_inventories/application/octet-stream/2006_ipcc_guidelines.7z

2.2 *Waste*

2.2.1 Definitions and background for waste from the extractive sector in Europe

This section refers to solid waste only, other waste streams are covered by other sections. The term 'waste' is defined by the European Commission (EC) in Directive 75/442/EEC as "any substance of object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force" (EC, 1975).

For the extractive sector, there is the European Directive 2006/21/EC, which specifically relates to 'mining waste' and is known as the 'Mining Waste Directive'.

The term mining waste refers to tailings, for example solid waste or slurries generated after the treatment of minerals, waste rock and overburden produced during the stripping of the ore or mineral body, in pre-production stages and topsoil, provided that all the above constitute waste as defined by the Waste Framework Directive

The mining and quarrying sectors represents the second largest sector that generates waste in EU-28 (Figure 2). Directive 2006/21/EC[11] *on the management of waste from the extractive industries and amending Directive 2004/35/EC* (Mining Waste Directive – MWD) represents the principal legal document on mining waste in EU-28. This regulates the management of waste from mining and quarrying and aims to ensure prevention and reduction of adverse impacts to the environment and human health Directive 2006/21/EC applies to land-based extractive industries.

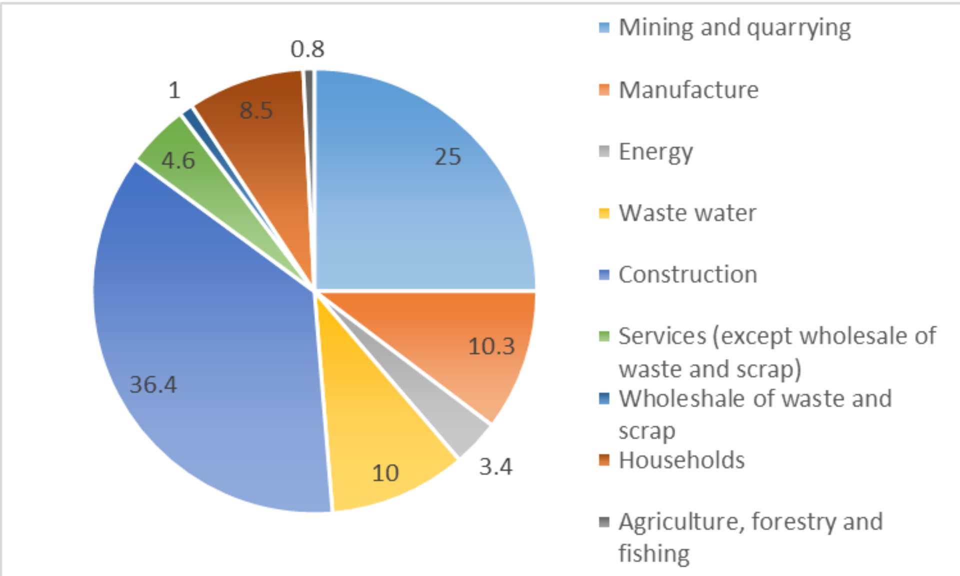


Figure 2: Waste generation (%) by economic activities and households, EU-28 – 2016. Data from Eurostat (waste statistics)[12].

A waste facility is defined as any designated area used for the accumulation or deposit of extractive waste, in solid or liquid form or in solution or suspension. The definition of what comprises a waste facility is also determined by the period of time that waste stored on site. For

[11] Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC - Statement by the European Parliament, the Council and the Commission. URL: http://data.europa.eu/eli/dir/2006/21/oj

[12] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Waste_generation_by_economic_activities_and_households,_EU-28,_2016_(%25).

example, if the inert waste is stored on site for more than a year, then operators should define this as a waste facility. The only exception is for Category A waste facilities, which are deemed of high risk and therefore have no time-period associated with them[11].

The overarching EU Waste Framework Directive[13] endorses a hierarchical approach (Figure 3), which is applicable to the mining sector. For example, backfilling of voids in quarries is preferred. Reprocessing of extractive waste for use in construction is common practice. The recovery of valuable metals, for example, critical metals, gold, copper etc. is also encouraged.

The MWD requires operators to develop waste management plans. These should be developed during the mine design stage and when mineral extraction and processing methods are decided. Waste management plans should include steps for waste minimisation and environmentally viable recovery of waste.

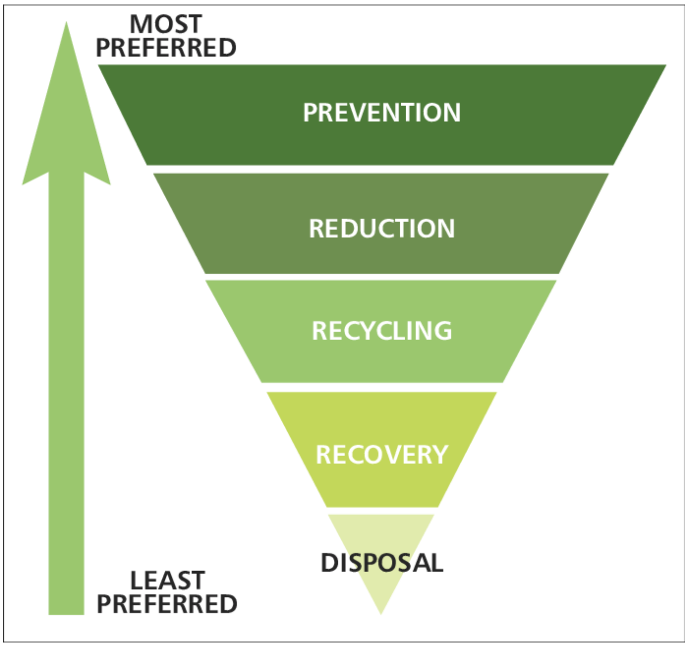


Figure 3: The waste hierarchy as described in the EU Waste Framework Directive[14].

Additional important documents associated with the Mining Waste Directive[11] include:

- The Seveso III Directive, which addresses issues, associated with major accident hazards. This covers disposal facilities such as tailing pods or dams containing dangerous substances[14].
- The Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries in accordance with Directive 2006/21/EC (MWEI BREF) (Garbarino et al., 2018). In this document, updated data and information on the management of extractive waste are presented, including best available techniques and monitoring practices. The BREF document includes a wealth of useful information not just about waste management, but also general facts about the extractive sector in Europe, key environmental issues, applied techniques, waste treatment, emissions and

[13]Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. URL: http://data.europa.eu/eli/dir/2008/98/oj.

[14] Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0018

many more. For example, the graph in Figure 4, taken from the MWEI BREF document outlines the waste produced by the extractive sector between 2004 and 2014.

- The assessment of Member States performance regarding the implementation of the Extractive Waste Directive (European Commission, 2017). This study investigated the implementation of the MWD across the EU Member States and identified issues associated with its implementation, including possible causes. It identified the need for additional guidance to become available for enforcing the MWD, accident prevention and waste management plans. The study suggested the need for additional clarification on the links between permitting regimes and the use of BAT in permitting. It also highlighted several areas of incomplete data and information, for example on waste facility classification, mine closure and transboundary effects. There is a dedicated section on reprocessing of extractive waste. This concluded that only a limited number of countries have strategies or statements on the reprocessing of extractive waste. When reprocessing takes place, then this is often towards the use of inert waste in construction applications. The report also includes a limited number of short case studies on reprocessing activities taking place in different sites in Europe.

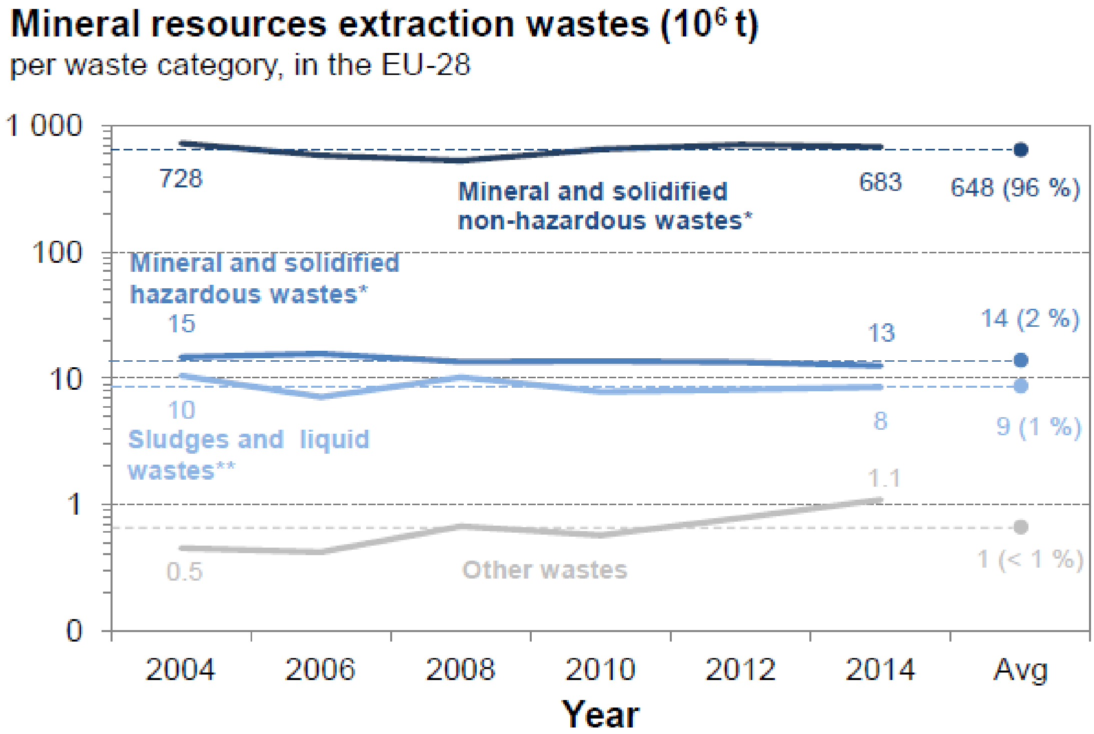


*Figure 4: Waste production by the mining sector in EU-28 between 2004-2014 (10^6 t), based on data from the Eurostat database and reported in the MWEI BREF document (Garbarino et al., 2018). Average represents the 2004-2014 average, * Excluding solid wastes from construction and demolition and combustion wastes, ** industrial effluent sludge, sludge and liquid wastes from waste treatment.*

2.2.2 Available data on waste from mineral extraction in Europe

European Waste Statistics – Eurostat database

Available data on mining waste generated are available from the Eurostat database – waste statistics (Eurostat, 2019). Data on waste from mining and quarrying are found under the '*Waste* *generation and treatment*' area and in the '*Generation of waste by waste category, hazardousness and NACE Rev. 2 activity*' table. The database does not include a waste category named mine waste, but it contains data on waste generated by the extractive sector (NACE code on mining and quarrying). Data are reported for the EU Member States and candidate countries. The database provides quantities of waste generated and can be adjusted to present data on specific countries, time (single year or multiple), hazardous, non-hazardous or total waste and different waste categories as described in the European Waste Catalogue classification for statistical purposes (EWC-Stat). All values are in tonnes of waste or kg per capita. The EWC-Stat classification is mainly substance oriented, for example, chemical waste, metallic waste non-ferrous, but it is not detailed enough to provide sufficient information on the composition of waste. This is problematic, when exploring potential recovery options for waste generated, or when trying to assess the resource potential of waste. Figures for primary waste produced directly from the mining and quarrying sector and secondary waste, produced after the treatment of waste (e.g. ashes from incineration) are available.

National Data sources

All European Member States hold national statistics with datasets on waste, which also cover the extractive sector. Published data are often very similar to the Eurostat data as they may be presented using the EWC-Stat codes. In practice, most of the countries collect their data using the List of Waste (LoW) classification (Eurostat, 2010) (more detailed waste categories) and then convert them into the EWC-Stat categories (more aggregated waste categories). National statistics, therefore, are useful, if further disaggregated information on waste generation is required. This information is often available from the National Statistics Offices, Department of Environment or Environment Agency, depending on how data collections are organised within different countries.

Data on mine waste may also be available from national geological surveys through geoportals and inventories on mine activity that they may hold. National geological surveys will likely have information both on active mining sites, but also historical data on past mining activities. Several projects in the past have reported the capabilities of national geological surveys[15].

Finally, inventories of closed mining waste facilities are available from EU Member States as requested by the MWD.

European projects

Several European projects investigated data availability of mine waste in Europe and have developed reports and portals. Key projects are presented below:

- SMARTGROUND[16]: The aim of this project was to improve the availability and accessibility of data and information on secondary raw materials in the EU. The project worked towards the development of a single EU database that integrates data from existing sources into a single website. The SMARTGROUND platform represents a geoportal that includes information on mine waste and mine sites across Europe. The search engine of the portal allows to investigate information availability using the material name, mine site, country name, waste code and others. The platform

[15] Minerals4EU project: http://www.minerals4eu.eu/; ProSUM project: http://www.prosumproject.eu/; MICA project: http://mica.eurogeosurveys.org/

[16] http://smart-ground.eu/

demonstration states that compositional data on mine waste and ore mineralogy may also be available. Unfortunately, however, the platform was not functional during the development of this document and we were, therefore, unable to interrogate data availability on mine waste further.

- ProSUM[17]: The ProSUM (Prospecting Secondary Raw Materials in the Urban Mine and Mining Waste) project undertook an investigation of data availability on mine waste to inform the development of a data model, which works as an add-on to the Minerals4EU data platform. The model includes additional code lists that describe methods for estimating the amount of mining waste and methods for estimating the composition of mining waste. Overall, ProSUM has developed guidelines for future work, a common database, new code lists and recommendations for further work and exploration. One of the key recommendations of this project is that a more complete characterization of mining waste sites in Europe is required to further improve and expand the currently limited data.
- Minerals4EU and ProMine[18, 19]. These two earlier projects investigated mining waste in Europe too. ProMine provides information on mining waste under the anthropogenic concentrations category. Minerals4EU provide statistical information on waste in the Minerals Yearbook. The data in the Yearbook are primarily from the Eurostat waste statistics database. The map viewer in Minerals4EU also includes spatial information on mine waste, similar to the ProMine project.
- Minventory portal:[20]: The portal provides information on the Competent Authorities responsible for collecting and publishing sets of data on mining waste in EU-28.
- ORAMA project[21]: Work Package 2 of the ORAMA project explores in more detail mining waste data from four countries in Europe and develops relevant case studies. This analysis is published in Deliverable D2.2.

Company reports

Useful information on mining waste generated by specific sites or companies are often found in company annual reports and environmental reports. The content of information in them varies between different companies. Many follow sustainability reporting standards, such as the Global Reporting Initiative standards. Information may include the quantity of waste generated, the types of waste, locations of waste facilities and many more.

[17] http://www.prosumproject.eu/project-reports
[18] http://minerals4eu.brgm-rec.fr/minerals4EU/
[19] http://promine.gtk.fi/
[20] https://ec.europa.eu/jrc/en/scientific-tool/minventory
[21] https://orama-h2020.eu/

2.2.3 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Eurostat waste statistics	Quantity of waste generated using the EWC-Stat	EU 28 / national	https://ec.europa.eu/eurostat/data/database
National Data sources	Various (see description in the bullet point above)	EU 28 / national	Various
Smart Ground platform	Waste facilities site locations, waste type, composition etc.	EU 28	http://smart-ground.eu/
Minerals4EU data platform	Mine sites, waste facilities locations, waste type; data from Promine and ProSum projects are incorporated in this	EU 28 28 / point data for spatial locations, national resolution for statistical data	http://minerals4eu.brgm-rec.fr/minerals4EU/
Minventory	Information on competent authorities reporting data on mine waste.	EU 28 / national	https://ec.europa.eu/jrc/en/scientific-tool/minventory
ORAMA project	Case studies discussing in detail data availability on mine waste for Hungary, Ireland, Slovenia and Norway; Overview of data sources in Europe	EU 28 / national	https://orama-h2020.eu/
Company reports	Waste facilities locations, waste generated, composition etc.	Company or site-specific	Company websites; GRI database (http://database.globalreporting.org/)

Table 5: Key datasets for waste data relating to the minerals sector in Europe

2.2.4 Recommendations for improving mine waste data availability and harmonisation

The only quantitative data available on waste generated from the mining and quarrying sector are from the Eurostat database. However, the resolution of these data is not detailed enough to differentiate between commodities and the spatial resolution is on country level only, rather than site level.

Regarding the various datasets developed by European projects, although they have enhanced our knowledge on mine waste, they are lacking harmonisation and interoperability. Their quality is also highly questionable, as they seem to take information readily available from project partners and stakeholders rather than provide an integrated picture on mine waste in Europe. They include substantial gaps that should be addressed in the future. In addition, they should undergo an exercise of harmonisation to enable a single data model and procedure for data collection to be established.

The most important lack of data is on the composition of mine waste. Approaches to address this with indirect methods (e.g. GIS tools and topographical models) or sampling have been discussed by some projects. The availability of such data remains low, but of high importance, if we are seeking to evaluate the potential of reworking mining waste, for example for the recovery of critical metals. An EU project dedicated to generating compositional data on mine waste, focusing on working closely with primary producers could close this gap and provide the information required.

2.2.5 References

European Commission, 2017. Assessment of Member States' performance regarding the implementation of the Extractive Waste Directive; appraisal of implementation gaps and their root causes; identification of proposals to improve the implementation of the Directive. https://publications.europa.eu/en/publication-detail/-/publication/f39af478-8d2e-11e7-b5c6-01aa75ed71a1

Eurostat. 2019. Waste statistics database. https://ec.europa.eu/eurostat/web/waste/data/database

Eurostat, 2010. Guidance on the classification of waste according to EWC-Stat categories. https://ec.europa.eu/eurostat/documents/342366/351806/Guidance-on-EWCStat-categories-2010.pdf/0e7cd3fc-c05c-47a7-818f-1c2421e55604

Garbarino, E., Orveillon, G., Saveyn, H.G.M., Barthe, P., Eder, P., 2018. Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries. JRC Science for Policy Report. http://susproc.jrc.ec.europa.eu/activities/MWEI/documents/jrc109657_mwei_bref_-_for_pubsy_online.pdf

2.3 *Nuisance, including noise, visual and traffic*

2.3.1 Definition of a nuisance for the purposes of comparing data for the extractive sector

The term ‘nuisance’ literally means something that causes inconvenience or annoyance. In this section, nuisance is related to noise, visual intrusion and traffic. These individual aspects can often be interlinked especially between traffic and noise or between traffic and visual intrusion. Before and during the life cycle of a quarry these three aspects will have been assessed and reassessed.

Noise nuisance

The definition of noise nuisance is an unwanted sound judged to be loud and can be disruptive to hearing. Noise pollution is also known as environmental noise pollution and is the element of noise with a harmful impact on the activity of human or animal life.

There are two main types of noise arising from the extractive sector: the noise exposure to the employees or contractors working in the sector and the noise experienced by those in neighbouring areas beyond the quarry boundary. Employers have a duty of care under Noise Regulations to reduce the risk of damage to the hearing of their employees and contractors. Health and safety training, education and the use of appropriate safety equipment can minimise the immediate noise exposure. This particular aspect is discussed in the human health and health and safety sections of this report.

Environmental noise nuisance is the measurement of noise from the extractive industry experienced by neighbouring areas and this will be the focus of this section.

The activities of the extractive industry will inevitably cause some noise. Movement of vehicles on site happens at every quarry as soil and overburden are removed to expose the mineral, as mineral excavation proceeds, and as the mineral is moved to the processing areas. Some sites may have noise generated from the blasting of rock. Noise from powered machinery, including the use of crushing, grading and other processing plant. Mineral transportation off site to market by increased lorry or rail movement.

Noise has no long-term adverse effect on people, as long as the exposure is such that it does not cause any change in behaviour or attitude. There is not a simple relationship between noise levels and the impact on those affected. Noise can affect people at different levels in different ways. This will depend on various factors, for example:

- Time of day the noise occurs e.g. people tend to be more sensitive to noise at night when they are trying to sleep.
- Frequency, when the noise occurs i.e., is it continuous, or does it happen at certain times or only occasionally.
- Pattern and character of the noise is it intermittent or continuous when it occurs.
- Spectral content of the noise i.e. whether or not the noise contains high or low-frequency content.
- Distance from the noise source.

Noise is generally one of the main concerns addressed in the permitting process for a mine or quarry. All operators are required to provide information on predicted noise levels at different stages of the working of the mine or quarry and provide details of mitigation measures for the noise. The relevant authorities will assess whether noise levels are acceptable and once operational, a quarry or mine will usually be required to monitor noise levels.

There are measures the extractive industry can take to mitigate against noise:

- Noise sources like processing plants could be placed far away from residential areas, contained within buildings and/or surrounded by structures that are clad with sound-reducing materials.
- Screening by natural vegetation, soil mounds or fencing could be created to minimise noise levels.
- Noisier aspects of quarrying, e.g. blasting, could be done in daytime hours only.
- Lining crusher plant bins, conveyor transfer points and truck bodies with rubber to reduce the noise impact.
- Careful (sensitive) haul road design and effective maintenance to minimise noise emissions from heavy machinery.
- Replacement of reversing warning beeps on vehicles with cameras.
- Avoidance of unnecessary revving of engines or the use of vehicle horns.

Visual impact

The definition of a visual impact is defined as a change in the appearance of the landscape as a result of development which can be a positive (improvement) or negative (detraction) (The Landscape Institute, 2012).

Landscape change and visual intrusion are some of the key environmental issues associated with quarry developments. The original landform is permanently altered and the original vegetation cover is removed. The visual impact of the quarry can extend over large areas as noticeable scars, reducing the aesthetic appeal of the landscape. The potential impacts can vary considerably as can the mitigation measures.

Various visual screening techniques can be used at extractive sites, these include: replication of local landforms/landscape, creation of (semi-) permanent external slopes, phasing of landform construction, bare earth bunds, naturally vegetated and planted bunds, interlocking bunds, shrub/tree planting, fencing, walls, buildings as screening elements, stretched fabric/hoardings and using false perspective and trompe d’oeil. Other mitigation measures may include minimising building impact and processing plant through consideration of height, colour and silhouette. The processing plant may be placed indoors or cladding may be used to hide the equipment. Careful thought must be given to the design of an extractive site; landform screening has proved to be one of the most effective to hide the location of plant and buildings. Each extraction site will benefit from a range of different screening techniques.

Lighting is also an important consideration because bright lights in a rural setting can be seen as light pollution. Even in an urban location lighting that is too intrusive into people’s homes can cause problems. Appropriate levels of lighting should be determined that are not intrusive but provides enough light where it is required. Some areas of the site may not need to be lit permanently and low-level lighting may be more than adequate in other areas. Directional lighting can minimise light pollution and intrusion.

The method of extraction and associated restoration scheme, where properly planned and implemented, can minimise potential impacts. Progressive working and restoration during the lifetime of a mine or quarry should aim to minimise the duration of visual intrusion and avoid excessive areas of disturbance (Higson, 2018).

Within the EU, The European Council's Environmental Impact Assessment (EIA) Directives "On the assessment of the effects of certain public and private projects on the environment" (European Parliament and Council, 2014), have "landscape" as a factor that must form part of the information for the EIA report.

In England, visual impact and design of screening measures are a priority. The National Planning Policy Framework requires that planning authorities should provide for the restoration and aftercare of mining sites at the earliest opportunity and that it is carried out to a high environmental standard (HCLG, 2018). Planning guidance and policy have helped greater consideration to be given to the landscape and the visual impact assessment. It is acknowledged that a 'well-designed development can make a positive contribution to the landscape' (The Landscape Institute, 2012). Where possible the visual screening should be permanent and part of the overall final restoration.

Traffic nuisance

In the context of the extractive sector, traffic nuisance usually relates to the number of vehicles travelling along roads in the vicinity of the site, but it could also include the quantity of trains or ships used to deliver the mine's or quarry's products. The amount of traffic generated from a quarry has a number of principle inconveniences, which include noise and ground vibration, dust and dirt, visual effects, accidents and safety risks. Health and safety is considered in more detail in a separate section within this report.

Traffic nuisance is not solely caused by the number of delivery trucks. In addition, there is the traffic generated by the personnel working at the quarry, supplier's delivering consumables or equipment and other contractors attending the site. The operating hours of the site may mean that this traffic is not limited to just a few hours per day. All of this traffic may put a strain on the local infrastructure, cause noise or visual intrusion and can result in congestion on local roads. Vehicles travelling to and from a mineral extraction site may also cause dust or deposit mud on local roads if their wheels are not cleaned when leaving the site. There can also be concern over traffic vibration from large trucks and sometimes this can lead to an assumption that if vibrations can be felt, then damage is inevitable.

The potential traffic impact is one of the most commonly discussed issues between extractive industry companies and the local authorities during the permitting process. Solutions may include the construction of new industrial roads that diverts traffic from minor and congested roads (Brodkom, 2000), agreed traffic routes for deliveries or limitations on the times of day for vehicle movements. Quarry and mine operators generally impose haulage rules on their delivery trucks and these may include instructions relating to the cleaning of trucks, washing of wheels and covering of materials to prevent the spread of dust. Responsible operators will make every effort to see that the drivers of HGVs adopt a responsible attitude.

An increase in rail utilisation is proving to be more environmentally friendly than road transport due to the quantities that can be transported with lower emissions. Obviously, this would require the appropriate rail and road infrastructure facilities to be in place relative to the market destination. However, both rail and lorry infrastructure can cause issues with vibration where they are in proximity to residential areas. However, increased rail traffic carrying cargo, because of its sheer volume, can cause serious congestion issues for passenger rail services.

In a few European Member States e.g. The Netherlands, Germany and France, some companies consider moving commodities from the extractive industry by inland waterway as the most effective and progressive system of transport, with virtually no limits on capacity and minimal environmental problems. River barges, for the most part, have little impact on densely populated areas. Barge transits are relatively infrequent because of the large tonnage moved at one time. River operations take place in channels away from the shore, and the engines of a towboat are usually below the water line, which muffles the sound. In addition, levees and seawalls also shield residents from towboat noise in the same manner as highway sound barriers do (U.S. Department of Transportation, Maritime Administration, 1994).

However, in some remote areas, quarry or mine operators will build or repair roads and railways to transport materials. In such regions, the local communities can gain long-term benefits from such infrastructure work (Brodkom, 2000).

2.3.2 How can noise, visual and traffic nuisance be measured

Noise nuisance

Noise is measured using decibels (dBA). Decibels are measured on a sound level meter incorporating a frequency weighting which differentiates between sounds of different frequency in a similar way to the human ear.

Within the EU, the Environmental Noise Directive (END) relates to the assessment and management of environmental noise. Through the Directive, noise pollution levels are identified and this prompts the necessary action, both at Member State and at EU level. The European Commission has identified noise as one of the most persistent problems in urban areas across Europe and stressed the need to take action on various sources of noise, as part of its Environmental Action Plan. There is a policy relating to a list of different types of outdoor machinery, however, there appears to be no specific data sets relating to the extractive industry. There are noise factsheets available for each country containing datasets, but the data relates very much to transport noise and again these are not specific to the extractive industry.

An evaluation was done by the European Commission and a paper produced (European Commission, 2016) looking at each member state and how they assess and manage environmental noise in relation to the European Noise Directive. However, this directive is not exclusive to the extractive agency.

Most Member States have their own noise policies which are linked to the European Environmental Noise Directive. In the United Kingdom, the Noise Planning Policy Framework requires those making mineral development proposals to carry out a noise impact assessment, which should identify all potential sources of noise. For each source, they are required to take account of the noise emission, its characteristics, the proposed operating locations, procedures, schedules and duration of work for the life of the operation, and its likely impact on the surrounding neighborhood. Although data may be found for individual quarry sites, no comprehensive data sets exist publically for the United Kingdom as a whole.

In Ireland, the Environmental Protection Agency (EPA) has produced a Guidance Note for Noise in Relation to Scheduled Activities (Environmental Protection Agency, 2009). It describes in general terms the approach to be taken in the measurement and control of noise and provides advice in relation to the setting of noise emission limit values and compliance monitoring. In relation to quarry developments, the EPA recommends that the noise from the activities on site shall not exceed 55 dBA in the day and 45 dBA at night.

In Denmark, Nordic noise prediction method, Nord2000, was introduced in 2007 by the Danish Environmental Protection Agency for mapping of road and railway noise. The mandatory use of Nord2000 specifies most of the parameters to be used for the calculation including weather statistics for different weather conditions, the method includes source models for road and rail traffic in third-octave bands from 25 Hz to 10 kHz (Ministry of Environment and Food of Denmark, 2018).

Visual impact

The visual impact of the extractive industry is not something that can easily be measured because it is something that is quite subjective, i.e. different people may perceive the impact in a dissimilar way. There are no available datasets on a consistent European level.

Visual impact is assessed during EIA stage at a localised level on a site-by-site basis in the individual member states, an EU directive 2014/52 /EU governs this (Official Journal of the European Union, 2014).

The use of geographic information systems and visualization techniques historically have been used to help communities understand and manage their resources.

In the United Kingdom, the Landscape Institute and Institute for Environmental Management and Assessment published the third edition of 'Guidelines for Landscape and Visual Impact Assessment' in April 2013. This provides key information for Landscape professionals on how to carry out visual impact assessments (The Landscape Institute, 2013).

Traffic

The data collected by Eurostat in connection with transport is not specific to the extractive industry, nor specific to any nuisance caused by traffic. The data simply refers to the amount of a type of transport and goods carried, aggregated for each member state. Within the freight, statistics section is a brief explanation of how the data are collected (Eurostat, 2018).

Almost all of the inland freight transport statistics are based on movements in each reporting country, regardless of the nationality of the vehicle or vessel involved. The methodology used across the EU Member States is not completely harmonised. All the data is collected under an EU regulatory framework for each mode of transport. Road freight: Regulation 70/2012; Rail freight: Regulation 2016/2032 and waterways freight: Regulation 2018/974.

Road freight data are collected using sample surveys carried out in the EU Member States. They record the transport of goods by road, as undertaken by vehicles registered in each member state. It is important to note that most apply a cut-off point for carrying capacity under which vehicles are not surveyed. Rail freight data is collected quarterly or annually depending on the size of the load. Eurostat also voluntarily collects rail freight data themselves by questionnaire. Waterways freight data is only required for Member States where the annual quantity of goods transported exceeds one million tonnes. Countries can provide data on a voluntary basis and currently only eighteen Member States provide data. Data collection is based on an exhaustive survey of all inland waterway enterprises for all goods that are loaded or unloaded. In the case of transit, some countries make use of sampling methods in order to estimate the volume of goods transported.

In the UK, under the Department for Transport, there is a survey which collects a range of information on freight movements from a sample of HGVs which is carried out by the 'Continuing Survey of Road Goods Transport Great Britain' (CSRGT GB.) Figures are weighted to be representative of the HGV population.

The rail industry reports data on a periodic basis. Some quarterly data that are reported require some apportionment of the periodic data collected. The UK's rail operator Network Rail supplies data on freight moved at the end of each railway period. The data includes a breakdown of total freight moved by commodity and operator. The Office of Rail and Road publishes the following commodity groups within a quarterly report: Coal, Metals, Construction, International, Domestic Intermodal and Others not connected to the extractive industry. Freight lifted data (mass of goods carried by rail, measured in tonnes) are provided by the four freight operating companies, as the data comes from different operators, there is little consistency between the commodity groupings.

2.3.3 Available data on noise, visual and traffic nuisance in the mineral extraction sector in Europe

Noise

There are numerous datasets that collect noise data at sites across Europe; however, these are not particularly useful for analysing the impact of noise from mineral extraction, as the information available is site specific and very localised data to the extractive site.

The European Environment Agency has a webpage http://noise.eea.europa.eu/ for 'The NOISE Observation & Information Service for Europe' (The European Environment Agency, 2017). This presents the environmental noise levels across Europe for Roads, Railways, Airports, Industry and specific cities. These maps are updated every five years (last updated in July 2017) and require Member States to provide information. None of the maps on this website is specific to the extractive industry. There are noise factsheets for each country within the EU, also last updated in 2017. These factsheets are full of data, but again only relate to noise produced from transport, and not specific to the extractive industry.

Some of the Member States produce more localised noise maps. The Danish Environmental Protection Agency is responsible for coordinating and publishing noise maps. After having mapped the noise, authorities make a noise action plan to reduce or prevent noise. Traffic is the main source of noise impact in Denmark (Ministry of Environment and Food of Denmark, 2018). They do have noise policies relating to industry, providing acceptable data relating to noise levels, however, the maps do not appear to be published publically, and none of this data appears specific to mineral extraction.

Visual

There are no 'visual' datasets on an aggregated level available for the extractive industry.

Traffic

Eurostat publishes datasets relating to annual road freight transport by NACE Rev. 2. The data are available as million tonnes per kilometre, million vehicles per kilometre and thousand journeys. Under the Classification of economic activities, it is possible to narrow the selection down to:

- Mining of hard coal
- Mining of lignite
- Mining of iron ores
- Mining of uranium and thorium,
- Mining of other non-ferrous metal ores
- Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate

- Operation of gravel and sand pits; mining of clays and kaolin
- Mining of chemical and fertiliser minerals
- Support activities for other mining and quarrying

The data are available by country and for the European Union. However, a significant proportion of the data are confidential or not available. It would appear that for individual countries it is possible to gather data specific to a particular part of the extraction industry.

The Eurostat 'Statistics explained' webpages (https://ec.europa.eu/eurostat/statistics-explained/index.php/Road_freight_transport_statistics) provide more information that is specific to road freight transport with a summary showing statistical tables and graphs. These data are applicable for years from 2008 to 2017 (although the summary text related to 2016). The categories relating to the extractive industry are very broad e.g.: "Metal ores and other mining and quarrying products, peat, uranium and thorium" all in one category and "coal, lignite crude petroleum and natural gas" combined together in another. It does, however, have the data listed country by country for comparisons.

There are some data published by Eurostat named 'Freight transport statistics' which differentiates between the different modes of transport (road, rail and maritime) and comparing the different EU Member States. Again the data have the most recent year of 2016. Although products from the extractive industry are transported by road, rail and sea, the available data on these specific pages do not have sufficient resolution to identify the product that is being transported.

In the United Kingdom, the Department for Transport collects data on road traffic. None of this information is specific to the extractive industry but could be useful when putting together a Transport Assessment as part of a planning application for a quarry or an 'Agreed Route Plan' for haulage vehicles to and from a quarry. The Road traffic website (https://roadtraffic.dft.gov.uk/) has traffic datasets based on the volume of traffic for different regions and cities, with sufficient detail to identify specific road junctions and or type of vehicle. The information classified as 'All HGV's' and then a little further detail to separate categories by the number of Axles the HGV has.

The United Kingdom Department of Transport also has The National Trip End Model (NTEM) (Department of Transport, 2017), which forecasts the growth in trip origin-destinations up to 2051 for use in transport modelling. The forecasts take into account national projections of population, employment, housing and car ownership, and the information is shown by regions across the United Kingdom. These forecasts are subject to some uncertainty, but it could be useful in forwarding planning in areas surrounding quarries.

2.3.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Eurostat	Annual road freight transport	European / national	https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Freight_transport_statistics
Eurostat – Statistics Explained	Road freight transport statistics	European / national	https://ec.europa.eu/eurostat/statistics-explained/index.php/Road_freight_transport_statistics
Eurostat – Statistics Explained	Freight transport statistics	Europe / national	https://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics#Modal_split
European Environment Agency	Noise mapping dataset – transport and industry	Europe/ point data, variable between countries	http://noise.eea.europa.eu/
Department for Transport	Road traffic website (Beta)	United Kingdom / point data	https://www.dft.gov.uk/traffic-counts/download.php
Department for Transport	National Trip End Model (NTEM)	United Kingdom / point data	https://data.gov.uk/dataset/11bc7aaf-ddf6-4133-a91d-84e6f20a663e/national-trip-end-model-ntem

Table 6: Key datasets for nuisance and mineral extraction

2.3.5 Recommendations for harmonisation and standardisation of data on the interaction of nuisance and mineral extraction

There are data available at a European level on noise, visual impacts and transport but very little is made available specific to the extractive industry. Any detailed data is extremely localised to a specific extractive site. There are plenty of published and available datasets in relation to noise but, at a European level, data only have to be provided by member states every five years to the European Environment Agency, and the categories are too broad to be able to resolve minerals specific impacts. Visual impact data at a European level does not exist and is very difficult to quantify.

Data collected at European level in relation to transport nuisance can vary in the data supplied from each Member State, due to the level of interpretation, human error and some confidentiality issues. The categories for mineral extraction could benefit from being broken down further.

2.3.6 References

Brodkom, F. 2000. Good Environmental Practice in the European Extractive Industry: a Reference Guide. Centre Terre et Pierre - Belgium. http://www.wbcsdcement.org/pdf/tf5/2000-03-Guide-to-Good-Practices.pdf

Department for Environment Food & Rural Affairs. 2014. Noise Action Plan: Roads (Including Major Roads), Environmental Noise (England) Regulations 2006, as amended, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/276237/noise-action-plan-roads-201401.pdf

Department of Transport. 2017. National Trip End Model (NTEM). https://data.gov.uk/dataset/11bc7aaf-ddf6-4133-a91d-84e6f20a663e/national-trip-end-model-ntem

Environmental Protection Agency. 2009. Guidance Note for Noise Action Planning, for the first round of the Environmental Noise Regulations 2006. https://www.epa.ie/pubs/advice/general/EPA_management_extractive_industry.pdf

European Commission. 2016. Evaluation of Directive 2002/49/EC relating to the assessment and management of environmental noise. The Centre for Strategy & Evaluation Services LLP. http://ec.europa.eu/environment/noise/pdf/country_fiches_study_evaluation_directive_environmental_noise.pdf

The European Environment Agency. 2017. The NOISE Observation & Information Service for Europe. http://noise.eea.europa.eu/

Eurostat. 2018. European Commission. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Freight_transport_statistics#Relative_growth_of_freight_transport_and_the_economy

Higson, S.J. 2018. What Landscape Strategy? In Hunger, E., Brown, T.J., Anderson, A. and Smith G (Eds). 2018. Proceedings of the 19th Extractive Industry Geology Conference 2016 and technical meeting 2017, EIG Conferences Ltd. https://static1.squarespace.com/static/54199a46e4b05afa19b4e68c/t/599d3f5d7131a572fa9c0f89/1503477603284/Higson_EIG2016_What+Landscape+Strategy_FINAL+%281%29.pdf

The Landscape Institute. 2013. Guidelines for Landscape and Visual Impact Assessment 3rd edition – consultation draft. https://www.landscapeinstitute.org/PDF/Contribute/GLVIA3consultationdraftformembers.pdf

Ministry of Environment and Food of Denmark. 2018. Danish Environmental Protection Agency. https://eng.mst.dk/air-noise-waste/noise/

Ministry of Housing, Communities and Local Government. 2018. The National Planning Policy Framework. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740441/National_Planning_Policy_Framework_web_accessible_version.pdf

Official Journal of the European Union. 2014. Directive 2014/52/EU of the European Parliament and of the Council. L/124. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0052&from=EN

U.S. Department of Transportation, Maritime Administration. 1994. Environmental Advantages of Inland Barge Transportation. http://www.uppermon.org/visions/DOT_environ_barge.htm

2.4 *Water use*

2.4.1 Background and definitions for water use in the extractive sector

Extractive industries need the right amount of water in the right moment and with the required quality. Water availability can be a decisive factor in determining the location of a mineral operation site in water-scarce environments or in locations where there is strong competition with other uses such as agriculture, households or tourism. Although total water use by the extractive sector is generally relatively small compared to other economic activities, such as agriculture or public water supply, water uptake by the sector can markedly influence water availability at local level.

Direct water withdrawal from extractive operations depends very much on the commodity extracted, the ore grade, the physical water conditions (water resources available, evaporation level, etc.) and other aspects such as water price or environmental regulation. Mining facilities often count on self-supplies of water, which might come from local water bodies, groundwater or from the sea (Figure 5). Water might also be supplied by the public network. Additional water resources are usually available from mine dewatering, which often satisfies the facility requirements and also may provide additional resources for other water users in the region. Although as a drawback, dewatering might lead to a drawdown of the water table under certain circumstances. Depending on the water quality requirements of the mining and industrial processes, water supplies might require pre-treatment. After the water has been used, the incurring wastewater is treated and discharged to nature. Facilities might set up different types of dedicated ponds and dams for wastewater management. Often, wastewater is reused and/or recycled and loop back in the facility for processes that are less demanding in terms of water quality (cascading use).

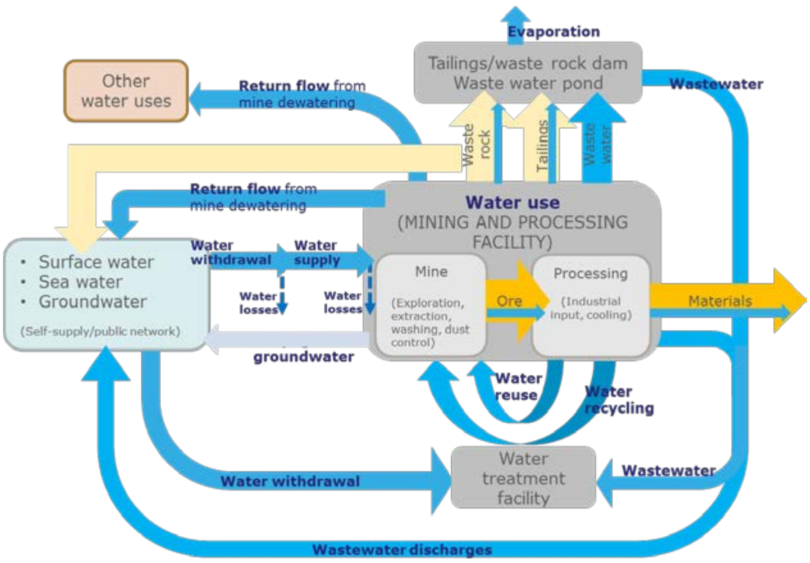


Figure 5: Use of water by a typical mining facility. Source: Vidal Legaz et al., (2018).

Beyond the direct use of water at the facility, mining relies on the use of auxiliary materials for onsite extraction and processing (such as chemicals), as well as technical equipment and often energy supplies that are produced offsite. The production of all these items requires additional water inputs.

In order to understand the impact of water use by the extractive sector data are needed on the absolute volumes of water used and on water intensity, which provides insight into water efficiency, and water discharges, which impacts the quality of water and soils. For a sound assessment of the water impacts of the sector, the specificities of the geographical location need to also be considered (Northey et al., 2016; Fonseca et al., 2014), since they determine the eventual level of impact to humans and on the natural ecosystems, and even the continuity of the extractive operation.

The assessment of water use by the extractive sector is a very complex task. First, water use is very industry-specific. Further, water supply and distribution networks are complex, often with both public authorities and private stakeholders involved. In addition, regulatory frameworks for water pricing, water allocation, etc. vary across countries and regions, which drive changes in water use and water efficiency differently. The sound assessment of water performance by mining activities is also challenged by the fact that water use and water production (from dewatering) often coexist (Schultze, 2012) and several water sources with different quality levels might be used.

2.4.2 Policy background on water use by extractive activities in Europe

In order to safeguard water resources, the Water Framework Directive (WFD) (European Commission, 2016) establishes the quality objectives for water bodies', and determines the need for establishing River basin management plans (European Commission, 2019) and reporting obligations on water-related data.

Although the industrial sector is regulated at EU level by the Industrial Emissions Directive, which requires the adoption of the so-called Best Available Techniques (BAT), detailed in the Best Available Techniques Reference documents (BREFs) (JRC, 2019), which include standards for the water use and water discharge of industrial processes, no BREF conclusions are available for specific mining operations beyond the specification in the just release BREF for the management of extractive waste, which anyway is not binding to the sector.

Apart from that, the impact of mining sites on water quality falls under the extractive waste directive (European Commission, 2006), currently under review, and which provides for measures, procedures and guidance to prevent or reduce as far as possible any adverse effects on the environment from extractive industries. The directive calls on all EU Member States (EU-28) to require the extractive industries to apply monitoring and management controls in order to prevent water and soil pollution. In addition, new industrial projects require an environmental authorisation according to the environmental impact assessment directive (EU, 2011), which also covers the use of water and the release of pollutants to water.

2.4.3 Available data on water use in Europe

Although not fully complete, EUROSTAT collects and harmonizes data on water use by the industry, based on data reported by Member States, covering also the mining sector. More complete data series are available directly from the national statistical offices and/or competent bodies. The European Pollutant Release and Transfer Register (E-PRTR) provides data on pollutant releases to water and industry reporting provides (limited) water data at facility level.

Here some insights extracted from Vidal-Legaz et al., (2018) are provided (see this report for further details and plotted data).

Eurostat, water withdrawal, water use and wastewater discharges

Eurostat collects and harmonises water statistics over time at national level that covers water use by the industry. Data are based on reporting by Member States following the Eurostat/OCDE joint questionnaire on inland waters (Eurostat/OCDE, 2014). Reporting is done on a voluntary basis, based on the guidance provided in the questionnaire, which details the methodology to be followed for the reporting, and which provides supporting data to compute the estimates when there are no direct measurements (e.g. water coefficient factors for industry). This source includes data on water withdrawal (abstraction)[22], water use[23] and waste-water discharges[24] by economic sector (see table below), following the NACE activity classification.

Data on water withdrawal, water use and water discharges are available for the mining and quarrying sector, with no further breakdown. Under 'mining and quarrying', water for the mining of metals or industrial minerals, etc. is reported together with that for oil and gas extraction — which are beyond the scope of this study.

Water withdrawal is the volume of water removed from any source, either permanently or temporarily. Currently available estimates cover water taken from self-supplies, both from the surface and from groundwater (data are reported as total and by water source). Water use is calculated as water withdrawal minus returned water, which includes supply from the public network and from self and other supplies. Water discharges are the volume of water after being used in industrial production, excluding cooling water.

The completeness of these Eurostat datasets is limited since data are missing for many countries and years, especially between 1970 and 2000, which is very incomplete and totally missing for water use. Data are missing for several Member States (Austria, Cyprus, France, Italy, Portugal and Spain). Furthermore, the set of Member State reporting is not comprehensive and varies for the different indicators. Incompleteness is partly due to the voluntary nature of reporting.

Also, although Eurostat provides extensive guidance on how the survey should be filled in, and how the water accounts could be estimated, the interpretation by Member States of this guidance seems to have introduced uncertainty in the estimates. Indeed it is considered that these data are useful to follow general trends but not for a sound time-trend analysis (ETC, 2017a).

The intensity of water use can be estimated based on Eurostat water use related to the economic output of each sector (also taken from Eurostat, measured as inflation – corrected gross value added). Production data in physical units, which could be used to estimate water intensity independently of economic fluctuations, are not available.

Member State national offices, water withdrawal

Water data by sector and over time can be also obtained directly from the Member States national statistical offices as described by Reynaud (2016) and further assessed by Vidal-Legaz et al., (2018). According to the latter study, some of the EU-28 provide relevant water-related data for specific raw materials sectors (see table in the section below – note that not all items

[22] Annual freshwater abstraction by source and sector (env_wat_abs).

[23] *Water use in the manufacturing industry by activity and supply category* (env_wat_ind, only manufacturing, including also C17 and C24) and *water use by supply category and economical sector* (env_wat_cat, which includes sector B). Although the data series name refers to 'water use' it contains explicitly data on 'water supply'.

[24] Generation and discharge of wastewater (env_ww_genv).

are fully up-to-date). While here we only refer to data on water withdrawal/use, national statistical offices often provide other data sets such as water discharges. The data listed here often are disaggregated by water source (surface and groundwater). The underlying data ranges from estimates for abstraction permits, actual measurements, estimates derived from production volume, etc.

These national statistical offices generally follow a more disaggregated sector classification than the Eurostat datasets, generally also adapted to the NACE classification. Data are usually provided for mining and quarrying yet data following a more disaggregated sector classification (mining of metal ores, mining of non-metallic minerals, etc.) are available for some Member States such as Germany, Spain or Poland. Generally, data completeness is higher than that of the Eurostat data sets. As a drawback, these data have not been harmonised among Member State, and the methodologies to compute the water indicators often differ, considering different inflows and outflows. This means that comparability among Member States cannot be granted.

Similar to Eurostat, in most cases, national statistical offices also provide data on the economic output of the sectors in monetary value, which could allow the calculation of water use intensity. However, production data in monetary value are not always available, and if so they are often reported following a classification not fully compatible with the water data.

European pollutant release and transfer register (E-PRTR)

E-PRTR (see description in the section on GHG emissions) provides pollutant-release data by facility, which can be aggregated by economic sectors (an own classification) and adapted to the NACE classification. The register covers pollutant releases embodied in treated wastewater from, among many other industrial activities, mining activities such as mining of iron ores, mining of clays and kaolin, mining of non-ferrous metal ores, other mining and quarrying n.e.c, quarrying of limestone, gypsum and chalk, quarrying of ornamental and building stone, limestone, gypsum, chalk and slate and operation of gravel and sand pits.

Pollutant-release data are provided for a complete substance set (heavy metals, inorganic substances, pesticides, organic pollutants, etc.), which also includes priority substances such as cadmium (Cd), mercury (Hg), nickel (Ni) and lead (Pb). Diffuse pollution sources reported under E-PRTR cover also all emissions below the fixed thresholds. However, for many countries the emissions below are at least partly quantified as stemming from point sources (ETC, 2017b). Accidental releases can be reported to the E-PRTR, yet there are very few records of accidental releases as compared with the number of total releases reported (ETC, 2017b).

As mentioned above, although industrial facilities are asked to report their activity data, the completeness of these data is very limited. Therefore, a sound estimation of the intensity of pollutant emissions to water is not possible.

Data from industry reporting

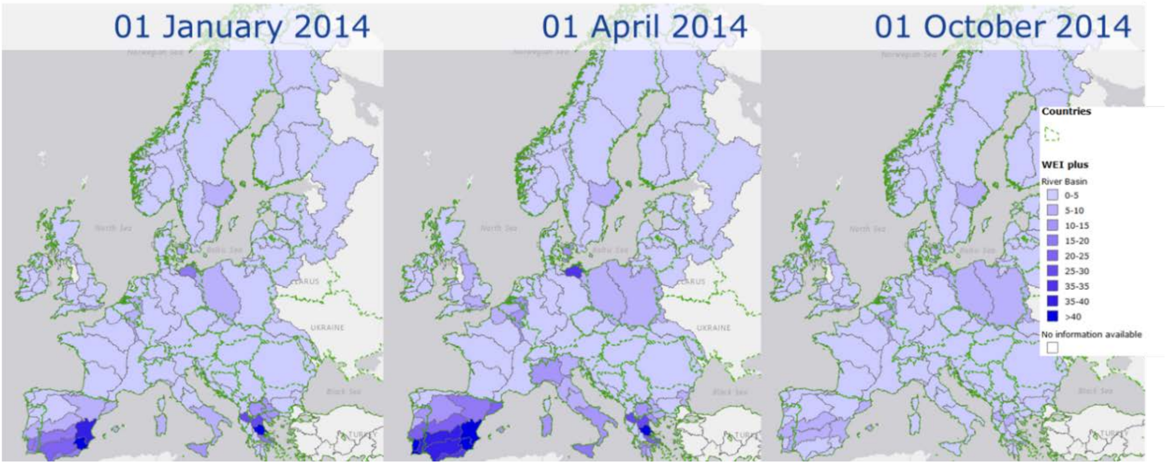
Private companies also disclose some water-related data, even though reporting schemes and studies are still highly heterogeneous. Examples are the disclosures on water withdrawal, consumption and discharges in the Global Reporting Initiative (GRI, 2019) and the CDP's water program (CDP, 2019) both covering also raw materials production companies, among others. Data from the GRI and CDP water schemes as well as from specific mining facilities are used in the scientific literature that follows up on the water performance of mining activities (e.g. Northey et al., 2013; Northey et al., 2016; etc.).

Having sound water intensity figures from these reporting schemes are challenged by the fact that the volumes of water reported are assigned to the whole production of the company. Moreover, companies are classified by the location of their headquarters, while production often takes place elsewhere. Furthermore, especially for the case of mining, water is often used for the production of several commodities simultaneously (co-production), and the disclosures do not specify how much water is used for each commodity/product.

Additional datasets

Other data sources exist that, although not providing data with comprehensive coverage and regular updates, it is worth to mention, since they provide complementary data. See Vidal-Legaz et al., (2018) for further details and plotted data.

Beyond data on water use and pollutant discharges, particularly in arid and semi-arid environments, it is important to consider the local level of water stress. As an example, the Water Exploitation Index plus (WEI+) (Figure 6) compares freshwater use with long-term water availability by river catchment and river network system (ECRINS). A WEI+ value above 20 indicates water stress and above 40, severe water stress.



Source: Vidal Legaz et al. (2018) - adapted from EEA (2017) (EEA, 2019).

Figure 6: WEI+ by European catchment and rivers network system.

Finally, it is worth mentioning that although it is not a data source itself, the International Mine Water Association (IMWA) (IMWA, 2019), gathers research from experts in the field worldwide.

2.4.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Official datasets			
Eurostat - Annual freshwater abstraction by source and sector (env_wat_abs)	Water abstraction for mining and quarrying (gross and total abstraction; abstraction from surface water and from groundwater) Million cubic meters, cubic meters per inhabitant	EU (data only for selected EU countries since limited data completeness)	http://appsso.eurostat.ec.europa.eu/nui/show.do?lang=en&dataset=env_wat_abs
Eurostat - Water use by supply category and economic sector (env_wat_cat)	Water use for mining and quarrying (from public water supply and from self and other supply) Million cubic meters	EU (data only for selected EU countries since limited data completeness)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wat_cat&lang=en
Eurostat - Generation and discharge of wastewater (env_ww_genv)	Wastewater discharge volume for mining and quarrying Million cubic meters	EU (data only for selected EU countries since limited data completeness)	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ww_genv&lang=en
Member States national offices* (competent authorities and state agencies identified by Reynaud (2016)	Water withdrawal/use for mining and quarrying and in some cases for specific mining sectors (by water source for some countries) Several volume units	AT, BG, DE, DK, EE, ES, HR, MT, PL (non-exhaustive list, following Reynaud, 2016). DE and PL datasets are particularly good and more disaggregated by mining activities	**Austria**: STATcube – Statistical Database of STATISTIC AUSTRIA (http://statcube.at/statistik.at/ext/statcube/jsf/tableView/tableView.xhtml), Dienstleistungen der Wasserversorgung sowie des Wasserhandels durch Rohrleitungen, **Bulgaria:** National Statistical Institute (NSI) – Water used by economic activity - total for the country (http://www.nsi.bg/en/content/5142/water-used-economic-activity-total-country). **Croatia**: Croatian Bureau of Statistics - Utilization of Water and Protection of Waters from Pollution in Industry (http://www.dzs.hr/default_e.htm). **Denmark**: Statistics Denmark (http://www.dst.dk/en) - Extraction and consumption (Water Accounts) by water type, measure, industry and time. **Estonia**: Statistics Estonia – (http://www.stat.ee/en) "Water extraction by country, economic activity, and type of water", http://pub.stat.ee/px-web.2001/Dialog/varval.asp?ma=EN048&ti=WATER+EXTRACTION+BY+COUNTY%2C+ECONOMIC+ACTIVITY+%28EMTAK+2008%29+AND+TYPE+OF+WATER&path=../I_Databas/Environment/04Natural_resources_and_their_use/10Water_use/&lang=1. **Germany**: Water use from Statistisches Bundesamt, Wiesbaden 2016 Material, raw material, water Extraction of water from nature and Receipt of water from waterworks or other established sources. https://www.destatis.de/EN/FactsFigures/NationalEc

			onomyEnvironment/Environment/MaterialEnergyFlows/MaterialEnergyFlows.html#Tabellen . GVA from National accounts of the Federation, https://www.destatis.de/EN/FactsFigures/NationalEconomyEnvironment/NationalAccounts/DomesticProduct/Tables/GrossValueAddedIndustries_BWS.html. **Malta**: National Statistics Office of Malta, https://nso.gov.mt. **Poland**: Water use from Central Statistical Office of Poland - Ochrona środowiska - Environment (2006-2015), http://stat.gov.pl/en/topics/environment-energy/environment/environment-2015,1,7.html (2015 report). GVA from the Statistical Yearbook of industry 2015, http://stat.gov.pl/en/topics/statistical-yearbooks/statistical-yearbooks/statistical-yearbook-of-industry-2015,5,9.html. **Spain** Data come from the publication "Cuenta satélite del agua en España (series 2007-2010)"- Use of water in manufacturing industry 2007-2010" by the National Institute of Statistics, http://ine.es/dynt3/inebase/index.htm?type=pcaxis&path=/t26/p067/p02/agua07-10&file=pcaxis
European Environment Agency - European Pollutant Release and Transfer Register (E-PRTR)	Release of pollutants to water	EU and EFTA countries	prtr.eea.europa.EU (data viewer); https://www.eea.europa.eu/data-and-maps/data/member-states-reporting-art-7-under-the-european-pollutant-release-and-transfer-register-e-prtr-regulation-21 (database)
Data from industry reporting			
Global Reporting Initiative – disclosure database	Water withdrawal by water source, percentage of water recycled and reused, water discharge by destination (and by quality, water sources significantly affected by withdrawal of water (data for a selection of mining facilities) Cubic meters and other	World (limited set of facilities), including some EU-28 Member States (Austria, Belgium, Czech Republic, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Poland, Slovakia, Spain, Sweden, The UK)	http://database.globalreporting.org/ (single disclosures can be searched for free, disclosure list under fee)
CDP's water program	Water consumption and water intensity	World (limited set of facilities)	https://www.cdp.net/en/water, https://www.cdp.net/en/water#a8888e63070314c2285625253a462815

Table 7: Key datasets for water use and mineral extraction in Europe.

**Note that data for Member States national offices is not fully up-to-date and may be not fully comprehensive for the whole EU.*

2.4.5 Recommendations for harmonisation and standardisation of water data

One of the main challenges of water data for extractive activities is the lack of harmonisation of the definitions for water indicators (e.g. water withdrawal, water use, discharges, etc.) across data sources and among countries. This is a frequent problem, which limits the capacity to carry out sound comparisons between different data sources and across countries. As illustrative examples, generally, by definition, water withdrawal includes intakes from all sources, yet the Eurostat dataset considers only water from self-supplies. Another example is the fact that many single countries use the denomination ‘water supply’ for water data that match the Eurostat definition of water withdrawal. Although this harmonization is more evident in the data generated by the national statistical offices, it might affect also the data reported by countries to Eurostat, and the data reported by private companies within their reporting schemes.

Sector disaggregation needs to be further developed. For Eurostat data and national statistics, mining activities are generally aggregated under the mining and quarrying sector, which cover also water use associated with oil and gas extraction. This impedes the identification of the activities contributing the most to water intakes and discharges. Beyond discriminating data on the mining of non-energy commodities, further disaggregation in the different mining sectors would be needed. Data at facility level would be the most suited, this type of data can be available generally from national environmental agencies at national, sub-national or even local level. Considering data at facility level would be key to understanding the key determinants of water demand.

In addition, not all data sources specify in a clear manner whether data comes from surface, groundwater or other sources. Counting on data to assess trends and patterns in, for example, the ratio between surface-groundwater resources is very relevant to understand pressures on key resources such as groundwater. Data on local water stress would be important to understand the potential impacts of extractive activities on water resources. Having sound estimates for this is still challenging given the sometimes complex and *ad hoc* water supplies network for mining sites.

Regarding data on water discharges, available data is either too detailed (E-PRTR data on single pollutant releases) or lacking detail on the quality parameters of the water discharges (Eurostat data on water discharges). It would be useful that E-PRTR reports not only on releases to water but also on water resources inputs. Finally, it is important to note that all data sources consider only water estimates under ‘normal’ operation conditions, i.e. they exclude accidents.

2.4.6 References

CDP (2019), CDP website, https://www.cdp.net/en/water

European Commission, EIP on Raw Materials (2018), “Raw Materials Scoreboard 2018", Publications Office of the European Union.

EEA (2019), Water exploitation index plus (WEI+) for river basin districts (1990-2015). https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-exploitation-index-for-river-2

European Commission (2019), Status of implementation of the WFD in the Member States. http://ec.europa.eu/environment/water/participation/map_mc/map.htm

European Commission (2016), The EU Water Framework Directive - integrated river basin management for Europe. http://ec.europa.eu/environment/water/water-framework/index_en.html

European Commission (2006), *Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006 on the management of waste from extractive industries and amending Directive 2004/35/EC.*

ETC (European Topic Centre on Inland, Coastal and Marine Water), EEA (2017a). Zal, N., Bariamis, G., Zachos, A., Baltas, E., Mimikou, M. *Use of Freshwater Resources in Europe 2002-2014. An assessment based on water quantity accounts*, ETC/ICM technical report 1/2017.

ETC, EEA (2017b). Van den Roovart, J., van Duijnhoven, N., Fribourg-Blanc, B., Siauve, S., Prchalova, H., *Emissions of pollutants to Europe's waters — sources, pathway and trends*, ETC/ICM Technical Report 3/2017.

Fonseca, A., McAllister, M. L., Fitzpatrick, P. (2014), 'Sustainability reporting among mining corporations: a constructive critique of the GRI approach'. *Journal of cleaner production,* 84:70-83.

GRI (2019) Global Reporting Initiative. https://www.globalreporting.org/Pages/default.aspx

IMWA (2019), web site of the International Mine Water Association IMWA. https://www.imwa.info/

JRC (2019), Reference documents under the IPPC Directive and the IED. http://eippcb.jrc.ec.europa.eu/reference/

Northey, S. A., Haque, N., Mudd, G. (2013), 'Using sustainability reporting to assess the environmental footprint of copper mining', *Journal of Cleaner Production*, 40, 118-128.

Northey, S. A, Mudd, G. M., Saarivuori, E., Wessman-Jääskeläinen, H., Haque, N. (2016), 'Water footprinting and mining: Where are the limitations and opportunities?' *Journal of Cleaner Production*, 135, 1098-1116.

Schultze, M. (2012). 'Maximising use of water produced by mining', *International mine water association 2012*, Bunbury, Australia, 11-19.

Vidal-Legaz, B., Torres de Matos, C., Latunussa, C., Bernhard, J.H. (2018), Non-energy, non-agriculture raw materials production: data to monitor the sector's water use and emissions to water, EUR 29424 EN, Publications Office of the European Union, Luxembourg, ISSN 1831-9424, ISBN 978-92-79-97037-5, doi:10.2760/007059, JRC113206.

2.5 *Biodiversity*

2.5.1 Background and definitions

Biodiversity is broadly defined as the variety of all life on earth and "it plays a key role in the functioning of ecosystems and the provision of ecosystem services which are essential for human life and well-being" (European Environment Agency, 2018). Biodiversity is impacted by all human activity and efforts are being made internationally to reduce the negative losses of biodiversity. Biodiversity can be specifically impacted by the extractive sector throughout the life cycle of operations. These impacts can be indirect or direct and positive or negative.

The main policy for protecting biodiversity across Europe is through protected areas, namely the Natura 2000 Network. This network is made up of sites protected under the EU Habitats Directive and the EU Birds Directive. Natura 2000 is designed to safeguard Europe's rarest and most endangered species and habitat types. Under the Birds, Directive member states designate Special Protection Areas (SPAs). Under the Habitats Directive Special Areas of Conservation (SACs) are designated by the member state (European Union, 2011). In some European countries, the Natura 2000 network overlaps with nationally protected areas. For example, in England, UK policy and law requires all SPAs and SACs to be designated nationally as Special Sites of Scientific Interest (SSSIs).

Designation as a SPA or SAC does not mean that human activity is excluded from these sites and surrounding areas. Even plans and projects that are likely to have a significant effect are not necessarily automatically refused permission if there are exceptional circumstances or no alternatives. This could be the case with mineral extraction, as minerals can only be extracted where they naturally occur. Assessment takes place on a case by case basis with mitigation measures put in place to prevent or reduce negative impacts. In addition, new habitat can be created elsewhere to compensate for the lost habitat.

There is also the potential for the industry to contribute positively to biodiversity and there are many good practice examples of this (see later). Biodiversity is important to the mineral extractive industry because stakeholders value it and there are regulations protecting it (Cowley and Vivian, 2007). Protecting biodiversity therefore contributes to social licence to operate (see section 3.3).

2.5.2 How can biodiversity be measured?

Biodiversity is mainly measured by counting the number of different species and their populations in different habitats at different times and assessing the losses and gains of these. These measurements are used to 'indicate' how well a species is doing so action can be taken to reduce the decline of the species thus preserving biodiversity. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is another indicator that is used to assess critically endangered species that are at risk of extinction.

The European Commission (EC, 2016) uses indicators to measure progress towards biodiversity targets. There are currently six targets as follows:

- Target 1 Protect species and habitats
- Target 2 Maintain and restore ecosystems
- Target 3 Achieve more sustainable agriculture and forestry
- Target 4 Make fishing more sustainable and seas healthier
- Target 5 Combat invasive alien species

- Target 6 Help stop the loss of global biodiversity

Each target has its own associated actions and it is through these that the biodiversity losses and gains can be measured.

Unfortunately, there is no simple measure for biodiversity due to its complex and dynamic nature, which presents challenges in choosing effective indicators (International Council on Mining and Metals, 2006). In addition, attempting to link these to the extractive industry is not a simple task.

2.5.3 Available data on biodiversity in Europe

There are numerous datasets that collect species data and habitat data at sites across Europe, however, these are not particularly useful for analysing the impact of mineral extraction. The datasets act as a baseline from which changes over time are monitored. The national planning systems across Europe can then use this baseline to ensure that before any mineral extraction takes place the biodiversity of an area is considered and protected or enhanced.

BISE – Biodiversity Information System for Europe

BISE acts as a single point of entry for data and information on biodiversity in Europe. It covers habitats, species and genetic resources. There are nine data centres and several data portals relevant to biodiversity.

The Biodiversity data centre (BDC) is one of the nine European environmental data centres managed by the European Environment Agency (EEA). It provides access to data and information on species, habitat types and sites of interest in Europe and to related products for biodiversity indicators and assessments (BISE, 2019). Biodiversity data and information will also be provided by the other eight data centres due to the cross cutting nature of biodiversity. These are as follows:

- air pollution
- climate change
- water
- land use
- soil
- forest
- natural resources
- waste

However, it is very difficult to 'drill' down into these additional datasets to find anything directly relevant to minerals extraction.

There are a number of other data portals listed on BISE that are cross cutting with biodiversity, for example:

- **Global Biodiversity Information Facility (GBIF) Data Portal** offers access to millions of biodiversity data records (see later for more detail on this). https://www.gbif.org/

- **Copernicus** is the European Programme for the establishment of a European capacity for Earth Observation. The most relevant services in the context of biodiversity are: land monitoring, climate change and marine environmental monitoring. https://www.copernicus.eu/en
- **Group on Earth Observations Biodiversity Observation Network (GEO BON)** is the biodiversity arm of the Global Earth Observation System of Systems (GEOSS). This aims to make biodiversity data more accessible to decision makers and the scientific community. https://geobon.org/
- **LifeWatch** is a research infrastructure with a particular focus on climate change and its impact on biodiversity https://www.lifewatch.eu/
- **The European Marine Observation and Data Network (EMODnet)** is the gateway to marine data in Europe. http://www.emodnet.eu/
- **EuMon (European Monitoring) and EU BON (European Biodiversity Observation Network)** combine to provide a portal for biodiversity monitoring in Europe. http://eumon.ckff.si/index1.php and http://www.eubon.eu/

European Red List of species

The ICUN Red Lists for various species including amphibians, bees, mammals and birds have been reviewed to produce a European Red List (EC, 2018). Geographic patterns (spatial data) and a corresponding report are available for most Red List species. Major threats are also shown (non-spatially) and include a category ‘energy production and mining’. The maps could be used with quarry location data to show the risks and opportunities to the biodiversity of particular species. Risks to endangered species in quarry locations could be identified, but also opportunities to potentially enhance species richness through planned restoration and during operation. It is likely that most quarry operators will be aware of these risk and opportunities through their Industry Biodiversity Action Plans (see below).

Land use, land cover and biodiversity

There is some overlap with this section on biodiversity and section 2.10 on land use. Many of the datasets outlined in the land use section are relevant to biodiversity, in particular, the CORINE database portal. The CORINE maps show two themes; land use or land cover. The land use theme includes a category for mineral extraction sites as one of the 44 classes that the dataset covers (the section on land use discusses this in more detail). This dataset will be very useful for comparing with protected areas such as the Natura 2000 network (see below).

Natura 2000 network

This dataset is useful to show the location of protected areas across Europe. These sites are protected via national planning legislation. Some of the sites in the network may be designated as part of the Natura 2000 network as a consequence of extraction, either accidentally through abandonment or deliberately through restoration. However, the number of sites associated with mineral extraction is not known. Highlighting sites that are as a result of extraction, be it through abandonment or restoration, could show the positive contribution that minerals extraction can have on biodiversity.

Currently, the Natura 2000 data table does not 'explicitly' hold information to let the user know a site was important as a consequence of mineral extraction. Sometimes this can be inferred from the data columns: 'site name', 'designation', 'quality', and 'other characteristics' as the word 'quarry' is mentioned. It may be possible to go through the table and filter those sites in the network that are a result of minerals extraction using translations of the word quarry for the different languages present. However, this is unlikely to capture all the sites related to quarrying and extraction. Alternatively, the Natura 2000 sites could be overlaid with the CORINE database to compare designated sites with areas that have a land use class as mining and quarrying. This could be used to highlight the positive contribution that minerals extraction can have on biodiversity.

Nationally protected areas

In addition to Natura 2000 sites, individual countries often designate sites as 'protected' through various pieces of international or national legislation. These are mapped at the European level in a dataset administered by the European Environment Agency (European Environment Agency 2019). A similar exercise to the Natura network (see above) could be undertaken to identify those sites that can be attributed to mineral extraction.

Biodiversity Networks

The Global Biodiversity Information Facility (GBIF) is one of the BISE data portals. It offers free and open access to biodiversity data on a global scale. Participant countries adhere to common standards and tools in order to share information about where and when species have been recorded (Global Biodiversity Information Facility, 2018). Unfortunately, there does not appear to be any scope to use this data to look at the impact of quarrying and extraction. This is because it only provides point source information on the number and type of species. If there was an interest in a particular species it may be useful to compare to the locations of quarry or if there was a particular interest in a quarry the reverse could be undertaken.

The UK has a similar facility, called The National Biodiversity Network (NBN) Atlas, again offering free and open access to biodiversity data such as occurrences and species. There is little scope to use this data to look at the impact of quarrying and extraction due to data being point source although there may be potential to compare this against spatial data for the extent of known mineral workings.

Industry Biodiversity Action Plans

Many extraction companies have biodiversity action plans and a number of these are publically available. These plans outline how the company will achieve biodiversity targets at individual sites. These could be used as examples of good practice of how biodiversity can be maintained or ideally enhanced alongside mineral extraction. However, these reports are fragmented, not readily available in one location and not harmonised across Europe so are of limited use for a regional assessment of the effects of mineral extraction on biodiversity.

Some examples from major European mineral producing companies include:

- EuroGypsum: http://www.eurogypsum.org/wp-content/uploads/2015/04/EUROGYPSUMPERFORMANCEINDICATORSBD.pdf
- CEMEX: https://www.cemex.com/sustainability/model/biodiversity
- Hanson Heidelberg Cement Group: https://www.hanson-sustainability.co.uk/en/water/site-biodiversity-action-plans

Another way of considering metrics for biodiversity is to look at the levels of investment and effort the industry is putting into biodiversity beyond what is required to gain legal consent. Company motives for biodiversity positive impacts include; offsetting, social licence to operate, and social exchange (Boiral and Heras-Saizarbitoria, 2017)

This investment and effort could be examined using industry sustainability reports, however, these are usually on a site by site basis making it hard to obtain an industry or geographic overview. Furthermore, there is no standard way of reporting between companies or sites, although there are commonly used guidelines, for example, see the Global Reporting Initiative (Global Reporting Initiative, 2011).

2.5.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Natura 2000	European protected areas	Europe / national	http://natura2000.eea.europa.eu/#
National designations	National protected areas	Europe / national	https://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-13
CORINE land cover	The spatial extent of mineral extraction, measured over 4 specific periods between 1990 and 2012.	Europe/ individual mineral extraction sites	https://land.copernicus.eu/pan-european/corine-land-cover

Table 8: Key datasets for biodiversity and mineral extraction in Europe

2.5.5 Recommendations for harmonisation and standardisation of biodiversity data

Data regarding biodiversity in Europe has achieved a good level of harmonisation due to the EU regulations surrounding it. Datasets such as the Natura 200 sites, nationally designated areas database, the BISE database and European red list species are all administered on a European level. What however is lacking is datasets, or the ability to link these existing datasets to mineral extraction.

The Natura 2000 sites could be used to demonstrate the positive impact extraction can have on biodiversity. In order to do this, the dataset will need to be analysed to highlight all those sites that are on existing or past extraction sites. This can be achieved through using filters in the database and searching for keywords such as' quarry', 'pit' or 'mine' in different languages. Alternatively, Natura 2000 sites could be overlaid with mines and quarries information in the CORINE dataset to analyse where they coincide. Mines and quarries databases also exist for many European countries, this is discussed in detail in section 2.10 on land use.

A similar methodology could also be applied for National Designations (for those that are not Natura 2000 sites) if data regarding the location and spatial extent of mining and quarrying activities could be obtained.

It may be possible to use the CORINE land use classification for mineral extraction and compare this to the spatial extent of the Natura 2000 sites to demonstrate points one and two above.

It should be noted, however, that these recommendations rely on good spatial coverage of existing, abandoned and restored mineral sites.

2.5.6 Good practice

There is a plethora of good practice guidance for reducing and mitigating negative biodiversity impacts, and enhancing biodiversity to create positive impacts across Europe. There are several examples of partnerships between the extractive industry and non-government organisations (NGOs) whereby a positive contribution to biodiversity is achieved through good practice.

Some examples include:

- BirdLife International and Heidelberg https://www.birdlife.org/europe-and-central-asia/partnership-heidelbergcement
- Nature After Minerals http://afterminerals.com/
- Quarry Life Award https://www.quarrylifeaward.com/participating-quarries

The Industry Biodiversity Action Plans (mentioned above) are also examples of good practice.

2.5.7 References

Biodiversity Information System for Europe (BISE). 2019. https://biodiversity.europa.eu/data

Boiral, O, and Heras-Saizarbitoria, I. 2017. Managing biodiversity through stakeholder involvement: why, who, and for what initiatives? Journal of business ethics, Vol. 140, 403-421

European Environment Agency. 2019. Nationally designated areas database. https://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-13

European Commission (EC). 2016. Biodiversity Strategy. European Commission Environment. http://ec.europa.eu/environment/nature/biodiversity/strategy/

European Commission (EC). 2018. European Red List. European Commission Environment. http://ec.europa.eu/environment/nature/conservation/species/redlist/index_en.htm

Cowley, M, and Vivian, B. 2007. The business of biodiversity: a guide to its management in organisations. (IEMA.)

European Environment Agency. 2018. Briefing - biodiversity [cited 11/07/2018]. https://www.eea.europa.eu/soer-2015/europe/biodiversity

European Union. 2011. EC Guidance on undertaking new non-energy extractive activities in accordance with Natura 2000 requirements. Luxembourg, European Commission,

Global Biodiversity Information Facility. 2018. Global Biodiversity Information Facility. [cited 8/8/2018]. https://www.gbif.org/

Global Reporting Initiative. 2011. Sustainability Reporting Guidelines & Mining and Metals Sector Supplement.

International Council on Mining and Metals. 2006. Good practice guidance for mining and biodiversity, ICMM London.

2.6 *Human health*

2.6.1 Definition of human health

Human health is a broad subject area and 'intimately linked' to environmental quality (European Environment Agency (EEA), 2013). The World Health Organisation acknowledges the interdependence of health with development and the environment. It notes that there are three principal objectives: to protect human health and wellbeing, to protect other forms of life and conserve biological diversity, and to protect the physical environment. It states that human health can only be protected if it is part of sustainable development (WHO, 1994). Human health is covered by the United Nations Sustainable Development Goal 3, 'ensure healthy lives and promote well-being for all at all ages'. The UN goals are very broad and cover child health, maternal health, HIV/AIDS, malaria and other diseases.

Historically, the impacts on human health have driven environmental legislation. The European Environment Agency lists the following as key issues that can impact human health: indoor and outdoor air pollution (fine particulate matter and ground-level ozone), poor water quality, poor sanitation, hazardous chemicals, noise, electromagnetic fields, ultraviolet radiation, nanotechnology, green spaces and the natural environment and climate change. The impacts on human health include respiratory and cardiovascular diseases, cancer, asthma, allergies, reproductive disorders and neurodevelopment disorders.

This chapter is, by its nature, cross-cutting with other chapters because of how intimately linked human health is with environmental quality at the highest level. For example, if the biodiversity is reduced then this will impact human health. If human rights are affected this can have a negative impact on human health. The same can be said for the other chapters as they all impact the environment. Specifically, this chapter will include noise and air pollution.

2.6.2 How can the impact of the minerals extractives sector on human health be measured?

Human health is measured by using environmental and social indicators as proxies of human health. In this chapter, only environmental indicators are considered because social indicators tend to be very high level and not directly attributable to the mining sector. For example; maternal care and child mortality, improving reproductive care, ending the epidemics of major communicable diseases; and reducing non-communicable and mental diseases (WHO, 2018) Environmental indicators may include water quality, water pollution, transboundary air pollution, air quality in urban areas and life expectancy. However, any assessment of health based on these types of measurements has many uncertainties. Different methodological approaches have tried to estimate the impacts of environmental factors on health, for example, the Environmental Burden of Disease (EBD) or environmental health impact assessments. Both these approaches have their limitations because they rely on single risk factors when in fact the impact on health often has complex interrelated factors involved. This leads to high uncertainties in the data (EEA, 2013).

The Environmental Burden of Disease considers workers in certain sectors, such as mining, to have an increased risk of occupationally acquired hearing loss. 'Globally, exposure to excessive noise at work caused 22% of hearing loss in 2010' (WHO, 2016). This means the disease burden of hearing loss due to the environmental factors is 22%. However, it is not possible to know how much of this could be attributable to mining as there are no figures for individual sectors of industry. Within Europe personal protective equipment (PPE) will be used as part of health and safety legislation to mitigate against exposure to unacceptable levels of noise.

According to the EBD, exposure to ambient air pollution is responsible for 8% of the environmental disease burden and this compares to 33% from exposure to smoke from cookstoves (WHO, 2016). Unfortunately, it is not possible to use the EBD data in a meaningful way to determine the contribution of mining to ambient air pollution.

The European Environment Agency uses a set of 12 indicators to measure the impact on human health. These are looked at below with regard to their relevance to the minerals industry.

- **Population exposure to environmental noise:** Noise Directive 2002/49/EC states that 55 dB (decibel) is the EU threshold for excess exposure to noise. Data for noise from major and minor railways, major and minor airports, industry and major and minor roads inside and outside of urban areas are reported. Noise from roads impacts people the most. Noise from industry has the least impact but these data are not sector specific. Noise country factsheets are available for most of the European countries.
- **Persistent organic pollutant emissions:** These are dioxins and furans, Hexachlorobenzene (HCB), polychlorinated biphenyl (PCBs), a total polycyclic aromatic hydrocarbon (PAHs). The main source of these related to the extractive industry would be those produced in the sectors ‘energy use in industry’ and ‘road transport’. However, these are small producers compared to the industrial processes sector, for example.
- **Heavy metal emissions:** These include emissions of cadmium, mercury and lead across various sectors. However, the resolution is insufficient to isolate the extractive industry specifically. The indicator focuses on the progress being made with reducing these elements in the environment. Energy use in the industry sector is one of the largest sources for these elements so the extractive industry may contribute to this. (See section 2.9 on energy use).

The above indicators are relevant to the minerals industry through energy use and transport. It may be possible to use a value per kilometre for transport and value per kilowatt of energy used to make some kind of measurement of the impact by the minerals industry.

- **Hazardous substances in marine organisms:** Heavy metals may be discharged into watercourses and abandoned mines may be a threat if mitigation measures are not put in place to ensure groundwater does not flood abandoned workings. According to the EEA, ‘mine discharges threaten the attainment of good water quality in a number of locations across Europe’.
- **Progress in management of contaminated sites:** Mining sites are dominant contributors to ‘soil contamination in Cyprus and the Former Yugoslav Republic of Macedonia (> 30 %),’ (EEA, 2019). These are difficult to separate as mining is agglomerated under ‘industrial and commercial activities which include industrial and commercial services, mining, oil extraction and production and power plants’. However, by far the greatest contributor to this type of pollution across Europe is the production sector (as opposed to the service sector).

The following indicators are not particularly relevant to the minerals industry but are included here for completion:

- **Emissions of air pollutants from large combustion plants:** This indicator looks at the emissions of sulphur dioxide and nitrogen oxides from large combustion plants.
- **Large combustion plants operating in Europe:** These plants emit pollutants to air, water and land. They are not of direct relevance to the extractive industry.
- **Water and food borne diseases:** This indicator is not directly relevant to the extractive industry. However, the extractive industry may contribute indirectly via climate change, but there is no way to attribute this.
- **Extreme temperatures and health:** This is not relevant to the extractive industry.
- **Floods and health:** This indicator looks at river and coastal flooding incidents which are not directly relevant to the extractive industry.
- **Vector borne diseases:** This is not relevant to the extractive industry.
- **Air pollution due to ozone: health impacts and effects of climate change:** This is not relevant to the extractive industry.

2.6.3 Available data on human health in Europe related to the extractive sector

There are numerous health related statistics including an 'App' of health statistics.

Human health datasets directly linked to the minerals industry are not widely available. It is probably fair to say that in Europe the health impacts associated with the minerals industry are very much mitigated through environmental and health and safety legislation.

In Europe, the contribution of particulate emissions, such as PM10, PM2.5, and total suspended particulates (TSP) from non-coal mining and quarrying is thought to be less than one percent of national levels. It is therefore not a significant contributor (EEA, 2016). Emissions factors have been developed that could be used with mining and quarry data to attribute the particulates emission rate of mining and quarrying activities (reported as grams emissions per megagram of mineral). However, these emissions factors do have a lot of uncertainty attached to them so they could only ever be used as a guide and caution must be exercised when using these factors.

2.6.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Emissions factors for the minerals industry	PM10 PM2.5 Total Suspended Solids (TSP)	Non-spatial	https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/2-industrial-processes/2-a-mineral-products/2-a-5-a-quarrying/view
European Health Information Gateway	Indicators of health impacts, but not attributable to the minerals industry	European / national	https://gateway.euro.who.int/en/
Eurostat	Good health and well-being statistics	European / national	https://ec.europa.eu/eurostat/web/sdi/good-health-and-well-being
The European health statistics app	General health	European / national	http://www.euro.who.int/en/data-and-evidence/the-european-health-statistics-app

Table 9: Key datasets identified for human health and mineral extraction

2.6.5 Recommendations for harmonisation and standardisation of human health data

Data harmonisation is difficult for health impacts due to the broad nature of the types of datasets available. There are numerous sources of statistics relating to human health available, but most are in no way attributable to the minerals industry. To link the majority of these datasets to the extractive sector further disaggregation, by industrial sector is required.

2.6.6 Good practice

In Europe, human health is protected by the minerals industry through the environmental and health and safety legislation that has to be complied with. Each company will have its own good practice based on this legislation.

2.6.7 References

EEA (2016) EMEP/EEA air pollutant emission inventory guidebook 2016 Technical guidance to prepare national emission inventories. https://www.eea.europa.eu/publications/emep-eea-guidebook-2016

(EEA) European Environment Agency, European Union (2013) Environment and human health. Joint EEA-JRC report No5/2013, EUR 25933 EN. ISSN 1725-9177

EEA (2019) https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/assessment

WHO (1994) Environmental Health Action Plan for Europe, Second European Conference on Environment and Health.

WHO (2016) Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks

WHO (2018) Health 2020 indicators. Updated 2018. https://gateway.euro.who.int/en/datasets/health-2020-indicators/

2.7 *Soils*

2.7.1 Background and definitions

Soil is defined as the top layer of the earth's crust and is formed by mineral particles, organic matter, water, air and living organisms. Soil formation is an extremely slow process and therefore can be considered as a non-renewable resource. The interface between earth, air and water, soil acts as a multifunctional centre for food and other biomass production, storage, filtration and transformation of many substances including water, carbon and nitrogen. Further, soil has a role as a habitat and gene pool, serves as a platform for human activities, landscape and heritage and acts as a provider of raw materials.

2.7.2 Measuring the potential impacts on soil from mineral extraction

Depending on the extraction type of mining (open pit mining, underground mining and surface or strip mining), various impacts on the environment are possible. For example, underground mining involves digging and tunnelling to reach deep mineral deposits, which causes deforestation. The loss of forest leads subsequently to the destruction of soils. Further, surface or strip mining removes surface vegetation and soil to exploit shallow deposits of coal. This especially causes soil erosion, as the fertile topsoil is blasted and displaced. General consequences of mining such as erosion, use of heavy machines, contamination lead to increased susceptibility to wind and water erosion, compaction and loss of fertility (ELAW, 2010). Due to soil degradation and deterioration of soil functions, the entire loss of soil may occur. Soil losses are irreversible mainly due to erosion and soil sealing. Mining and quarrying may cause acidification, soil contamination and soil compaction. Problems like soil contamination can be improved with suitable measures, such as clean-up and remediation plans, while soil compaction is a nearly irreversible process.

Soil contamination: Mining and mineral processing operations are often the most serious local sources of environmental contamination by metals and metalloids. The occurrence of heavy metals in soils is a matter of concern because of their toxicity to humans and their persistence in the environment. Spills, and leaks of hazardous materials, and deposition of contaminated windblown dust can lead to soil contamination (ELAW, 2010; Singh, 2016). Mining of mineral resources has the potential to alter microbial communities and affecting vegetation due to contamination through heavy metals and acid mine drainage, which can lead to the destruction of vast amounts of land. Abandoned mines and mines which activity is based on old operations, which may not have worked to modern environmental standards and which may be without environment management, constitute the highest risks with regard to environmental impacts. Methods to measure soil contamination consider soil composition (heavy metal content e.g., lead, copper, zinc, cadmium, mercury, chromium), soil strength (resistance to crushing), mineral content, pH, and cation exchange capacity (the total number of cations absorbed on soil colloids gives some indication of potential fertility) (ELAW, 2010).

Subsoil compaction: Macropores, large spaces created by plant roots, are the most vulnerable pores to soil compaction. The loss of macroporosity and pore continuity reduces strongly the ability of the soil to conduct water and air. Further, soil fertility is directly connected to soil compaction. Particularly the use of heavy machinery for mining and extraction causes soil compaction, as well as the leave of pits and heaps of waste material from underground and surface mining. To assess soil compaction, measurable parameters are bulk density, mechanical resistance and fluid conductivity.

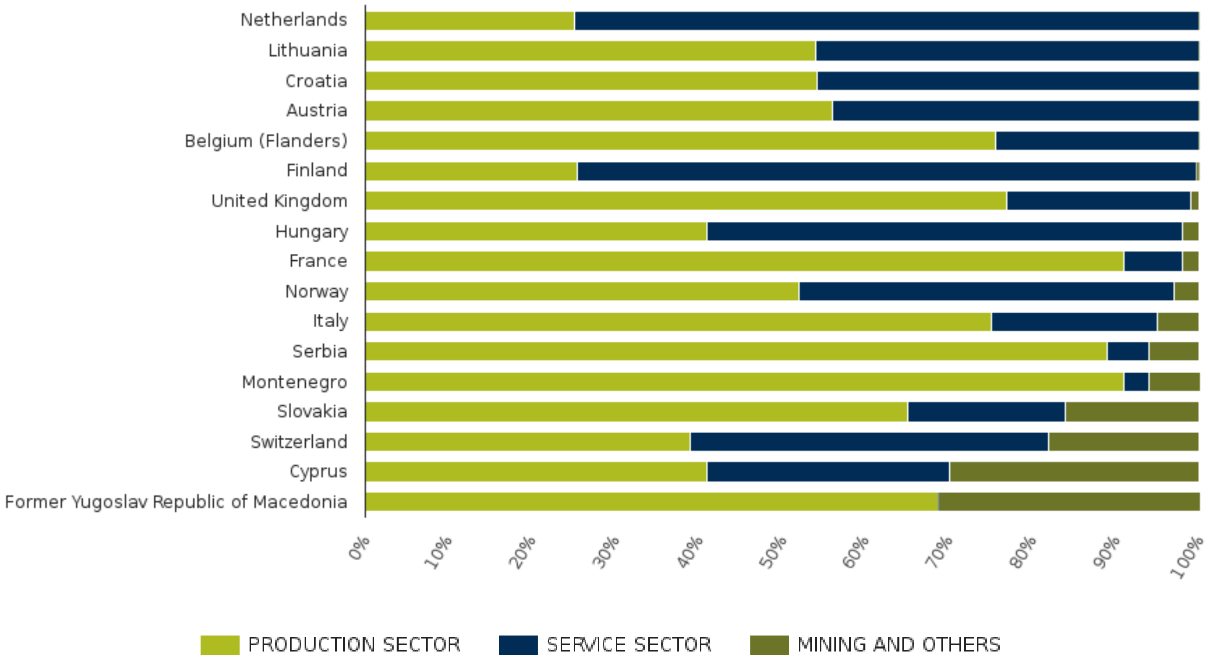


Figure 7: Breakdown of sectors responsible for soil contamination (published by the European Environment Agency, data collection provided by the Joint Research Centre).

Mitigation and benefits of mining:

Reclamation is the process to restore the ecological integrity of disturbed mine land areas. It includes the management of all types of physical, chemical and biological disturbances of soils such as soil pH, fertility, microbial community and various soil nutrient cycles that makes the degraded land soil productive. Ecological restoration and mine reclamation have become important parts of the sustainable development strategy in many countries. Good planning, e.g. mechanical separation, extraction and storage, and environmental management will minimize the impacts of mining on soil and will help in preserving eco-diversity.

2.7.3 Data availability

Strategies for soil monitoring and protection are not adequately developed at European or national level, as compared with already existing monitoring, assessment and policy frameworks for air and water. A broader policy framework is needed which recognises the environmental importance of soil and takes account of problems arising from the competition among its concurrent uses (ecological and socio-economical) (EEA Report, 1999).

National soil monitoring systems exist throughout Europe. The Soils Map Viewer (UKSO) of Britain provides data on various soil properties (chemistry, pH, textures etc.) managed by different organisations (http://mapapps2.bgs.ac.uk/ukso/home.html).

Although there is no EU wide soil protection law, there are several national approaches to establish indicators and threshold values. For example, in Romania, the valuation of soil pollution is carried out according to Order 756/3.11.1997, which sets the typical values, alert thresholds and action levels for inorganic and organic pollutants, by type of land use. Germany has a similar approach (Bundes-Bodenschutz, 1999), whereby threshold values consider the soil use, i.e. soils for agriculture have lower threshold values than soils for industry. It is assumed that contents below the threshold values do not affect the soil functions and the environment. Other countries such as the Netherlands concentrate only on point pollution. Spanish environmental authorities established site-specific criteria for metals (As, Cd, Cu, Pb and Zn) in the soil, which provides guidance for further remedial actions (BRGM, 2001). Chemical elements in soil and sediments have to respect distinct criteria, according to the near future land use (JRC Technical report, 2016).

Although not specific to mining activities, it is important to have an accurate baseline of soil data to assess any impacts development activities may have. There is an abundance of data regarding soils on a variety of scales within Europe.

Available data sets of the European Soil Database (ESDB) are described in the following. Further detailed information can be taken from the "Soil Atlas of Europe".

1) The Soil Geographical Database of Eurasia at scale 1:1,000,000 (SGDBE): This database is a simplified representation of the diversity and geographical variability of the soil coverage at a European level.
2) The Pedotransfer Rules Knowledge Database (PTR): As for pedotransfer functions, a pedotransfer rule is a tool that enables the estimation of a soil property using available information that corresponds to numerous biological, chemical, mechanical and hydrological properties of soil, e.g., topsoil organic carbon content, topsoil and subsoil mineralogy, topsoil and subsoil packing density etc.
3) The Soil Profile Analytical Database of Europa (SPADE): This database connects the Soil Typological Units (STU) of the Soil Geographical Database of Europe with chemical and physical soil profile data that would be representative of these STUs. Since particular measurements regarding hydraulic properties of soils are very expensive and are thus generally not performed, estimated soil profiles are developed in case parameters such as texture, electric conductivity and pH are lacking.
4) The Database of Hydraulic Properties of European Soils (HYPRES): To develop this database, 20 institutions from 12 European countries collaborated to establish a database about hydraulic properties of European soils (HYPRES). Data for 5521 horizons were collected and analysed to define pedotransfer functions for estimating soil water retention and hydraulic conductivity for topsoil and subsoil using the texture class of the Soil Geographical Database of Europe.

The European Soil Data Centre (ESDAC) publishes relevant data sets in Europe and currently provides links to 22 regional soil datasets for Belgium, Germany, France, Italy, Spain and United Kingdom (Scotland) on their website (https://esdac.jrc.ec.europa.eu/content/regional-data).

The LUCAS SOIL (Land Use/Cover Area frame statistical Survey Soil) is a topsoil survey acting throughout the European Union, providing policy-relevant statistics on the effect of land management of soil characteristics. The main aim of the LUCAS Soil programme was to create the first harmonised and comparable dataset of topsoil properties at the EU scale. This was made possible because (i) all samples were collected following the same sampling protocol and (ii) all samples were analysed by a single laboratory using standard analytical methods (ISO).

The ESDAC of the European Commission created a project to collect data on contaminated sites from national institutions in Europe based on the European Environment Information and Observation Network for soil (EIONET-SOIL). The data were collected in the period 2011-2012 from representative institutions in 38 European countries, providing official soil data at national level. A special focus was given to the industrial and commercial sectors such as mining, oil extraction and production, and power plants, causing soil contamination. Although the EIONET-CSI (Contaminated Sites) data set displays a comprehensive data set, there are several heterogeneities due to different ways of interpreting contaminated sites, and large uncertainties in terms of methodologies and data (Panagos et al., 2013).

There is no common recommendation for undertaking the development of post-mining regions after mine closure nor is there a common definition of good practices or policy in this field. Several European projects or studies like READY 2006 (Rehabilitation and Development in Mining Regions) and REKULA 2006 (Restructuring Cultural Landscapes) have focused on revitalising post-mining land and society, but they have failed to assess the benefits and delivery of projects (Marot and Mali, 2012). There is a need of basic standardised criteria for mine closure plans across Europe, which can be based on the methodological approaches already defined in European working groups like CARACAS (Concerted Action on Risks Assessment for Contaminated Sites) or CLARINET (Contaminated Lands and Risks Network for European Technologies). There exist several national mining closure plans and recommended guidelines such as the Finish Mine Closure Handbook and Swedish Guidelines. Several European countries have monitoring programmes on a national level, e.g., Bulgarian national databases concerning mining, waste and related environmental information are created by different organisations. Approaches and methodologies for environmental impact assessment are detailed by Jordan and D'Alessandro (2004). For countries such as Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia there are also national programmes, projects and inventories related to mining, mining waste and environmental impacts (Jordan and D'Alessandro, 2004).

The European Commission introduced the Directive 2006/21/EC of the European Parliament and Council on the management of waste from the extractive industries (The Mining Waste Directive). The aim is to reduce the negative effects of mining and to regulate the waste produced by mining industries. The Directive came into force in England and Wales on 7 July 2009 implemented by the Environmental Permitting. Article 20 of the Directive requires Member States to publish, by 1 May 2012, an inventory of closed and abandoned mining waste facilities that are causing serious environmental impacts or have the potential to cause such an impact (Potter and Johnston, 2014).

Cross cutting case studies

Individual EU countries such as Germany, Denmark, Czech Republic and the Netherlands already have national legislation about soil conservation, but the majority of EU countries are just starting to introduce basic regulations.

Regarding soil functions and the impact of degradation processes over time, it is essential to develop decision support systems for land evaluation such as MicroLEIS DSS (system for agricultural soil protection with special reference to the Mediterranean region developed by Consejo Superior de Investigaciones Científícas/ /Instituto de Recursos Naturales y Agrobiología de Sevilla-CSIC-IRNAS). They are very appropriate tools to include the soil and climatic attributes for better identification of soil contamination and vulnerable zones and, eventually, for the formulation of action programs. A few examples of developing programmes are described in the following.

The project ENVASSO (Environmental Assessment of Soil for Monitoring) managed by the Federal Institute for Geosciences and Natural Resources (BGR) aims to design and test a single, integrated, operational and EU-wide set of measurable criteria and indicators as a basis for a harmonised comprehensive European soil and land information system.

The project GS SOIL aims to establish a cross-border harmonisation of soil relevant data by means of recently used methods and best-practice examples. The objective is a structural specification for the description and harmonisation of spatial soil data within Europe as well as the operation of a corresponding Spatial Data Infrastructure (SDI). On the GS Soil portal, European soil data from heterogeneous sources are bundled and best practice expertise is exposed.

The objective of the RAMSOIL project is to provide scientific guidelines on possible EU parameter harmonisation. These are based on detailed information on present risk assessment methods of soil threats within EU Member States. In RAMSOIL, present risk assessment methods used in the EU are collected and evaluated by thematic coordinators and thematic partners. Various methods are used in the EU Member States for the risk assessment for different soil threats related to various agricultural practices (compaction, erosion, landslides, organic matter decline and salinization). These methods are based on different approaches, where different parameters are entered, as well as different values occasionally are used for the same parameter. Currently, RAMSOIL reviews and provides scientific support on current risk assessment methods, especially which parameters can and should be harmonised. For parameters, which should not or cannot be harmonised, scientific evaluations will be provided.

The PECOMINES project involves Central and Eastern European Countries such as Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, in an EU research action on the environmental impact of mining waste in collaboration with Directorate General (DG) Environment and the European Environmental Agency (EEA).

2.7.4 Key datasets identified

Name of data set	Metrics considered	Special coverage/resolution	Link
European Soil Database (ESDB)	Soil parameters	Europe/country	https://esdac.jrc.ec.europa.eu/resource-type/european-soil-database-soil-properties
Soil Threats Data	Soil erosion, organic carbon decline, compaction, salinization, soil biodiversity decline, land take, food security, landslides, heavy metals	Europe/country	https://esdac.jrc.ec.europa.eu/content/esdac-themes
Soil Point Data (LUCAS and SPADE 2, SPADE M)	Particle size distribution, pH, organic carbon, carbonate and phosphorus content etc.	Europe/country	https://esdac.jrc.ec.europa.eu/resource-type/spade-2; https://esdac.jrc.ec.europa.eu/resource-type/spadem
Soil Projects Data	Various soil properties	Europe/country	https://esdac.jrc.ec.europa.eu/resource-type/soil-projects-data
Soil Geographical Database	Diversity and geographical variability of the soil coverage	Europe	-
HYPRES	Hydraulic soil properties	Europe	-
EIONET-CSI	Soil data especially of contaminated sites due to mineral/oil extraction and production	Europe/country	-

Table 10: Key datasets for soil and the minerals sector in Europe

2.7.5 Relevance/usefulness of the data sets

The available datasets related to soil are not specific to mining activities, but it is important to have an accurate baseline of soil data to establish any environmental impacts the mining activities may have. There are numerous datasets regarding soils on a variety of scales within Europe, which are very useful to report at least common soil characteristics and properties. These datasets should be widened to monitor modifications of soil characteristics, especially in areas of mining activities and mining waste deposits.

2.7.6 Recommendations for harmonisation and standardisation

It is important to have standardised and harmonised baseline data on soil before specific impacts of extraction are addressed. In general, there is a gap in industry specific data or data relates to ground conditions, which hampers the possibility to work out causes of any contamination and soil degradation.

The European Environment Agency aims to develop a European soil monitoring network to achieve data comparability due to the harmonisation of methods, implying the calibration of the monitoring networks through a common reference method.

There is a need for a harmonised approach to soil monitoring and data assessment of Europe's soil. This requires the establishment of a data flow and collection programmes on Europe's soils.

To assess a standardised and harmonised monitoring programme on soils across Europe, first the standardisation of terminology in various European languages would be helpful to create a framework and facilitate collaboration. Furthermore, in order to summarise the information at the European level, it is important to identify the type of information and methods commonly used in the soil assessment as a guide to data collection (JRC report, 2016). There is neither a definition of soil protection as a clear objective at European level nor soil indicators that are necessary to guarantee the linkage of all environmental legislation and policy initiatives. The lack of a definition of soil protection and soil indicators hinders the complete integration of soil protection objectives into European policies.

A European cross-border description of soil condition status and change requires the availability of harmonised and comparable soil data, but at the European level data sources and database management are extremely heterogeneous. Building on experience within the European Soil Bureau Network, data delivered by national or regional data centres are centrally stored and lack further updating.

The proposal for a Soil Framework Directive from the European Commission aims to establish a common, harmonised approach for the protection and sustainable use of soils in Europe (DNR/EEB Report, 2011). A Soil Communication was first proposed in 2002 and underwent a consultation process (Van-Camp, 2004) which resulted in the development of the Draft Soil Framework Directive COM (2006) 231 and the proposal of the Directive (SFD) (COM (2006) 232) in 2006. The proposal considers common principles for protecting soils across the EU, and EU Member States will be in a position to decide how best to protect soil and how to use it in a sustainable way on their own territory. The European Parliament adopted its first-reading opinion on 14 November 2007. The Committee of the Regions the Economic and Social Committee delivered their opinion on 13 February and on 25 April 2007, respectively. In Council, the proposal was repeatedly discussed but always ran into a blocking minority. Since the proposal is being pending for several years without a qualified majority in the Council, the Commission took the decision to withdraw the proposal for a Soil Framework Directive on 30 April 2014 (http://ec.europa.eu/environment/soil/process_en.htm).

There is a substantial gap in consistent information on a European level, how mining wastes in EU Member States and Candidate Countries are managed, what their major hazards are and where the sites generating the greatest hazards are located, including abandoned mines. This information is needed to assess the whole range of environmental impacts caused by mining across the different policies related to the protection of soil resources. The key problems hindering a standardisation and harmonisation of datasets related to mining and mining waste are: 1) existing datasets are not comparable, 2) a lack of standard methods for collecting inventory data for baseline assessment, 3) a lack of standard methods for ranking mine sites on the basis of environmental risk assessment, 4) a lack of standard methods and networks for harmonised long-term monitoring, and 5) a lack of specific EU legislation and directives that consider soil contamination in relation to mining extraction. For example, the combination of comprehensive data sets like LUCAS and EIONET-SOIL would be an important step in assessing soil contamination in Europe (Panagos et al., 2013).

In order to support EU soil management policies, soil-related indicators need to be developed which requires appropriate data collection and establishment of harmonised datasets for the EU Member States. The objective is to apply the same terminology in all countries in subsequent data collections. Difficulties arise from the fact that countries may interpret specific data in different ways, which lead to increase heterogeneities in data reported (Panagos et al., 2013).

2.7.7 References

BRGM, 2001, Management of mining, quarrying and ore-processing waste in the European Union, Report BRGM/RP-50319-FR,79 p., 7 Figs., 17 Tables, 7 annexes, 1 CD-ROM (Collected data)
http://ec.europa.eu/environment/waste/studies/mining/0204finalreportbrgm.pdf

Environmental Law Alliance Worldwide (ELAW), 2010, Guidebook for Evaluating Mining Project EIAs

Environment in the European Union at the turn of the century, 1999, Environmental assessment report No 2, European Environment Agency

European Soil Bureau Network European Commission, 2005, Soil Atlas of Europe, 128 pp Office for Official Publications of the European Communities, L-2995 Luxembourg

Joint Research Centre, European Commission Technical Report, 2016, Soil threats in Europe, Status, methods, drivers and effects on ecosystem services

G. Jordan and M. D'Alessandro (eds) 2004: Mining, mining waste and related environmental issues: problems and solutions in Central and Eastern European Candidate Countries – Joint Research Centre of the European Commission, Ispra, EUR 20868 EN, ISBN 92-894-4935-7, 208 p

German League for Nature and Environment (DNR)) and European Environmental Bureau (EEB), 2011, Soil: worth standing your ground for, Arguments for the Soil Framework Directive.

Marot N. and Černič Mali B., Using the Potentials of Post-Mining Regions – A Good Practice Overview of Central Europe. In: Post-Mining Regions in Central Europe: Problems, Potentials, Possibilities, 2012, oekom, München

Panagos, P., Liedekerke, M. V., Yigini, Y., Montanarella, L., 2013, Contaminated Sites in Europe: review of the Current Situation Based on Data Collected through a European Network, Jounral of Environmental and Public Health, v. 2013, p. 11., http://dx.doi.org/10.1155/2013/158764

Potter, H. and Johnston, D., 2014, Inventory of closed mining waste facilities, Environment Agency

Singh, R.S., 2016, Environmental and social impacts of mining and their mitigation, Conference Paper, national Seminar, ESIMM 2016

2.8 *Recycling and re-use of materials*

2.8.1 Definition

Recycling is defined as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. This includes reprocessing of organic material but not energy recovery and reprocessing into materials that are to be used as fuels or for backfilling operations. Re-use means any operation by which products or components that are not waste are used again for their original purpose. Both definitions are laid down in the Directive 2006/21/EC. The definition of waste is as defined in Article 1(a) of Directive 75/442/EEC, saying that waste means any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force. Mining waste also means materials that result from exploration, mining and concentration of substances legally determined and monitored by laws on mines and quarries (BRGM, 2001).

Many routes for recycling and re-use of mining wastes (waste rocks, mine waters, mine drainage sludges), processing wastes (tailings) and metallurgical wastes (bauxite red mud, historical base metals smelting slags, phosphogypsum) exist. It is important that their economic and environmental viability is assessed prior to adoption (Bian et al., 2012). The majority of mining waste is still being placed into waste storage facilities. Waste rock may comprise a potential resource of minerals and metals. It can find use as backfill material for open voids, in landscaping application, as capping for waste repositories, as asphalt components, as aggregate in embankment, road and pavement construction and feedstock for cement and concrete (Lottermoser, 2011). Bian et al. (2012) and references therein lists various opportunities for mining waste re-use, e.g. waste rocks and iron/steel slags have been used as alternative aggregates for construction of roads and railroad banks; waste rocks and tailings as auxiliary source materials for cement, hollow bricks, concrete and glass production; and crushed and mixed waste rock and tailing material as backfill in mined cavities. Recycling and re-use options of mining waters include recovery of metals from acid mine drainage (AMD) waters for industrial or agricultural use and as coolant or heating agent. New technologies like filtration, reverse osmosis and ion exchange may enables the converting of mining waters into drinking water (Lottermoser, 2011). Mine drainage sludges may be recycled to extract hydrous ferric oxides and manganese for paint pigments and pottery glaze, respectively (Lottermoser, 2011).

2.8.2 Data availability

Eurostat statistics on mining waste only provide a database on “Generation of waste by the Mining and quarrying sector, by country, year and waste category, in kg per inhabitant and tonnes”. Data of recycling rates are available for municipal waste, household waste and packaging waste on the website of the European Environment Agency and Eurostat. Recycling rates for mining wastes are not available. For example, as pointed out by the BRGM (2001) in the German Potash Industry, solid waste is 22% recycled, 58% dumped and 7% backfilled, the liquid waste is 8% deep well disposal and 5% discharged into rivers (Kali und Salz GmbH). Waste rock may had no market. If a market later developed, the rock stored temporarily may be sold as aggregate when environmental specifications are met.

Detailed French databases are used by Bellenfant et al. (2013) for demonstrating cross-cutting case analyses on French mining sites: 1) ProMine Anthropogenic Concentrations (AC) database

(Cassard, 2012), 2) BDSTM (French Database of Sites and Mining Titles) and 3) Dechminue database.

The EU-FP7 **ProMine** project from 2009 to 2013, developed a Pan-EU GIS data management and visualisation system for natural and manmade mineral resources (http://gtkdata.gtk.fi/Promine/default.htm) (Bellenfant et al., 2013, Cassard et al., 2015). The ProMine AC database emphasizes major anthropogenic concentrations and includes data regarding volume or tonnage and metal content (i.e. possible presence of strategic metals). The total number of records in the database is 3,412, among which 644 are located in France.

The BDSTM (Bouroullec et al., 2001) Database of Sites and Mining Titles is used by the French Geological Survey (BRGM) to identify mining sites that need environmental monitoring, including environmental data but this can also include data from mineral deposits like the location of tailings and sometimes their tonnages and grades.

The Dechminue database (Thomassin, 2001) was developed during 2000 and 2001. This database is based on a European project and pinpoints many mining waste sites over 9 European countries (Bulgaria, Finland, France, Germany, Greece, Ireland, Portugal, Spain and Sweden) with their location, the period of activity, the type of process and the type of waste generated.

The study of Lèbre et al. (2017) describes the role of the mining industry within the circular economy, demonstrating that mine sites could be remediated in accordance with the circular economy principles. The principal aim of circular flows within the economy is to keep resources in use for as long as possible and limit final waste disposal. The operation of mines through cost-effective and environmental extraction of minerals will minimize the loss of non-renewable resources, which also can be viewed as a contribution of the mining industry to circular economy objectives (Lèbre et al., 2017).

The ProSUM project aimed to provide a state of the art knowledge base by using the best available data that are harmonised and continuously updated, allowing the recycling industry and policymakers to make more informed investment and policy decisions and to increase the supply and recycling of secondary raw materials. Batteries, electrical and electronic equipment, vehicles and mining waste contain both significant amounts and a large variety of raw materials, including base metals, plastics, precious metals and critical raw materials (CRMs). ProSUM intended to improve and expand the knowledge of mining and mineral processing. Therefore, they gathered data from mines and mineral processing plants, conducted sampling and analysis of mining waste and present a complete characterisation of waste including CRMs (Huisman et al., 2017).

2.8.3 Enhancing data availability

In 2012 the Consultative Commission on Industrial Change (CCMI) on the processing and exploitation of industrial and mining waste deposits in the European Union made several observations and proposals as no Europe-wide database exists to date on the location and the physical and chemical characteristics of mining waste and other industrial deposits. They suggest to reassess the economic potential of waste resulting from old industrial activities and to make this domain environmentally sound (Bellenfant et al., 2013).

The “Assessment of Member States' performance regarding the implementation of the Extractive Waste Directive” from 2017 reports information on policies and practices with respect to reprocessing of extractive waste of 22 European Member states.

National policies and practice examples

The BRGM summarises EU country legislation on mining waste of 15 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom) (BRGM, 2001).

The Minventory metadata portal provides information about relevant authorities responsible for collecting and publishing datasets on mining waste. The datasets covers the EU28 and a number of neighbouring countries (https://ec.europa.eu/jrc/en/scientific-tool/minventory).

For example in Austria, materials described as extractive waste are termed as “barren rock”, and are excluded by the Austrian waste law. These materials are governed by the “mineral raw material law”, which directs to deposit not usable materials from mining operations in dumps, tailing ponds or to use them for technical and safety measures such as backfill within the mining site (BRGM, 2001).

The German definition of mining wastes as “mining structural residues” is based on the definition of drop (waste) from the German circuit economy law, referring to all residues of industrial and public process either used (waste to recycling) or eliminated (waste to removal).

The United Kingdom introduced an extension of the Mine and Quarries Act 1954 termed in 1969, stating to prevent disused tips constituting a danger to members of the public.

The “Assessment of Member States' performance regarding the implementation of the Extractive Waste Directive” summarizes detailed national policies and practice examples for the reprocessing of wastes. Four EU Member States have indicated that a defined strategy has already been adopted on reprocessing waste from mineral extraction. For example, in Belgium (Walloon region) a national strategy foresees the recovery of unpolluted topsoil and loose rock for backfilling operation usage, development work in urban sites and reclaim work of polluted sites. Also, calcareous dust can be used as souring and flocculating agent in chemical and water treatment industry, respectively. In Bulgaria, the National Strategy for Development of Mining Industry includes as a principle the importance of recycling and reusing of raw materials. Ireland has been implemented the “Management of Waste from the Extractive Industries” strategy that indicates the obligation of operators and authorities when dealing with waste from extractive activities. Sweden reported that the 1) EPA strategy on long-term management of extractive waste and 2) Guidelines on reusing extractive waste for construction projects have been adopted. The Environmental Protection Agency in cooperation with the Swedish Geological Survey works on a national policy for the management of extractive waste considering the assessment of costs and remediation measures. This policy was expected in April 2017.

2.8.4 Case studies

A range of case studies and EU funded projects show that the industrial mineral sector endeavours to quantify and reduce the overall impact on the environment. A universal method for a re-use of all kinds of mining and mineral-processing wastes is not feasible, as each kind of waste has its own properties and therefore potential for recycling and re-use. In addition, local environmental conditions such as the proximity to drinking water or depth of mining activity can influence their fate (Bian et al., 2012).

The Industrial Minerals Association (IMA) Europe gather available data on the recycling rate of several industrial minerals. The calculation of recycling rates of industrial minerals via different end use applications resulted in the following total recycling rates (data from April

2013): Bentonite (50%), Silica (73%), Lime (68%), Feldspar (67%), Kaolin and Clay (49%), Calcium Carbonate (58%), Talc (60%).

Project/Future studies	**Recycling and reuse**	**References**
"Experl" (Efficient exploitation of EU perlite resources for the development of a new generation of innovative and high added value micro-perlite based materials for Chemical, Construction and Manufacturing)	Development of sustainable and innovative solutions for the extraction, processing, use and re-use of minerals Development of micro-sized closed structure perlite and similar micronized perlite based particles to improve the functionality of perlite such as durability and weight at lower costs.	CORDIS European Commission
STOICISM ("Sustainable Technologies for Calcined Industrial Minerals")	Development of new, innovative, clean and resource efficient mineral processing routes and technologies for use and re-use of minerals and waste for energy along the entire value chain	CORDIS European Commission
Natural drying of bentonite in open fields in Milos, Greece	Reduction of energy consumption and CO_2, as well as optimisation of resource efficiency	IMA-Europe Report 2018
Kaolin waste as source of Light Rare Earth Elements (LREE) in the UK	Assessment of viability of kaolin processing waste from Cornwall operations of Imerys for process and supply of LREE and metals	IMA-Europe Report 2018
METGROW+ project	Development of new metallurgical technologies for extracting valuable metals from metallurgical waste and low-grade ores in the most cost-effective and environmentally-friendly process	http://metgrowplus.eu/ METGROW Plus D2.6
Reprocessing of tailings • Sand-rich tailings • Clay-rich tailings • Manganese-rich tailings • Bauxite tailings • Copper-rich tailings	Mixing with cement and use as backfill in underground mines Use as addition to sandy soils and for manufacturing of bricks, cement, floor tiles and porcelain Use in agro-forestry, building and construction materials, coatings glass, ceramics and glazes Sources of aluminium Extenders for paints	Lottermoser, 2011
Bauxite red mud	Re-use for environmental compatibility and metal trapping capacity of seawater-treated red mud at Sardinia (Italy)	Brunori et al., 2005
Base metal-containing smelting slags	Recycling to extract Cu, Pb, Zn, Ag and Au	Lottermoser, 2011

Table 11: case studies for recycling of waste products from mineral extraction

There is a number of other studies concerning mining waste reprocessing (Bellenfant et al., 2013 and references therein):

i) The recovery of cobalt by bioleaching from pyritic wastes, which was previously accumulated during the exploitation of a copper mine (Uganda).
ii) The recovery of lead from lead-zinc mining wastes using a multi-gravity separator.
iii) The recovery of nickel from nickeliferous pyrrhotite tailings containing 0.8% nickel.
iv) The biological recovery of nickel from tailings.
v) The recovery of Cu and Ag (Germany).
vi) A Swedish project identified mineralisation and deposits, with the majority of them being associated with mine dumps of high average rare earth elements contents.
vii) The project VALODEM is aimed to identify interesting old mining wastes deposits at national level and assess the metal recovery potential of these dumps. (France-BRGM).

The work of Careddu et al. (2013) studies the opportunity to create a Centre for the recycling of stone materials in the Orosei Marble district, Sardinia (Italy). Several companies are operating within the marble producing area regarding quarrying and stone processing. The aim is to rehabilitate the total area of 17 ha in size, which was previously used as a landfill for waste deriving from marble quarrying and processing.

Based on the “Assessment of Member states’ performance regarding the implementation of the Extractive Waste Directive”, six case studies of best practice on reprocessing of extractive waste were registered in Estonia, Ireland, Poland, Spain, Belgium and UK.

For example, in Estonia limestone layers within the oil shale quarry are reprocessed in limestone crushing plants as limestone gravels that are used for cement production. The project BRAVO (Bauxite Residue and Aluminium Valorisation Operations) is managed by the University of Limerick, Ireland with support by the Irish Environmental Protection Agency. The principal aims are optimising the aluminium manufacturing process including the re-use of bauxite residue (red mud) as a source of critical materials and as construction raw material, as well as the development of a waste residue value chain.

The reprocessing of flotation tailings in requires aspires further processing of extractive waste, which means that aggregates are produced from extractive waste heaps in the form of red shale. These aggregates are used in buildings, road construction and for reclamation works in brownfield areas. Overburden rocks are being stored, and those of economic interest are processed such as sand, gravel, clay. Furthermore, the Boleslaw flotation tailings processing plant in Poland aims to produce zinc concentrate from flotation waste from the end of 2016.

The reprocessing of extractive waste from the closed Penouta Mine in Spain considers the reprocessing of mining waste, especially from flotation tailings abundant in tin and tantalum becoming valuable elements.

Two examples for the reclamation of extractive waste disposals site in Belgium were provided. Old extractive waste heaps rich in biodiversity have been replanted and now offer leisure spaces within urban areas of Charleroi. In Moha an old decantation pond of a limestone quarry and surrounding site has been developed into a natural reserve with a wide range of biodiversity.

The reclamation of the Force Crag mine in Cumbria, United Kingdom studies mining waters of the mining site, particularly surface water pollution due to zinc and cadmium. The passive treatment system is based on bacteria that reduce sulphate in mine waters to sulphide, which helps to absorb and accumulate metals in a basin. Once the limit of the absorption is reached, it is replaced and metals recovered.

An attempt of data harmonisation methodology described by Bellenfant et al. (2013) was developed by the BRGM. The principal steps include 1) link of several databases and information from BRGM archives using selection criteria (e.g., waste quantities, metal content, waste age, metallogeny, mineralogy, process characteristics) to select important waste deposits, 2) test of on-site sampling methodology completed by lab analysis, and 3) test of pilot scale metal recovery technics to assess the economic potential of the sites.

2.8.5 Key datasets identified

The presented case studies and EU projects have shown that best practice of e.g., flotation tailings and waste heaps, may be transferable to any comparable mining sites. Steps of mining companies for reclamation of abandoned sites and remediation may be replicated by other countries as well.

Name of data set	**Metric considered**	**Special coverage/ resolution**	**Link**
The ProSUM project, EU Urban Mine Knowledge Data Platform	Information on arisings, stocks, flows and treatment of waste electrical and electronic equipment, end-of-life vehicles, batteries and mining wastes	Pan-European /country	http://www.urbanmineplatform.eu/homepage
Generation of waste by the Mining and quarrying sector	Waste amount in kg per inhabitant and tonnes	Europe by country, year and waste category	http://ec.europa.eu/eurostat/web/waste/waste-generation-and-management/generation/mining-quarrying
Circular Economy Indicators	Production and consumption, Waste management, Secondary raw materials, Competitiveness and innovation	Pan-European /country	http://ec.europa.eu/eurostat/web/circular-economy/indicators/main-tables
ProMine Anthropogenic Concentrations (AC) database	Tonnage and metal content (i.e. possible presence of strategic metals)	France	http://ptrarc.gtk.fi/ProMine/default.aspx
BDSTM (French Database of Sites and Mining Titles)	Environmental data, also mineral deposit data (location of tailings tonnage and grade)	France	-
Dechminue database	Mining waste sites with location, period of activity, type of process and type of waste generated	Europe (Bulgaria, Finland, France, Germany, Greece, Ireland, Portugal, Spain, Sweden)	-

Table 12: Key datasets identified for recycling and re-use of materials and mineral extraction

2.8.6 Recommendations for harmonisation and standardisation

A Europe wide data collection and subsequent harmonisation requires the usage of standardised definitions of the term “mining waste”. The BRGM report from 2001, based on a country-by-country inventory within the European Union, describes sites with respect to their management of mining, quarrying and ore-processing waste. Main differences result from different legal definitions concerning types of mining waste from exploitation and processing standpoints. Some materials are potentially recyclable to a certain extent in consideration of environmental and economic points but are not always considered locally as waste despite the legal waste definition (BRGM, 2001). The end-of-waste criteria, elaborated by the Joint Research Centre (JRC) through the SUSPROC (Sustainable Production and Consumption) project, identify when waste ceases to be waste and obtains a status of a secondary raw material. The European Commission is preparing a set of end-of-waste criteria for priority waste streams. The criteria for iron, steel and aluminium scrap, glass cullet and copper scrap are already implemented (http://ec.europa.eu/environment/waste/framework/end_of_waste.htm). The government of the United Kingdom provides quality protocols, explaining the converting of waste into non-waste products. The aim are high quality products by the recovery and recycling of waste. The ProSUM project has shown that for future improvement of their initial database a complete characterisation of the thousands of mining waste sites in Europe is necessary. This includes further sampling and modern multi-element analyses of the mining and processing waste in order to identify CRMs, to estimate amounts and metal grades, and to better understand where they occur in nature.

2.8.7 References

Bellenfant, G., Guezennec, A., Bodénan, F., D’Hugues, P., Cassard, D., 2013, Re-processing of mining waste: Combining environmental management and metal recovery? Mine Closure 2013, Cornwall, United Kingdom, v. 2013, p. 571-582

Bian, Z., Miao, X., Lei, S., Chen, S., Wang, W., Struthers, S., 2012, The Challenges of Reusing Mining and Mineral-Processing Wastes, Science, v. 337, p. 702-703

Bouroullec I., Cottard F., Dutartre P., Fleury L., Serrano J.J. and Guérangé J., 2001, Notice d’explication la base de données sur les anciens sites miniers de Midi-Pyréenées, BRGM/RP-51211-FR

BRGM, 2001, Management of mining, quarrying and ore-processing waste in the European Union, 79 p., 7 Figs., 17 Tables, 7 annexes, 1 CD-ROM (Collected data)

Brunori, C., Cremisini, C., Massanisso, P., Pinto, V., Torricelli, L., 2005, reuse of a treated red mud bauxite waste: studies on environmental compatibility, Journal of hazardous Materials, v. B117, p. 55-63

Cassard, D., Bertrand, G., Billa, M., Serrano, J.J., Tourliere, B., Angel, JM., Gaal, G., 2015, ProMine Mineral Databases: New Tools to assess primary and Secondary Mineral resources in Europe, Mineral Resource Reviews, DOI 10.1007/978-3-319-17428-0_2

Cassard D., 2012. The use of standard exchange EarthResourceML in the ProMine project, 34th International Geological Congress (IGC), 5-10 August 2012, Brisbane, Queensland, Australia, #1993

Careddu, N., Siotto, G., Siotto, R., Tilocca, C., 2013. From landfill to water, land, and life: The creation of the Centre for stone materials aimed at secondary processing, Resources Policy, v. 38, p. 258-265

European Commission, Assement of Member States' performance regarding the implementation of the Extractive Waste Directive

Huisman, J., Leroy, P., Tertre, F., Söderman, M.L., Chancerel, P., Cassard, D., Løvik, A. N., Wäger, P., Kushnir, D., Rotter, V. S., Mählitz, P., Herreras, L., Emmerich, J., Hallberg, A., Habib, H., Wagner, M., Downes, S. Prospecting Secondary Raw Materials in the Urban Mine and mining wastes (ProSUM) - Final Report, ISBN: 978-92-808-9060-0 (print), 978-92-808-9061-7 (electronic), December 21, 2017, Brussels, Belgium

Komarov, M.A., Aleskerov, C.A., Kusevic, V.I., Saverdun, C.L., 2007, Mining and industrial waste - an additional source of raw minerals. "Mineral resources of Russia", No. 4, /http://www.vipstd.EN/gim/content/view/407/204/

Lèbre, E., Corder, G., Golev, A., 2017, The Role of the Mining Industry in a Circular Economy, Journal of Industrial Ecology, v. 21, p. 662-672

Lottermoser, B. G., 2011, Recycling, Reuse and Rehabilitation of Mine Wastes, Elements, v. 7, p. 405-410, DOI: 10.2113/gselements.7.6.405

Makarov, V.A., 2011, Gold technogenic mineral objects, Resources and problems of geological and technological assessment "Gold and technologies", No. 3(13) http://zolteh.ru/index.php?dn=news&to=art&id=375

Mineral resources and subsurface use of Kazakhstan (with changes and additions in 2014) law of Kazakhstan republic 24th of June 2010, No. 291-IV 11.04, art. 10 [Electronic source], access mode: http://online.zakon.kz/document/?doc_id=3077087

Pietek G., Kurylak, W., 2017, D2.6: Report on optimised pre-treatment methods of low-grade ores and waste, European Union, p.12

Rizo, J., 2014, The EU Directive on the management of waste from extractive industries, European Commission DG Environment, Brussels, June 2014

Tomassin J.F., 2001, Déchets miniers Européens-Notice d'utilisation de la base DECHMINUE, issue des données du rapport « Mining Waste Management » de la DG Environment- Report BRGM/51393-FR

2.9 *Energy use*

The extractive sector is responsible for producing the fossil fuels we use in our everyday activities, such as coal, crude petroleum and natural gas. At the same time, mineral extraction consumes energy to produce ferrous and non-ferrous metal ores, construction minerals and fossil fuels. This document is concerned with the energy consumption profile of the extraction sector.

2.9.1 Background

Large quantities of energy are utilised to extract ore, recover minerals, beneficiate and refine them and get them in a marketable form. In particular, the beneficiation, smelting and refining of raw materials are characterised as energy-intensive industries and responsible for the consumption of substantial quantities of energy and release of greenhouse emissions (IEA, 2019a). Figure 8 presents the energy consumption shares in EU-28 in 2017 that can be attributed to the raw materials sectors. Mining and quarrying activities appear less energy intensive than other sectors, with a share of 1% of the total EU industry energy consumption (Figure 8). The beneficiation, smelting and refining processes are the most energy-intensive sectors requiring between 100,000 to 600,000 GWh of energy (Figure 10.

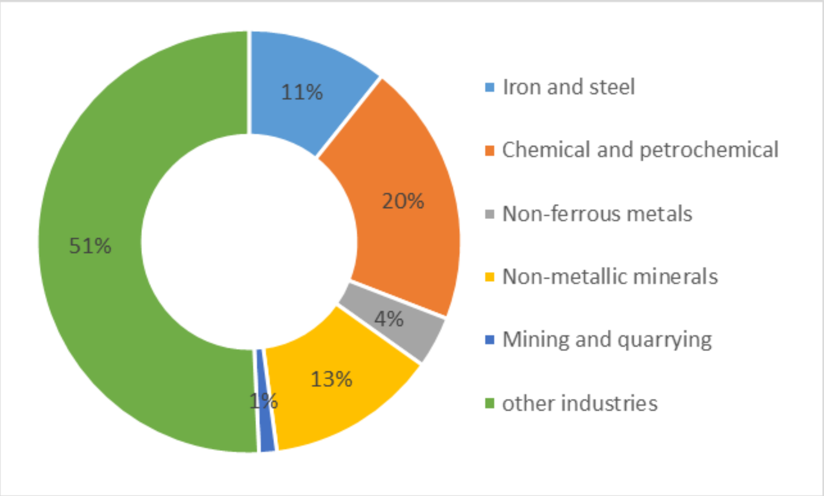


Figure 8: Energy consumption shares for the raw materials industries in EU-28 in 2017. Other industries represent all other industry sectors. Non-ferrous metals correspond primarily to aluminium and other non-ferrous metals (e.g. copper, tin, zinc, etc.). Non-metallic minerals include the cement industry and other non-metallic mineral sectors (e.g. glass, gypsum, clays, etc.). Data used for the production of this graph are from the Eurostat database[25] (energy statistics / simplified energy balances).

[25] https://ec.europa.eu/eurostat/data/database

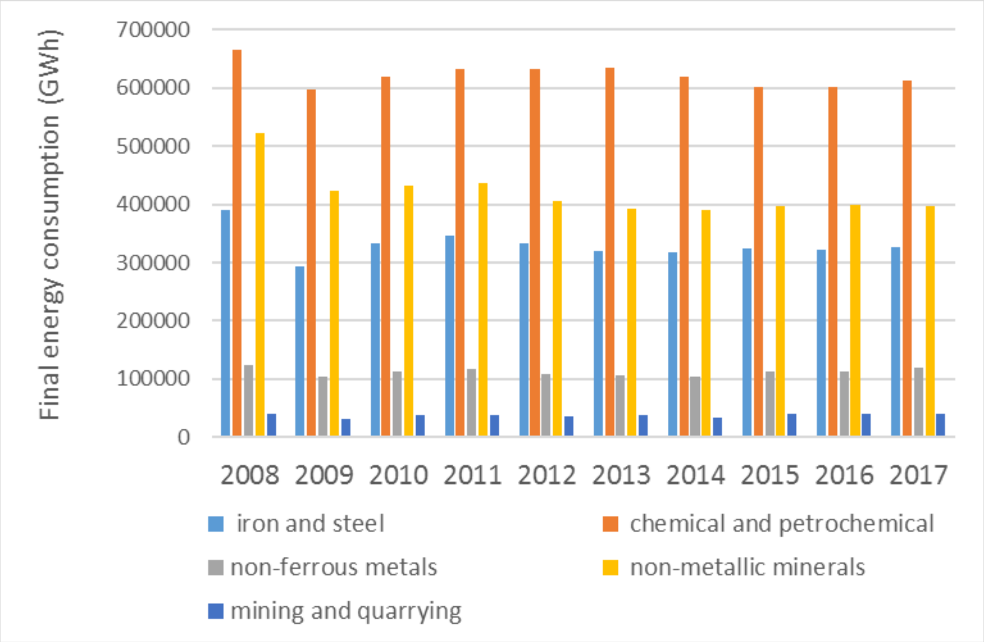


Figure 9: Final energy consumption by raw materials sector in EU-28. Data used for the production of this graph are from the Eurostat database[25] (energy statistics / simplified energy balances).

There is a wide range of regulatory and strategic documents available in Europe that aim to ensure access to secure, affordable and sustainable energy in Europe. The key theme and objective of all these documents is the EU commitment to reduce greenhouse gas emissions by 80 – 95% below 1990 levels by 2050 (European Commission, 2019a). These include:

- The 2012 energy efficiency directive and the 2016 update (European Commission, 2019d). These establish binding measures for the EU to reach a 20% energy efficiency target by 2020 and a 30% energy efficiency target by 2030.
- The energy union strategy aims to ensure energy security, create an integrated internal energy market, improve energy efficiency, and work towards decarbonisation, support research, innovation and competitiveness (European Commission, 2019f).
- The energy security strategy, which includes short-term and long-term measures to ensure security of supply, as the EU relies heavily on imports of the energy it consumes (European Commission, 2019e).
- The 2050 long-term strategy, which provides a vision for a climate neutral Europe and discusses the step change required with new technologies, citizens engagement and alignment in industrial policy, finance and research towards this goal (European Commission, 2019b).
- The clean energy for all Europeans, which provides an update to the EU energy policy framework with new binding conditions for renewable energy and energy efficiency to 2030. The new rules will formally be adopted in 2019 (European Commission, 2019c).

All the above policy, strategies and actions will influence the future of the extractive industry in Europe and will require further actions to improve energy efficiency and decarbonisation. At the same time, however, the move towards clean energy cannot be implemented without access to raw materials and in particular metals that are essential for these technologies.

2.9.2 Available data on energy use from the raw materials sector in Europe

A range of data sources on energy use is available from both international, regional (e.g. EU), national and industry sources, but their resolution varies substantially. Most international and regional sources provide aggregated figures for the industry sector overall, or sub-classes of the industry sector, including the mining and quarrying, but not for individual operations. Key data sets are described below:

Eurostat database[26]: The Eurostat energy statistics (quantities)/energy balances provide a breakdown of final energy consumption by industry sector. The mining and quarrying sector is included as a single entity, but additional entries for the iron and steel, non-ferrous metals and non-metallic minerals sectors are included too. However, these additional entries relate to the beneficiation, smelting and refining stages and can include a wide variety of materials, such as several non-ferrous metals, or in the case of non-metallic minerals, cement, industrial minerals and construction minerals. The database does not distinguish between different commodities and site operations, although statistics at country level are available.

International Energy Agency: The International Energy Agency produces statistics on industrial energy use globally (IEA, 2019a). The two publications ‘World energy statistics (IEA, 2019c)’ and ‘World energy balances’ (IEA, 2019b) included detailed tables on energy supply and consumption for 150 countries and regions. Final consumption by sector is included, but this is presented in an aggregated format. The publications are not freely available, but the IEA portal (IEA, 2019a) provides information about the energy intensity of aluminium, iron and steel and cement sectors. There is no further mentioning of the mining and quarrying sector.

National statistics: Statistic offices in Europe provide data on energy consumption by sector. Most of them follow a similar structure to the Eurostat database, but they are often more refined. For example, the mining of iron ore, coal and metal ores may represent separate entries. The production of cement, iron and steel, aluminium, lime, plaster and others may be presented separately too. These data are accessible through the individual national statistical office databases. These databases do not distinguish further the energy consumption associated with different types of activities taking place during primary extraction.

Company reports and corporate sustainability reporting: The most relevant information on energy consumption from the raw materials sector are given in company sustainability reports. The content of these reports varies substantially from one company to the next. Some utilise sustainability reporting standards in this process, but not all. For global corporations, reporting often takes place at different levels. For example, a global sustainability report may be available for the whole corporation with total energy use figures, as well as individual reports and data on specific sites and operations. Almost in all cases, these reports are available from company websites or databases, such as the sustainability disclosure database (GRI, 2019).

Life cycle inventories: Life cycle inventories, although not a direct data source, can provide useful information on energy use of unit processes. There are various life cycle inventories from open and private sources. The Global LCA Data Access portal (Global LCA, 2019) has attempted to combine datasets from different providers. Many of the available datasets are not freely available and to access relevant data on energy consumption within unit processes may require access to related LCA software and licenses.

[26] https://ec.europa.eu/eurostat/data/database

2.9.3 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Eurostat energy statistics	Final energy consumption by industry sector	EU 28 / National	https://ec.europa.eu/eurostat/data/database
National Data sources	Final energy consumption by sector; mining of coal, iron ore, metals often included as separate entries; production of cement, steel, aluminium also have separate entries	EU 28 / National	Various
International Energy Agency	World energy statistics and World energy balances included tables on energy supply and consumption for 150 countries; energy intensity statistics for aluminium, cement and steel production are available from the IEA portal	Global, OECD, non-OECD, Europe / national	https://webstore.iea.org/world-energy-statistics-2018 https://webstore.iea.org/world-energy-balances-2018 https://www.iea.org/tcep/industry/
Company reports	Sustainability reports in most cases contain information about energy use	Company or site-specific	Company websites; GRI database (http://database.globalreporting.org/)
Life cycle inventories	Data on energy use of unit processes compiled from multiple sources	Process, site or country specific	Various, but the Global LCA data access network (https://www.globallcadataaccess.org/) attempts to collate different datasets in a single place.

2.9.4 Recommendations for improving energy use data availability from the raw materials sector

Energy statistics are readily available, well harmonised and sufficiently detailed to describe both supply and consumption patterns from households and industry. In many cases, they are viewed as benchmarks for how statistical data should be developed, harmonised and become interoperable, but this well depends on the purpose that the data serve. The International Energy Agency played an important role in all the above as it provides a one-stop shop for the collation and harmonisation of data. Individual statistic offices and Eurostat contribute in their way by providing country and region-specific data.

As discussed in the background section, the extractive sector is important, but not a major energy user. However, downstream activities producing raw materials are considered highly energy intensive. For example, according to IEA the iron and steel, cement and aluminium sectors require more effort to reduce energy intensity and reach the climate change targets. It is important to remember that monitoring of energy consumption takes place to inform greenhouse gas emission levels, so in many cases, the data are not available as energy use, but as CO2 emissions and embodied carbon.

The figures available to describe the extractive sector are commonly available in an aggregated format. Only at country-level, it is possible to distinguish energy use figures for different mining activities, for example, coal mining and metal mining. This does not necessarily imply though that data are missing as most company reports include such data and may even provide breakdowns for specific sites, such data are not complied on a national scale, aggregated across different companies.

Considering the EU focus on decarbonisation and the ambitious targets set for greenhouse emissions, it would make sense that monitoring of all activities and sectors takes place in detail to identify quick gains and to assist the industry to meet these targets. Data on energy consumption for the different processes of the extractive sector could be collected initially through existing company reports and in consultation with companies. Energy use is a key operational cost for all industry sectors. Therefore by closer monitoring of energy intensity per process and commodity, it may be possible to identify opportunities for optimisation and result in cost savings. Industry-led projects could provide an option for developing relevant data and understanding. It is quite likely though that company data may be confidential and not available to share alongside existing energy statistics. In any case, energy use data should be explored alongside greenhouse emission data, as they are highly complementary.

2.9.5 References

European Commission. 2019a. 2050 Energy Strategy [cited 20/3/2019]. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2050-energy-strategy

European Commission. 2019b. 2050 Long-term strategy [cited 20/3/2019]. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2050-long-term-strategy

European Commission. 2019c. Clean energy for all Europeans [cited 20/2/2019]. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

European Commission. 2019d. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1399375464230&uri=CELEX:32012L0027

European Commission. 2019e. Energy Security Strategy [cited 20/3/2019]. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/energy-security-strategy

European Commission. 2019f. Energy Strategy and Energy Union [cited 20/3/2019]. https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/

Global LCA. 2019. Global LCA Data Access network. [cited 20/3/2019]. https://www.globallcadataaccess.org/

GRI. 2019. Sustainability disclosure database. [cited 20/3/2019]. http://database.globalreporting.org/

IEA. 2019a. Industry, Tracking Clean Energy Progress [cited 20/3/2019]. https://www.iea.org/tcep/industry/

IEA. 2019b. World Energy Balances 2018. [cited 20/3/2019]. https://webstore.iea.org/world-energy-balances-2018

IEA. 2019c. World Energy Statistics 2018. [cited 20/3/2019]. https://webstore.iea.org/world-energy-statistics-2018

2.10 *Land use*

2.10.1 Definition of land use for the purposes of comparing data with the extractives sector

Land use is simply a label ascribed to a specific area to define its socioeconomic use, land use should not be confused with land cover which defines the biophysical cover of a defined land area. For example, land use may be agricultural whereas land cover would be grassland. In a minerals context land use is often used as a metric of when minerals use conflicts with other, potentially competing land uses, especially areas designated with protected status for their biological or landscape characteristics.

Spatial planning systems aim to make the best use of land for society as a whole, taking into account a wide range of issues which have a land use dimension (such as housing, shops, recreational opportunities, amenities and the needs of society for a range of infrastructure types). This is achieved by sustaining the natural environment in which those activities take place and by managing the resources on which they depend. As mineral resources are used to produce ‘goods’ that society ‘needs’ (e.g. housing and infrastructure development), the working of mineral resources is necessary. However, planning for the working of minerals can be a contentious issue with regulators, industry and society, particularly where mineral extraction is undertaken, or proposed, in areas of high landscape or ecological value. Such areas include a wide variety of designations, such as national parks, nature reserves, national monuments and sites covered under the habitats or bird directives (Natura 2000 sites). The precise definition of protected areas will vary from country to country but most will have some basis in EU legislation (European Environment Agency, 2018b).

The interaction of mineral extraction and different forms of land use, especially with regard to designated areas needs to be considered with care. The proximity of mineral extraction to designated areas is often seen as having a very negative impact on the designated area, however, this may not be the case with suitable mitigation measures. In fact, many designated areas exist due to mineral extraction, as discussed in more detail in section 2.5, biodiversity, many former quarry sites are known for their rich biodiversity and are recognised in changing the landscape of an area. The mere presence of mineral extraction in, or close to, environmentally designated areas does not imply a negative impact, to investigate these factors site-specific impacts outlined in Environmental Impact Assessment (EIA) documents need to be analysed. However, most planning systems recognises that major industrial development in designated areas should be avoided unless essential. Many European countries have an outright ban on mineral development in designated areas, however those created under EU legislation (i.e. Natura 2000) do not specify that no minerals development can take place, but enhanced mitigation measures may be required (MinPol, 2017).

2.10.2 How can the interaction of land use and mineral extraction be measured?

Measuring the spatial extent of mining and quarrying on different land use types relies on knowing the spatial distribution of both areas of mineral extraction and spatial data for the specific land use type of interest. Simple spatial analysis can show the quantity of mineral workings within land use areas of interest or change in minerals workings in land use areas of interest over time. For example, a detailed analysis of the relationship between aggregate extraction and environmentally designated areas can be found in Mankelow et al. (2008).

Simple metrics could be:

- The number or area of mineral sites in or within a specified distance of an environmentally protected area or other land use are of interest.
- The change in the number or area of mineral sites related to specific land uses over a period of time.
- The area of land that is classified as used for mineral extraction as a percentage of a national/regional or specified land use area. This will be skewed by open pit workings, underground mines can have much less of a footprint.

2.10.3 Available data on the interaction of land uses and mineral extraction in Europe

As land use data is an important and useful indicator for many different purposes the majority of countries have spatial data for this, often in publically accessible formats. Land use data is also covered under the INSPIRE directive so any spatial data should be harmonised, according to INSPIRE guidelines across EU member states (INSPIRE Thematic Working Group on Land Use, 2012).

In terms of spatial data for mineral extraction sites, one of the most comprehensive datasets is the CORINE land cover maps (European Environment Agency, 2018a). This dataset is derived from the Copernicus network of earth observation satellites and in-situ sensors and present maps of a mixture of land use and land cover, including a category for mineral extraction sites as one of the 44 classes that the dataset covers. This dataset is Europe wide and is compiled at a continental scale so there are no harmonisation issues. The data can be viewed via a web portal at https://land.copernicus.eu/pan-european/corine-land-cover. This dataset is also periodically updated (there is currently data available for 1990, 2000, 2006, and 2012). As a result of this time series changes to the extent of areas that are classed as for mineral extraction can be seen over time. This dataset does not split mineral extraction sites by commodity.

One of the main focuses of the interaction of mining and quarrying on different types of land use is regarding environmentally designated areas. This is a topic that has seen a significant amount of effort and resultant legislation by the EC and as a result, there are clear standards in place across Europe as to what constitutes environmentally designated areas and much data are available (European Environment Agency, 2012).

With regard to spatial data on European protected areas the European Environment Agency (EEA) collect this data and provide an online web mapping service where it can be viewed (http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/european-protected-areas-1). This contains information on all Natura 2000 sites as well as specific nationally designated areas, which the EEA aggregate into seven categories due to differences in national categories across Europe shown in Figure 10

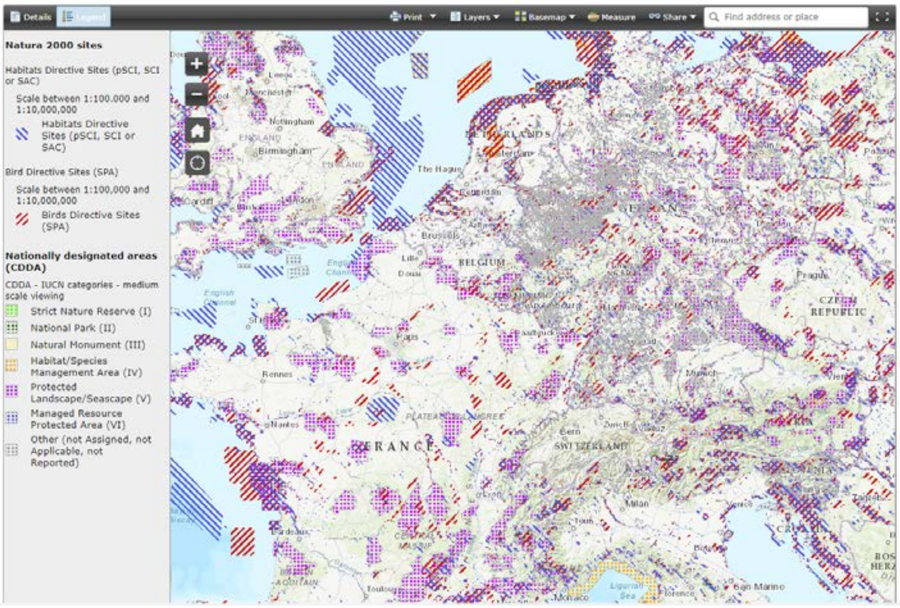


Figure 10 the EEA GIS mapping application

Many countries will have their own web mapping services to view or download this kind of data, for example in the UK the MAGIC database (http://magic.defra.gov.uk/MagicMap.aspx) produced by the Department for Environment, Food and Rural Affairs. This contains information on all environmental designations, both statutory and non-statutory as well as historic land use data and habitat data.

To assess the interaction of mineral extraction and land use the location of mineral extraction sites needs to be known. There is no comprehensive database of mineral extraction sites across Europe. This was attempted by the Minerals4EU project and the results can be seen on the project map viewer (http://minerals4eu.brgm-rec.fr/minerals4EU/). However, this relied on the provision of data from individual European countries, many of whom may not routinely collect this information, therefore, significant data gaps exist for countries who did not provide information shown in Figure 11.

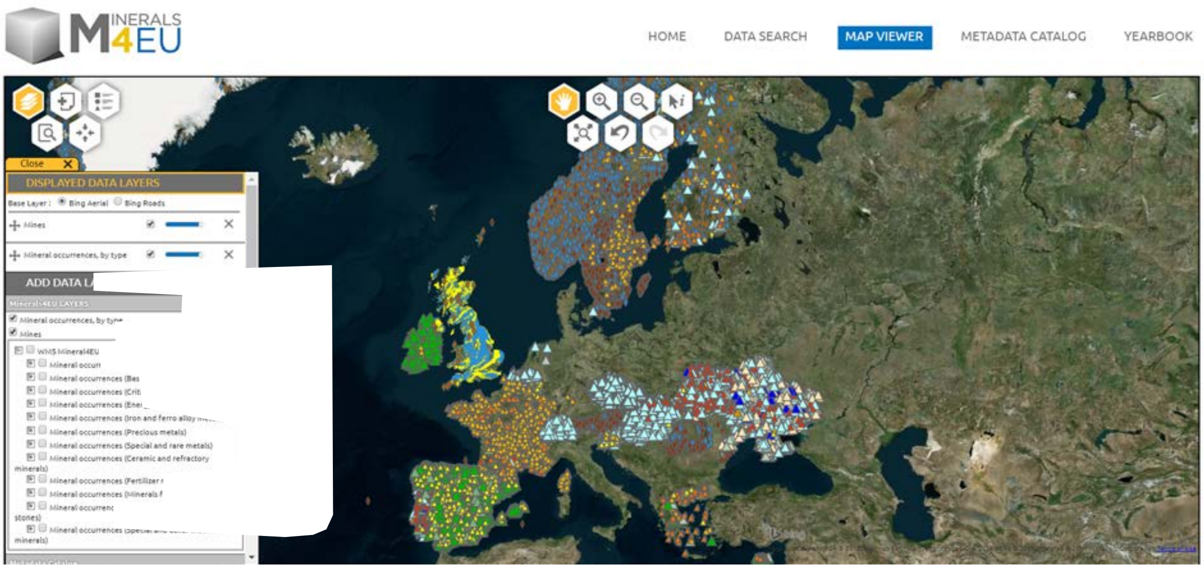


Figure 11 mines and quarries are shown by the Minerals4EU data viewer (showing areas of missing data)

Many geological surveys do collect and, make publically available, data for active mineral extraction, however, this is not harmonised across Europe. Some examples of publically available spatial data for the locations of extraction actives include the British Geological Survey Geoindex and the German Institute for Geosciences and Natural Resources (BGR) Georeviewer (https://www.bgr.bund.de/EN/Themen/Geodatenmanagement/Geoviewer/geoviewer_node_en.html) (http://mapapps2.bgs.ac.uk/geoindex/home.html?topic=Minerals) which have point data for active mines and quarries. Often smaller quarries will not be captured as they may be subject to different planning laws, for example in Finland small mineral operations are not registered and publically available data only includes larger mines (http://gtkdata.gtk.fi/mdae/index.html).

A list of geological survey data portals with information on the locations of mining and quarrying can be seen in Table 13.

Country	**Geological map portal**
Croatia	http://www.hgi-cgs.hr/images/geoloska-karta-republike-hrvatske-1-300.jpg
Czech	http://www.geology.cz/extranet-eng/maps/online
Denmark	http://www.geus.dk/UK/data-maps/Pages/default.aspx
Finland	http://en.gtk.fi/informationservices/map_services/index.html
France	http://infoterre.brgm.fr/
Germany	https://geoviewer.bgr.de/
Ireland	https://www.gsi.ie/Mapping.htm
Norway	https://www.ngu.no/en/topic/applications
Poland	http://bazagis.pgi.gov.pl/website/cbdg_en/viewer.htm
Romania	http://81.196.111.132/testgeo2/
Slovakia	http://infoportal.geology.sk/web/guest/mapovy-portal
Spain	http://info.igme.es/visorweb/
Sweden	http://apps.sgu.se/kartvisare/kartvisare-index-en.html
Switzerland	https://map.geo.admin.ch
United	http://www.bgs.ac.uk/geoindex/

Table 13: European geological surveys with data portals containing information on the location of mines and quarries

Aside from that gathered from remote sensed data (i.e. CORINE land cover) there is very little available data for the spatial extent of mineral extraction. This information is often recorded at a local/regional planning level depending on the specific planning requirements in a particular country or region. Although this data may be available for a few individual countries there are no Europe wide harmonised datasets with this information.

On a European scale, the LUCAS land use/coverage area survey gives an EU wide breakdown of changes in patterns of land use which can be broken down on a national level (Eurostat, 2015). This survey is based on sampling aerial photography to analyse patterns and give a statistical indication of changes in land cover and land use. Although unlike other land use datasets this is not spatial data (the points sampled as reused of a statistical analyses for general changes over a larger area) it does include mining and quarrying in its land use classification table and can, therefore, give an EU, or country level indicator of the changes on the spatial extent of mining and quarrying between surveys. The LUCAS survey complies with INSPIRE standards so all land use classifications used should be comparable with similar natural level data.

2.10.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Mineral4EU map viewer	Point location of active and inactive mineral operations	European / points for individual operations	http://minerals4eu.brgm-rec.fr/minerals4EU/
LUCAS land use/coverage area survey	Land use type (including for mineral operations)	European / national	http://ec.europa.eu/eurostat/web/lucas/data/primary-data/2015
EEA GIS map application for European Protected sites	Protected sites including national designations and EU designations	European / spatial extent of individual designations	http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/european-protected-areas-1
CORINE land cover	The spatial extent of mineral extraction, measured over 4 specific periods between 1990 and 2012.	European / individual mineral extraction sites	https://land.copernicus.eu/pan-european/corine-land-cover

Table 14 Key datasets for land use in Europe

2.10.5 Recommendations for harmonisation and standardisation of data on the interaction of land uses and mineral extraction

Although datasets for land use are comprehensive, harmonised and generally easily accessible across Europe it can be harder to understand the interactions with mineral extraction. A lack of harmonised European datasets on active mineral operations is a prohibiting factor, although in many countries this data does exist in some form. A database of active mines and quarries across Europe would be beneficial to many different types of data users, however, it must be considered that in some countries, not all mineral operations are captured due to legislative requirements relating to sizes of operations or temporary mineral operations related to infrastructure development. This is a much harder issue to overcome as data does not exist in any form and would require changes in planning legislation to ensure this information is recorded. It is also more difficult to analyse this data using the spatial extent of minerals operations, which is often not publically available on a national/regional level. Collation of such data in most countries would involve analysis of individual permissions and could be considerably laborious. This spatial data is available from remotely sensed data but this does not tie into the planning system and may miss sites and not cover all known workings, this data also gives no indication as to the type of working or the commodity worked.

2.10.6 References

European Environment Agency. 2012. Protected areas in Europe, an overview, EEA Report No 5/2012. https://www.eea.europa.eu/publications/protected-areas-in-europe-2012

European Environment Agency. 2018a. CORINE Land Cover. [cited 27/7/18]. https://land.copernicus.eu/pan-european/corine-land-cover

European Environment Agency. 2018b. An introduction to Europe's Protected Areas. [cited 20/7/18]. https://www.eea.europa.eu/themes/biodiversity/europe-protected-areas/europe-protected-areas-1

Eurostat. 2015. Lucas Land cover/use survey. [cited 20/7/2018]. http://ec.europa.eu/eurostat/web/lucas/data/primary-data/2015

Inspire Thematic Working Group On Land Use. 2012. Data Specification on Land Use – Draft Guidelines. http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_LU_v3.0rc2.pdf

Mankelow, J, Bate, D, Bide, T, Linley, K, Hannis, S, Cameron, D and Mitchell, C. 2008. Aggregate resource alternatives: Options for future aggregate minerals supply in England.

Minpol. 2017. Legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU final report.

3 Available data regarding social aspects of extraction

3.1 *Employment*

3.1.1 Definition and background

Employment can seem to be one of the more obvious 'social aspects' of the mineral extractives sector. As with any business in any sector, whether commercial or otherwise, its success depends entirely on its people because its activities cannot be conducted without staff. However, there are many different aspects of employment, which makes its measurement more complicated than might be expected.

There are three basic types of employment that can be created by the presence of a mine or quarry in an area. Firstly, there is 'direct employment', which is probably the most obvious, including all the personnel employed by the mining company directly to operate the mine and its associated support functions. Secondly, there is 'indirect employment', which includes persons employed by contractors working for the mining company and also the employees of suppliers that provide equipment or services to the business. In addition, all those direct and indirect employees will earn salaries or wages and a proportion of that money will be spent in the local area or region. As a consequence of that spending, additional jobs will be generated within the region in businesses such as supermarkets, shops, financial products, housing, construction of infrastructure, etc.

Other aspects of interest when considering employment are the number of males employed versus the number of females, the age range of the employees or the spread of employees across a range of ethnic, religious, language or cultural groups (Euromines, 2016). Also of interest, particularly for mining operations in developing countries of the world, is the split between expatriate employees brought into a country from overseas versus the number of host country workers.

Employment can lead on to other social or environmental aspects of mineral extraction, which may also be of interest to policymakers but are not considered further in this section (although many of them may be covered elsewhere in this deliverable). These may include the number of dependents supported by the employment, demographic and social changes brought about by the presence of jobs in an area or the amount of investment by the extractive company in staff training.

3.1.2 Available data for employment in the extractive sector in Europe

Direct employment

Many different aspects relating to population are routinely measured by European countries and this often includes figures for employment and/or unemployment. However, there are considerably fewer datasets that have sufficient resolution to allow 'mining and quarrying' to be isolated from other sectors of employment.

Some datasets relating to employment in the extractives sector are available from Eurostat, but also from global organisations such as the Socio-Economic Accounts of the World Input-Output Database, the OECD, the World Bank and the International Labour Organisation (an agency of the United Nations). However, the datasets provided by these latter organisations for EU member states appear to be sourced from Eurostat and/or do not provide sufficient resolution to isolate the 'mining and quarrying' sector (i.e. the sector is aggregated with other types of industry). National statistical offices also publish data for their individual countries and these are ultimately the source data used by Eurostat.

Within the Eurostat database (Eurostat, 2018) is a section headed “Population and social conditions” that contains a sub-section “Labour market”, which includes (amongst other things) the detailed annual results of the “Labour force survey”. These detailed results include three datasets that utilise the NACE Rev 2 classification system, which allows ‘Mining and Quarrying’ to be separated (category B). These datasets include:

a) Employment by sex, age and economic activity:

This report contains the numbers of employees to the nearest thousand and allows the separation of ‘males’ and ‘females’ and/or broad age categories (e.g. 15-64, 65 and over, etc.) with figures by country and year from 2008 to 2017 (as at July 2018).

b) Employment by sex, age and detailed economic activity

This report also contains the numbers of employees to the nearest thousand and again allows the separation of ‘males’ and ‘females’ and broad age categories. It also contains more details of the type of mining such as ‘coal and lignite’, ‘crude petroleum and natural gas’, ‘metal ores’, other mining and quarrying’ and ‘mining support services’. Again, the figures are available by country and by year.

c) Employment by occupation and economic activity

In addition to the numbers of employees to the nearest thousand, this report utilises the International Standard Classification of Occupations 2008. This enables the separation of occupations categories such as ‘managers’, ‘professionals’, ‘technicians’, ‘clerical’, ‘services and sales’, ‘plant and machine operators and assemblers’, ‘elementary occupations’, etc. The figures are also available by country and year but there is no option to divide the data by gender or age.

Within the “Industry, trade and services” section of the Eurostat database, there is a sub-section related to the “Structural business statistics”. These statistics include a further set of employment-related figures:

d) Industry by employment size class

This report includes indicators such as ‘persons employed’, ‘unpaid persons employed’, ‘employees’, ‘hours worked by employees’, turnover per person employed’, apparent labour productivity (GVA per person employed’), ‘GVA per hour worked’, ‘growth rate of employment’ and ‘persons employed per enterprise’ as well as others. The figures for ‘mining and quarrying’ can be separated from other sectors as well as a more detailed breakdown in to ‘coal’, ‘lignite’, ‘crude petroleum’, ‘natural gas’, ‘iron ores’, ‘non ferrous metal ores’, ‘stone, sand and clay’ and ‘nec’ (not elsewhere classified). The figures can also be divided by size of enterprise (based on numbers of employees, such as 0-9 or >250 persons). The data are available by country and by year from 2005 to 2015 (as of July 2018). The final version structural business statistics are released two years behind the reference year, meaning that data for 2016 will be made available during 2018.

All of the datasets available from Eurostat appear to relate to ‘direct’ employment only. Employment by contractors and suppliers would require examination of different NACE sectors (including, for example, ‘manufacturing’ [for equipment suppliers, category D], ‘electricity, gas and water supply’ [for utility suppliers, category E], ‘transport, storage and communication’ [for sub-contract hauliers, category I], etc.). However, these figures would include suppliers to any other sector not specifically to the ‘mining and quarrying’ sector. Consequently, it is difficult to calculate from these datasets the full positive impact resulting from employment generated by a mine.

The World Input-Output Database (WIOD) was originally launched in 2012 and the most recent data release covers the period to 2014. It was initially created by an EU-funded Framework 7 project (of the same name) with the intention of enabling analysis of European competitiveness in relation to international trade and globalisation. It includes data on social and environmental aspects in order to enable calculations such as the number of jobs or greenhouse gas emissions that were created by (and are, therefore ‘embodied within’) imports or exports. In terms of employment, the downloadable data includes figures for ‘a number of employees (thousands)’ and ‘total hours worked by employees (millions)’ (WIOD, 2016). Whilst it is possible to extract just the figures relating to mining and quarrying from these, there is no further breakdown by gender, age, or product grouping. The data are available for 43 countries globally, including all 28 EU Member States. These figures also relate entirely to ‘direct’ employment and do not account for ‘indirect’ or other employment generated as a result of mining. The information on data sources suggests that these data for the EU28 countries is sourced from Eurostat via the Labour Force Survey (Timmer, 2012).

The OECD (Organisation for Economic Co-operation and Development) publish various data related to employment, including ‘employment rate’ and ‘employment by activity’ but do not provide sufficient resolution to separate ‘mining and quarrying’ from other types of industry. These data are sourced from Eurostat (OECD, 2018). Similarly, the World Bank publishes data for ‘employment rate’ but without sufficient resolution to enable ‘mining and quarrying’ to be separated from other types of industry. These data are sourced from “nationally representative labour force surveys” (World Bank, 2017), which implies they are collected from each country individually but they are likely to be the same data that are supplied to Eurostat from each national statistical office.

The International Labour Organisation (ILO) is a ‘specialised agency of the United Nations’ with a remit that covers all work-related issues. Under a heading of “Statistics and database” there is a link to the ‘labour force survey’ of every country that conducts one and also a link to ILOSTAT, which is the ILO’s database of labour-related statistics (ILO, 2018). This database includes tables for various ‘key indicators of the labour market’ including ‘employment by sector’ but the data for European Countries are sourced from Eurostat (ILOSTAT, 2018).

The ILO has also established guidelines for individual countries to use when conducting their own ‘labour force survey’. In most cases, it is the national statistics office or agency that conducts these surveys and these organisations generally publish: the statistics, their own analysis based on the data and information about how the surveys are conducted. A good example of a methodology description for a labour force survey is provided by the Office for National Statistics in the UK (ONS, 2018).

In summary, there are datasets from Eurostat that provide figures for ‘direct’ employment but ‘indirect’ employment or the numbers of jobs generated by employee spending are more difficult to capture. Within the direct employment it is possible to separate data by gender, age category, broad groups of mined commodities and occupation types, but not by ethnic, religious, language or cultural groupings. A more detailed breakdown by commodity groups, including measures of productivity and hours worked, is available with a greater time lag from the structural business statistics.

Indirect employment

As noted above, the presence of a mine or quarry in an area creates more jobs than simply the ones directly employed by the mining company because the business will require goods and services from other companies. These supplying companies could be local, regional, national or even global in scale and in turn, will require supplies from additional businesses. Measuring the totality of these indirect employment effects is complex.

Some authors have pointed out that the presence of one particular company does not 'create' these indirect jobs but instead creates additional economic activity, which subsequently leads into the additional jobs (Jéquier, 1989). This implies that available figures for Gross Value Added (GVA) could be used as a proxy in some way. However, quantifying how many additional jobs are typically generated by an increase in economic activity is not straightforward. This is because the relationship between GVA and the quantity of jobs is not linear in time or space and varies by industrial sector and sub-sector. If labour productivity improves over time, then the same number of workers would generate a greater quantity of GVA. In other words, an increase in productivity will generate additional GVA but not necessarily additional jobs, so rising GVA does not always result in increased jobs. The technology available in different countries or regions would have a big impact on productivity because better technology often results in increased productivity and sometimes reduces the numbers of employees required. Some countries have, however, developed complex computer modelling techniques in order to make economic or employment forecasts (for example Wilson et al., 2014).

MacGillivray et al. (2017) studied indirect employment effects for a group of 484 businesses in Africa and South East Asia who received investment from CDC Group plc. They concluded that 'indirect' employment within suppliers added 5.49 additional jobs for each direct worker employed and 'induced' employment from the spending of wages added a further 2.32 jobs per direct worker (on average over the two years of 2014 and 2015). However, this study acknowledges that these figures are 'generic multipliers' and that their method includes many assumptions and caveats (MacGillivray et al., 2017). It is not clear whether any of the businesses in this study were involved in mining or quarrying.

In summary, there are no easily available datasets that specifically record 'indirect' or 'induced' employment. However, the structural business statistics available from Eurostat include data for GVA and, because this is a measure of economic growth, it could be used as a proxy for the additional employment generated by the presence of mining or quarrying.

3.1.3 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Eurostat - Employment by sex, age and economic activity (lfsa_egana)	Employment numbers, split by gender and age groups	All EU28 countries / national level	http://ec.europa.eu/eurostat/data/database Population and social conditions > labour market > employment and unemployment (labour force survey) > LFS series – detailed annual survey results (lfsa) > Employment – LFS series (lfsa_emp)
Eurostat - Employment by sex, age and detailed economic activity (lfsa_egan22d)	Employment numbers, split by gender and age groups; with a more detailed breakdown of mining types	All EU28 countries / national level	http://ec.europa.eu/eurostat/data/database Population and social conditions > labour market > employment and unemployment (labour force survey) > LFS series – detailed annual survey results (lfsa) > Employment – LFS series (lfsa_emp)
Eurostat - Employment by occupation and economic activity (lfsa_eisn2)	Employment numbers according to International Standard Classification of Occupations 2008	All EU28 countries / national level	http://ec.europa.eu/eurostat/data/database Population and social conditions > labour market > employment and unemployment (labour force survey) > LFS series – detailed annual survey results (lfsa) > Employment – LFS series (lfsa_emp)
Eurostat - Industry by employment size class (sbs_sc_ind_r2)	Hours worked, turnover, GVA, etc. with details by mining types and size of enterprises	All EU28 countries / national level	http://ec.europa.eu/eurostat/data/database Industry, trade and services > structural business statistics (sbs) > SBS – industry and construction (sbs_ind_co) > SMEs – annual enterprise statistics by size class – industry and construction (sbs_sc_ind)

Table 15: Key datasets regarding employment and the minerals industry in Europe

3.1.4 Recommendations for harmonisation and standardisation

A significant amount of standardisation has been carried out already, following guidelines published by the ILO. The figures published by Eurostat are already comparable between European countries and can be aggregated easily to provide EU-level datasets.

However, these employment figures are generally only ‘direct employment’ and therefore do not fully represent the full beneficial effects of the extractives sector in Europe. The development of additional datasets covering ‘indirect’ and ‘induced’ employment should be explored and this should be discussed with economists working in the area of forecasting employment trends.

3.1.5 References

Euromines. 2016. A quick guide to socio-economic analysis of a mining/quarrying project. http://www.euromines.org/publications/a-quick-guide-to-socio-economic-analysis-of-a-mining-quarrying-project

Eurostat. 2018. Database. http://ec.europa.eu/eurostat/data/database

International Labour Organisation (ILO). 2018. Statistics and database. http://www.ilo.org/global/statistics-and-databases/lang--en/index.htm

ILOSTAT. 2018. International Labour Organisation database. http://www.ilo.org/ilostat/faces/wcnav_defaultSelection?_afrLoop=1581052993850993&_afrWindowMode=0&_afrWindowId=21tf2h9yg_59#!%40%40%3F_afrWindowId%3D21tf2h9yg_59%26_afrLoop%3D1581052993850993%26_afrWindowMode%3D0%26_adf.ctrl-state%3D21tf2h9yg_79

Jéquier, N. 1989. Measuring the indirect employment effects of multinational enterprises: Some suggestions for a research framework. Working Paper No 56. International Labour Office, Geneva.

MacGillivray, A., Kim, R., van Moorsel, T. and Kehoe, A. 2017. Measuring total employment effects: a lean data methodology for a portfolio of investments in developing countries. Steward Redqueen and CDC Group plc (the UK's development finance institution (DFI), 100% owned by Department for International Development (DfID))

Office for National Statistics. 2018. A guide to labour market statistics. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/methodologies/aguidetolabourmarketstatistics

Organisation for Economic Co-operation and Development (OECD). 2018. Employment database. http://www.oecd.org/employment/emp/onlineoecdemploymentdatabase.htm

Timmer, M (Ed). 2012. The World Input-Output Database (WIOD): Contents, Sources and Methods. http://www.wiod.org/publications/source_docs/WIOD_sources.pdf

Wilson, R., May-Gilling, M. and Beaven, R. 2014. Working Futures 2012-2022: Technical report on sources and methods. Warwick Institute for Employment Research and Cambridge Econometrics. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/298511/working-futures-2012-2022-technical-report.pdf

World Bank. 2017. Employment in industry (% of total employment) (modelled ILO estimate). https://data.worldbank.org/indicator/SL.IND.EMPL.ZS

World Input-Output Database (WIOD). WIOD Data, 2016. Release 2016. http://www.wiod.org/release16

3.2 *Health and safety at work*

3.2.1 Background

Occupational safety and health (OSH) are important for the social sustainability of any economic sector. With respect to the extractive industry, a safe and healthy working environment is an important factor influencing the level of acceptance or approval of an industry and its operations by local communities and stakeholders. OSH is also essential for a productive and competitive economy: some studies prove that every euro spent on occupational safety and health will have a return in double (Braunig and Kohstall, 2012).

The UN Sustainable Development Goals (SDGs) framework recognises that OSH is a vital component of decent work (UN General Assembly, 2017). Accordingly, Goal 8 promotes decent work and target 8.8 aims to "protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular, women migrants, and those in precarious employment". The indicators used to monitor this target focus on the frequency rates of fatal and non-fatal occupational injuries and the increase in national compliance of labour rights based on ILO sources and national legislation.

OSH constitutes one of the areas where strict safety standards exist and where EU policies have had a large impact in recent years. Significant decreases have been achieved in most of the economic sectors in both the number of workplace accidents and the overall incidence rate (i.e. the number of accidents relative to the number of people employed in a sector) (Eurostat, 2018a).

The current EU policy is described in the EU Occupational Safety and Health (OSH) Strategic Framework 2014-2020 (COM/2014/0332 final). This policy underpins on the OSH Framework Directive (89/391) and is complemented by further directives focusing on specific aspects of safety and health at work.

In the extractive sector, specific hazards include the exposure of employees to chemicals, noise and high temperatures. Proper management of work-related risks and hazards helps to minimise employees' exposure to risk factors. Sound risk management may include employing operators with adequate skills and levels of expertise, having the proper protective equipment and establishing risk management systems at the production site. The Convention of the International Labour Organisation (ILO) on Safety and Health in Mines (1995, No. 176) regulates the various aspects of safety and health characteristics for work in mines, including inspection, special working devices and special protective equipment for workers. It also prescribes requirements relating to mine rescue.

Because of the presence of hazards, OSH also remains a challenge in the metal production sector, where the ILO provides codes of practice for the iron and steel industry (ILO, 2005) and for the non-ferrous metals sectors, assisting all those involved in these industries to improve safety and health records (ILO, 2003).

The concept of occupational health and safety focuses on workers, who might be affected by health problems and accidents in the workplace. However, health impacts from the extractive and materials processing sectors can also affect local communities, in different ways. For instance, environmental impacts caused by industrial activities can result in health impacts for local communities through contamination of water bodies and air pollution (Mancini and Sala, 2018).

Figure 12 provides a conceptual map of the main aspects related to health and safety in the minerals and metals sectors (thus including mining and material processing). Workers and local communities are the main stakeholders and impacts on health and safety can result in accidents (fatal or non-fatal) or diseases due to environmental conditions or the exposure to hazardous and carcinogen substances. Other potential health impacts are communicable diseases such as HIV/AIDS, tuberculosis and malaria, which can have a higher incidence in mining communities (e.g. Corno and de Walque, 2012; Kitula, 2006) and mental health issues.

As shown in the figure, the main available datasets concerning health and safety in the raw materials sectors focus on fatal and non-fatal accidents at work. Data on other aspects, like diseases due to working conditions, is scarce, or not disaggregated by economic activity.

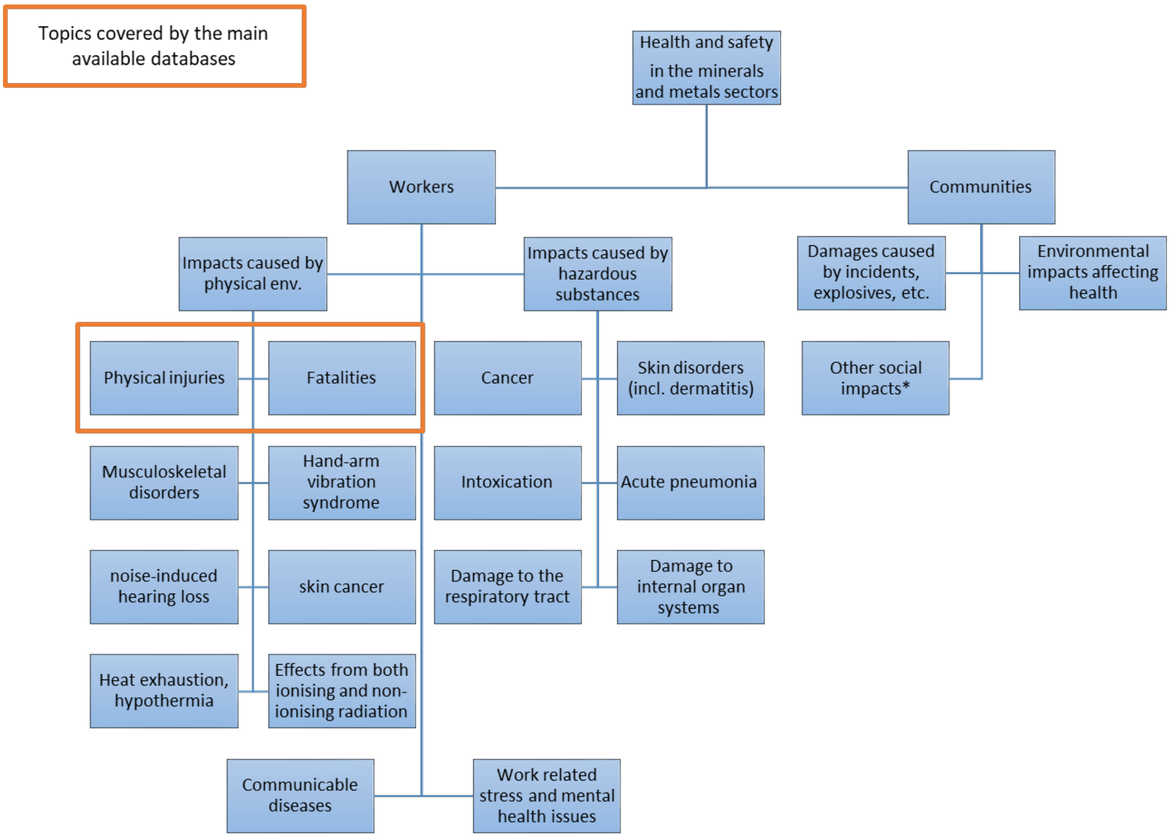


Figure 12 Conceptual map showing the main issues of concern for health and safety in the extractive sector. Based on ICMM, Mancini & Sala 2018, and other sources from the literature. Source: JRC elaboration.

3.2.2 Definitions

In this chapter, we focus on the available data regarding occupational safety and health (OSH) and take into account the ILOSTAT and EUROSTAT databases, which are the main sources at the international level. Both sources provide data on accidents at work (both fatal and non-fatal) but use slightly different definitions (Table 16). The definition of "decent work", which is also promoted by the SDGs, is also different. ILO covers a broad range of aspects, including working time, equal opportunities, etc. EUROSTAT uses two indicators to monitor decent work in the SDG framework: fatal accidents at work and in-work poverty rates, referring to the workers at risk of poverty due to low wages (Eurostat, 2018b).

Concerning the definition of accidents at work, ILO uses the term injuries and does not give a minimum number of days of absence for reporting it. In the case of EUROSTAT, in the ESAW database, only accidents causing an absence of more than 3 days must be reported

	ILO	EUROSTAT
Decent work	The Framework on the Measurement of Decent Work covers ten substantive elements which are closely linked to the four strategic pillars of the Decent Work Agenda, that is, (i) International labour standards and fundamental principles and rights at work (ii) Employment creation (iii) Social protection and (iv) Social dialogue and tripartism: • employment opportunities; • adequate earnings and productive work; • decent working time; • combining work, family and personal life; • work that should be abolished; • stability and security of work; • equal opportunity and treatment in employment; • safe work environment; • social security; and • social dialogue, employers' and workers' representation.	Work should deliver fair income, security in the workplace and social protection, and allow flexibility. Indicators: • People killed in accidents at work • In work at-risk-of-poverty rate
Fatal accident/ Fatal occupational injury	An occupational injury that is fatal is the result of an occupational accident where death occurred within one year from the day of the accident.	A fatal accident at work refers to an accident at work which leads to the death of a victim within one year of the accident.
Non-fatal accident/ Non-fatal occupational injury	A case of non-fatal occupational injury is the case of a worker incurring an occupational injury as a result of an occupational accident not leading to death. The non-fatal occupational injury entails a loss of working time.	A non-fatal accident at work is an accident which a victim survives and may result in one or more days of absence from work. A serious non-fatal accident at work is an accident at work resulting in more than three days' of absence from work. The Labour Force Survey modules on accidents at work and other work-related health problems report data on all non-fatal accidents (including the possibility to exclude those accidents with less than four days of absence). The administrative data collection on 'European Statistics on Accidents at Work (ESAW)' reports only data on accidents with four days or more of absence as well as fatal accidents at work.

Table 16: Definitions of key terminology in health and safety at work

3.2.3 Available data for employment in the extractive sector in Europe

Figure 13 shows the main available datasets for accidents at work provided by ILOSTAT and EUROSTAT, and the level of sector disaggregation. The former includes data on accidents cases and time lost, in addition to the labour inspections. Table 17 provides information on the main datasets.

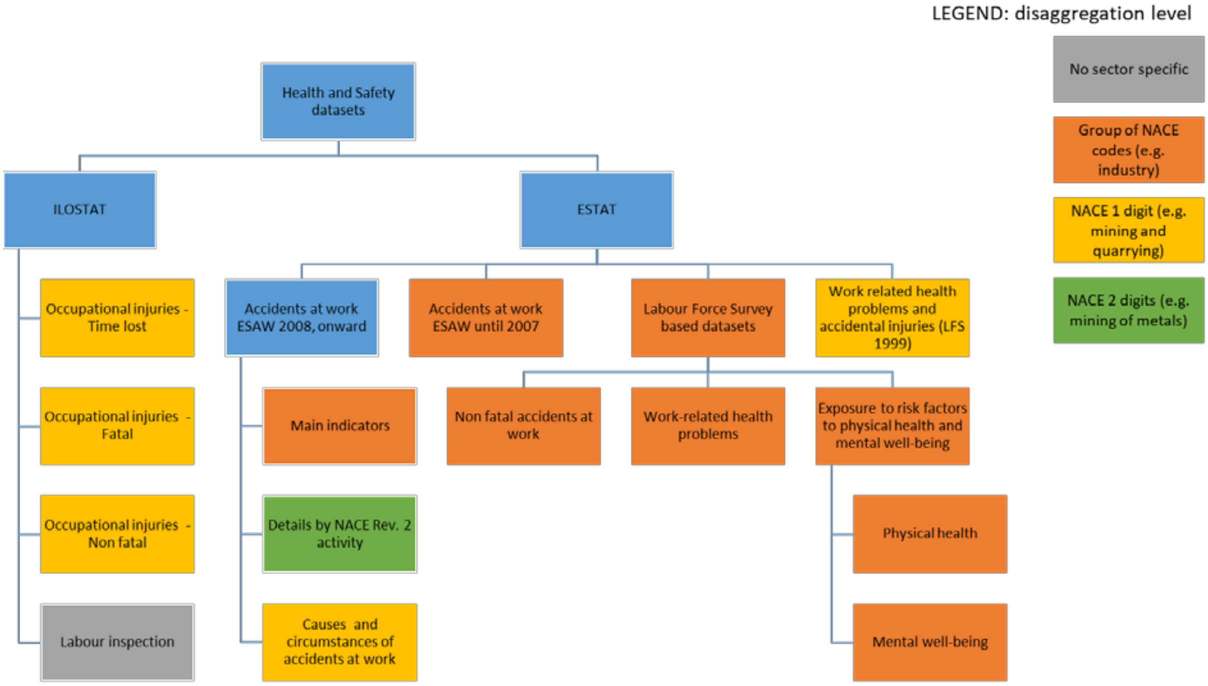


Figure 13: Main available data collections on occupational health and safety, colour code showing the sector disaggregation (JRC elaboration)

European Statistics on Accidents at Work (ESAW)

ESAW provides harmonized data on accidents at work, collected in the framework of an administrative annual data collection. Two main collections are available: until 2007 and 2008 onwards.

The variables collected on accidents at work include economic activity, size of the enterprise, employment status, occupation, age, sex and nationality of the victim, geographical location, type of injuries etc.

The national ESAW sources are the declarations of accidents at work, either to the accidents insurance of the national security system, private insurance or other national authorities. In the case of the Netherlands, only survey data are available.

The data is presented in form of numbers, percentages, incidents rates (where the denominator is the number of persons in employment) and standardized incidence rate (adjusted for the relative sizes of the economic sectors at EU level).

Concerning the sector disaggregation, only the dataset "*details by NACE Rev. 2 activity*" provides a two digits specification of NACE codes, which means that non-energy raw materials sectors can be distinguished (for instance, mining of metal ores). The dataset "causes and circumstances of accidents at work" provides details on the accidents, for instance specifying the working process and the specific physical activity during the accidents. The sector disaggregation, in this case, is one digit NACE Rev. 2, e.g. “mining and quarrying” sector.

Labour Force Survey ad-hoc modules (LFS)

EUROSTAT also provides a data collection based on specific Labour Force Surveys carried out in 2007 and 2013. It includes the following aspects:

- accidents at work (including also those with less than four days of absence of work)
- work-related health problems, both physical and mental
- exposure to risk factors that can adversely affect physical health

Compared to the administrative data collection ESAW, the LFS ad hoc modules give additional information on certain aspects, like road traffic accidents and mental well-being. Yet, the disaggregation of economic activities is lower, as they refer to NACE groups, where mining is included in the “industry” category (NACE B-E).

ILOSTAT

ILOSTAT provides annual data on occupational health and safety provided by countries.

Statistics on occupational injuries come from a variety of sources, including various types of administrative records (insurance records, labour inspection records, records kept by the labour ministry or the relevant social security institution, etc.), establishment surveys and household surveys. The variety of possible sources of data on occupational injuries hinders the comparability of data across countries since each type of source provides information on different specific concepts (ILO, 2018).

The datasets available in ILOSTAT are the following:

- Occupational injuries - Time lost
- Occupational injuries - Fatal
- Occupational injuries - Non-fatal
- Labour inspection (not disaggregated by economic activity).

The measures used for the above-mentioned indicators are calculated as explained in the table below:

Measure	**Numerator**	**Denominator**
Frequency rate	Cases of injury	Hours worked
Incidence rate	Cases of injury	Workers
Severity rate	Days lost	Hours worked
Average days lost	Days lost	Cases of injury

Table 17: Measures used for the ILO health and safety indicators (Taswell and Wingfield-Digby, 2008)

3.2.4 Key datasets identified

The table below summarizes the key datasets about occupational health and safety in the raw materials sectors. As explained above, these are only a small part of the available datasets, having a disaggregation by economic activity.

Name of datasets	**Metric considered**	**Spatial coverage / resolution**	**Link**
EUROSTAT - Accidents at work (ESAW, 2008 onwards) (hsw_acc_work): - Non-fatal accidents at work by NACE Rev. 2 activity and sex - Fatal Accidents at work by NACE Rev. 2 activity - Non-fatal accidents at work by NACE Rev. 2 activity and age - Accidents at work by days lost and NACE Rev. 2 activity	- Number of accidents; - Incidence rates of accidents (number of accidents per 100,000 workers) - Days lost	- National: for all EU-Member States and EFTA countries (Iceland (from 2012), Norway and Switzerland). - For EU: current composition; 15 countries; before the accession of Croatia	Non-fatal accidents at work by NACE Rev. 2 activity and sex (hsw_n2_01) Fatal Accidents at work by NACE Rev. 2 activity (hsw_n2_02) Non-fatal accidents at work by NACE Rev. 2 activity and age (hsw_n2_03) Accidents at work by days lost and NACE Rev. 2 activity (hsw_n2_04)
ILOSTAT - Safety and health at work - Days lost due to cases of occupational injury with temporary incapacity for work by economic activity - Cases of fatal occupational injury by economic activity - Cases of non-fatal occupational injury by economic activity - Non-fatal occupational injuries per 100,000 workers by economic activity	- Days lost - cases - accidents rates	National, for a variable number of countries, having different data completeness (data for the mining and quarrying sector) - days lost: 55 countries - cases of non-fatal: 75 - Non-fatal occupational injuries per 100,000 workers: 67 countries - cases of fatal: 74 countries - fatal occupational injuries per 100,000 workers: 61 countries	Days lost due to cases of occupational injury with temporary incapacity for work by economic activity Cases of fatal occupational injury by economic activity Fatal occupational injuries per 100'000 workers by economic activity (%) Cases of non-fatal occupational injury by economic activity Cases of non-fatal occupational injury by type of incapacity and economic activity Non-fatal occupational injuries per 100'000 workers by economic activity (%)

Table 18: Key datasets for health and safety and the minerals industry in Europe

3.2.5 Conclusions and recommendations

Among the international databases on accidents at work, the ESAW data collection by Eurostat has a higher level of disaggregation with data for non-energy raw materials sectors. ESAW data are considered to have a high level of accuracy, even though under-reporting of accidents can occur (Eurostat, 2018a). Fatal accidents have higher accuracy than non-fatal ones, as they are usually investigated by relevant state authorities. They also have a high level of comparability between countries, while the comparability of data on non-fatal accidents is limited for certain groups of countries (having the same notification system).

Data on health and safety for non-energy raw materials sectors focus on accidents at work only. Other health problems like diseases due to exposure to hazardous substances, work-related stress and mental health problems are not covered by international databases or are disaggregated by economic activities. Another area with data gap concerns the effects of extractive industries on local communities' health, an aspect with high relevance for the social licence to operate.

3.2.6 References

Braunig, D., Kohstall, T., 2012. Calculating the international return on prevention for companies: Costs and benefits of investments in occupational safety and health. Geneva Int. Soc. Secur. Assoc.

Corno, L., de Walque, D., 2012. Mines, migration and HIV/AIDS in Southern Africa. J. Afr. Econ. 21. doi:10.1093/jae/ejs005

Eurostat, 2018a. Accidents at work statistics. [WWW Document]. Stat. Explain. URL https://ec.europa.eu/eurostat/statistics-explained/pdfscache/11539.pdf

Eurostat, 2018b. SDG 8 - Decent work and economic growth. [WWW Document]. Stat. Explain. URL http://ec.europa.eu/eurostat/statisticsexplained/

ILO, 2018. Decent Work and the Sustainable Development Goals: A Guidebook on SDG Labour Market Indicators, Department of Statistics (STATISTICS). Geneve, International Labour Office.

ILO, 2005. Code of practice on safety and health in the iron and steel industry. Geneva, Switzerland.

ILO, 2003. Safety and health in the non-ferrous metals industries. ILO code of practice. Geneve, International Labour Office.

Kitula, A.G.N., 2006. The environmental and socio-economic impacts of mining on local livelihoods in Tanzania: A case study of Geita District. J. Clean. Prod. 14, 405–414. doi:10.1016/j.jclepro.2004.01.012

Mancini, L., Sala, S., 2018. Social impact assessment in the mining sector: Review and comparison of indicators frameworks. Resoures Policy. doi:10.1016/j.resourpol.2018.02.002

Taswell, K., Wingfield-Digby, P., 2008. Occupational injuries statistics from household surveys and establishment surveys. An ILO manual on methods. Geneve.

UN General Assembly, 2017. Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development.

3.3 *Social acceptance*

3.3.1 Definition of SLO for the extractives sector

Social Licence to Operate, or SLO, is complex to define being very context dependent, mainly based on local circumstances and a description of a process which has both qualitative and quantitative aspects. SLO is often used alongside, or interchangeably with Corporate Social Responsibility (CSR) and Social Acceptance (SA), however, there are differences between these terms.

A social licence to operate is required by industry before they can commence work on a mining project. It can be achieved through good CSR and demonstrated through the level of social acceptance. CSR is a concept whereby enterprises integrate social and environmental concerns into their mainstream business operations. Social acceptance is the agreement by a community for a project to commence.

SLO, however, is not like an environmental or legal licence to operate, in that it is not legislated for and there is no sign-off or official documentation, it is more a relationship between communities and the industry.

SLO will come from communities affected by a project. This ‘social area of influence’ can be complex, for example communities are not a single unified group, they can be defined as ‘communities of place’ (i.e. residents) or ‘communities of interest’ (i.e. wider organisations that may feel they have an interest like NGOs), these groups may have conflicting interests.

Without SLO it will be difficult or impossible for mining or quarrying to take place due to the hostile environment created and significant costs can be incurred by the industry (Davis and Franks, 2014).

A conceptual model showing the interactions between community and project to both earn and maintain SLO is shown in Figure 14. This conceptual model shows SLO being subject to four ‘benchmark’ levels of withdrawal, acceptance, approval and identification/ sense of ownership, which straddle three boundary conditions: legitimacy, credibility and trust.

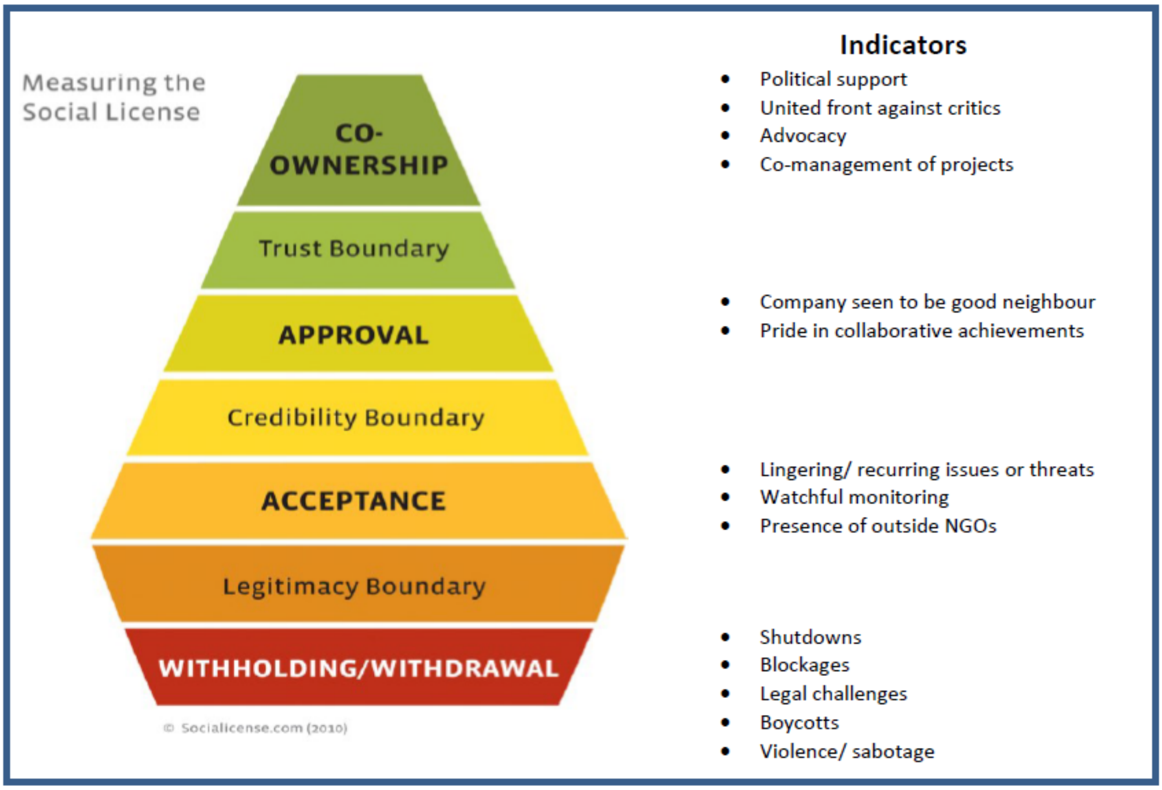


Figure 14 Conceptual model for SLO, adapted from Thomson and Boutilier (2011)

SLO can be split into three elements:

- Socio-political acceptance: i.e. public opinion, how is this considered in political circles, the media, campaigning groups etc.?
- Market acceptance: i.e. how do financial institutes accept the development?
- Community acceptance: how do the people living in the area that will be impacted feel about the development?

3.3.2 How can SLO be measured?

In many ways, SLO is an abstract concept and therefore very difficult to define by simple metrics, especially when trying to use metrics that are harmonised, or could be harmonised across a European scale. SLO is also a comparatively recent concept (compared to many other metrics commonly reported for social and environmental aspects of PRM extraction).

SLO and social acceptance are often very project specific and therefore it is difficult to compare across regional/national scales and metrics can be difficult to identify.

Whether a development has SLO or not will be down to a broad range of locally defined aspects, i.e. jobs created, local amenity improvement, environmental mitigation, quarry restoration etc. Many of these aspects will be covered under other sections of this report and it will not be useful to repeat in great detail here. However, it should be noted SLO cannot be defined by simple measurements, for example, the number of trees planted or jobs created, it is very dependent on the local context.

Measurement of SLO can be considered in terms of whether it being achieved or what is the risk that it might not be achieved. Depending on which of these viewpoints is taken, the metrics used to measure it will be different.

If the metric is whether SLO is being achieved at a particular site, then one way of measuring this will be to look at whether mining is going ahead without issues (SLO achieved) or alternatively whether permission has been refused or there are protests around the development (SLO not achieved). Data such as levels of planning permissions or refusals can give a proxy for this. Surveys of public perception relating to the extractives industry can also give a good view of whether SLO is being achieved. Levels of regulation with regard to mining is a poor indicator of SLO and cannot be used, as demonstrated by the fact that Europe has a heavily regulated extractives sector but the public has a poor perception of mining compared to other, less regulated, areas. The environmental performance also cannot be used because if a community have a relationship with an extraction site, through jobs or shared history, poor environmental practices may be ignored or overlooked, conversely good current environmental performance can be overlooked if there is a history of problems in the past.

Another way of measuring SLO on a national/continental scale could be to consider the risk of not gaining social acceptance for a project in a particular geographic area. This type of information may be useful for the mining industry and policymakers in determining where CSR effort needs to be focussed but does not give any information on wherever SLO is being achieved.

3.3.3 Available data on SLO in Europe

Public perception of mining

A dataset exists for the public perceptions of the efforts of industry to act responsibly, split by industrial sector (although for extractives this covers oil and gas as well the minerals considered in this study) and by country (European Commission, 2015) (the Flash Eurobarometer 365). This is used in the Raw Materials Scoreboard (European Commission, 2016) to analyse levels of social acceptance for mining within Europe. As discussed earlier social acceptance is not SLO but can be used as a proxy for some aspects of SLO for this dataset. This shows the extractives sector have the lowest rates of public acceptance of all industrial sectors considered. Other surveys of public perception of mining also exist in Europe on a country or regional level, for example, the INFACT project (Innovative, Non-Invasive and Fully Acceptable Exploration Technologies) is currently undertaking a survey to assess public attitudes to mining in Finland. In the UK a survey on planning, infrastructure and land use which was run by a private consultancy in 2008 and again in 2009 showed that quarrying had the lowest popularity amounts local residence of all infrastructure developments no data are available for recent years (ComRes, 2009).

Planning permissions

One method of SLO analysis could be to look at the national planning system. This, however, can be a potentially flawed proxy as it will very much depend on the national/regional planning system, which may not give much weight to local considerations (or wider political ones – for example in the UK drilling for shale gas has been permitted at several sites, but with significant protests and local opposition) (Whitmarsh et al., 2015) and planning systems vary greatly from country to country. This data is often not readily assessable on a national scale. The MinLex project is one source of information looking at permitting success rates at an EU level. This project compiled information on success rates for onshore exploration and extraction permits and licences from 2013-2015 on a national scale (MinPol, 2017). The collation was made by consultation with local country experts and figures given are based on qualitative and quantitative estimates as well as reported figures. For some countries, country level data is also available, in the UK the Aggregate Mineral survey collects data on permissions and refusals for aggregate sites, but only for England and Wales, not Scotland and Northern Ireland (due to the devolved system of planning for aggregates minerals) (Mankelow, 2016). Whether other countries also have this information will depend on how the planning system is structured.

Industry reports

- Population density: this is used because there is often friction between mining and local communities, therefore, the greater the population density the more impact mining will have on the local populace. Although this may be a simple measure of risk and cannot be used to draw any conclusions on whether adequate SLO has been achieved, or if suitable levels of CSR have been undertaken, population density is a very commonly measured statistic and is available from numerous different sources. One reliable, regularly updated source is the World Bank's data comparison tool (https://data.worldbank.org/indicator/EN.POP.DNST). This gives population density on an annual basis at a national level (World Bank, 2018). Another data set which displays this data spatially is the world population density interactive map (http://luminocity3d.org/WorldPopDen/#8/48.555/1.851). This gives residents per km^2 and is available from the Global Human Settlement Layer (GHSL) produced by the JRC via a mixture of evidence-based analytics and knowledge using spatial data mining technologies from remote sensing datasets (Pesaresi, 2016).

- Fund for Peace Fragile States Index: this is built from metrics measuring the potential for underlying discontent and is compiled by the Fund For Peace (Fund For Peace, 2018). This rating is based on the sum of scores for 12 indicators, scored from 0 (most stable) to 10 (least stable). Of these 12 indicators there are several which are more relevant to SLO, these being:
    - Factionalised elites: this considers the fragmentation of state institutes along ethic, class, clan, racial or regional lines, as well as brinkmanship and gridlock between ruling elites.
    - Group Grievance: this focuses on divisions and schisms between different groups in society – particularly divisions based on social or political characteristics – and their role in access to services or resources, and inclusion in the political process.
    - State legitimacy: this considers the representatives and openness of government and its relationship with its citizenry.
    - Demographic pressures indicator: this considers pressures upon the state deriving from the population itself of the environment around it.

  This information is annually updated and simply displayed on a national level and therefore harmonisation issues are not relevant.

- Heidelberg Conflict Barometer: this measures the intensity of conflict and therefore is not as relevant in an EU context fortunately due to low levels of conflict. This system looks at conflict processes, rather than quantitative measures, such as communications between different parties (Heidelberg Institute for International Conflict Research, 2018). Conflict intensity is measured on an intensity level from 1 (a dispute) to 5 (war). Only categories 3-5 involved violence. This information is annually updated and simply displayed on a national level and therefore harmonisation issues are not relevant.

Due to the significant risks involved to the mining industry, some consultancies have developed their own risk to SLO indexes, which plots risks to a project along various parameters to identify the total risk and what are the biggest issues. This, however, relies on qualitative input, on a project by project basis, a good example of this is one developed by the consultancy SRK (SRK consulting, 2016).

Other datasets

There are also many studies looking at individual sites using a variety of social science methods, principally by a survey of local communities, to rate how SLO is achieved for example studies by Bice (2014), Moffat and Zhang (2014) and Prno (2013). Although a review may draw some useful conclusions these cannot be used for any harmonised dataset at a regional/national/European level.

3.3.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
World Bank data comparison tool (Population density (people per sq. km of land area))	Population density	World / country	https://data.worldbank.org/indicator/EN.POP.DNST
Global Human Settlement Layer (World Population Density residents/km_2)	Population density	Europe / km^2	http://luminocity3d.org/WorldPopDen/#8/48.555/1.851
Fund for Peace Fragile States Index	Social risk to mining projects	World / country	fundforpeace.org/fsi/
Heidelberg Conflict Barometer	Social risk to mining projects	World / country	https://hiik.de/conflict-barometer/current-version/?lang=en
Fraser institute survey of mining companies	Social risk to mining projects	World / country	https://www.fraserinstitute.org/sites/default/files/survey-of-mining-companies-2017.pdf
MinLex project final report	Permissions and refusals of planning permissions for mining and quarrying	Europe / country	http://ec.europa.eu/environment/waste/studies/pdf/KH-01-17-904-EN-N.pdf
Flash Eurobarometer 363	Public perception of mining	Europe / country	https://data.europa.eu/euodp/en/data/dataset/S1036_363

Table 19: Key datasets for SLO in Europe

3.3.5 Recommendations for harmonisation and standardisation of SLO data

Data harmonisation on SLO is not a simple process due to the contextual nature of the information and the risk of losses of definition that would occur. Despite this, it may be useful to consider data on SLO on a European level either to consider how the extractive industry is performing with regard to social aspects or to understand the barriers to entry for the extractives industry due to social factors. Due to the rigorous permitting process for minerals operations which generally occurs across Europe, that in most cases incorporated some level of community engagement and social aspects, there is less of a risk of bad industrial practices as there may be elsewhere with less stringent planning regimes.

Data already exists at a country and continental scale with regard to public perception on risk to mining investment from social factors. For instance, from the EC survey on public perception to mining, various risk registers on mining investment and data compiled by the MinLex project as well as simple metrics in from population density information. Data from governance indicators or EIA's are less useful because the data are fragmented and not consistent with standards and codes. This issue is unlikely to be resolved without the introduction of environmental performance indicators (including social ones) on a European scale and the adoption of a single code or standard for industry reporting.

3.3.6 References

Behre Dolbear. 2014. 2014 Ranking of Countries for Mining Investment: Where Not to Invest. http://www.dolbear.com/wp-content/uploads/2016/04/2014-Where-to-Invest.pdf

Bice, S. 2014. What gives you a social licence? An exploration of the social licence to operate in the Australian mining industry. Resources, Vol. 3, 62-80

Comres. 2009. Saint Index 2009. [cited May 2018]. http://www.comresglobal.com/polls/saint-index-2009/

Davis, R, and Franks, D M. 2014. Costs of company-community conflict in the extractive sector. Corporate Social Responsibility Initiative Report. Harvard Kennedy School, Cambridge, USA

European Commission. 2015. Flash Eurobarometer 363: How Companies Influence Our Society: Citizens View. https://data.europa.eu/euodp/en/data/dataset/S1036_363

European Commission. 2016. Raw materials Scoreboard.

Fraser Institute. 2017. Survey of Mining Companies. https://www.fraserinstitute.org/sites/default/files/survey-of-mining-companies-2017.pdf

Fund for Peace. 2018. Fragile States Index.

Global Reporting Initiative. 2011. Sustainability Reporting Guidelines & Mining and Metals Sector Supplement.

Heidelberg Institute for International Conflict Research. 2018. Heidelberg Conflict Barometer.

IFC. 2018. Corporate Governance. [cited 5/6/2018]. https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+CG

Mankelow, J.M., Bide. T.P., Sen, M.A., E Raycraft, E. and Cameron, D.G. 2016. Collation of the results of the 2014 Aggregate Minerals survey for England and Wales. (British Geological Survey).

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/563423/Aggregate_Minerals_Survey_England___Wales_2014.pdf

Mining Journal. 2017. World Risk Report.

Minpol. 2017. Legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU final report.

Moffat, K, and Zhang, A. 2014. The paths to social licence to operate: An integrative model explaining community acceptance of mining. Resources Policy, Vol. 39, 61-70

Pesaresi M., Ehrlich D, Ferri S., Florczyk A.J., Freire S., Halkia S., Julea A.M., Kemper T., Soille P. and Syrris, V. 2016. Operating procedure for the production of the Global Human Settlement Layer from Landsat data of the epochs 1975, 1990, 2000, and 2014. Publications Office of the European Union

Prno, J. 2013. An analysis of factors leading to the establishment of a social licence to operate in the mining industry. Resources Policy, Vol. 38, 577-590

SRK Consulting. 2016. Quantifying the impact of Social License for Investment Decision-Making. https://www.srk.com/sites/default/files/file/MUpton_Current_Trends_In_Mining_Finance_2016.pdf

The Equator Principles Association. 2018. [cited 5/6/2018]. http://equator-principles.com/

Thomson, I, and Boutilier, R G. 2011. Social license to operate. SME mining engineering handbook, Vol. 1, 1779-1796

Whitmarsh, L, Nash, N, Upham, P, Lloyd, A, Verdon, J P, and Kendall, J M. 2015. UK public perceptions of shale gas hydraulic fracturing: The role of audience, message and contextual factors on risk perceptions and policy support. Applied Energy, Vol. 160, 419-430. http://www.sciencedirect.com/science/article/pii/S0306261915010727

World Bank. 2018. Population Density [cited May 2018]. https://data.worldbank.org/indicator/EN.POP.DNST

3.4 *Cultural heritage and archaeology*

3.4.1 Definition of cultural heritage and archaeology with regard to the extractives sector

Cultural heritage is defined as the legacy of human activities inherited from past generations. It includes both 'tangible' heritage (e.g. physical artefacts, buildings, monuments) and 'intangible' heritage (e.g. oral traditions, performing arts, rituals). Tangible heritage can be either 'movable' (e.g. paintings, sculptures, manuscripts) or 'immovable' (e.g. buildings, archaeological sites), but also on land or underwater (e.g. shipwrecks). Cultural heritage can also include natural heritage sites that have cultural importance attached to them and thus can include certain landscapes or biologically important locations (United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2017). The interaction with the mineral extractive industries is primarily connected with 'tangible' heritage and as a consequence, the 'intangible' heritage is not considered further in this chapter.

When a value is attached to cultural heritage by society, there is often a desire to conserve that heritage for future generations. The extractive sector is often seen as contrary to this desire, but historical mining and quarrying does also form part of cultural heritage, e.g. the former mines contained within the World Heritage Sites in the UK at "Blaenavon Industrial Landscape" or at the "Cornwall and West Devon Mining Landscape" (UNESCO, 2019). An assessment of the current knowledge relating to England's historic mining and quarrying heritage are described in some detail in a report for the National Association of Mining History Organisations, edited by Newman (2016).

Archaeology is the scientific study of human history through the excavation of sites and the analysis of artefacts and physical remains (Oxford University Press, 2019). Mineral extraction at the surface (i.e. excluding underground mines) will increase the risk of disrupting buried cultural heritage sites, especially ones that have not been previously identified. However, it can also provide an opportunity to discover and study archaeological sites because the surface soil layers will be removed before mineral extraction can start. A balance often needs to be established between giving archaeologists sufficient opportunity to look for anything of interest, while not unduly delaying the start of mineral extraction.

Aside from impacts resulting from the physical area of mineral extraction, additional impacts on cultural heritage can result from noise, dust and vibration (either from the mine or quarry itself or from traffic to/from the site). These potential impacts are covered in section 2.3 of this report.

3.4.2 How can the impacts of the extractives sector be measured with regards to cultural heritage and archaeology?

Culture is not something that can be measured by one single metric and consequently measuring the impact of one particular industrial sector upon cultural heritage is very difficult. UNESCO published a document in 2009 that identified a number of different ways in which 'culture', in its broadest sense, can be measured by existing statistical classifications (UNESCO, 2009). Within this document, there is a defined 'cultural domain' that includes cultural heritage and within this domain there are two aspects which are of particular interest to this chapter, i.e. 'archaeological and historical places' and 'cultural landscapes'. The other cultural domains and topics within this document are not considered to be relevant to the mineral extractives sector and therefore are not discussed further.

Attaching economic values to cultural heritage often rely on data such as the costs incurred in preserving heritage assets (e.g. the cost of professionals' time, the cost of equipment or materials), the amount of income generated by people visiting heritage sites (cultural tourism) or the amount that people are willing to pay to ensure an asset is preserved (obtained via a survey) (UNESCO, 2009). This ignores the 'social good' value that many people would attach to heritage assets, i.e. the value that comes through their importance for improved knowledge, their significance relative to other known sites, or simply their intrinsic worth (which is a perception that will vary from person to person). These social values are much more difficult to measure and in general are carried out by qualitative research methods, such as focus groups or interviews (Jones, 2017).

In theory, if an economic or social value is applied to cultural heritage, then the positive or negative impact of one particular industrial sector on that value can be measured. For example, from an economic value perspective, whether mining and quarrying increases or decreases the costs incurred in the preservation of cultural heritage, whether mining and quarrying increases or decreases the visitor numbers and income generated by heritage sites and whether people are willing to pay more to prevent heritage sites from being negatively impacted by quarrying. However, it should be remembered that these measures might be caused by an increase or decrease in the numbers of identified heritage sites. This could be either because quarrying has revealed previously unknown sites (resulting in an increase in the number of sites) or because mineral extraction has damaged or removed heritage sites (causing a decrease in their number). The latter may happen after the key artefacts have been moved to a museum for their preservation.

In practice, however, even where these economic values are captured, assigning any increases or decreases in them specifically to the effects of mining or quarrying is not carried out when the data are collected and therefore data at this resolution are not available. Separating the impact of the mineral extractive sector in these measurements from all other sectors of society will be difficult unless the raw data are specifically collected with this purpose in mind.

It might be possible to measure a non-economic value for cultural heritage by the number of times they are visited by citizens or the percentage of citizens that actively visit them. The European Commission (EC), Directorate-General for Education and Culture has commissioned two "Eurobarometer" studies examining "Cultural Access and Participation", the most recent was published in 2013 (EC, 2013). This study encompasses 'culture' in a broad sense and is not limited to cultural heritage but under the latter heading there were question(s) in the survey related to the number of times respondents had "visited a historical monument or site (palaces, castles, churches, gardens, etc.)". Although this category is likely to include a wide range of sites and not all of these will be relevant to this chapter, it does show that visiting these historical sites is joint third in the most frequent cultural activities undertaken, with 52% of respondents stating that they had done so within the last 12 months (compared with 72% for watching cultural programmes on TV and 68% for reading books; and with the same percentage as those attending a cinema). However, although the report does note changes in these percentage figures (e.g. visiting historical sites is down from 54% in 2007), it does not have sufficient resolution to explain the reasons behind these changes, nor to indicate whether any particular sector had an influence on the changes. Consequently, it is not possible to assess whether the activities of the mining or quarrying sector had any impact on these figures.

Measuring the number of heritage sites that are directly related to mining and quarrying might be a way of considering the contribution of former mining sites to the overall 'cultural heritage' of a country. However, in order to do this comprehensive studies such as that compiled by

Newman (2016) would be required for all countries of Europe and it is unlikely this kind of study has been carried out in many countries.

3.4.3 Availability of data on the impacts of the extractives sector with regards to cultural heritage and archaeology in Europe

The UNESCO document relating to the measurement of 'culture' (UNESCO, 2009) identified only a few existing statistical classifications that relate to 'cultural heritage' which could be of relevance, these included:

- productive activities such as 'museums activities and operation of historical sites and buildings';
- occupations such as 'sociologists, anthropologists and related professionals', 'gallery, library and museum technicians', 'environmental protection professionals' or 'archivists and curators'; or
- time use surveys for 'visit museum, art gallery, historical/cultural park, heritage site'.

As can be seen from the above descriptions cultural heritage and archaeology are often amalgamated with other cultural items in the statistics, e.g. museums, galleries or libraries, and consequently, none of these classifications have sufficient resolution to isolate cultural heritage and archaeology. As a consequence, the even more detailed resolution required to identify changes resulting specifically from the activities of the extractive sector will not exist either.

The Eurostat database (Eurostat, 2019) contains various datasets relating to 'culture', but most of these do not include reference to heritage or archaeology. The two that may include them are:

- Cultural employment by NACE Rev 2 activity (cult_emp_n2) – with the relevant NACE code being limited to "R91 Libraries, archives, museums and other cultural activities"
- Cultural participation (ilc_scp03 or ilc_scp04) – filtered on "Cultural sites (historical monuments, museums, art galleries or archaeological sites)"

As with the classifications identified from the UNESCO (2009) document, these classifications from Eurostat do not completely separate cultural heritage and archaeological sites from other types of culture. Therefore it is not possible to attach any kind of metric to the relevant part of a culture that may be impacted by the extractives sector. Consequently, it is also not possible to measure the impact of the extractives sector on those sites.

Some national level statistical agencies or government departments may collect more data than is available through Eurostat. For example, the UK's Department for digital, culture, media and sport (DCMS) publishes regional gross value added figures (in £million) for cultural sub-sectors that isolates "Operation of historical site and similar visitor attractions" from other types of cultural activities (DCMS, 2019a) and also figures for the numbers and sizes of businesses in the same sub-sector (DCMS, 2019b). However, these data do not provide any links or connections to other economic sectors so it is not possible to evaluate any impacts from the mineral extractives sector specifically. Similarly some counties publish data regarding archaeological excitation and historical archaeological sites, for example spatial data sets on the cultural environment published by the Finnish Heritage Agency[27]. These data however are only available for some Member States and cannot be related to the extractive sector without

[27] https://www.museovirasto.fi/en/palvelut-ja-ohjeet/data-systems/kulttuuriympaeristoen-tietojaerjestelmae/kulttuuriympaeristoen-paikkatietoaineistot

linking to additional datasets, such as the location of mine and quarry sites, which in itself cab be problematic, as discussed in the land sue section.

3.4.4 Key datasets identified

Although datasets exist on a national level relating to cultural heritage or archaeology without significant extra work there is no way of linking these datasets to mineral extraction

Name of dataset	Metric considered	Spatial coverage / resolution	Link
None available	n/a	n/a	n/a

Table 20: Key datasets for cultural heritage and archaeology in Europe

3.4.5 Recommendations for harmonisation and standardisation

As there are no data available to enable the measurement of the impact of the mineral extractive sector on cultural heritage or archaeology, there are no recommendations that can be made for harmonisation or standardisation.

The options for collecting raw data relating to this aspect needs to be examined first and this should be done as a collaboration across European countries to ensure its commencement is done in a harmonised or standardised way from the outset.

3.4.6 References

European Commission (EC). 2013. Cultural Access and Participation Report. Special Eurobarometer 399. Directorate-General for Education and Culture. http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_399_en.pdf

Eurostat. 2019. Statistical Database. https://ec.europa.eu/eurostat/data/database?p_p_id=NavTreeportletprod_WAR_NavTreeportletprod_INSTANCE_nPqeVbPXRmWQ&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_pos=1&p_p_col_count=2

Jones, S. 2017. Wrestling with the Social value of Heritage: Problems, Dilemmas and Opportunities. Journal of Community Archaeology & Heritage, 4:1, 21–37. https://doi.org/10.1080/20518196.2016.1193996

Newman, P. (Ed) 2016. A research framework for the archaeology of the extractive industries in England. Resource Assessment and Research Agenda. National Association of Mining History Organisations. https://www.namho.org/documents/MINING_FRAMEWORK_Pt_one.pdf

Department for digital, culture, media and sport (DCMS). 2019a. DCMS Sectors Economic Estimates 2017: Regional GVA. [Note: DCMS is the Department for Digital, Culture, Media and Sport]. https://www.gov.uk/government/statistics/dcms-sectors-economic-estimates-2017-regional-gva

Department for digital, culture, media and sport (DCMS). 2019b. DCMS Sectors Economic Estimates 2017: Business Demographics. [Note: DCMS is the Department for Digital, Culture, Media and Sport]. Tables 10–36: Businesses by sub-sector. https://www.gov.uk/government/statistics/dcms-sectors-economic-estimates-2017-business-demographics

Oxford University Press. 2019. Oxford Living Dictionaries. https://en.oxforddictionaries.com/definition/archaeology

United Nations Educational, Scientific and Cultural Organisation (UNESCO). 2009. UNESCO Framework for Cultural Statistics. https://unesdoc.unesco.org/ark:/48223/pf0000191061

United Nations Educational, Scientific and Cultural Organisation (UNESCO). 2017. Culture webpages. http://www.unesco.org/new/en/culture/themes/culture-and-development/

United Nations Educational, Scientific and Cultural Organisation (UNESCO). 2019. World Heritage List. https://whc.unesco.org/en/list/

3.5 *Human/indigenous rights*

3.5.1 Definition of Indigenous rights and human rights with regard to the extractives sector

Indigenous peoples are defined as the original inhabitants of a region, as opposed to other groups of peoples that later migrated to, occupied or colonised an area. Indigenous peoples will usually maintain strong cultural connections to a specific area and maintain traditions associated with a region's early culture. Indigenous peoples' traditions with regard to land ownership are often at odds with concepts of private land ownership that form the basis of most mineral extraction operations and this can cause conflict.

The conflict between indigenous peoples and mineral operations, along with associated human rights problems, is, unfortunately, a significant issue across the developing world. However in Europe, whilst there are significant populations of ethnic groups that are associated with a particular region, such as the Basques of Spain and France or Gorals of Poland and the Czech Republic, due to the long history of land ownership in Europe issues over land rights for mining are not significant on a continent scale. The most notable group of indigenous people that these issues affect is the Sami of Norway, Finland and Sweden. Other ethnic groups also exist further east into the Caucuses and northern Russia but they are outside the scope of this study.

3.5.2 How can the impacts of the extractives sector be measured with regard to Indigenous rights and human rights?

To assess the impacts of the extractives sector on indigenous peoples it is important to understand how mineral activities (mines, quarries and exploration) interact with the lives of indigenous groups. This requires the areas of land occupied by indigenous groups and their associated rights to be well understood. A specific issue regarding indigenous people in the Nordic countries relates to reindeer migration routes because an important part of the Sami culture is linked to reindeer herding. Therefore studies on the impacts on reindeer migration routes by mining-related activities may be able to provide useful metrics.

There are often specific laws regarding rights for indigenous peoples in many countries, especially regarding access to land and rights over that land and these may differ from standard laws and practices. The presence or absence of these could be used to measure whether and how human rights are adequately considered when proposing mineral extractive activities.

3.5.3 Available data on the impacts of the extractives sector with regard to indigenous rights and human rights in Europe

In northern Europe issues around the conflict between the Sami peoples and mineral extraction is often related to issues around reindeer herding, which is seen as central to Sami livelihoods and a fundamental part of their culture. Therefore, accurate maps of reindeer herding areas are essential. Nordregio, a Nordic research institute, have produced a map of reindeer herding areas in Nordic countries (http://www.nordregio.org/maps/reindeer-herding-area-in-the-nordic-countries/) showing the total number of reindeer per district and boundaries between herding areas. This could be compared to areas of known mining to see how the two activities interact. The map produced by Nordregio is based on data produced by the Norwegian Ministry of Agriculture, the Finnish Association of Reindeer Herding and the Sami Parliament of Sweden (Landbruksdirektoratet, 2014; Paliskuntain yhdistys, 2017; Sametinget, 2018).

It is also important to consider specific national rights and laws when dealing with indigenous groups and human rights, especially as areas of land historically used by groups of indigenous peoples may not correspond to national borders. This can be a complex issue, as every country will have its own set of specific laws regarding rights and land access. For issues regarding the Sami several reports and resources summarise the legal issues faced in the various different jurisdictions such as Amatulli (2015) and UNRIC (2018).

Individual companies also may have specific information contained within Environmental Impact Assessments (EIA) or other reports regarding the impact of mining on indigenous populations as this will often form an important part of corporate social responsibility. For example, Boliden has actively sought long-term cooperation with the Sami in order to mitigate the impacts of its mining activities in Sweden (Boliden, 2018). Other NGOs also take a very active role in this area which may form a useful baseline for information on a site-specific level, for example, Lawrence (2016).

3.5.4 Key datasets identified

Name of dataset	Metric considered	Spatial coverage / resolution	Link
Reindeer herding areas in Nordic countries	the total number of reindeer per district and boundaries between herding areas	Nordic countries/ districts within individual countries	http://www.nordregio.org/maps/reindeer-herding-area-in-the-nordic-countries/

Table 21 Key datasets for human and indigenous rights in Europe

3.5.5 Recommendations for harmonisation and standardisation

With the exception of the Sami in the Nordic area, the issues surrounding indigenous rights and human rights are not as a large an issue for Europe as it is globally. Due to the limited extent of these issues, site and regional specific studies are most suitable to address these issues. Consequently, there is little need to harmonise existing datasets.

3.5.6 References

Amatulli, G. 2015. The Legal Position of the Sami in the Exploitation of Mineral Resources in Finland, Norway and Sweden. Institute for Human Rights. https://www.abo.fi/wp-content/uploads/2018/03/2015-Amatulli-The-legal-position-of-the-Sami-in-the-exploitation-of-mineral-resources.pdf

Boliden. 2018. Building trust with Sami communities: Boliden's approach. [cited 1/9/2018]. https://www.boliden.com/sustainability/case-studies/building-trust-with-sami-communities

Landbruksdirektoratet. 2014. Årsrapport. https://www.regjeringen.no/contentassets/a34b107c580e48288f48c53b5f2b7dbf/arsrapport-ldir-2014.pdf

Lawrence, R. and Larsen, R.K. 2016. Då är det inte renskötsel” - Konsekvenser av en gruvetablering i Laver, Älvsbyn, för Semisjaur Njarg sameby. Stockholm Environment

Institute. https://www.sei.org/mediamanager/documents/Publications/SEI-PR-2016-sami-mining-swedish.pdf

Paliskuntain Yhdistys. 2017. Porotalouden organisaatio ja hallinto. [cited 1/9/18]. https://paliskunnat.fi/py/organisaatio/

Sametinget. 2018. Website of the Sami Parliament of Sweden. [cited 1/9/2018]. https://www.sametinget.se/

Unric. 2018. The Sami of Northern Europe – one people, four countries [cited 1/9/2018]. https://www.unric.org/en/indigenous-people/27307-the-sami-of-northern-europe--one-people-four-countries

4 Recommendations for data for potential inclusion in a new version of the European Minerals Yearbook

A key goal of this data analysis was to provide recommendations for Work Package 3 of the ORAMA project. Work Package 3 aims to test a selection of the datasets identified by Work Package 1 in newly developed INSPIRE type data models for possible inclusion in a new European Minerals Yearbook.

The vast majority of the data that may be suitable for inclusion in a new European Minerals Yearbook and that are available without any requirement for further processing, analysis or harmonisation is generally (with some exceptions) statistical data from Eurostat. However, without detailed knowledge of the systems/procedures used to harvest data, it is difficult to estimate how feasible it will be, although it should be noted that Eurostat data can be downloaded in a variety of different formats. To avoid just a reproduction of Eurostat data it may be worth considering using infographics, such as already used in the commodities section of the existing European Minerals Yearbook, to show values on a national level on a map and/or a chart. A wide variety of alternative ways of displaying some of these datasets for a range of thematic areas can be seen in the country summaries of the Raw Materials Information System (RMIS)[28] or the Raw Materials Scoreboard[29].

4.1 *Shortlist*

Below is a proposed shortlist of datasets (derived from the many datasets identified in this report) relating to social and environmental aspects of mineral extraction to be investigated for testing by BRGM for inclusion in the European Minerals Yearbook.

As already identified by the draft chapters for task 1.4, there is a long list of datasets that could be incorporated into the European Minerals Yearbook to highlight various social and environmental aspects relating to mining and quarrying. These come from a wide variety of data sources and are provided in a range of formats. It should be noted that for some datasets oil and gas are included, whereas ideally these should be omitted as they are out of scope of the ORAMA project. For example, for most datasets that use NACE rev 2 ‘mining and quarrying’, energy minerals will be included.

These datasets have been narrowed down to a select few to recommend to BRGM in order to begin testing to see how easily some of these can be automatically ‘harvested’ for inclusion in the European Minerals Yearbook. For a first pass, four different data sources will suffice to allow Work Package 3 to decide exactly what should be included. From the many different sources of data for the different themes of data the following points have been considered to identify suitable data sources. Ideally data sources should:

- be available on a harmonised EU level already;
- come from ‘official’ and regularly updated sources;
- be statistical rather than spatial data (the European Minerals Yearbook is currently a statistical data platform and does not host spatial data);
- be very relevant to mineral extraction without the need to for further work to process and modify the data and

[28] http://rmis.jrc.ec.europa.eu/?page=country-profiles#/
[29] https://publications.europa.eu/en/publication-detail/-/publication/117c8d9b-e3d3-11e8-b690-01aa75ed71a1

- ideally, are at a disaggregated level where data for primary mineral resources (excluding energy minerals) can be obtained.

To this end, the shortlist is the following:
(Note: these recommended metrics are both heavily reliant on Eurostat data and also do not cover much of the environment topic. For instance, Eurostat data on water, although available for abstraction, use and discharges, is not listed here since reliability and completeness is limited. However, no pan-European datasets relating to water issues that can be disaggregated to be mining and quarrying specific that can be simply harvested have been identified.

4.1.1 The Flash Eurobarometer data

These data highlight the public's perception to mining in the EU and therefore covers social licence to operate (SLO) and public acceptance aspects with the question "do mining and oil and gas industry companies make the effort to behave responsibly" the data is regularly updated in excel table format volume A Q6.5. Using this either a simple table or graph could be made (see the image from the raw materials scoreboard in the long list) or alternatively, the values could be ascribed to a country map of Europe and shading could dictate the percentages for yes answers (or no). It should be noted however that this dates also includes energy minerals, which is not ideal but no further disaggregation is available.

Link: http://data.europa.eu/euodp/en/data/dataset/S1036_363

4.1.2 Greenhouse gas emissions

This may be a good metric to use for general emissions to air/pollution/environmental impact from mining and quarrying. Eurostat has several datasets for GHG emissions, specifically for mining and quarrying. Data availability is limited for the dataset Greenhouse gas emissions by source sector: Eurostat does not provide data for energy-related emissions from mining activities; process-emissions falling under the mineral industry sectors may refer to production processes beyond extraction.

Data from the Air Emissions Accounts, mapped to the NACE classification could be used. It could be included either at a national level as a time series in a graph or on a shaded map of i) total GHG emissions per country for mining and quarrying, ii) as GHG emissions per population (also computed by the Air Emissions Accounts) or iii) GHG emissions per unit of production (this is the dataset emission intensity, and refers to production in monetary value).

Link (Air Emissions Accounts by NACE Rev. 2 activity):
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_ainah_r2&lang=en

Link (Air Emissions Intensities by NACE Rev. 2 activity):
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_aeint_r2&lang=en

As well as the Eurostat data another source of greenhouse gas emissions data is the EDGAR dataset, published by JRC, this breaks down GHG emissions by country and by a range of industrial sectors. Related to mining and quarrying are; non-ferrous metals production and non-metallic minerals production (there is also a category for iron and steel production, however, this relates more to processing then extraction). The data can be downloaded as a time series up to 2012 (dataset for CO_2 already available up to year 2017, and new updates coming soon) and the industrial sectors can be sub dived via codes (which are explained on the website)

Link: http://edgar.jrc.ec.europa.eu/overview.php?v=432_GHG.

Link (new release of the CO2 dataset):
http://edgar.jrc.ec.europa.eu/overview.php?v=booklet2018

4.1.3 Percentage of land use for mining and quarrying

Perhaps not a great indicator of actual 'impacts' of mineral extraction as the size of land area for mineral extraction will depend very much on the industry of the country. However, this is potentially an interesting statistic for the European Minerals Yearbook and could be considered a potential 'easy win'. This can be obtained from Eurostat (Land use overview by NUTS 2 regions (lan_use_ovw) and then by selecting mining and quarrying for land use). This could be displayed in a table, graph or shaded map. This data is also used in the RMIS country profiles and is displayed as a table.

Link: https://ec.europa.eu/eurostat/web/lucas/data/database

4.1.4 Employment data

Another Eurostat source but very focused on mining and quarrying and an indication of national minerals industries.

Link: http://ec.europa.eu/eurostat/data/database

Population and social conditions > labour market > employment and unemployment (labour force survey) > LFS series – detailed annual survey results (lfsa) > Employment – LFS series (lfsa_emp) > Employment by sex, age and economic activity (lfsa_egana) and then by selecting mining and quarrying.

This could be displayed either as is or the per capita employment in the mining industry could be displayed to allow comparison across European countries.

As well as the employment statistics the Eurostat structural business statistics also (as well as some other economic metrics), this data is collected via a separate survey compared to the employment statistics. It includes greater granularity with regard to industrial sectors within mining and quarrying that can be disaggregated.

Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_na_ind_r2&lang=en

4.2 *Conclusions regarding datasets available relating to environmental and social dimensions of extraction*

The provision of datasets specifically relating to environmental and social aspects of mining and quarrying is highly variable across the themes considered in this report.

For some thematic areas datasets already exist that directly report on, or act as good proxies for, assessing impacts of the extractive sector on social and environmental issues. Eurostat data, using the NACE codes, provide a wide range of easily accessible, data with some degree of quality assurance for most published datasets that have a suitable resolution to be able to specifically disaggregate the extractive sector from the rest of the data. However, in many cases, it is not always possible to split energy and non-energy minerals, link downstream activities of the extractive sector such as smelting and processing to mineral extraction or get breakdowns for specific mineral sectors. Depending on the use requirements, this may or may not be sufficient.

However, a common theme across many of the thematic subject areas discussed in this report is that either no data are available, or much of the available data cannot be related to specific impacts of mineral extraction. For example, data are available across Europe for soil quality, water use, the movement of heavy goods vehicles, dust emissions etc. but there is often no way of separating the extractives sector's contribution to these from other economic sectors. If extraction sector specific datasets are required at a European level, further disaggregation by industrial sector is required when collecting data. This may not be a realistic prospect given the high administrative burdens of collecting the existing data. Alternatively, it may be possible to integrate existing datasets in innovative ways to link the extractive sector to other datasets. There has been several instances where this may be possible which have been indicated in this report, such as linking land use maps with known locations of mineral extraction sites. However, to develop these ideas further into published datasets significant additional research is required and consequently, there needs to be a strong desire for particular datasets, combined with the necessary resources to enable them to be created. It is hoped that the examples given in this report show what could be possible should more detailed or more specific datasets of the impacts of mineral extraction be required.

This review of European datasets has also highlighted that although the many European funded projects in recent years have enhanced our knowledge on many issues regarding raw materials, they are often lacking harmonisation and interoperability. Their quality can also by highly variable, as they seem to take only information readily available from project partners and stakeholders rather than provide an integrated picture of raw materials issues in Europe. This highlights the need for an exercise of harmonisation to enable a single data model and method to ensure data interoperability is established.