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Environmental information in the Raw Materials Information System (RMIS)

Background and thematic information on environmental considerations related to the production of non-food, non-energy raw materials

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Abstract

The 2008 Raw Materials Initiative (RMI) aimed to promote, among other aspects, the sustainable supply of raw materials from both EU sources and outside the EU. Moreover, the new Green Deal and the Circular Economy action plans put sustainability and circularity at the core of economic growth in the EU, and very much link to the future of the EU's raw materials sector. For the implementation of the these policies, information and data are needed covering a variety of environmental aspects. Indeed, environmental considerations in relation to raw materials supply are manifold. Firstly, raw materials pose pressures on the environment through the use of natural resources (land, water, fuel, etc.) and through the emission of polluting substances over the whole life cycle, from extraction, to transport, processing, manufacturing of final products and until their end of life. At the same time, raw materials are essential for industrial processes that allow societyies to develop, as defined by the Sustainable Development Goals (SDGs). Certain raw materials are also essential for the deployment of green and low-carbon technologies. In addition, varied environmental conditions and heterogeneous environmental regulatory frameworks at different locations, can determine the suitability of raw materials production itself.

The Raw Materials Information System (RMIS) is the EC's reference web-based knowledge platform on non-energy, non-agriculture raw materials. It acts as the core access point to such knowledge and as interface for policy support. As it is stated in the RMIS roadmap, the RMIS aims to provide information on the emission of greenhouse gases and pollutants to the environment, the use of resources such as land or water, and the framework environmental conditions (e.g. water scarcity, nature protection areas) in which extractive and processing facilities operate. This should cover, whenever information and data availability allow for that, all relevant raw materials sectors, covering primary and secondary production and all relevant supply chain stages. The main environmental impacts of the sector, and best practices are to be also highlighted in the RMIS.

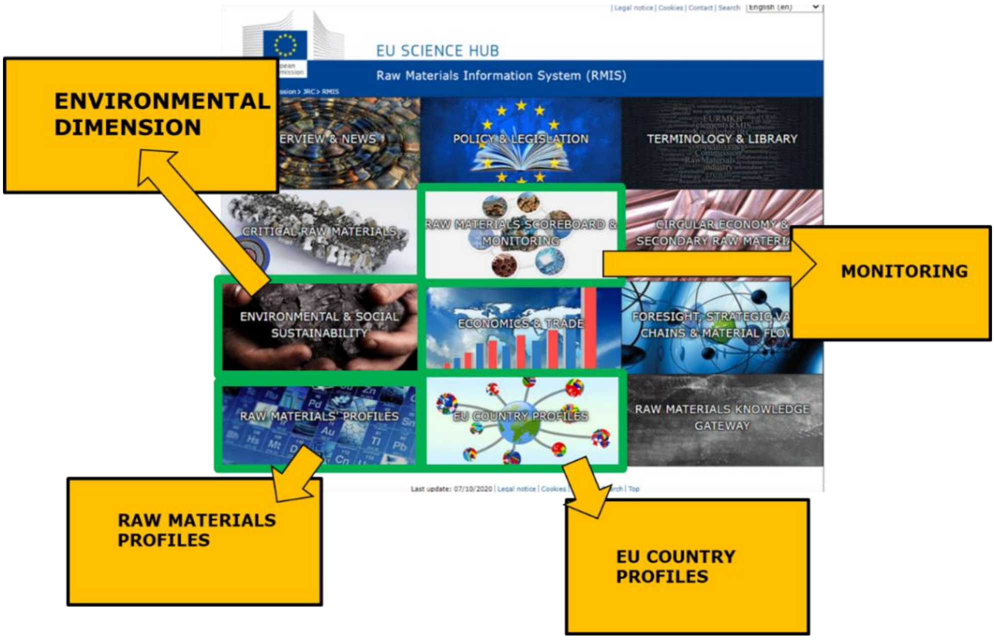
This report describes the environmental information and data included to date in the RMIS. In particular, the report mirrors the full content of the dedicated section on the environmental dimension, and describes also the environmental content available in other related sections. The dedicated section on the environmental dimension first sets the framework of the environmental considerations to be taken into account, based on the mapping and analysis of relevant literature. Then, information related to specific aspects/impacts/media is presented. The latter covers so far industrial emissions, climate change and decarbonisation, water, air pollution and land use and soil. Other sections providing environmental information and data are the raw materials´ profiles, EU country profiles and the section on monitoring schemes.

1 Environmental information in the Raw Materials Information System

The Raw Materials Information System (RMIS)[1] is the EC's reference web-based knowledge platform on non-energy, non-agriculture raw materials, covering primary (extracted/harvested) and secondary (recycled/recovered) sources. The RMIS acts as the core access point to such information and knowlegde and as interface for policy support. The RMIS provides information on a variety of topics (see Figure 1), from policy and legislation to materials flows, trade, sustainability, etc. As it is stated in the RMIS roadmap (JRC, 2019), the RMIS aims to provide information on the following environmental aspects: emission of greenhouse gases and pollutants to the environment, the use of resources such as land or water, and the framework environmental conditions (e.g. water scarcity, nature protection areas) in which extractive and processing facilities operate. This should cover, whenever information and data availability allow for that, all relevant raw materials sectors, covering primary and secondary production and all relevant supply chain stages. The main environmental impacts of the sector, and best practices are to be also highlighted in the RMIS.

Environmental information and data related to the production of raw materials is contained mostly in four sections of the RMIS (Figure 1). First, a dedicated sub-section called ´environmental dimension´ under the section ´environmental & social sustainability, which is fully transcribed in chapter 3 in this report. Environmental information is also present in other sections of the RMIS (see chapter 4 in this document). The latter includes information at material level, given in the raw materials' profiles; environmental data at country level, within the ´country profiles´; and environmental indicators within the section on the Raw Materials Scoreboard[2] & other monitoring schemes. This report mirrors the full content of the dedicated section on the environmental dimension, and describes also the environmental content available in other related sections.

Figure 1. Structure of the RMIS and, highlighted in green, sections containing most environmental information.



Source: Modified from the snapshot of the entry point in the RMIS web page (version 2.0 as for September 2020).

[1] https://rmis.jrc.ec.europa.eu/

[2] The EU monitoring tool to follow track of challenges of the raw materials sector (see chapter 4.1.1).

2 Environmental dimension (within the section environmental & social sustainability)

Within the RMIS section ´Environmental & social sustainability´, the sub-section ´Environmental dimension' intends to provide an overview of the main environmental considerations linked to the raw materials production chain. The sub-section starts with more overarching, general chapters, which set the scene – introduction, life cycle impacts – and inform about the most relevant trends – industrial emissions – and regulation (Figure 2).

In addition, the section aims to give dedicated information, and links to related data sources, for the main environmental media, namely air, water and soils/land. To that aim, chapters targeting specific environmental considerations follow, covering climate, air pollution, water and soil. These dedicated chapters cover the main challenges to the sector (e.g. environmental pressures and impacts, risks to secure supply) and opportunities (e.g. contribution of raw materials to low-carbon technologies).

Figure 2. Structure of the RMIS sub-section ´Environmental dimension´, within the ´Environmental & social sustainability' section.

Source: Modified from the snapshot to the entry point to the environmental & social sustainability section of the RMIS (version 2.0 as for September 2020).

3 Environmental aspects related to raw materials production

Environmental considerations in relation to the raw materials sector are manifold. Firstly, raw materials pose pressures on the environment through the use of natural resources (land, water, fuel, etc.) and through the emission of polluting substances over the whole life cycle (extraction, transport, processing, use and end of life). Accidents caused by problems in operation or by natural hazards can, in addition, lead to severe environmental impacts.

At the same time, raw materials are essential for industrial processes that allow societies to develop, as defined by the Sustainable Development Goals (SDGs). Indeed, almost half of the 17 SDGs relate to environmental factors that can be directly affected by the activity of the raw materials sector, such as good health, clean water, affordable and clean energy, and climate (Figure 3). Certain raw materials are also essential for the deployment of green, low-carbon and pollution abatement technologies.

Figure 3. Sustainable Developments Goals more directly related to the environmental considerations linked to raw materials production (framed by green squares in the figure).

Source: own elaboration.

In addition, local environmental conditions, and the varied environmental regulatory frameworks at different locations, can determine the suitability of raw materials production itself. For instance, natural hazards, scarcity of resources such as water or energy, or competition with other alternative land uses may prevent the development of an industrial activity or lead to disruptions in the production of raw materials once the activity has started to operate. In addition, regulations with stringent environmental standards can also result in the phasing out of the use (and therefore production) of certain materials.

The 2008 Raw Materials Initiative aimed to promote the sustainable supply of raw materials from both EU sources and outside the EU, as well as boost resource efficiency and recycling. Related to that, the European Commission has developed a series of actions to promote best practices (e.g. in land use planning), reconcile extractive activities with nature conservation sites, and boost research and innovation in the field of materials and resource efficiency. Moreover, one of the action areas of the European Innovation Partnership on Raw Materials is the mitigation of environmental, social and health impacts linked to the raw materials sector.

3.1 Environmental impacts along the supply chain

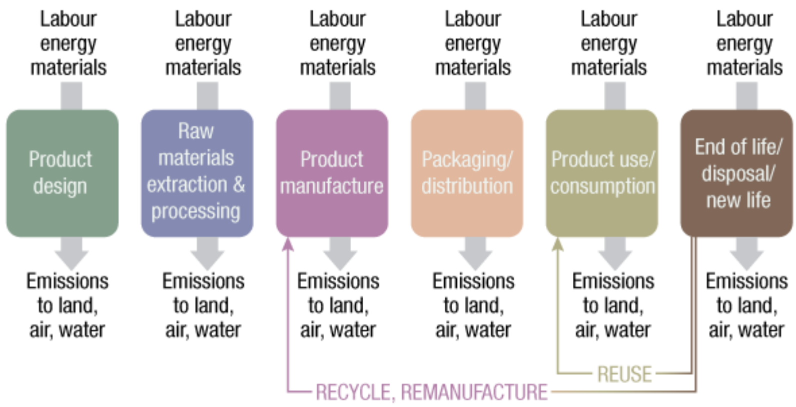
The production of raw materials and derived products takes place along different stages, often occurring in multiple locations. This leads to different types of environmental impacts.

The supply chain starts with a product's design, and continues with the extraction of the required materials (e.g. bauxite, iron ore or wood), transport and subsequent processing to yield semi-finished products such as steel or planed wood (Figure 4). The supply chain continues with the manufacturing of final products (e.g. machinery, furniture or vehicles), and their distribution and use. All these stages lead to environmental impacts, which will depend on, for example, the material and energy inputs required and the resulting emissions and waste streams.

In addition, products may be managed in various ways when they reach their end of life: they may be reused, recycled, used for energy recovery, or disposed of, which will have different impacts on the environment. For a sound comparison of alternative ways of production (e.g. different techniques/technologies, energy inputs, materials sourcing, etc.), the environmental impacts along the whole materials life cycle need to be accounted for: the so-called 'cradle-to-grave approach'.

Figure 4. Phases in the life cycle of a product.

Life Cycle Assessment (LCA)[3] is a quantitative tool that facilitates the systematic quantitative assessment of products, in terms of environmental, human health, and resource consumption considerations. The methodology is internationally standardised by ISO 14040[4].

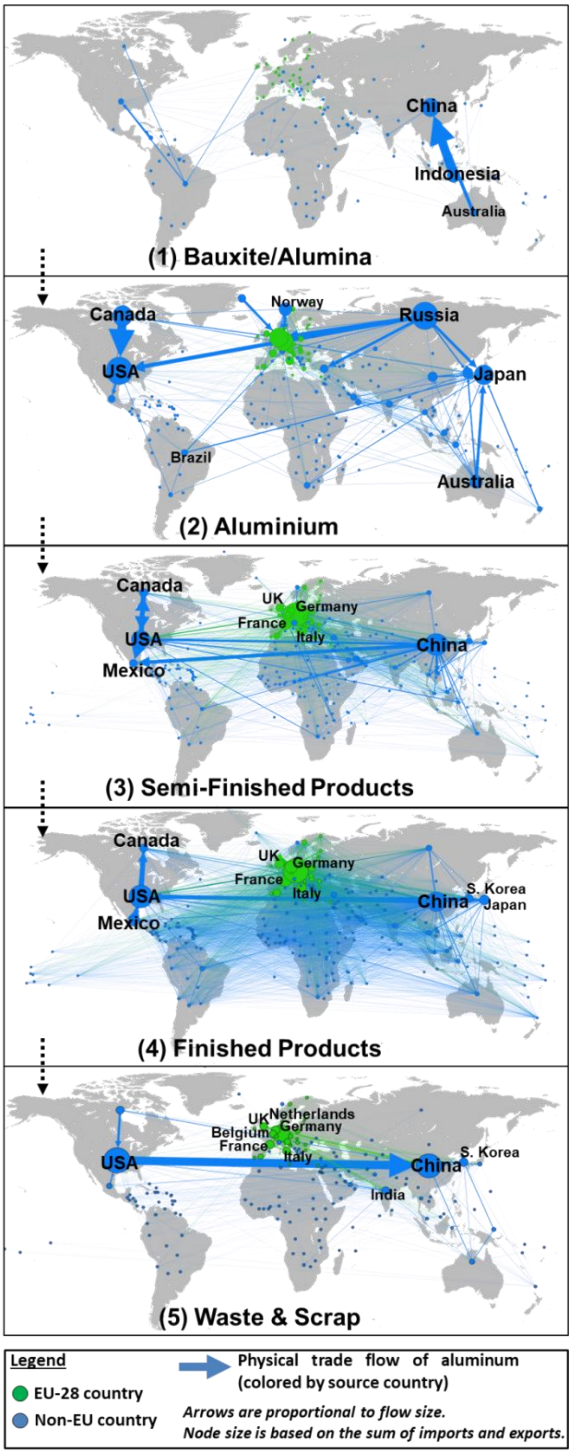


Source: Modified from UNEP Life Cycle Initiative[5].

Raw materials' markets are global in nature. Therefore, the physical trade in raw materials at different production stages builds complex and often interlinked supply networks (Figure 5 shows an example for aluminium). This means that raw materials usually flow across several countries. In this context, a sound estimate of the environmental impacts of supply chains needs to account for the transport of materials and products, often over long distances. In addition, environmental performance can vary significantly between locations, due to different production techniques and technologies, combustion of different fuels, etc. This will determine the ultimate environmental impacts on the local and global environment.

[3] http://eplca.jrc.ec.europa.eu/?page_id=43
[4] https://www.iso.org/standard/37456.html
[5] http://www.lifecycleinitiative.org/starting-life-cycle-thinking/benefits/

Figure 5. Global physical trade networks for aluminium and EU-28 position (2012).



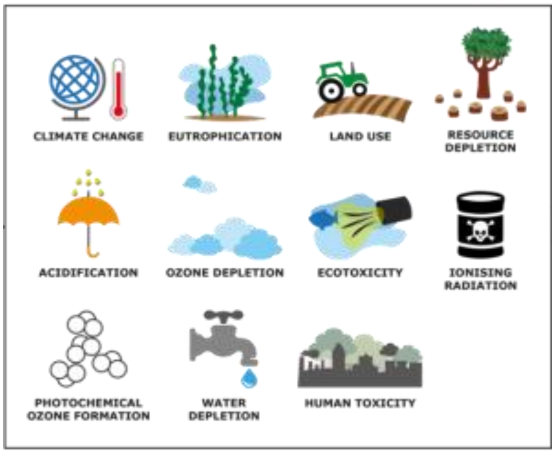
Source: 2018 Raw Materials Scoreboard (EC, 2018b), based on Nuss P. and Mancini L. (publication in preparation).

3.1.1 Types of environmental impacts

Environmental impacts along raw materials supply chains are caused by, for example, the use of resources and the emission of pollutants to the environment. For instance, land uptake by mining facilities can contribute to biodiversity loss; mine tailings can lead to water acidification; industrial processes (e.g. calcination in cement production) or the combustion of fuels generate greenhouse gases that contribute to global warming (Figure 6). These impacts can affect ecosystems and human health, and may be local or global in nature. An additional impact of raw materials production is contribution to the dispersion or dissipation of natural, non-renewable resources (such as minerals or fossil fuels).

Environmental impacts associated with mining and the production of biotic materials (pulp, natural rubber, etc.) have some distinctive features. At mining facilities, pollution is usually more diffuse, and environmental impacts frequently continue during the post-closure phase. In the case of biotic products, sustainable harvest rates can guarantee renewal of the resource. However, growing and harvesting biotic materials can also cause a number of specific impacts on the natural ecosystem.

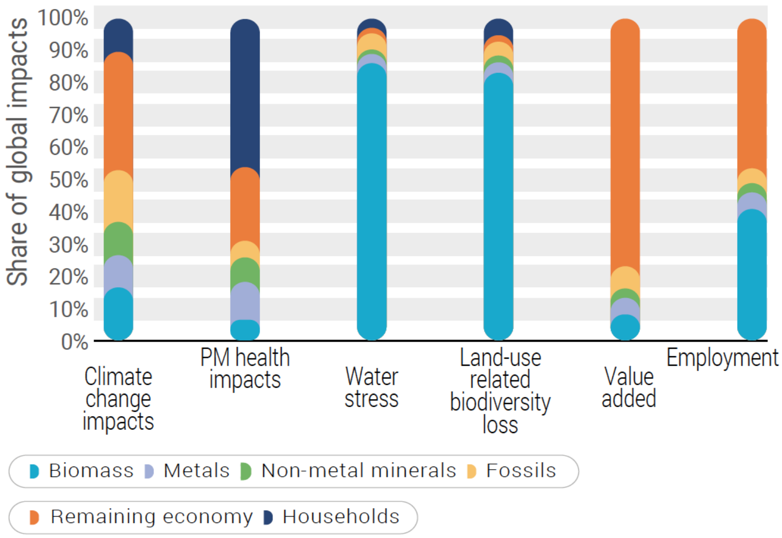
Figure 6. Environmental impact categories considered for LCA.



Source: European Platform on Life Cycle Assessment[6].

The extraction and processing of raw materials accounts for significant shares of the total global environmental impacts, especially for some impact typologies (Figure 7). An example for this are climate change and particulate matter (PM) impacts from metals and non-metallic minerals extraction and processing.

Figure 7. Share of global impacts and socio-economic benefits between resource types (extraction and processing), the remaining economy and households (year 2011).

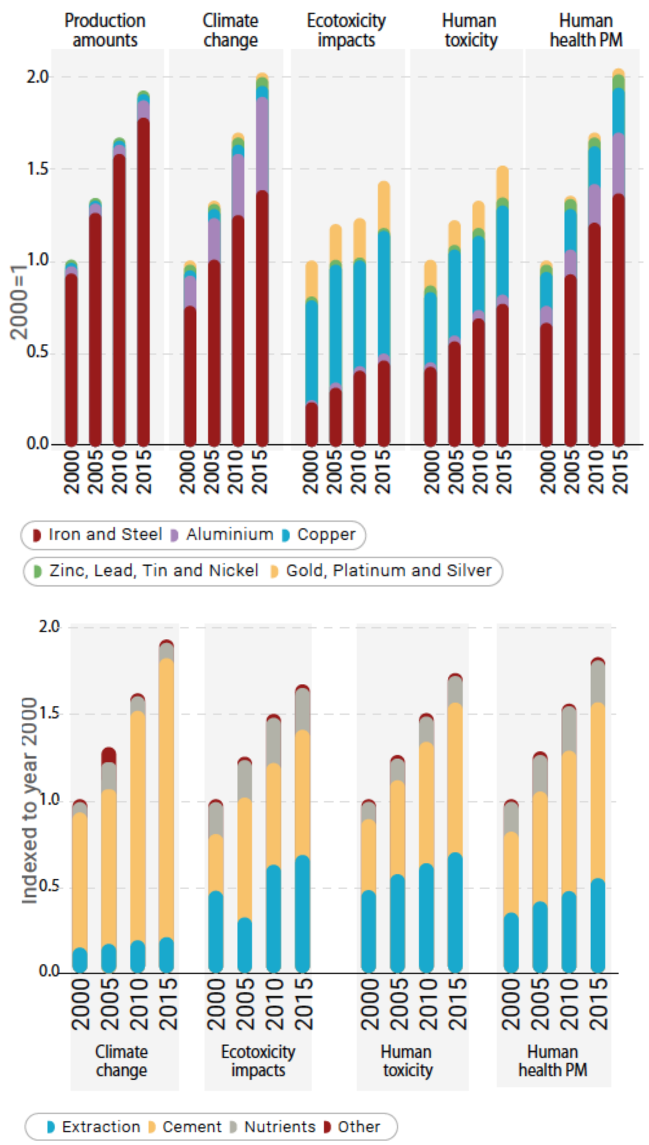


Source: IRP (2019). Note that biomass includes also energy and agricultural commodities.

[6] http://eplca.jrc.ec.europa.eu/?page_id=1517

Impacts have also changed over time. Between 2000 and 2015, the climate change and PM health impacts of metals extraction and processing almost doubled (Figure 8 top). Toxicity impacts also increased in the same period, but at a slower pace. Significant increases were also observed for non-metallic minerals (Figure 8 bottom).

Figure 8. Environmental impacts of metal mining (up) and of non-metallic minerals extraction and processing (bottom) over time.



Source: IRP (2019). Metal mining cover 10 metals meeting > 95% of global extraction of metal ores (according to the UNEP MFA database[7]).

The type and intensity of environmental impacts depend on the intrinsic features of the commodity being produced; the technologies, techniques and management practices in place; and the environmental and socioeconomic framework conditions. As an example, the impact of a mining facility on water will depend on the specific water requirement for mineral extraction and processing, the level of water reuse and depuration at the facility, and local water availability.

The environmental impact associated with the production of one unit of commodity (e.g. 1 kg) varies significantly between commodities; it can be very high in some cases (Table

[7] https://www.resourcepanel.org/global-material-flows-database

1). However, some materials with lower environmental impact per mass unit may emerge at the top of the overall total environmental impact ranking, due to the large volumes of materials being produced (Table 1). For instance, this is the case for base metals such as iron or aluminium.

Table 1. Ranking of metals according to their impact per kg (left) and to their contribution to total environmental impact (right).

Ranking	Impact per kg primary metals	Impact global production primary metals
1	Palladium	Iron
2	Rhodium	Chromium
3	Platinum	Aluminium
4	Gold	Nickel
5	Mercury	Copper
6	Uranium	Palladium
7	Silver	Gold
8	Indium	Zinc
9	Gallium	Uranium
10	Nickel	Silicon

Source: adapted from UNEP (2010). Diverse types of environmental impact are considered. For fair assessment when comparing the environmental performance of different raw materials, it should be taken into account that very different quantities of alternative materials may meet the same function.

3.1.2 Environmental impacts from use and at the end of life

Raw materials can be embodied into products or be used along the production chain in very different quantities and qualities. Due to the complexity of material applications, assessment of the environmental impact associated with the production of a material usually accounts for stages from extraction up to the manufacturing of semi-finished products (e.g. plain wood or aluminium). This approach is known as 'cradle-to-gate', and it accounts for neither the impacts of the manufacturing of the final products and their use phase, nor for the environmental impact once products reach their end of life.

However, it is worth noting that the replacement or substitution of specific materials in products can lead to improvements in a product's environmental performance during the use phase. An example is the use of aluminium in the automotive sector, which can reduce the weight of the vehicle and therefore the energy consumption during the use phase.

In addition, the way products are managed when they reach their end of life can significantly affect their total environmental impacts. With this in mind, products can be designed in a way that maximises their potential reuse and recycling (so-called 'design for recycling'). The 2015 Circular Economy Action Plan[8] established a concrete and ambitious programme with measures for 'closing the loop' in the life cycle of products. It aims at boosting repair, reuse and recycling, which generally (although not always) can improve the environmental performance of the production chain. Moreover, the 2020 Circular Economy Action Plan[9] intends to further boost circularity in production processes and enhance waste policies. Closely linked to these aspects, regulation on Eco-design establishes requirements for the design of resource-efficient products and aims to reduce energy requirements and improve the material efficiency of energy related products (e.g.

[8] COM/2015/0614 final
[9] COM(2020)98 final

household appliances, information and communication technologies, or building and engineering products).

3.1.3 Environmental impacts from accidents

Apart from the environmental impacts associated with facilities under 'normal' operation, accidents may also occur. For instance, failures of mining tailing dams may be considered the events with the largest of all environmental impacts related to mining. Spills due to maintenance problems, or unexpected discharges due to human error may also occur. Accidents may be more likely to occur under specific framework conditions such as higher tectonic activity or heavy rainfall.

Accidents are not accounted for in environmental impact life-cycle assessment. These can be addressed instead through environmental management systems or Environmental Impact Assessment[10].

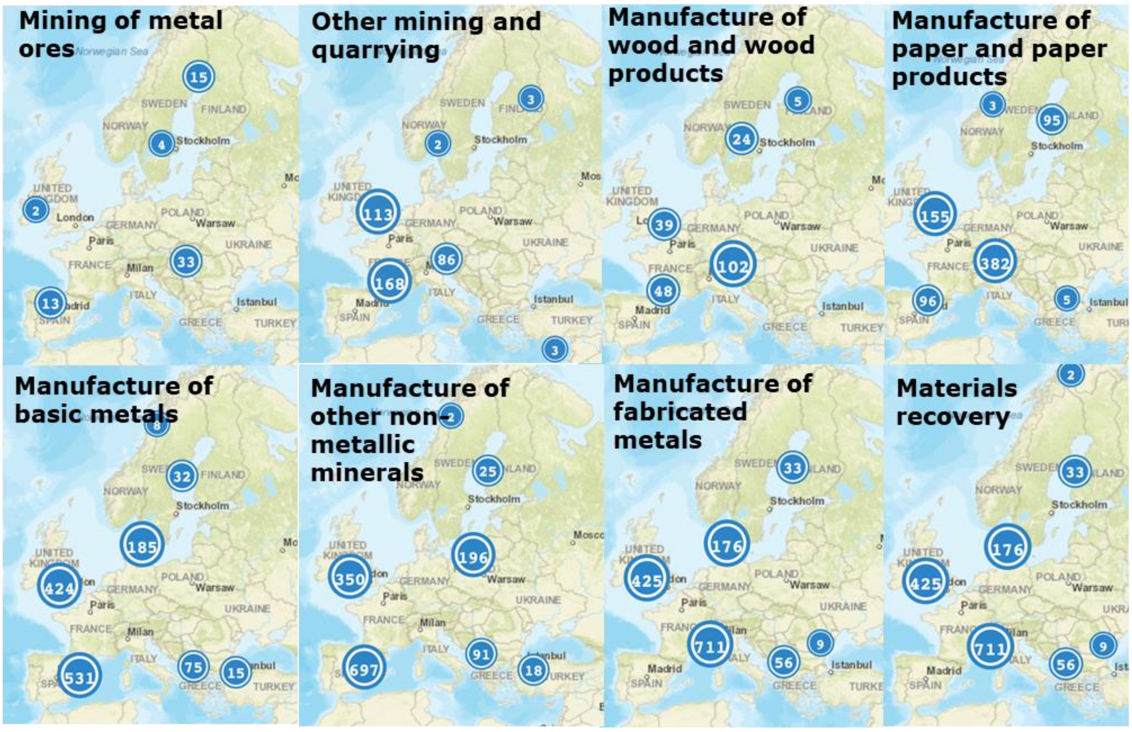
3.2 Industrial emissions from facilities producing raw materials in the EU

The EU relies on numerous industrial facilities producing raw materials. This includes mining facilities; facilities producing intermediate products such as metals, non-metallic minerals, pulp and paper, wood and wood products; facilities manufacturing final products; and materials recovery industries (Figure 9).

At EU level, the emissions to air, water and soil of most major facilities are systematically monitored by the European Pollutant Release and Transfer Register (E-PRTR)[11]. The registry covers facilities that produce emissions above certain sector-specific thresholds, which have been set with the intention of covering significant proportions of the total mass emissions from industrial facilities. These thresholds generally depend on the production capacity of the facility. Thresholds for some mining-related activities depend on the area under extractive operation. For some specific activities, pollutants must be reported regardless of the facility's production capacity (underground mining, metal ore roasting/sintering, etc.).

[10] http://ec.europa.eu/environment/eia/index_en.htm
[11] http://prtr.eea.europa.eu/

Figure 9. Number of EU major raw materials facilities by industry sector.



Source: JRC elaboration based on E-PRTR (data for 2017). EPRTR is the Europe-wide register providing key environmental data from industrial facilities in EU Member States and other countries.

3.2.1 Industrial Emissions Directive and Best Available Techniques Reference Documents

The Industrial Emissions Directive (IED)[12] covers the largest installations producing raw materials in the EU. This directive requires facilities to adopt the so-called Best Available Techniques (BAT) to obtain the operation permit, which is managed by the competent authorities at national or sub-national level. BATs are detailed in the Best Available Techniques Reference documents (BREFs)[13]; these include standards for industrial emissions as well as for energy use, and their use is also promoted by the Circular Economy Action Plans.

BREF documents are prepared by the European Integrated Pollution Prevention and Control Bureau (EIPPCB)[14] of the European Commission's Joint Research Centre, and are the result of participatory processes, with full engagement by stakeholders using an evidence-based approach.

BREFs contain BAT conclusions that are given legal force by the Commission. BREFs have been adopted for several industry sectors such as iron and steel (EC, 2013a), ferrous metals processing (EC, 2001), non-ferrous metals (EC, 2017a), cement, lime and magnesium oxide (EC, 2013b), wood-based panels (EC, 2016a), pulp and paper (EC, 2015), glass (EC, 2013c) and ceramic (EC, 2007a). In addition, a reviewed version of the BREF on Management of Tailings and Waste-rock in Mining Activities (EC, 2018a), whose standards will yet not be binding for the mining sector, has just been released.

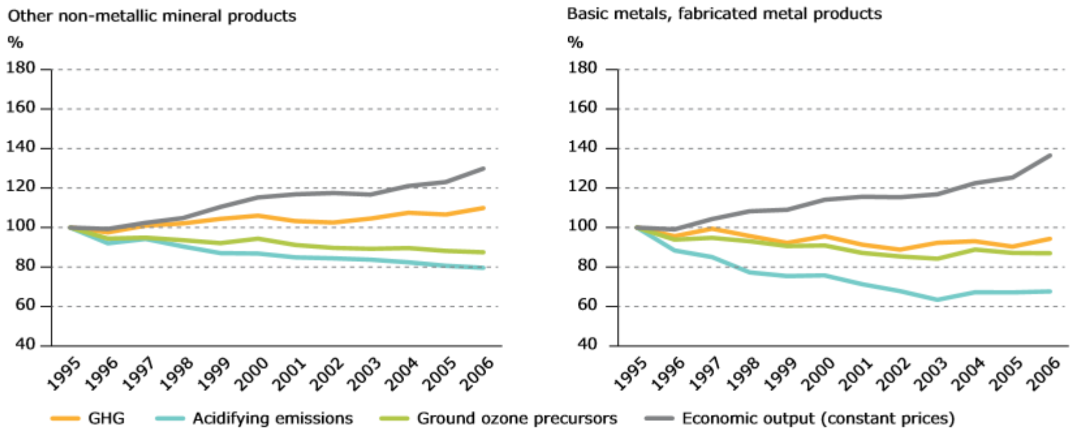
[12] http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm
[13] http://eippcb.jrc.ec.europa.eu/reference/
[14] http://eippcb.jrc.ec.europa.eu/about/

3.2.2 Recent and emerging trends

Over the past decades, EU raw material industries have made efforts to improve their environmental performance. Trends show a decrease in some environmental pressures[15], partly related to production levels in the sector. Improvements in efficiency have also contributed to this decreasing trend. For instance, a relative decoupling of some environmental pressures (such as acidifying emissions and ground ozone precursors) from growth in economic output has been observed in the manufacturing of non-metallic mineral products, and of basic and fabricated metals (Figure 10).

Figure 10. Decoupling of some environmental pressures from growth in economic output, for selected raw materials manufacturing industries (EU-25, 1995–2006).

Note that the economic output refers to monetary values (on the basis of 1995 fixed prices), which reflect not only production volumes in physical units but also e.g. price trends.



Source: EEA (2013).

Globally, there has been a remarkable acceleration in raw materials extraction rates over the past decades. These trends, which are expected to continue (UNEP, 2016) are driven by a growing population and by increasing use of raw materials per capita. Although the adoption of more efficient technologies is expanding, the demand for materials is growing faster. As a consequence, there has been a marked increase in environmental impacts associated with raw materials production over recent decades (see chapter 3.1.1 above). Eco-innovation, resource-efficient technologies and human consumption patterns will be key determinants of demand for materials and products and their subsequent environmental impact in the future.

3.3 Raw materials: environmental policy and legislative framework

According to the third pillar of the Raw Materials Initiative (2008), resource efficiency, recycling and increased use of renewable materials are among the strategies to reduce EU dependence on primary raw materials and improve the overall environmental performance of the industry.

Very recently, the European Green Deal[16] has been adopted and acts as core environmental policy in the EU. Within its action plan[17], among many other sustainability goals, the Green Deal aims to reach carbon neutrality by 2050, zero-pollution and decoupling of economic growth from resource use. This ambitious policy counts on the engagement of multiple stakeholders, including also the industry. In what regards to raw

[15] See also https://www.eea.europa.eu/themes/industry/industrial-pollution/industrial-pollution-country-profiles-2018

[16] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

[17] https://ec.europa.eu/info/files/annex-roadmap-and-key-actions_en

materials, the Green Deal states that the Commission will consider legal requirements to boost the market of secondary raw materials with mandatory recycled content. The Commission will also ensure the supply of sustainable raw materials, in particular of critical raw materials necessary for clean technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources.

Furthermore, the 2015 Circular Economy Action Plan[18] states that attention must be paid to the environmental (and social) impacts of the production of primary raw materials, both in the EU and in non-EU countries. More specifically, this action plan established a concrete and ambitious programme with measures for 'closing the loop' in the life cycle of products. The measures in the action plan cover production, consumption, waste management, and the market for secondary raw materials. More recently, the 2018 Circular Economy Package has been developed in order to continue implementation of the 2015 Circular Economy Action Plan. Moreover, the new (2020) Circular Economy Action Plan[19] aims at accelerating the transformational change required by the European Green Deal[20]. For that, it intends to further boost circularity in production processes and enhance waste policies.

Ad hoc monitoring systems have been set up to support assessment of the implementation of the raw materials and circular economy-related policies. A key example is the Raw Materials Scoreboard (EC, 2018b), which includes data on several environmental and resource-efficiency aspects, focusing particularly on raw materials industries. The Circular Economy Monitoring Framework (COM(2018)29 and its accompanying document SWD/2018/017) also monitors advances in resource-efficiency, with a scope also beyond raw materials.

Complementary to the policies on raw materials and the circular economy, the EU relies on a sound and comprehensive set of environmental policies and legislation, which are at the core of the Union's functioning and origin. These drive and regulate the environmentally sound operation of industrial facilities, from their inception to their functioning and through to their closure.

3.3.1 Environmental impact assessment of programmes and projects

Strategic Environmental Assessment (SEA)[21], and its related directive[22], is applied at an early stage to ensure that environmental and human health considerations are incorporated into the development of public plans and programmes, such as those related to land use, transport, energy, waste, agriculture, etc. Subsequently, the development of new projects - of specific types and above a certain size - must undergo an Environmental Impact Assessment[23], in line with the related directive[24] (currently under review) which aims to guarantee a high level of environmental protection, and the inclusion of environmental considerations before a project is developed.

3.3.2 Pollution control at operational facilities

Once industrial facilities are operating, their pollutant emissions are regulated by the Industrial Emissions Directive (IED), which sets out the main principles for permitting and controlling large industrial installations, based on an integrated approach and the application of Best Available Techniques (BATs). BATs are the most effective techniques for achieving a high level of environmental protection, taking into account costs and benefits. The BAT conclusions contained in the BAT Reference Documents (BREFs) provide the standards for setting permit conditions at EU level in order to prevent or, where impracticable, to reduce emissions to air, water and land and to prevent the

[18] COM/2015/0614 final
[19] COM(2020) 98 final
[20] COM/2019/640 final
[21] http://ec.europa.eu/environment/eia/sea-legalcontext.htm
[22] Directive 2001/42/E
[23] http://ec.europa.eu/environment/eia/index_en.htm
[24] Consolidated text: Directive 2011/92/EU

generation of waste. The relevance of BATs is highlighted in the Circular Economy Action Plan.

The BREF on mining waste, which refers to one of the largest waste streams[25] in the EU, is not subject to the IED but supports implementation of the Extractive Waste Directive[26], which is currently under revision. This directive aims to prevent or reduce adverse effects on the environment from the management of waste from extractive industries, and calls on Member States to require operators to apply monitoring and management controls in order to prevent water and soil pollution.

3.3.3 Environmental performance of products

The EU has developed regulations to improve the environmental performance of products, as well as to advance the collection and recycling of waste. The regulations on Eco-design[27] and Energy Labelling[28] establish requirements for the design of resource-efficient products and aim to improve the energy and material efficiency of energy-related products (e.g. household appliances, information and communication technologies, engineering products). Furthermore, the initiative on Greening of the Market[29] will support sound final consumer choices when selecting environmentally friendly products, by providing standards for the environmental performance of products and organisations, based on Life Cycle Assessment. Pilot project[30]s covering batteries, intermediate paper, and metals, among other items, have been already developed, and the transition phase[31] is established between the pilots and the possible adoption of policies. This initiative complements the Ecolabel[32], a voluntary scheme that highlights products and services with reduced environmental impact over their life cycle, helping producers and consumers to make more environmentally friendly choices.

3.3.4 Waste and chemicals

Waste of Electrical and Electronic Equipment (WEEE)[33], one of the fastest growing waste streams, is regulated through the WEEE directive[34], which aims to improve the environmental management of WEEE through the enhancement of collection, treatment, reuse and recycling.

Additionally, the RoHS Directive[35] restricts the use of hazardous substances (e.g. heavy metals) in electrical and electronic equipment. In parallel, the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)[36] has the aim of ensuring a high level of protection for human health and the environment, by addressing the production and use of chemical substances. The REACH shifts responsibility from public authorities to industry in terms of assessing, managing and informing users about the risks posed by chemicals.

3.3.5 Climate, air, water and soil

The environment is at the core of EU regulation. Specific regulations have been established to cover environmental concerns such as climate change, air quality and safeguarding water resources and soil. The EU is already taking steps to implement its target to reduce emissions by at least 40 % by 2030[37], in line with the Paris Agreement[38],

[25] http://ec.europa.eu/environment/waste/mining/index.htm
[26] Directive 2006/21/EC
[27] http://ec.europa.eu/growth/industry/sustainability/ecodesign_en
[28] Regulation (EU) 2017/1369
[29] http://ec.europa.eu/environment/eussd/smgp/
[30] http://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm#pef
[31] https://ec.europa.eu/environment/eussd/smgp/ef_transition.htm
[32] http://ec.europa.eu/environment/ecolabel/facts-and-figures.html
[33] http://ec.europa.eu/environment/waste/weee/index_en.htm
[34] Directive 2012/19/EU
[35] Consolidated text: Directive 2011/65/EU
[36] https://ec.europa.eu/growth/sectors/chemicals/reach_it
[37] https://ec.europa.eu/clima/policies/strategies/2030_en

which aims to limit global warming to an increase of 1.5 °C. Moreover, decarbonisation (including carbon neutrality by 2050) is one of the main goals of the recently adopted European Green Deal[39], within its ambitious action plan[40]. Industries such as metals, cement, and pulp and paper fall within the EU Emissions Trading System (EU ETS), a cornerstone of the EU's policy to combat climate change, which allows operators to trade emission allowances in a cost-effective manner. Furthermore, to guarantee good air quality[41] in the EU, national emission ceilings[42] for specific air pollutants, as well air quality standards[43], have been established. As regards water resources, the EU Water Framework Directive (WFD)[44] committed EU water bodies to achieving high quality status by 2015. Guidelines on integrating water reuse into water planning and management[45], in the context of the WFD, have been also developed.

In terms of soil protection, while the Commission decided to withdraw the proposal for a Soil Framework Directive, the Seventh Environment Action Programme[46] calls for soil to be adequately protected by 2020, and for the EU and its Member States to commit, among other aspects, to remediating contaminated sites[47].

3.3.6 Nature and biodiversity

The Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats directive) aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. Together with the Birds Directive 2009/147/EC (after the last amendment of the directive), it forms the cornerstone of Europe's nature conservation policy, and establishes the EU Natura 2000[48] ecological network of protected areas. Natura 2000 is the largest coordinated network of protected areas in the world. It offers a haven to Europe's most valuable and threatened species and habitat, and stretches over 18% of the EU’s land area and almost 6% of its marine territory.

Despite the existence of EU frameworks, strategies and action plans to protect nature and restore habitats and species, the recent Mid-term review of the of the EU Biodiversity Strategy[49] and the fitness check of the nature legislation[50] found that the implementation and enforcement of legislation has been insufficient.

Very recently, the EU Biodiversity Strategy for 2030 and an associated action plan (annex)[51] have been adopted. The Strategy intends to improve and widen the EU network of protected areas: at least 30% of the land and 30% of the sea should be protected in the EU, which means a minimum of an extra 4% for land and 19% for sea areas as compared to today. Designations should either complete the Natura 2000 network or be under national protection schemes. The Strategy also intends to develop an ambitious EU Nature Restoration Plan. The Strategy judges as essential to protect all the EU’s remaining primary and old-growth forests, significant carbon stocks, and to advocate for the same globally. Peatlands, grasslands, wetlands, mangroves and seagrass meadows, also carbon-rich ecosystems, should also be strictly protected.

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[38] https://ec.europa.eu/clima/policies/international/negotiations/paris_en
[39] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[40] https://ec.europa.eu/info/files/annex-roadmap-and-key-actions_en
[41] http://ec.europa.eu/environment/air/index_en.htm
[42] https://www.eea.europa.eu/themes/air/national-emission-ceilings/national-emission-ceilings-directive#tab-related-data
[43] http://ec.europa.eu/environment/air/quality/standards.htm
[44] Directive 2000/60/EC
[45] http://ec.europa.eu/environment/water/pdf/Guidelines_on_water_reuse.pdf
[46] Decision No 1386/2013/EU
[47] https://ec.europa.eu/jrc/en/publication/status-local-soil-contamination-europe-revision-indicator-progress-management-contaminated-sites
[48] https://ec.europa.eu/environment/nature/natura2000/index_en.htm
[49] COM/2015/0478 final
[50] https://ec.europa.eu/environment/nature/legislation/fitness_check/docs/nature_fitness_check.pdf
[51] COM/2020/380 final

Within the action plan of the Strategy, an assessment of the EU and global biomass supply and demand it is already ongoing.

With respect to marine ecosystems, the Strategy states that in international negotiations the EU should advocate that marine minerals in the international seabed area cannot be exploited before the effects of deep-sea mining on the marine environment, biodiversity and human activities have been sufficiently researched, in line with the precautionary principle. The EU will continue to fund research on the impact of deep-sea mining activities and on environmentally-friendly technologies, and it should also advocate for more transparency in international bodies such as the International Seabed Authority.

3.4 Climate change and decarbonisation

3.4.1 Climate change and decarbonisation

Decarbonisation is one of the main goals of the European Green Deal[52], with the ambition to have a carbon-neutral Europe by 2050. This goes in line with the Paris Agreement[53], which 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 to work towards climate neutrality before the end of the century. The EU should by 2050 be among the first to achieve net-zero GHG emissions leading the way worldwide. Goal 13 of the Sustainable Development Goals calls on countries to take urgent action to combat climate change and its impacts.

The EU is already taking action: the 2030 climate and energy policy framework[54] 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[55] announces 80 % cuts by 2050, also compared to 1990 levels. Moreover, climate action - decarbonising the economy[56] is among the priorities of the European Commission. It is also integral to the creation of the Energy Union[57], which aims to ensure secure, affordable and climate-friendly energy, while also creating jobs and growth.

In this context, the raw materials industries can both contribute to global warming, and at the same time provide the materials that are being used and will be required for the deployment of low-carbon technologies. Furthermore, climate change itself is expected to have an impact on the secure supply of raw materials. This section consists of several sub-sections (Figure 11) covering all these aspects. In addition, a dedicated sub-section describes the datasets available on greenhouse gas (GHG) emissions.

[52] COM/2019/640 final
[53] https://ec.europa.eu/clima/policies/international/negotiations/paris_en
[54] https://ec.europa.eu/clima/policies/strategies/2030_en
[55] https://ec.europa.eu/clima/policies/strategies/2050_en
[56] https://ec.europa.eu/commission/priorities/energy-union-and-climate/climate-action-decarbonising-economy_en
[57] https://ec.europa.eu/commission/news/energy-union-2017-nov-24_en

Figure 11. Structure of the RMIS section on climate change and low-carbon (the structure slightly differs from the one followed in this report).

Climate change and decarbonisation

- Climate change and decarbonisation
- Direct GHG emissions from raw materials production
- Indirect GHG emissions
- GHG emissions from consumption
- GHG emissions data
- Decarbonisation – potential of the sector
- Decarbonisation - challenges
- Raw materials contribution to low-carbon technologies
- The EU Emissions Trading System and carbon leakage
- Innovation and financing for decarbonisation
- Climate change adaptation and risk to raw materials supply
- Additional references

Source: RMIS.

3.4.2 GHG emissions from raw materials production

GHG are generated throughout the raw materials value chain, by processes such as drilling, ventilation, beneficiation, manufacturing, transport and waste management. While for some materials emissions concentrate in the extraction stages, for other materials emissions during processing are higher.

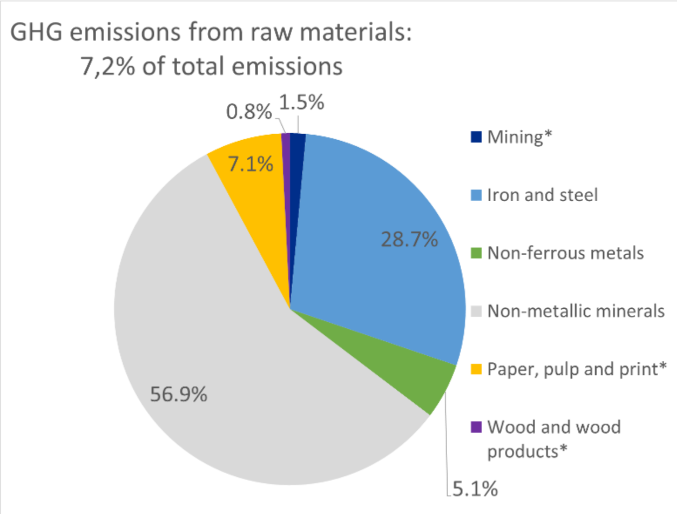
Emissions can be direct, i.e. they are emitted on site at producing facilities, or indirect, i.e. they are emitted elsewhere. Most direct emissions originate from the use of energy or fuels for mechanical processes (e.g. drilling) or for the production of heat. In fact, the raw materials sector is generally considered energy-intensive. In addition, so-called ‘process-emissions’ derive from some industrial processes where chemical reactions release carbon, e.g. calcination of limestone to yield cement, or metallurgical furnaces.

3.4.2.1 **Direct GHG emissions**

Major greenhouse gas (GHG) emissions are generated by the raw materials sector throughout the raw materials value chain. These emissions derive from a variety of processes, e.g. fuel combustion, extraction and refining of materials, processing, manufacturing and waste management. Direct GHG emissions generated onsite by EU raw materials industrial facilities account for 7.2% of all direct GHG emissions in the EU (2015). Most of the direct emissions from these industries, which are generally considered energy-intensive, originate from the use of energy. However, some industrial processes, such as calcination for cement production or metallurgical furnaces in metals production, also release significant amounts of GHGs. Overall, the biggest contributors to GHG emissions are the production of non-metallic minerals and of iron and steel (Figure 12). Yet values change across Member States.

Figure 12. Direct greenhouse gas emissions share by raw materials sector (EU-27, 2015).

GHG emissions are the sum of CO_2, N_2O, CH_4 and SF_6 emissions considering their Global Warming Potential (GWP) in CO_2 equivalents.



* GHG emissions are available only for combustion processes.

Source: JRC elaboration based on EDGAR[58] data.

Direct GHG emissions from the raw materials sector in the EU have decreased over the past decades (Figure 13). This has been due to the shift of production to other countries and to efficiency improvements[59], particularly related to changes in the fuel mix (e.g. moving from the use of coal to gas or renewable sources). Efficiency improvements have been also linked to technological enhancements in production processes, such as the introduction of direct reduction in iron and steel-making (PBL, 2018). Emission trends also follow fluctuations in production volumes due to changes in demand, such as the decrease experienced during the financial crisis.

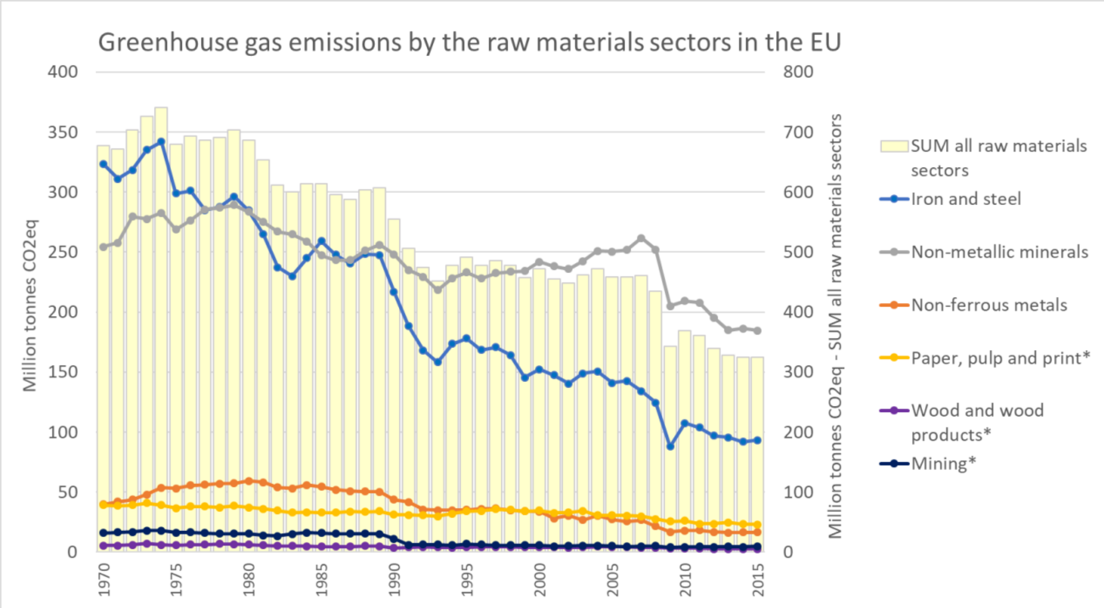
Zooming into the trends in the different EU raw materials sectors, iron and steel production showed the largest absolute decrease in the last 15 years (59 thousand tonnes of CO_2 equivalent, almost 39% reduction), followed by the production of non-metallic minerals (57 thousand tonnes, -24%), non-ferrous metals production (17 thousand tonnes, -50.8%), paper production (11.6 thousand tonnes, -34%), wood products (1.6 thousand tonnes, -38.4%) and mineral mining (864 tonnes, -15.4%) (Figure 13). The contribution from different Member States is very heterogeneous.

[58] http://edgar.jrc.ec.europa.eu/index.php

[59] See indicator on greenhouse gas emissions in the 2018 Raw Materials Scoreboard, http://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/20

Figure 13. Direct greenhouse gas emissions from the EU-27 raw materials sectors.

The sum of all sectors (columns) refers to the right axis. GHG emissions are the sum of CO_2, N_2O, CH_4 and SF_6 emissions considering their Global Warming Potential (GWP) in CO_2 equivalents.



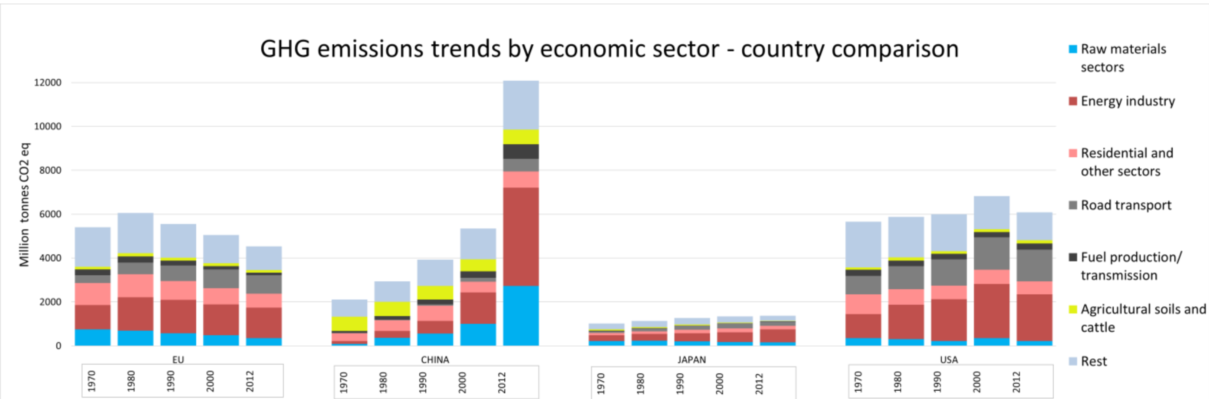
*GHG emissions only from combustion processes are available.

Source: JRC elaboration based on EDGAR[60] data.

In contrast to the EU trends, GHG emissions from the raw materials sector have seen a remarkable increase at the global level (Figure 14). This increase has mostly been driven by the expansion of industrial production in developing economies such as China. The consumption of materials in both developed and developing countries has been a key driver for this expansion of the sector.

Figure 14. Direct greenhouse gas emissions trends by economic sector for the EU-28 and a selection of countries.

GHG emissions are the sum of CO_2, N_2O and CH_4 emissions considering their Global Warming Potential (GWP) in CO_2 equivalents.



Source: JRC elaboration based on EDGAR[61] data.

60 http://edgar.jrc.ec.europa.eu/index.php

61 http://edgar.jrc.ec.europa.eu/index.php

3.4.2.2 **Indirect GHG emissions**

In addition to direct GHG emissions from EU industries, other GHG emissions are embodied in the raw materials production chain. For instance, emissions associated with the production of the electricity, fuels, chemicals, equipment, etc. that are used at raw materials production facilities; or the emissions during the transportation of materials (processed minerals, secondary materials, etc.), which may even be sourced from distant countries.

In addition, the way in which industrial waste is managed, the lifetime of products and the way in which products are managed when they reach their end of life, influence the total GHG emissions along the raw materials supply chain. Once a product reaches its end of life, it may be reused, recycled, used for materials/energy recovery or disposed of, which will result in different GHG balances. For instance, increasing the use of recycled materials as input to production has been proven to significantly reduce GHG emissions in the production of metals such as steel or aluminium (Deloitte, 2016).

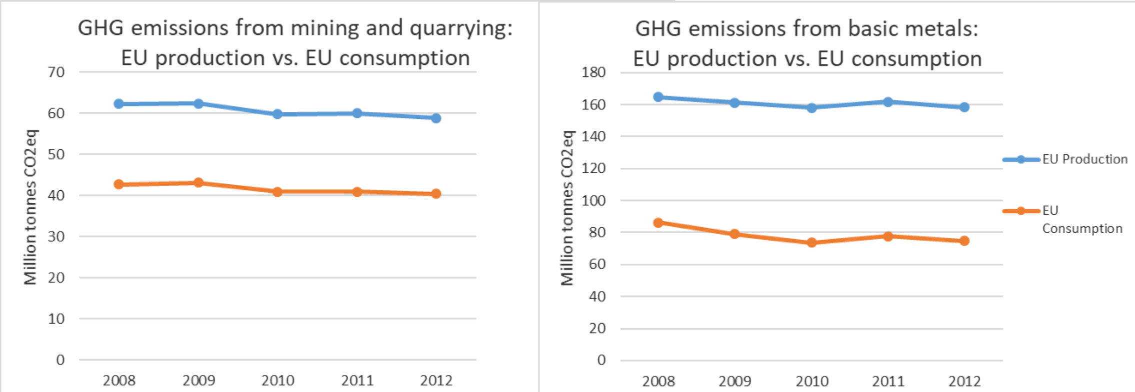
The use of specific raw materials in final products can also have a strong impact on the emissions performance of the product, i.e. the amount of emissions generated during the use phase. For instance, the use of light materials such as aluminium in vehicles can in some cases considerably lower energy requirements during use of the product. Extending the use of a household product (e.g. a washing machine) by a few years could do more to reduce life cycle GHG emissions than immediately replacing the product with one in a higher energy class (JRC, 2012).

Finally, the sector can also have indirect impacts on global warming. For instance, the removal by extractive activities of forest areas that function as carbon sinks can play a significant role in the GHG balance; excessive deep-sea drilling can negatively affect the GHG mitigation capacity of the oceans, due to disturbances in the sea floor which may release the stored carbon.

3.4.2.3 ***GHG emissions from consumption***

The final consumption of goods by EU industries and households is a major driver of GHG emissions, both within and outside the EU. In the EU in the last years GHG emissions from EU domestic production of raw materials and GHG emissions linked to EU consumption of raw materials products (which covers production and imports) have shown quite similar patterns (Figure 15). GHG emissions associated to consumption are a challenge to global GHG mitigation.

Figure 15. GHG emissions from EU production and from EU consumption, for mining and quarrying and for basic metals manufacturing.

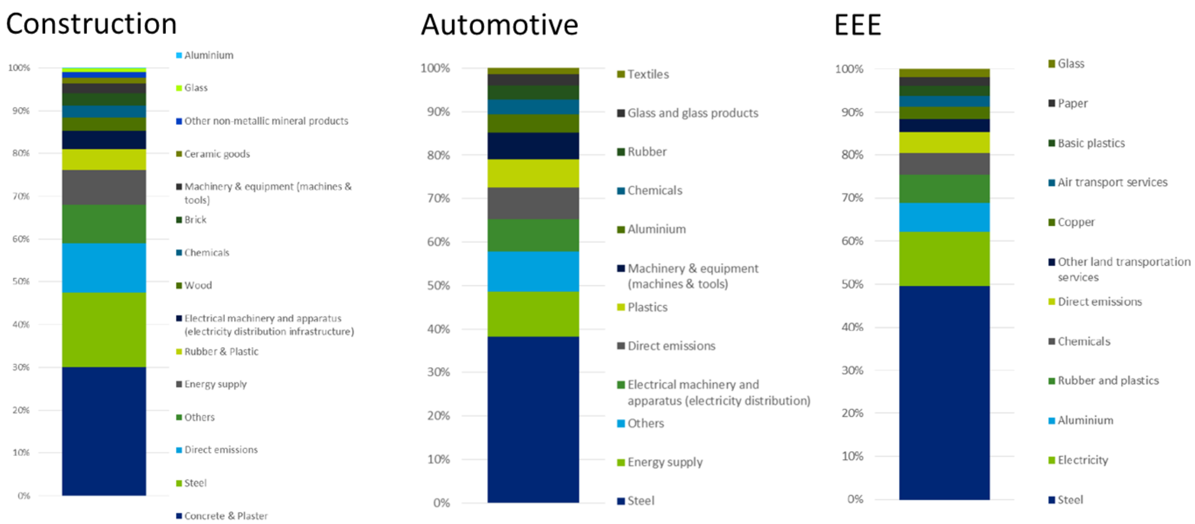


GHG emissions are the sum of CO_2, N_2O, CH_4, HFC, PFC, NF_3 and SF_6 emissions considering their Global Warming Potential (GWP) in CO_2 equivalents. Emissions from consumption arise from domestic production and imports, while emissions from exports are not considered.

Source: JRC elaboration based on Eurostat Air Emissions Accounts[62] and Emissions of greenhouse gases and air pollutants from final use of CPA08 products - input-output analysis, ESA 2010[63].

To develop targeted actions for climate mitigation in relation to raw materials, it is useful to understand which types of final products are responsible for most GHG emissions along the production chain, and how much of the total emissions are associated with raw materials production. For instance, raw materials-related GHG emissions represent a significant share of emissions generated by the energy, construction, automotive, and electrical and electronic equipment (EEE) sectors, considering emissions throughout the production chain. The production of concrete, plaster and steel accounts for a significant share of emissions from construction; steel, aluminium and rubber production are significant contributors to emissions from the automotive sector and from the manufacture of EEE (Figure 16).

Figure 16. GHG emissions breakdown for the consumption of final products (construction, automotive and EEE).



Source: Deloitte (2016). GHG emissions over the product/sector life cycle are accounted for.

[62] https://ec.europa.eu/eurostat/web/products-datasets/-/env_ac_ainah_r2
[63] https://ec.europa.eu/eurostat/web/products-datasets/-/env_ac_io10

3.4.2.4 ***GHG emissions data***

Eurostat provides GHG emissions data by source sector[64], compiled by the European Environment Agency, in accordance with the United Nations Framework Convention on Climate Change (UNFCCC)[65]. These data give insights into GHG emission trends in the raw materials industries over recent decades. Furthermore, Eurostat Air Emission Accounts (AEA)[66] provide GHG emissions data by NACE sector[67] (from the year 2007/2008). While UNFCCC emissions data are based on a territorial principle, AEA follow the residence principle for national accounts[68]: emissions are included even if they take place outside the EU territory, if the residence of the activity falls within the EU (for instance a shipping company operating abroad). Based on the AEA, Eurostat also estimates GHG emission intensities[69].

Scientific databases such as EDGAR[70] provide GHG emission times series starting from the year 1970, using reference data sources for emission factors and activity data. Emission factors are average emission rate of a given GHG for a given source, relative to units of activity. Activity data gauges the magnitude of human activity resulting in emissions or removals taking place during a given period of time (e.g. fuel consumption, production volume).

These data sources report on GHG emissions linked to direct onsite production in industrial facilities, but do not consider emissions from energy generation taking place off site, from production of auxiliary inputs, or from transport and delivery of products. Based on the AEA and input/output tables[71] modelling, Eurostat also estimates GHG emissions from the final use of products[72] (EU total aggregate only), i.e. GHG emissions embodied in products for final use - also referred to as carbon footprint[73], which accounts for GHGs emitted by sector along the full production chain of products that are consumed within the EU.

In addition, private companies also disclose climate-related data, although reporting schemes and studies are still highly heterogeneous. Examples include the Global Reporting Initiative[74], where companies are asked to report direct emissions, emissions derived from energy use, emissions intensity and emissions reductions. Also the Climate Disclosure Project[75], to which companies report emission savings and saving targets. Both reporting initiatives cover also raw materials production companies.

In addition to that, trends of indicators on climate change and energy are monitored by the Resource Efficiency Scoreboard[76] and the SDGs EU monitoring framework[77].

3.4.3 Decarbonisation

3.4.3.1 ***Decarbonisation potential***

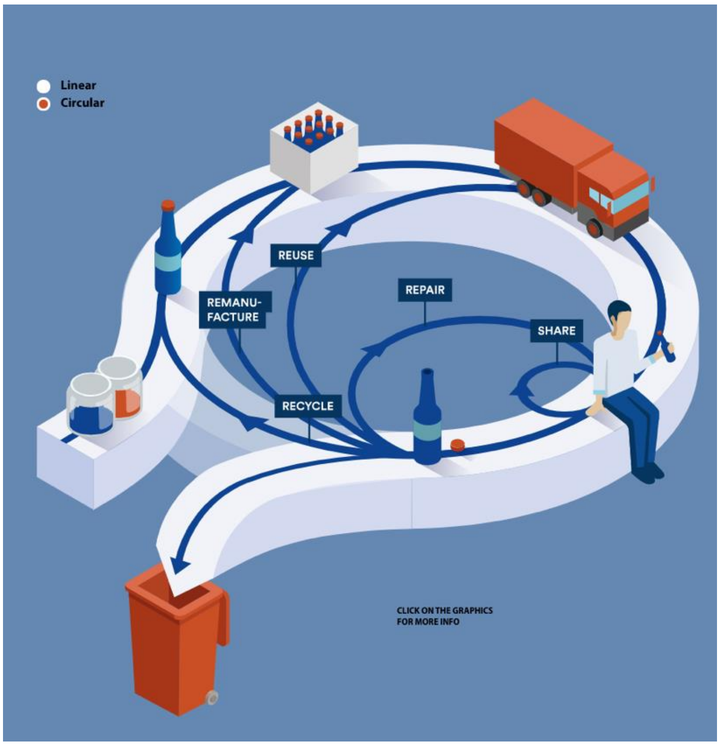
Recently, several studies have been completed or are ongoing to explore possible mitigation paths for energy-intensive industries. In particular, the in-depth analysis to

[64] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en
[65] http://unfccc.int/2860.php
[66] https://ec.europa.eu/eurostat/web/products-datasets/-/env_ac_ainah_r2
[67] http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)
[68] https://ec.europa.eu/eurostat/web/national-accounts/overview
[69] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_aeint_r2&lang=en
[70] http://edgar.jrc.ec.europa.eu/index.php
[71] https://ec.europa.eu/eurostat/statistics-explained/index.php/Supply_and_use_tables_-_input-output_analysis
[72] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_io10&lang=en
[73] https://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics_-_carbon_footprints
[74] https://www.globalreporting.org/Pages/default.aspx
[75] https://www.cdp.net/en/climate
[76] https://ec.europa.eu/eurostat/web/europe-2020-indicators/scoreboard
[77] http://ec.europa.eu/eurostat/web/sdi/overview

the Communication 'A clean planet for all'[78] gives an overview of the recent trends in sectors such as iron and steel, non-metallic minerals and chemical, and explores several mitigation scenarios. Also, a set of energy-intensive industries, covering steel, cement, ceramics, paper, glass, and non-ferrous metals, have contributed to the study by Vrije Universiteit Brussel (2018) presenting GHG mitigation paths. The study presents their mitigation potential, as well as the technological implications and costs of the mitigation actions.

Some of the measures towards mitigation involve moving from a linear to a circular economy (Figure 17). The circular economy promotes resource efficiency, recycling and enhanced waste management, and may offer considerable GHG mitigation potential. The circular economy may boost repair, reuse and recycling, which generally (although not always) save GHG emissions. It may also boost activities such as refurbishment (a product's manufacturer updates the product's appearance to expand the product's life), remanufacturing (the manufacturer uses parts of an old product in a new product), and eco-design (more efficient products with longer life and easier to recycle). Mitigation measures should also target the resource consumption patterns of households, e.g. the promotion of public and shared mobility systems can also significantly contribute to climate mitigation.

Figure 17. A circular economy.

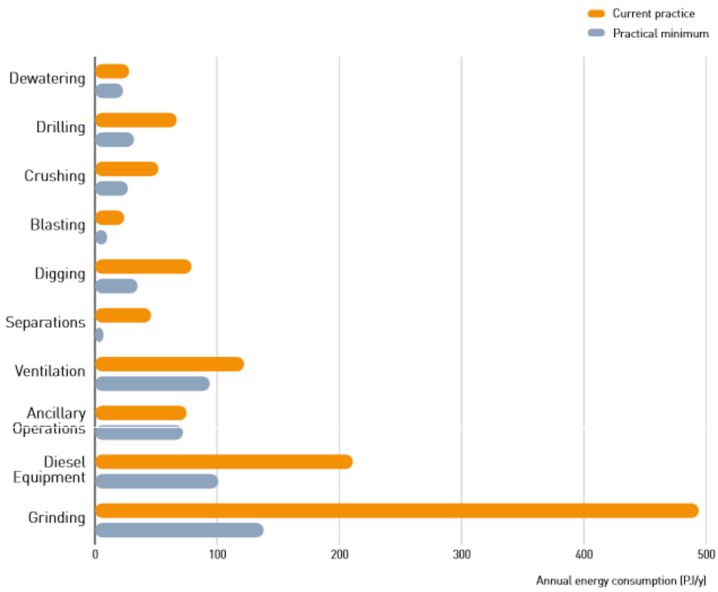


Source: European Parliamentary Research Service.

There are many energy efficiency opportunities in the mining and mineral processing sector (Figure 18). However, the decreasing trends in ore grade (UNEP, 2013) observed over recent years are a challenge to the mitigation potential in the mining sector, since decreasing ore grades generally lead to additional processing requirements and associated energy use.

[78] 'In-depth analysis in support on the COM(2018) 773: A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy'.

Figure 18. Current (2007) and practical minimum annual energy consumption for the US mining and mineral processing sector.



Source: US DoE (2007), in UNEP (2013).

Increasing recycling, reuse and repair in manufacturing sectors could also contribute to mitigation (Deloitte, 2016). For instance, increasing the use of recycled materials (secondary materials) as input to production can be a significant saver of GHG emissions in the consumption of metals such as steel and aluminium, but also many others (Table 2).

Table 2. Energy saving from recycling in the consumption of various ferrous and non-ferrous metals.

Metal/Product	% Savings	References
Aluminium	90 – 97	Norgate & Rankin (2002), Gaballah and Kanari (2001), Quinkert et al. (2001), International Aluminium Institute (2011), Chapman and Roberts (1983)
Copper	84 – 88	Norgate and Rankin (2002), Gaballah and Kanari (2001)
Gold	98	Ecoinvent v2.2
Lead	55 – 65	Norgate and Rankin (2002), Gaballah and Kanari (2001
Magnesium	97	USEPA (1994)
Nickel	90	Norgate and Rankin (2002)
Palladium	92 – 98	Ecoinvent v2.2
Platinum	95	Ecoinvent v2.2
Rhodium	98	Ecoinvent v2.2
Silver	96	Ecoinvent v2.2
Steel	60 – 75	Norgate and Rankin (2002), Gaballah and Kanari (2001)
Stainless steel (304)	68	Johnson et al. (2008), Eckelman (2010)
Titanium	67	Chapman and Roberts (1983)
Zinc	60 – 75	Norgate and Rankin (2002), Gaballah and Kanari (2001)

Source: Adapted from Norgate (2004), as in UNEP (2013).

With respect to biotic raw materials, mitigation could focus on replacing fossil fuel-based materials with forest-based materials in the construction sector and in long-lasting products such as furniture, etc., which will increase biotic carbon storage. Furthermore, promoting cascade use, reuse and recycling of wood (EC, 2018c) is expected to improve efficiency in wood use and maximise the mitigation potential of the sector.

3.4.3.2 ***The EU Emissions Trading System and carbon leakage***

For decarbonisation[79] of the EU economy in line with the 2030 and 2050 targets, and the New European Green Deal, all sectors need to cut emissions.

The EU Emissions Trading System (EU ETS)[80], a cornerstone of EU policy to combat climate change, was created with the idea of promoting reduction in emissions where it proves more cost-effective. It covers specific sectors such as the production of metals, cement, lime, glass, pulp and paper (in some cases only in facilities above a certain size). Other subsectors of the raw materials industry that do not fall within the EU ETS, such as the waste and transport sector, are regulated by the effort sharing decision[81], which sets national emission targets for 2020.

The EU ETS, now in its Phase 3 (2013-2020), allows free allocation of GHG emission allowances[82] to the best performing installations, while installations not meeting the best performers' benchmarks[83] must 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[84] from emission-saving projects around the world.

The EU ETS scheme considers that some industries competing in the global market may be more exposed to so-called carbon leakage[85], 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[86] may be entitled to higher shares of free emission allowances. Many of these are energy-intensive industries producing raw materials.

The latest revisions of the EU ETS scheme tend to reduce the amount of free emission allowances and increase the share of auctioned[87] allowances, where installations have to pay for emission allowances, provided these are available. However, the free allocation of emission allowances will continue until 2030, to keep on rewarding the best performers. This is partly because, as highlighted in the 2030 climate and energy policy framework[88], keeping key enabling industries within the EU is important for EU industrial competitiveness. Moreover, a High Level expert Group on energy-intensive industries[89], led by DG Internal Market, Industry, Entrepreneurship and SMEs, has been set up to promote a smooth transition to a low-carbon economy, and provide the Commission with advice and expertise on the challenges faced by these industries.

3.4.3.3 **Challenges for decarbonisation**

In a commodity's supply chain, GHG emission hotspots and potential emission cuts can vary strongly according to the material´s features. They also depend on whether most emissions come from energy use or from other industrial processes, and on the availability of cleaner energy options.

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[79] https://ec.europa.eu/commission/priorities/energy-union-and-climate/climate-action-decarbonising-economy_en
[80] https://ec.europa.eu/clima/policies/ets_en
[81] https://ec.europa.eu/clima/policies/effort_en
[82] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32011D0278
[83] https://ec.europa.eu/clima/policies/ets/allowances/industrial_en
[84] https://ec.europa.eu/clima/policies/ets/credits_en
[85] https://ec.europa.eu/clima/policies/ets/allowances/leakage_en
[86] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32014D0746
[87] https://ec.europa.eu/clima/policies/ets/auctioning_en
[88] https://ec.europa.eu/clima/policies/strategies/2030_en
[89] http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=3326

The raw material industry has already made significant efforts to reduce emissions. Some examples are the optimization of industrial processes such as steel production, the increase of production based on secondary materials, electrification, and the use of biomass and waste as fuel and for heat generation (in paper industries). Yet, significant challenges remain. For instance, the reliance on fossil fuels[90] used for ventilation, drilling, etc., is high in mining operations, especially in remote areas. Moreover, the average energy demand per mining output is expected to increase due to the trend of decreasing ore grades and more stringent mining conditions. Process-related emissions, often having been optimized for decades, do not show significant potential to be reduced further[91]. In the case of the raw materials sector, this is also due to the composition of materials. Apart from the challenges to reducing GHG emissions per unit of material production, the increasing global demand for minerals, metals and biotic products (IRP, 2019) challenges the GHG emissions´ mitigation needed to combat climate change.

Further reduction of GHG emissions in the EU economy in general, and in the raw materials sectors in particular, may be also limited by potential bottlenecks in the supply of certain materials required for the deployment of low-carbon technologies (JRC, 2016) (see dedicated section 3.4.4). In addition, the manner of sourcing materials needed for the low–carbon economy will determine its overall contribution to sustainable development and a peaceful world, since materials extraction in some world regions can reinforce weak governance (IISD, 2018).

Mitigation could also be constrained by a limited availability of quality secondary raw materials, whose use as inputs to production, as indicated above, generally helps reduce GHG emissions. The current limited uptake of secondary raw materials[92] is partly due to the downgrading of material after recycling and the need for quality standards for secondary raw materials[93]. The EU has a consolidated recycling industry for some materials (e.g. aluminium, copper and iron) (JRC, 2018a), which supplements the inputs to production from primary sources. However, the road towards a more circular use of raw materials is long, especially for some critical materials that are key enablers of low-carbon technologies (JRC, 2016). Moreover, significant amounts of potentially recyclable waste are leaving the EU in the form of used products, waste and scrap[94]. There is no evidence as to whether this exported waste and scrap is handled in an efficient/circular way and is actually contributing to the production of secondary raw materials, thereby reducing GHG emissions globally. While these outflows increased significantly in the past decade[95], trends may change due to the dynamic nature of the global market. For instance, some major importers of waste from the EU have introduced bans on that trade.

3.4.4 Raw materials contribution to low-carbon technologies

Power generation is one of the major contributors to climate change. Low-carbon technologies play a fundamental role in the transition towards a clean, secure and sustainable energy system. This includes wind power, solar photovoltaic, electricity grid and bioenergy technologies, which are prioritised in the EU's Strategic Energy Technology (SET) plan, and expected to see a significant increase in market share according to the energy market scenario outlined in the EU Energy Roadmap 2050.

Raw materials are and will be indispensable for sustaining the development and large-scale deployment of such technologies. Currently, the EU relies on imports of raw

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[90] http://www.euromines.org/publications/providing-metals-and-minerals-for-carbon-neutrality

[91] https://www.umweltbundesamt.de/sites/default/files/medien/376/publikationen/strategy_for_long-term_eu_greenhouse_gas_emissions_reduction.pdf

[92] See indicator 16 within the 2018 Raw Materials Scoreboard, http://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/16

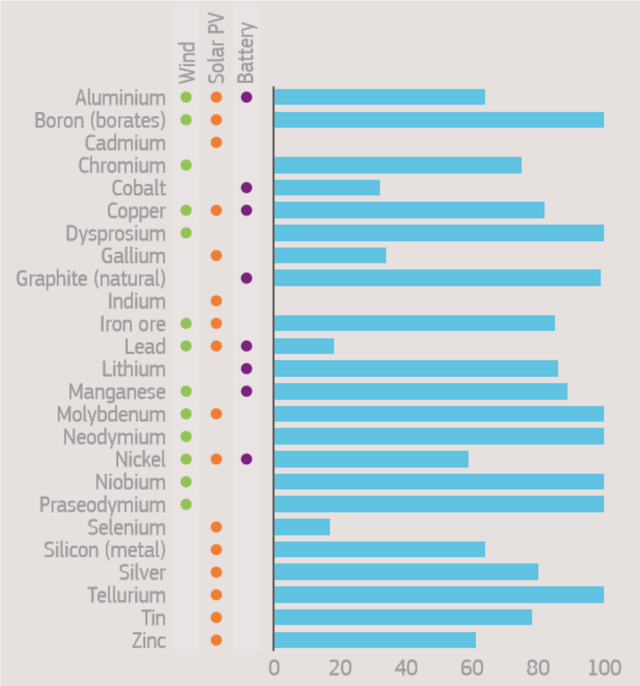
[93] http://rmis.jrc.ec.europa.eu/?page=from-waste-to-resources-2f4f0b

[94] See indicator 18 within the 2018 Raw Materials Scoreboard, http://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/18

[95] Ibid.

materials[96] needed for renewable energies, such as manganese, chromium, cobalt and copper (Figure 19).

Figure 19. Import dependency for selected materials used in wind, photovoltaic and battery technologies.



Source: JRC, in EPSC (2018).

Many of the relevant materials required for low-carbon technologies are considered critical raw materials[97] (Figure 20). Moreover, several of these materials are also used by competing applications, e.g. electric vehicles and wind power, and demand is increasing at an accelerated pace globally, which may challenge the deployment of low-carbon technologies (JRC, 2017)through possible bottlenecks in supply of materials.

Although the market may move towards wind or solar photovoltaic technologies that will require less critical materials per kWh generated, through increasing material efficiency and substitution, the demand for most raw materials used in these technologies is still projected to increase by 2030 (JRC, 2013) (Figure 20). For example, the annual demand for raw materials used in solar PV technology is projected to increase on average by 270 % by 2030. For wind power, demand for dysprosium may increase by about 660 % and neodymium by about 2 200 %, due to the increase in market share of rare earth-based generators in both onshore and offshore wind applications.

Furthermore, to enable transmission of electricity from dispersed and concentrated renewable sources, for example, from offshore wind applications, a 'smart' electricity system needs to be developed, including installation of submarine cables. Such cables will require copper and lead.

As a viable alternative to fossil fuel in the EU's transport sector, biofuels will also help to reduce GHG emissions and improve the security of fuel supply within the EU. However, sustainable biofuel production relies on specific catalysts, which are based on cobalt and ruthenium metals. The demand for these metals by 2030 is expected to be over 300 times today’s level.

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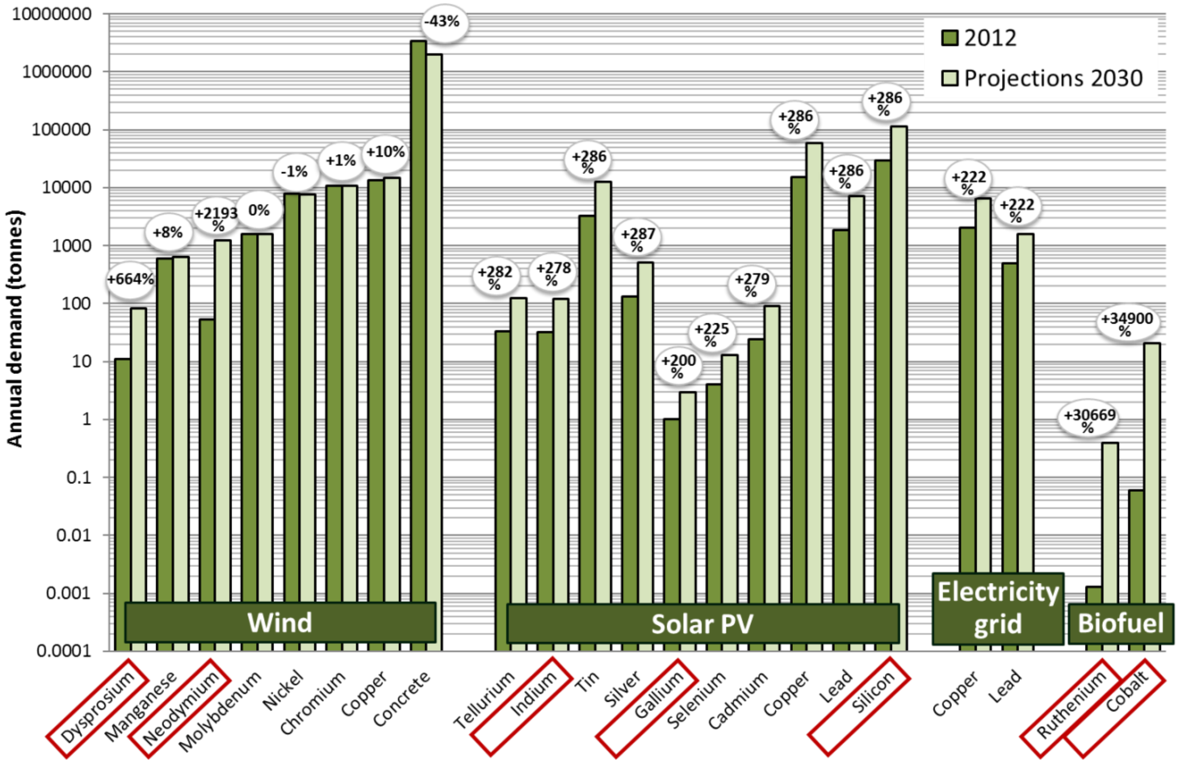
[96] See indicator 3 within the 2018 Raw Materials Scoreboard, http://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/3

[97] https://setis.ec.europa.eu/critical-materials-in-low-carbon-technologies

Figure 20. Current (2012) and projected (2030) annual demand for raw materials used for selected low-carbon energy technologies.

Critical Raw Materials are highlighted in red boxes.

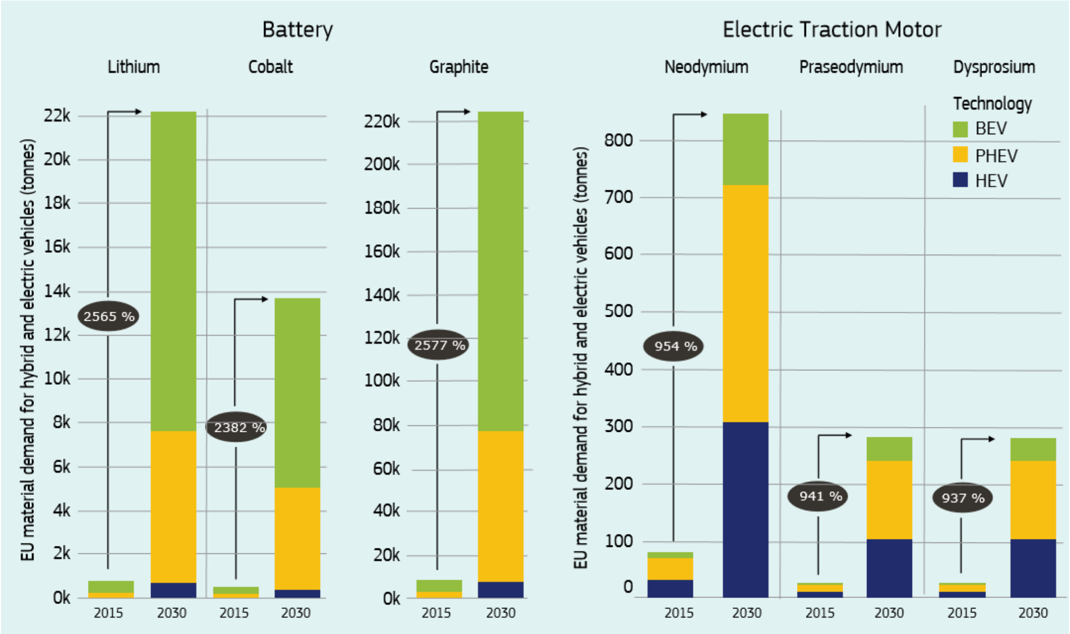


Source: Introduction of the EU Raw Materials Scoreboard (EC, 2016), based on methodology by JRC (2014) and JRC (2013).

Electro-mobility is also essential for a broader shift towards a modern, low-carbon and circular economy. It can help reduce EU GHG emissions and improve air quality in cities. According to the European Roadmap for Electrification of Road Transport, over 5 million electric vehicles should be on EU roads by 2020, increasing to 15 million by 2025. To accomplish emission reduction goals, according to JRC (2016), even more ambitious targets are sometimes put forward, e.g. as many as 8-9 million electric vehicles on the road by 2020, with further increases in electric vehicle sales beyond 2025. Higher quantities of critical and non-critical raw materials will be necessary to sustain this future uptake of electro-mobility (Figure 21).

Figure 21. Demand forecast in the EU for selected critical raw materials for the hybrid and electric vehicles segments.

BEV: battery electric vehicle; PHEV: plug-in hybrid electric vehicle; HEV: hybrid electric vehicles.



Source: Raw Materials Scoreboard 2018 (EC, 2018b).

3.4.4.1 ***Innovation and financing for decarbonisation***

To help achieve its climate goals, the EU is determined to integrate climate action[98] (mitigation and adaptation) into all major EU spending programmes[99] and proposes to further strengthen climate action.

So far, the Commission has promoted low-carbon technologies through the Sustainable Industry Low Carbon (SILC) programmes[100]. In parallel, among many other funding initiatives, the biggest research and innovation programme in the EU, Horizon 2020[101], is supporting the development of enabling technologies in resource and energy efficiency. The new research and innovation programme currently under discussion, Horizon Europe[102], will target the decarbonisation of energy-intensive industries.
The next EU ETS Phase (4)[103] will also itself support industry and the power sector through several low-carbon funding mechanisms, and will include reserves for the deployment of innovative renewable energies and technologies such as carbon capture and geological storage (CCS)[104].
In addition, NER 300[105] is one of the world's largest funding programmes for innovative low-carbon energy demonstration projects, and also seeks to leverage a considerable amount of private investment and/or national co-funding across the EU. NER 300 is intended as a catalyst for environmentally safe CCS and innovative renewable energy technologies on a commercial scale within the EU, involving all Member States.
Alongside this, the EIT Climate-KIC[106] is the European knowledge and innovation community that identifies and supports innovation contributing to mitigation and

[98] https://ec.europa.eu/clima/policies/budget/mainstreaming_en
[99] http://ec.europa.eu/budget/mff/programmes/index_en.cfm
[100] https://ec.europa.eu/growth/industry/sustainability/low-carbon-economy/silc-programmes_en
[101] https://ec.europa.eu/programmes/horizon2020/
[102] https://ec.europa.eu/info/designing-next-research-and-innovation-framework-programme/what-shapes-next-framework-programme_en
[103] https://ec.europa.eu/clima/policies/ets/revision_en
[104] https://ec.europa.eu/clima/policies/lowcarbon/ccs_en
[105] http://rmis.jrc.ec.europa.eu/?page=other-funds-1d7a4a
[106] https://www.climate-kic.org/

adaptation. It provides support to several initiatives aimed at reducing industrial GHG emissions.

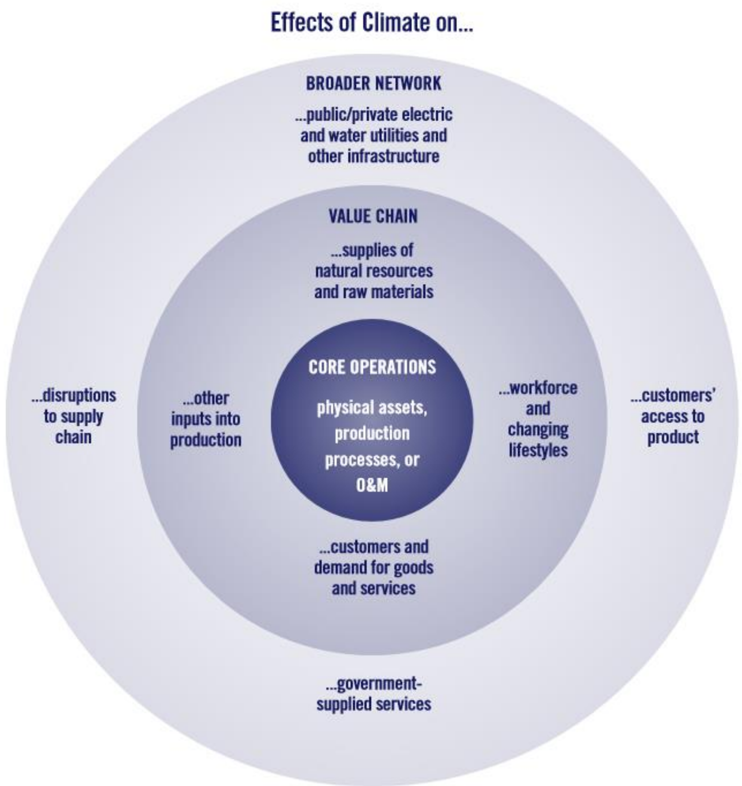
There are also many potential synergies between measures promoted in the context of climate mitigation policies and those developed in the context of the circular economy. The latter promotes resource efficiency, recycling and enhanced waste management, to reduce negative environmental and social impacts, and to boost EU competitiveness and the security of the EU supply of materials.

3.4.5 Climate change adaptation and risk to raw materials supply

Climate change itself is also expected to have an impact on the production of raw materials. For instance, some of the world's largest mining facilities operate in climate sensitive regions. Adaptation, i.e. anticipating and taking measures to minimise damage from climate change, may be needed to ensure a sustainable and secure supply of raw materials.

Any business can be impacted by climate change at several levels: direct impacts on operating facilities, impacts on the supply/value chain, and further impacts in other related aspects (Figure 22). These impacts could include for instance increasing water shortages, which may trigger water competition problems, closely linked to public acceptance of operations[107]; flooding, which could damage mining infrastructures such as tailings, dams; etc. Limitations may also arise in the availability of energy, e.g. due to decreasing water flows in rivers used for hydropower generation. The International Council on Mining and Metals (ICMM)[108] provides an overview of the main climate-related challenges faced by the mining sector.

Figure 22. Types of risk from climate change for businesses.



Source: Sussman and Freed (2008).

[107] See indicator 14 within the 2018 Raw Materials Scoreboard, http://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/14

[108] https://www.icmm.com/climate-adaptation

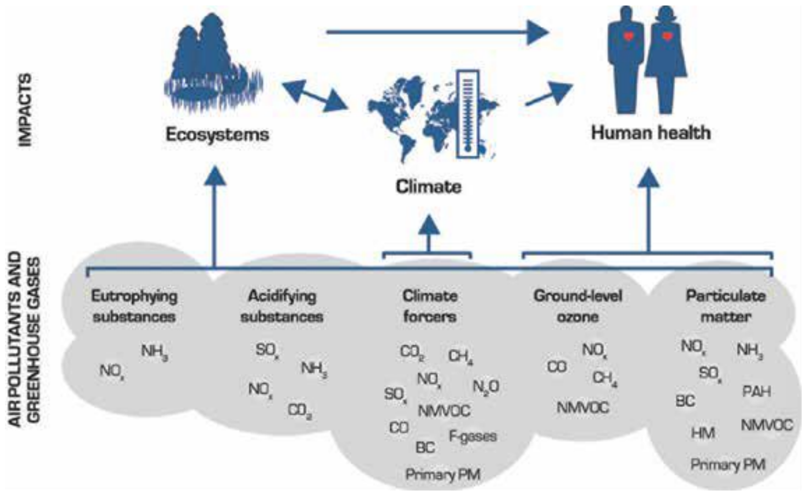
Furthermore, climate change may damage forests' adaptive capacity[109], while at the same time increasing pressures on forests such as disturbances through storms, fire, pests and diseases. This may impact forest growth and production capacity and affect the function of forests as carbon sinks. The economic viability of forestry may be affected, mainly in southern areas of Europe. These and other challenges for the forest sector are addressed by the EU Forest Strategy[110].

3.5 Air pollution and air quality

Preserving air quality is among the main objectives of the European Union policies on environmental protection. Based on a fitness check of the Ambient Air Quality Directives, the European Green Deal[111] announces for a sustainable industry the adoption of a zero-pollution action plan in 2021 and the proposal to align air quality standards to World Health Organization (WHO) recommendations. To achieve this, monitoring, modelling, and controlling industry emissions play an interconnected key role.

In addition to the release of substances that contribute to global warming, industrial activities also emit pollutants to the atmosphere that can affect air quality. These emissions are associated with impacts on human health and on ecosystems (Figure 23).

Figure 23. Impacts of air pollution.



BC=black carbon (a typology of particulate matter), CH_4=methane, CO=carbon monoxide, CO_2=carbon dioxide, F-gases= fluorinated gases, HM=heavy metals, N_2O=nitrous oxide, NH_3=ammonia, NMVOC=non-methane volatile organic compounds, NOx=nitrogen oxides, PAH=polycyclic aromatic hydrocarbons, PM=particulate matter, SOx=sulphur oxides.

Source: EEA, 2014.

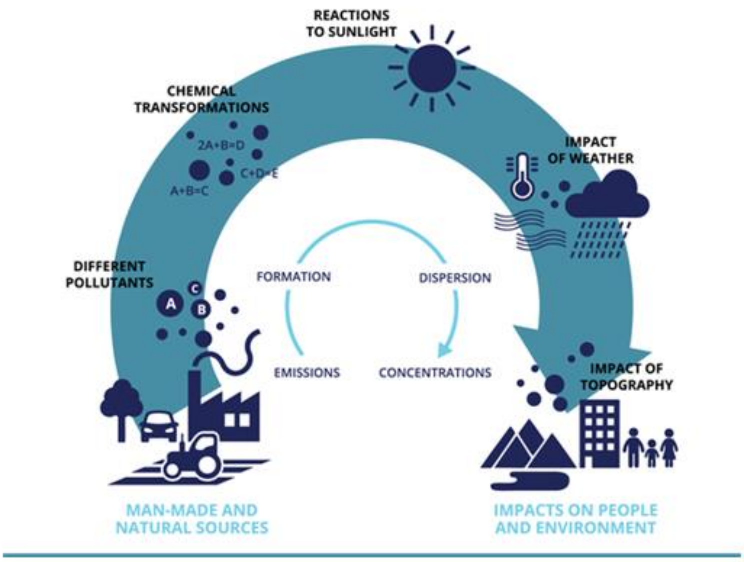
The relationship between air quality and emission of pollutants is complex[112]. Primary pollutants, i.e. pollutants directly emitted by a source, interact with the atmosphere and can form other type of substances, i.e. secondary pollutants, after being in contact with water, sun light, other pollutants, etc. Primary air pollutants include particulate matter, sulphur dioxide, nitrogen (di)oxide, ammonia, volatile organic compounds and methane, while secondary air pollutants are e.g. secondary particulate matter and ozone (EC, Cleaner air for all[113]).

The ultimate impact of air pollution depends not only on pollutant concentration but also on other variables such as topographic conditions and the possible further transport of primary and secondary pollutants - even for very long distances - (see Figure 24 and

[109] https://climate-adapt.eea.europa.eu/eu-adaptation-policy/sector-policies/forestry
[110] COM/2013/0659 final
[111] COM/2019/640 final
[112] https://www.eea.europa.eu/themes/air/intro#tab-see-also
[113] http://ec.europa.eu/environment/air/cleaner_air/#introduction

EEA[114]). Indeed, transboundary pollution entering the EU from other northern hemisphere countries is growing, which also has an impact on the concentration of air pollutants. As a result of this complexity, the relationship between volume of pollutants emitted, concentration of air pollutants in the air and pollutants' ultimate impact is neither linear nor easily predictable.

Figure 24. Air pollution: from emissions to exposure.



Source: EEA signals, 2013.

In addition, noise pollution is a major environmental concern in Europe. This includes also industrial sources of noise, such as extraction and production of non-energy raw materials, with activities like rock loading and unloading, power generation, drilling, transport, etc. The European Environment Agency present in the NOISE Observation & Information Service for Europe[115] data on exposure to different levels of noise from roads, industries, etc.

3.5.1 Air quality policy

Air pollution and air quality[116] have been among the main political concerns in the EU since the 1970s. The EU air quality policy[117] aims to establish air quality targets[118] and emission ceilings[119] that are compatible with economic growth and sustainable development, and in line with relevant international conventions.

One of the pillars of the EU air quality policy is the establishment of emissions standards for key sources of pollution. To that aim the Industrial Emissions Directive (IED)[120] requires the adoption of 'Best Available Techniques' (BATs) by large industrial installations. This affects industries such as the production of metals, minerals, paper and wood. BATs are specified in the BAT reference documents (BREF)[121], which set reference limit values for the emissions of some substances. BREFs have been adopted for several industry sectors such as iron and steel (EC, 2013a), ferrous metals processing (EC, 2001), non-ferrous metals (EC, 2017a), cement, lime and magnesium oxide (EC, 2013b), wood-based panels (EC, 2016a), pulp and paper (EC, 2015), glass (EC, 2013c) and

[114] https://www.eea.europa.eu/themes/air/intro#tab-see-also
[115] https://noise.eea.europa.eu/
[116] http://ec.europa.eu/environment/air/quality/
[117] http://ec.europa.eu/environment/air/index_en.htm
[118] http://ec.europa.eu/environment/air/quality/standards.htm
[119] https://www.eea.europa.eu/themes/air/national-emission-ceilings
[120] http://ec.europa.eu/environment/industry/stationary/ied/legislation.htm
[121] http://eippcb.jrc.ec.europa.eu/reference/

ceramic (EC, 2007a). In addition, a reviewed version of the BREF on Management of Tailings and Waste-rock in Mining Activities (EC, 2018a), whose standards will yet not be binding for the mining sector, has just been released

3.5.2 Pollutant emissions from raw materials production

Emissions of pollutants from the raw materials sector can occur across the entire value chain, from the extraction of raw materials to the production of semi-finished products, the manufacturing of final products, waste management, and recycling processes. Pollutant emissions may originate from the combustion of fuels, e.g. at industrial facilities or during transport, from non-combustion industrial processes, or from mechanical operations such as land clearing or drilling.

Air pollutants from the raw materials industries include primary particulate matter (PM) from operations that generate dust, from fuel combustion and from specific industrial processes. PM is a complex mixture of microscopic solid or liquid matter in the air, and a key pollutant affecting human health. Depending on the size of particles, PM is classified as $PM_{2.5}$ (particle size up to 2.5 μm), PM_5, PM_{10}, and so forth.

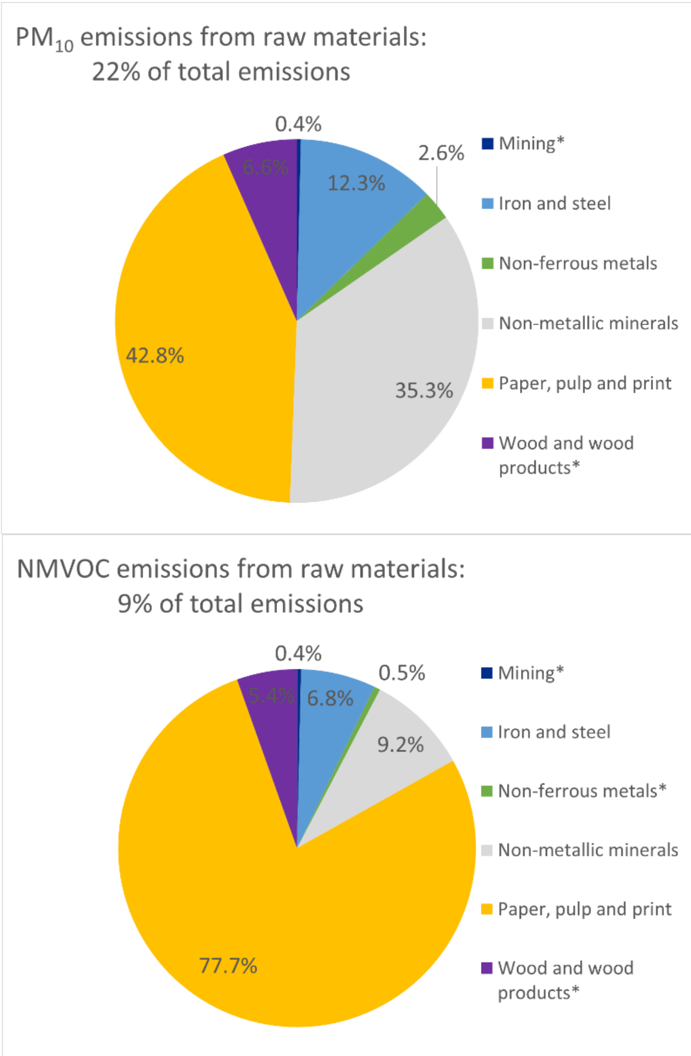
Raw materials industries also release chemical substances such as non-methane volatile organic compounds (NMVOCs). NMVOCs are a mixture of organic compounds with various chemical compositions that behave similarly in the atmosphere, emitted by combustion activities and by certain industrial production processes. NMVOC emissions can potentially form tropospheric ozone, which has a negative impact on human health. The raw materials industries also generate substances that contribute to acidification, such as sulphur dioxide (SO_2) - which originates primarily from the burning of fuels that contain sulphur-, or nitrogen oxides (NO_x), mostly from road transport activities.

The sector can also emit heavy metals, which contributes to toxic deposition in soils and organisms (EEA, 2017). For instance, some cadmium and lead emissions come from the production of non-ferrous metals, and iron and steel; some arsenic originates from metal smelters and fuel combustion, and some mercury originates from iron and steel and cement production. Nickel emissions originate from nickel mining and primary production, and from steel manufacturing.

3.5.2.1 *Direct pollutant emissions*

PM_{10} direct emissions generated onsite by the EU raw materials industrial facilities account for 22% of all PM_{10} direct emissions in the EU (Figure 25, top graph). A significant share of this PM_{10} corresponded to $PM_{2.5}$, the PM fraction that is responsible for the most severe damages to human health given their greater potential to pass deeper into the respiratory system. NMVOC direct emissions generated onsite by the EU raw materials industrial facilities account for circa 9% of all NMVOC direct emissions in the EU (Figure 25, bottom graph). Values for both PM_{10} and NMVOC change across Member States.

Figure 25. Direct PM_{10} and NMVCO emissions share by raw materials sector (EU-27, 2015).



Source: JRC elaboration based on EDGAR data.

In the last few decades, the industry has made major efforts to control and reduce pollutant emissions in the EU (EEA, 2017). This includes implementing emission management plans, adopting process-integrated and end-of-pipe pollution abatement technologies, and changing fuel mixes. However, the concentration of some pollutants such as particulate matter in the air remains a major concern in some areas, in particular with regard to impacts on public health (EEA, 2017).

Direct PM_{10} emissions have significantly decreased in the last decades for most raw materials sectors (Figure 26 top). The production of iron and steel and of non-metallic minerals showed the most marked reductions, followed by the mining sector and the production of non-ferrous metals. However, PM_{10} emissions from the paper and wood industries increased, mostly due to the rise of the manufacturing of bio-based products. In addition, an increase of PM_{10} emissions has been observed since 2012, yet values vary across Member States.

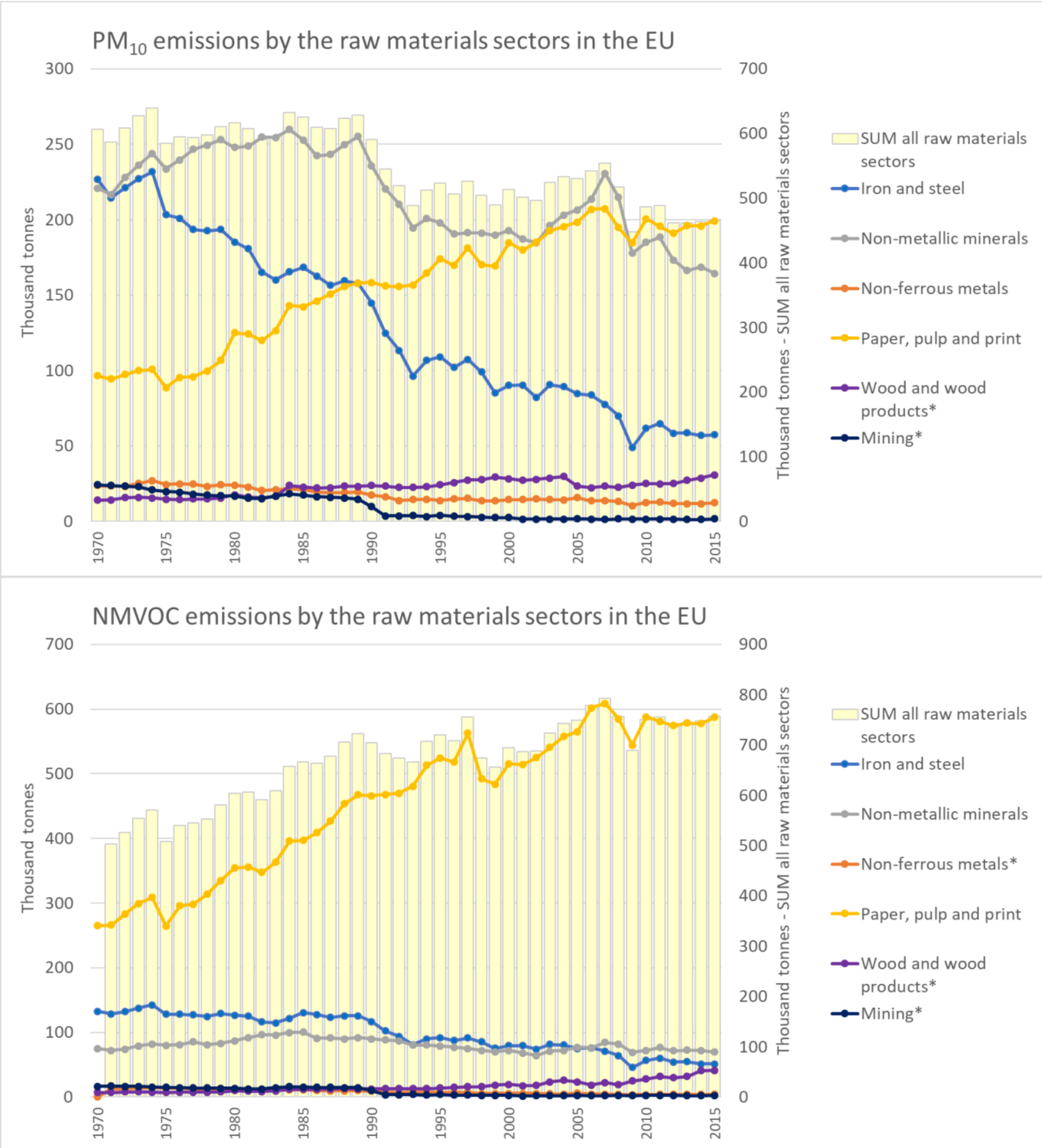
The decreases in absolute PM_{10} emissions reflect the overall reduction of absolute production volumes of raw materials in the EU[122]. Decreases were also due to efficiency improvements in most sectors. Efficiency improvements were particularly relevant for the

[122] See indicator 21 in the 2018 Raw Materials Scoreboard, https://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/21

production of iron and steel and non-ferrous metals, as well as for mining, where they were mostly associated with reductions of on-site energy requirements.

On the contrary, NMVOC emissions showed increasing trends for the raw materials sectors overall since the 70´s. The paper sector, which is the main contributor to total raw materials-related NMVOC emissions, and the wood industries showed more accentuated increases of emissions of NMVOCs than they showed for PM_{10}. This was also due to an increase of NMVOC emissions intensity of the latter sectors. In addition, iron and steel making showed limited NMVOC emissions efficiency improvements. As for PM10 emissions, values vary across Member States.

Figure 26. Direct PM_{10} and NMVCO emissions from the EU-27 raw materials sectors.



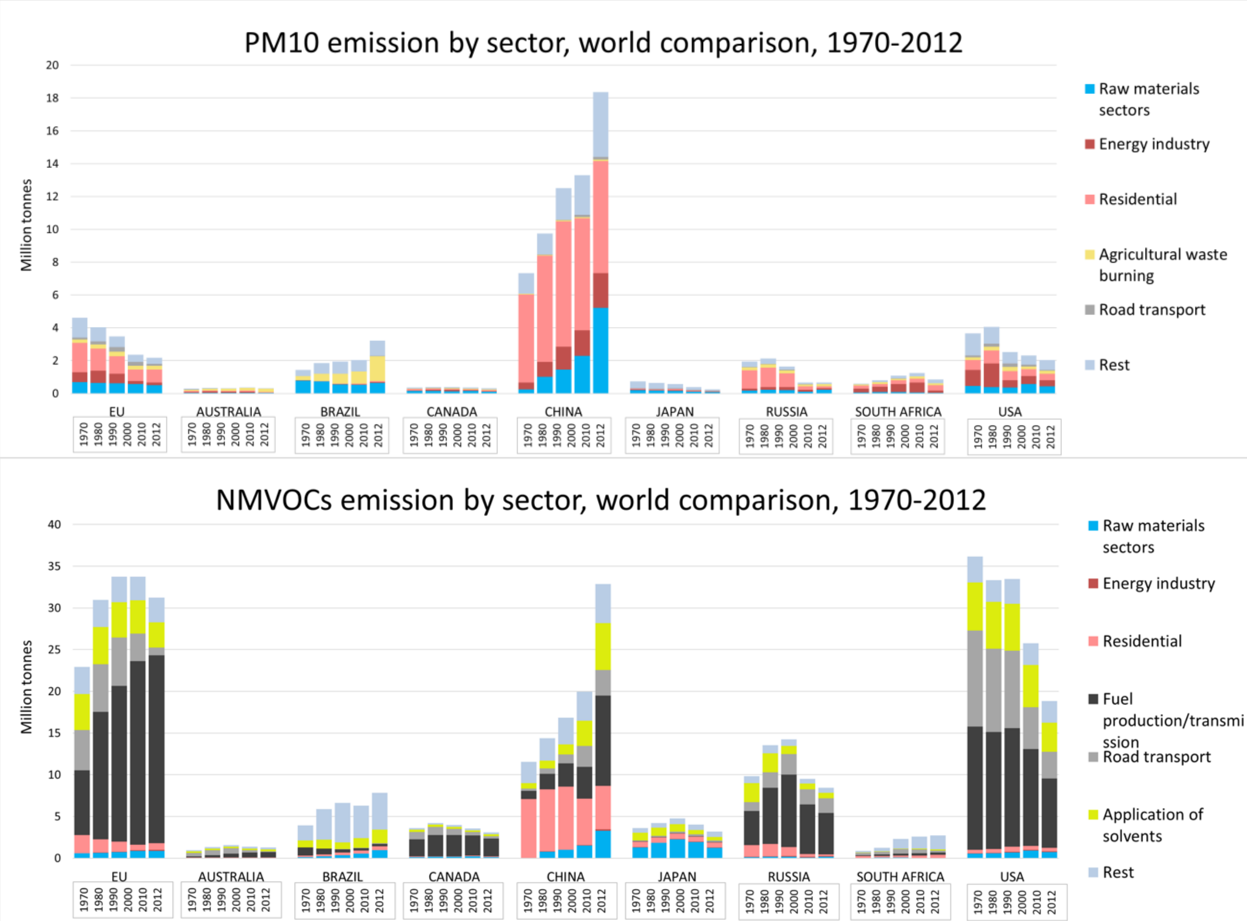
*Only accounts for emissions from combustion processes.

Source: JRC elaboration based on EDGAR[123] data.

[123] http://edgar.jrc.ec.europa.eu/index.php

In contrast to the EU trends, PM_{10} and NMVOC emissions from the raw materials sector increased remarkably at a global level (Figure 27), mostly driven by the expansion of industrial production in developing economies such as China. The consumption of materials in both developed and developing countries has been a relevant driver of this expansion of the sector in developing economies.

Figure 27. Direct PM_{10} and NMVOC emissions trends by economic sector for the EU-28 and a selection of countries.



Source: JRC elaboration based on EDGAR[124] data.

3.5.2.2 ***Air pollutant emissions data***

The European Environment Agency compiles data on emissions of air pollutants[125] (such as NMVOCs, PM, sulphur oxides and nitrogen oxides) following the reporting obligations of the Convention on Long-range Transboundary Air Pollution (LRTAP Convention)[126]. Data are available for industrial processes and product use, energy use in industry, etc.

These data give insight about the air pollutant emission trends of the raw materials industries over the last decades. Further, the Eurostat Air Emission Accounts (AEA)[127] provide air pollutant emission data by NACE sector (from year 2008). While LRTAP emissions data follows a territory principle, AEA follow the national accounts' residence principle. Emissions are accounted for even if they take place outside the EU territory, if the residence of the activity falls within the EU (for instance a shipping company

[124] http://edgar.jrc.ec.europa.eu/index.php
[125] https://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-convention-on-long-range-transboundary-air-pollution-lrtap-convention-12
[126] http://rod.eionet.europa.eu/obligations/357
[127] https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_ainah_r2&lang=en

operating abroad). Based on the AEA, Eurostat also estimates air pollutant emission intensities[128].

Scientific databases such as EDGAR[129] provide air pollutant emission times series from year 1970 using reference data sources on emission factors and activity data. EDGAR is the data source that has been used for the graphs presented here and also in the air pollutant emission indicator of the 2018 Raw Materials Scoreboard[130]. Emission factors are average emission rate of a given pollutant for a given source, relative to units of activity. Activity data gauges the magnitude of human activity resulting in emissions or removals taking place during a given period of time (e.g. fuel consumption, production volume).

These data sources provide air pollutant emission from direct onsite production in industrial facilities, but do not consider emissions from energy generation that takes place off site, from the production of the auxiliary inputs, or from products transport and delivery. Based on the AEA and input/output tables[131] modelling, Eurostat also estimates the air pollutant emission from the final use of products[132] (only the EU total aggregate), i.e. emissions embodied in products for final use, which account for pollutants emitted by sector along the full production chain of products that are consumed within the EU.

In addition to that, trends in exposure of population to pollutants (particulate matter) are also monitored by the Resource Efficiency Scoreboard[133] and for the SDGs EU monitoring framework[134].

3.6 Water – a precious input to the economy

Water is an essential input to the economy and to life. Safeguarding its supply and quality is crucial for citizens and for the health of ecosystems. Water is also an essential input to the raw materials extractive and manufacturing industries, being used in ore processing, dust suppression, cooling processes, and as a material input for most industrial processes.

Although water can be reused multiple times at facilities, some raw materials industries can be water-intensive, and this can significantly reduce water availability at the local level. In turn, water stress may put the security of supply of some raw materials at risk, when water supply for production is not guaranteed.

Apart from water-volume related aspects, discharges from the raw materials industry and run-off from mining sites can affect the quality of water bodies and soils. Extractive practices in the seabed and deep sea can also impact coastal and marine ecosystems.

This section consists of several sub-sections (Figure 28) covering all the aspects mentioned above. In addition, a dedicated sub-section describes the datasets available on water use and emissions to water and policies safeguarding water.

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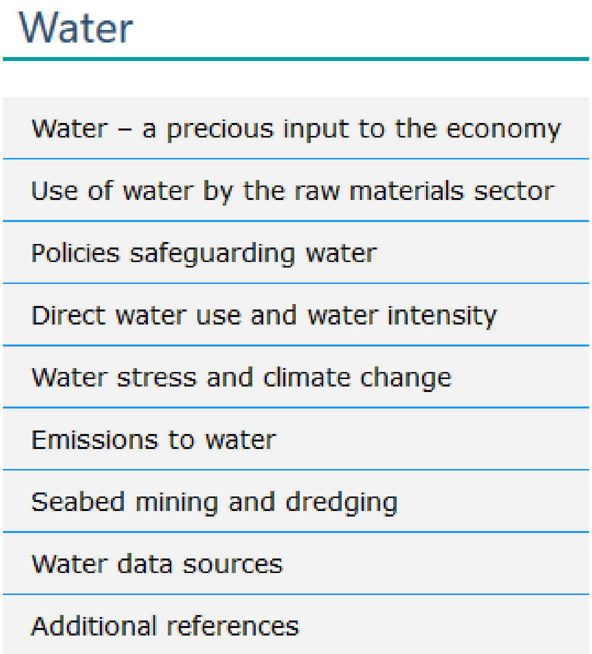
[128] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_aeint_r2&lang=en
[129] http://edgar.jrc.ec.europa.eu/index.php
[130] See indicator 21 in the 2018 Raw Materials Scoreboard, https://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/21
[131] https://ec.europa.eu/eurostat/statistics-explained/index.php/Supply_and_use_tables_-_input-output_analysis
[132] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_io10&lang=en
[133] http://ec.europa.eu/eurostat/web/europe-2020-indicators/resource-efficient-europe
[134] http://ec.europa.eu/eurostat/web/sdi/overview

Figure 28. Structure of the RMIS section on water (the structure slightly differs from the one followed in this report).



Source: RMIS.

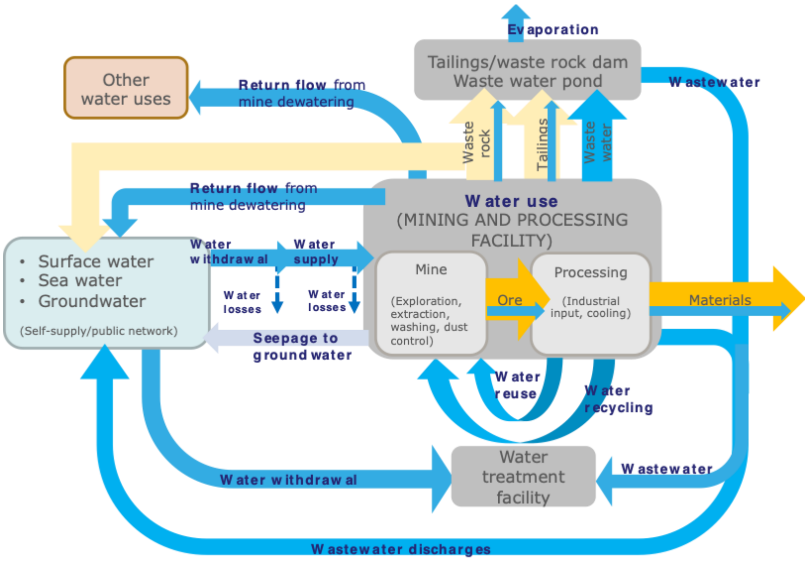
3.6.1 Use of water by the raw materials sector

Raw materials industries need the right amount of water, at the right moment and of the required quality. To this end, mining and processing facilities often rely on self-supply of water, which may come from local water bodies, groundwater or the sea (Figure 29). Water may also be supplied through the public network. In the specific case of mining operations, additional water resources are usually available from mine dewatering, which often satisfies the facility's requirements and may also provide additional resources for other water users. As a drawback, dewatering may lead to drawdown of the water table under certain circumstances.

Depending on the water quality requirements for the mining and industrial processes, water supplies may require pre-treatment. After water has been used, the resulting wastewater is treated and discharged into the environment. Facilities may set up various types of dedicated ponds and dams for wastewater management. Often, wastewater is reused and/or recycled and loops back into the facility for processes that are less demanding in terms of water quality (cascading use).

The EU is quite advance in terms of water management at mining and other industrial operations. More recently, the sector can also learn from other countries ahead, with advance applications and regulation for e.g. desalinated seawater.

Figure 29. Use of water by a typical non-energy mining and processing facility.



Source: Vidal Legaz et al. (2018).

In addition to the direct use of water at the facility, the production of raw materials relies on the use of auxiliary materials for onsite production (such as chemicals), on technical equipment, and often on energy supplies that are produced off site. The production of all these items requires additional water inputs.

3.6.2 Policies safeguarding water

In order to safeguard water resources, the Water Framework Directive (WFD)[135] establishes quality objectives for water bodies, and specifies the need to establish River Basin Management Plans[136] and reporting obligations on water-related data.

Water use and wastewater discharges are also regulated by the Industrial Emissions Directive. This directive covers the largest installations producing metals and minerals, and part of the wood sector, and requires adoption of the so-called Best Available Techniques (BAT), detailed in the Best Available Techniques Reference documents (BREFs). As indicated in sections above, BREFs include standards for water use and water discharges by industrial processes. A number of BREFs exist for sectors such as iron and steel, wood and ceramics.

In parallel, the EU Roadmap to a Resource Efficient Europe[137] highlights the need to promote water efficiency, and declares that it could be significantly improved based on technological innovation. Boosting water reuse and recycling, in a context of increasing water scarcity problems, is also promoted by the Circular Economy Action Plan, which further promotes implementation of the BREFs standards.

In addition, at Member State level, water protection restricts mining activity by the designation of no-go areas in most countries, or in other ways such as limiting the depth of extraction in some open pit mines (Czech Republic, Austria), or prohibiting the exploitation in the riverbed (Romania) or around water springs (Serbia) (Minatura, 2016a).

3.6.3 Direct water use and water intensity

Direct water withdrawal by facilities extracting and processing raw materials is generally relatively small, compared to other economic activities such as agriculture or public water

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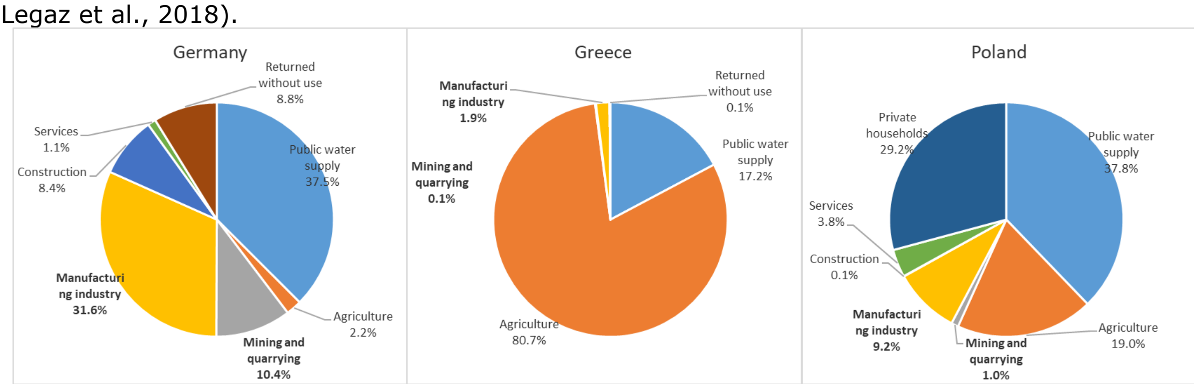
[135] Directive 2000/60/EC
[136] http://ec.europa.eu/environment/water/participation/map_mc/map.htm
[137] http://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm

supply (Figure 30). Depending on the commodity mined, a significant proportion of the water withdrawn may return to the environment without major alterations to quality. At mining sites and in the manufacturing sector, water consumption is usually well below water withdrawal volumes, due to circular use of water within the facility. However, water uptake by the sector can still markedly influence water availability at the local level, although figures vary widely between countries.

Figure 30. Water withdrawal by economic sector. Data are displayed for a selection of countries based on data availability.

Data provide an overview but should be not considered as fully accurate (see more details in Vidal Legaz et al., 2018).

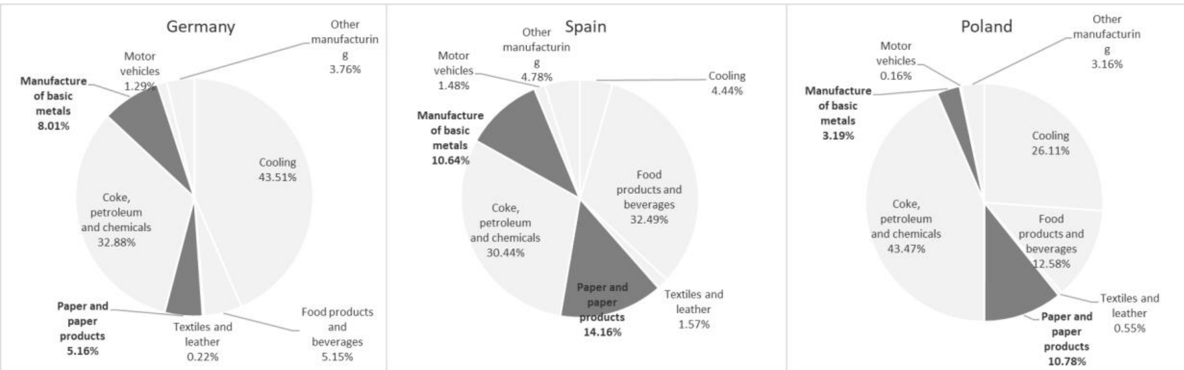


Source: JRC elaboration, based on Eurostat data (env_wat_abs[138], retrieved August 2020). Data for Germany and Greece is 2016, data for Poland 2017.

Among the raw materials manufacturing sectors, the production of basic metals such as steel, and of paper and paper products, typically use significant amounts of water (Figure 31).

Figure 31. Water use by manufacturing sector. Data are displayed for a selection of countries based on data availability.

Data provide an overview but should be not considered as fully accurate (see more details in Vidal Legaz et al., 2018).



Source: JRC elaboration, based on Eurostat data (env_wat_ind[139]) retrieved August 2020). Data for 2016.

Within the raw materials sector, water requirements per unit of production are highly industry-specific. For instance, the extraction of precious metals and the manufacture of iron, steel, and paper are typically water-intensive activities. The manufacture of wood and of non-metallic minerals are usually less demanding of water. Particularly variable are the water requirements for mineral processing (Table 3), where water consumption also varies greatly between production stages (Figure 32).

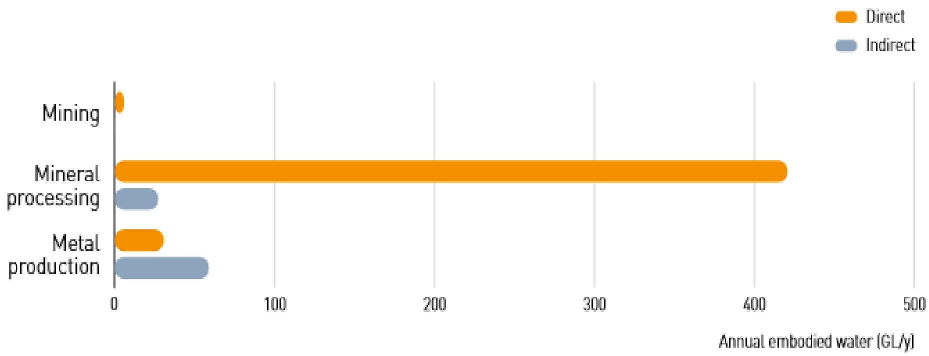
[138] http://appsso.eurostat.ec.europa.eu/nui/show.do?lang=en&dataset=env_wat_abs
[139] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wat_ind&lang=en

Table 3. Reported water consumption during mineral and metal processing, based on data from sustainability reports.

Mineral/metal	Total number of years of data	v. ore throughput (e.G. kL/t ore)		v. ore grade (e.G. kL/t metal)	
		Average	SD	Average	SD
Bauxite (kL/t bauxite)	17	1.09	0.44	–	–
Black coal (kL/t coal)	18	0.30	0.26	–	–
Copper (kL/t ore; kL/t Cu)	48	1.27	1.03	172	154
Copper-gold (kL/t ore; kL/t Cu)	42	1.22	0.49	116	114
Diamonds (kL/t ore; kL/carat)	11	1.32	0.32	0.477	0.170
Gold (kL/t ore; kL/kg Au)[a]	311[a]	1.96[a]	5.03[a]	716[a]	1,417[a]
Zinc ± lead ± silver ± copper ± gold (kL/t ore; kL/t Zn ±Pb ± CU ±)	28	2.67	2.81	29.2	28.1
Nickel (sulfide) (kL/t ore; kL/t Ni)	33	1.01	0.26	107	87
Platinum group (kL/t ore; kL/kg PGM)	30	0.94	0.66	260	162
Uranium (kL/t ore; kL/t U_3O_8)	24	1.36	2.47	505	387

Source: Mudd (2008) as in UNEP (2013).

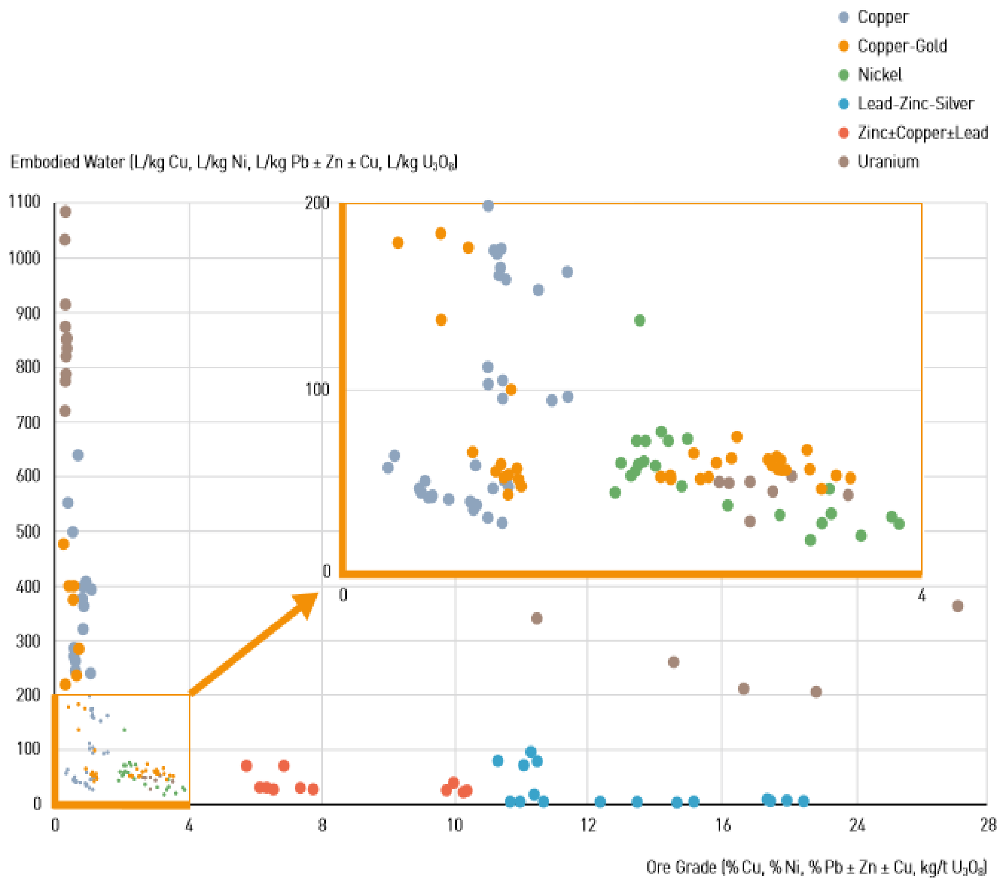
Figure 32. Contribution of processing stages to annual embodied water for metal production in Australia.



Source: Norgate and Aral (2009) as in UNEP (2013).

Water requirements for processing a specific commodity can vary greatly between locations and depending on the mineral concentration in the ore (Figure 33). In regard to the latter, a current challenge to further improvements in water efficiency at mining sites is the decreasing trend in ore grade (UNEP, 2013), which means further processing is required to extract the mineral, with a subsequent increase in water demand.

Figure 33. Reported water consumption during ore processing of several materials, depending on the ore grade.

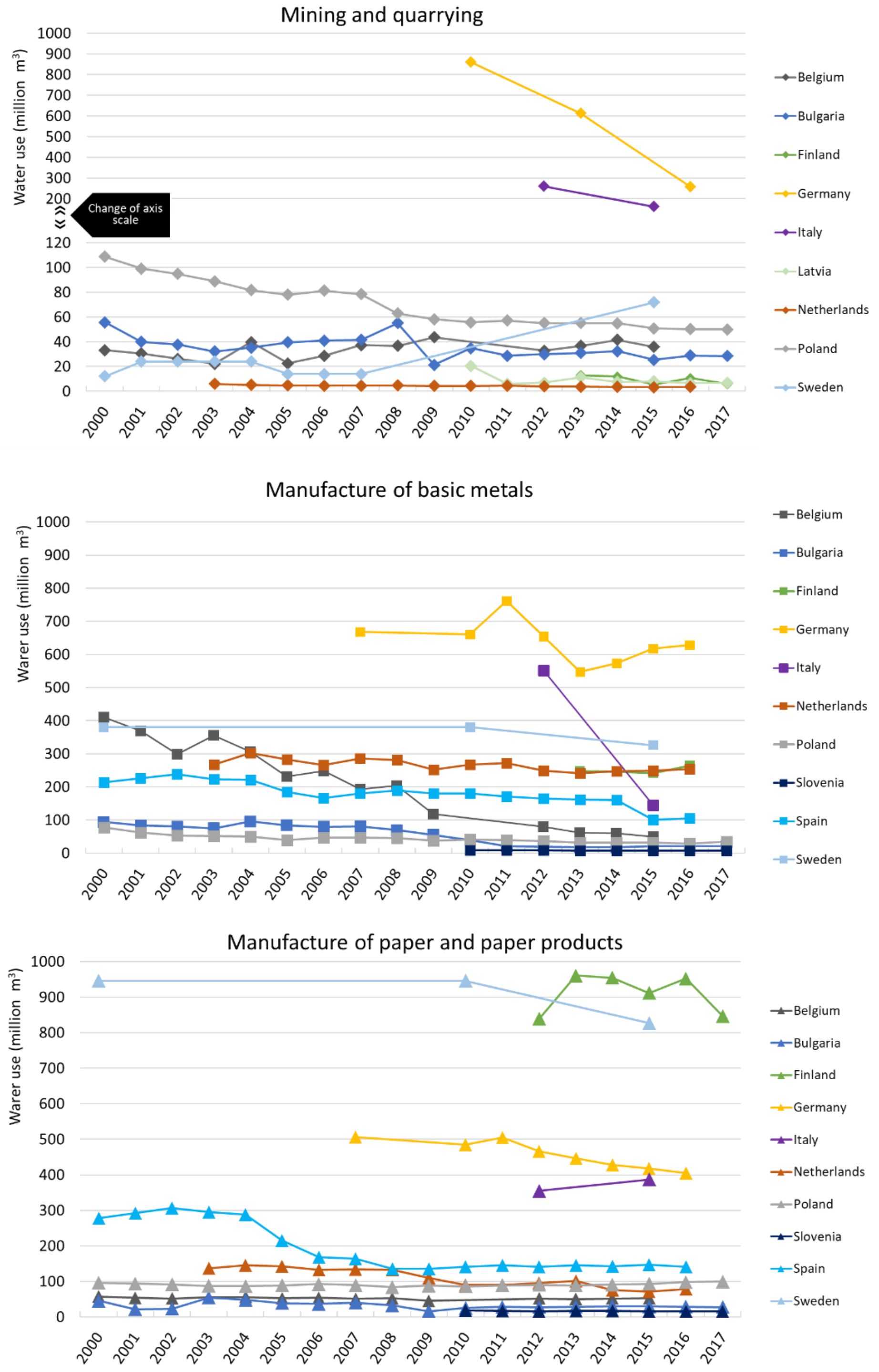


Source: Mudd (2008) as in UNEP, 2013.

There is evidence of overall decreasing trends in several raw materials sectors in the first half of the 2000´s, while trends are more varied in the second half (Figure 34). In the last years, water use for basic metals manufacturing increased in some countries, while less water was used by the paper industry and mining and quarrying. Increases generally took place in locations with no water stress (see also Figure 36).

Figure 34. Water use trends by raw materials sector (selection of EU countries, 2000-2017).

Data are displayed for a selection of countries based on data availability, yet for visibility reasons the country list is not exhaustive.



Source: JRC elaboration, based on Eurostat data (env_wat_cat[140] and env_wat_ind[141], retrieved August 2019).

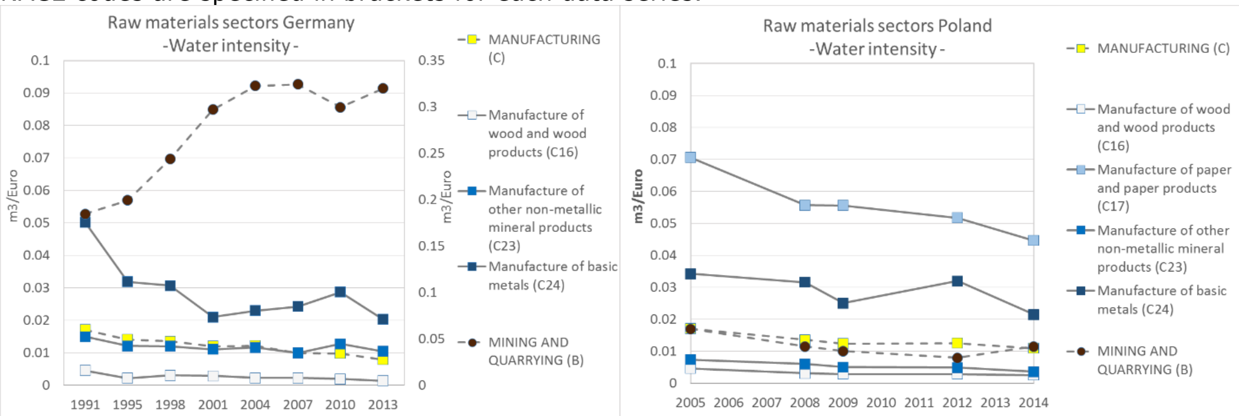
These trends seem to be closely linked to production volumes, but also to improvements in water efficiency in some sectors (Figure 35), for instance increasing rates of water reuse and recycling. Volumes of wastewater discharge[142] followed the decreasing trends

[140] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wat_cat&lang=en
[141] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wat_ind&lang=en
[142] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ww_genv&lang=en

in water withdrawal in the mining and quarrying sector, and show very noticeable decreasing trends overall. Indeed, the raw materials industry claims to have made strong efforts to reduce water use and wastewater discharge over recent years through, for example, improvements in water reuse (CEPI, 2014). The implementation of industrial and water policies has contributed to such improvements, especially those policies pushing towards increasing rates of wastewater treatment.

Figure 35. Water intensity over time for Germany (left) and Poland (right) based on national offices data.

NACE codes are specified in brackets for each data series.



Source: Vidal Legaz et al. (2018).

3.6.4 Water stress and climate change

Water availability influences the capacity of the raw materials sectors to supply materials in a secure manner. Indeed, water availability (often closely related to water price and therefore production costs) can be a decisive factor in determining the location of an operation site in water-scarce environments or in locations where there is strong competition with other uses such as agriculture, households or tourism. Depending on national or subnational regulations, under water stress conditions, water supply to industry is usually not given priority over other uses such as supply to households.

In this context, the Framework for Responsible Mining[143] explains that the mining industry has been at the forefront in water conservation, since companies recognise that decreasing water consumption is closely linked to decreasing processing costs, as well as to the ability of a company to operate during dry periods. However, there are growing concerns worldwide about the risk of water stress[144], which may result in disruptions to production, including in the raw materials industries. Indeed, water withdrawal for industrial use and for other purposes is projected to increase significantly (IRP, 2019) in the next decades.

Although the use of water resources can be considered sustainable in the long term in the EU overall, specific regions in southern Europe already face water stress problems (Figure 36). Information on risks to raw materials production related to water scarcity and to other considerations is available in the ´Environmental and social sustainability aspects´ section of the RMIS country profiles[145].

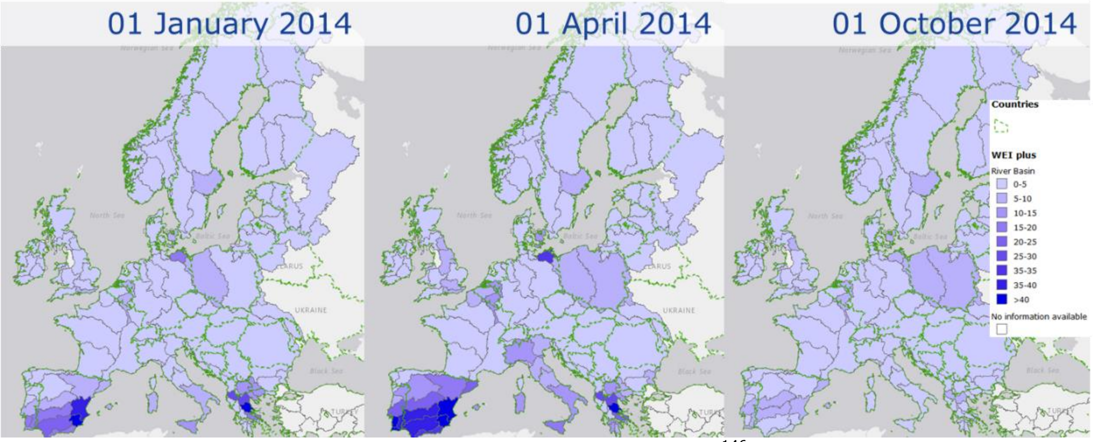
[143] http://www.frameworkforresponsiblemining.org/docs.html

[144] http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/#x=0.00&y=-0.00&l=2&v=home&d=bws&f=0&o=139

[145] https://rmis.jrc.ec.europa.eu/?page=rm-profiles#/

Figure 36. Water Exploitation Index Plus (WEI+), by European Catchment and Rivers Network System (ECRINS).

WEI+ compares freshwater use with long-term water availability. A WEI+ value above 20 indicates water stress and above 40, severe water stress.



Source: Adapted from EEA (2017)[146].

Water stress problems are likely to accentuate under the effects of climate change and will require adaptation of the sector[147]. For instance, in the past decades, the frequency of droughts has increased, especially in south-western and central Europe (Figure 37). The annual flow of rivers has also decreased considerably, especially in southern and parts of Eastern Europe (Figure 38), some of which were already water-scarce areas for at least some periods of the year. Moreover, climate change is projected to significantly change the seasonality of river flows across Europe; summer flows are projected to decrease overall, even in the regions where annual flows are forecast to increase.

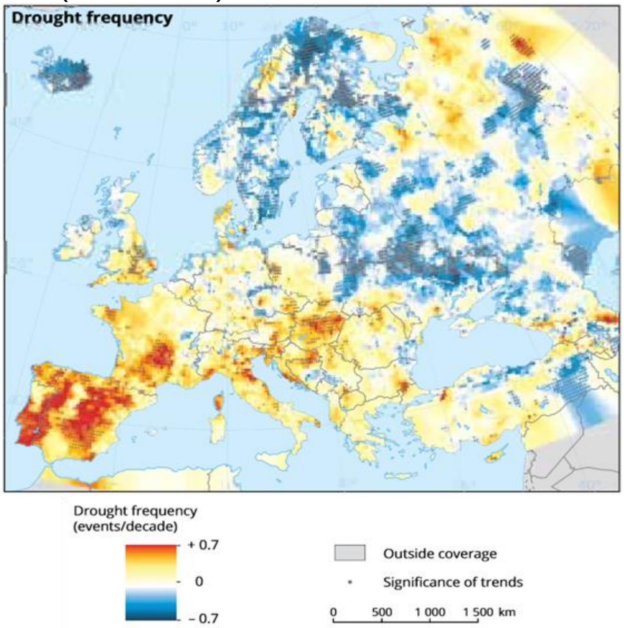
On the other hand, trends in many water-abundant areas have been the opposite: in some of these regions, water has become more abundant and flooding episodes have increased. This situation may lead to increasing needs for dewatering at mining sites.

[146] http://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-exploitation-index-for-river-1

[147] https://www.icmm.com/en-gb/publications/climate-change/adapting-to-a-changing-climate-implications-for-the-mining-and-metals-industry

Figure 37. Trends in drought frequency between 1950 and 2012.

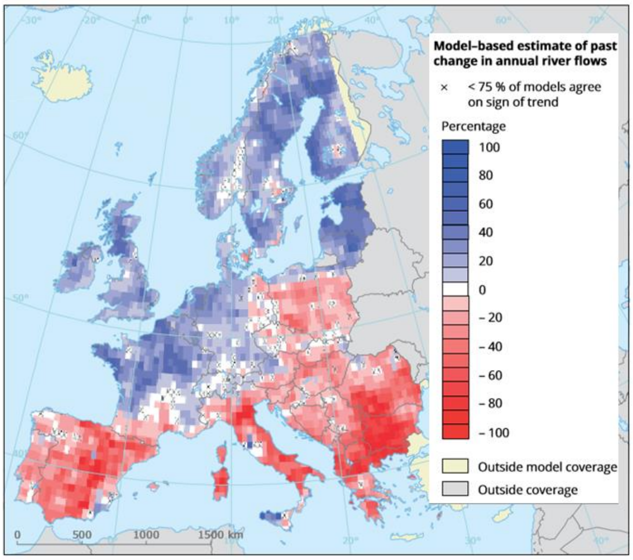
Dots show significant trends (at 5 % level).



Source: Spinoni, Naumann, Vogt et al. (2015) as in EEA (2011).

Figure 38. Average trends in annual river flow between 1963 and 2000.

'x' means grid cell with less agreement among different hydrological models (less than 75 %).



Source: Stahl et al. (2012) as in EEA (2011).

3.6.5 Emissions to water

In addition to aspects related to water volume, discharges from the raw materials industries can affect the quality of water bodies and soils. These industries can release nutrients (e.g. nitrogen, phosphorous), metals and heavy metals into water (ETC-EEA, 2017). Toxic effluents and leakages from waste management or storage facilities may penetrate groundwater resources, which are essential sources of clean water in many European areas. Pit lakes, which may originate from relief alteration caused by extractive activities, can also cause similar impacts (STRADE, 2016). The treatment of e-waste illegally shipped in developing countries is often managed using rudimentary techniques, causing environmental and health-related impacts.

While manufacturing industries are generally 'point' pollution sources, water pollution at mining facilities is generally also 'diffuse'. For instance, acid mine drainage (AMD) from sulphide minerals can have extensive impacts on water and soil quality. AMD, which is one of the main soil and water-related problems of mining activities, occurs when sulphide minerals react with oxygen and water, leading to the formation of sulphuric acid forms, which can dissolve e.g. heavy metals. In addition, chemicals used for processing such as cyanide or nitrogen-compounds, ore elements and tailings sludge can further contaminate water and soils, and even lead to high concentrations of toxic reagents and heavy metals in groundwater when leakages from tailing ponds occur (STRADE, 2016).

In addition, accidents still occur, both in developing and developed countries, and they can be responsible for the biggest impacts on water and soils. Accidents are mostly due to heavy rainfall and seismic activity (however, operation and design mistakes are also responsible for that) (STRADE, 2016).

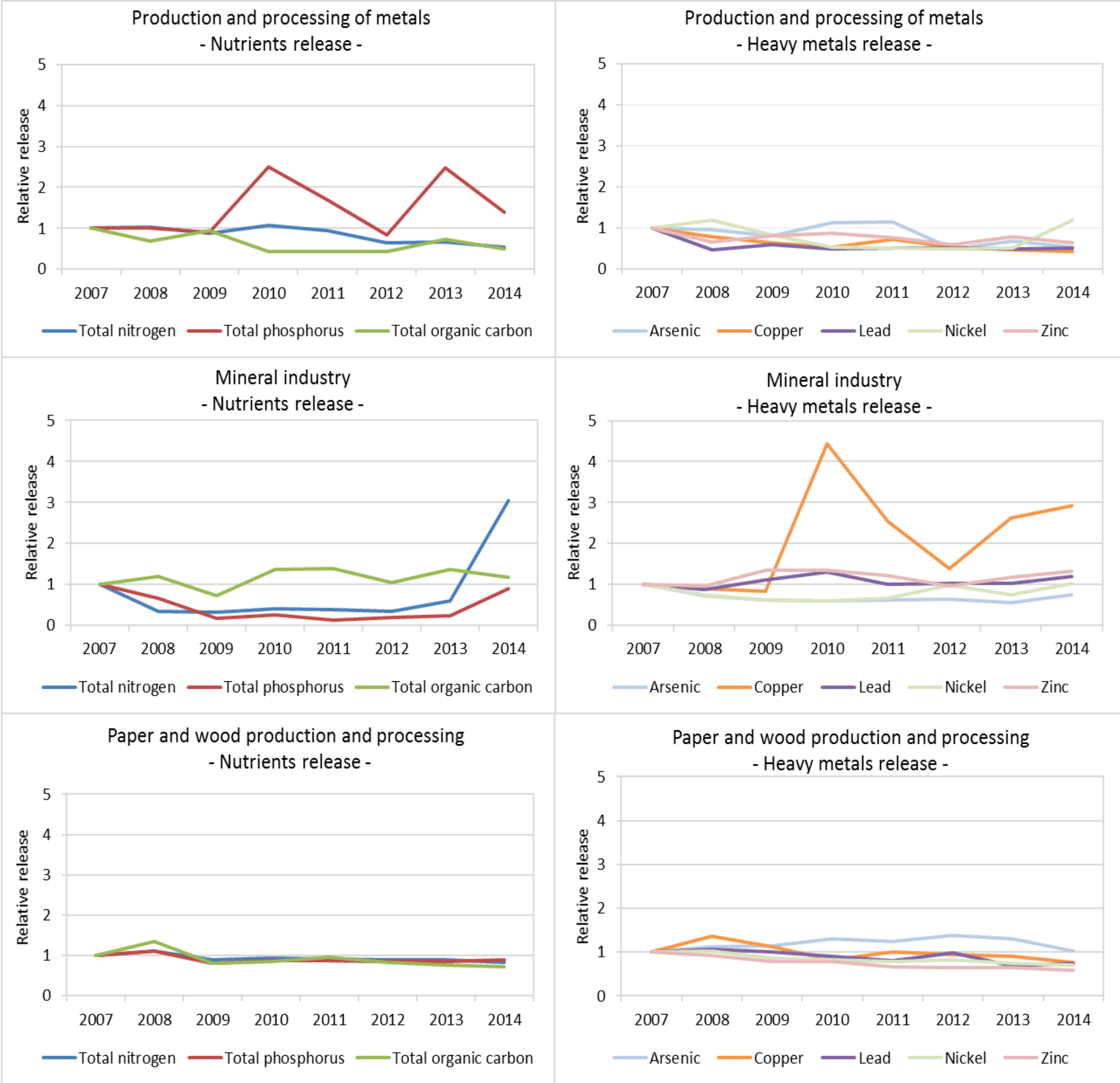
Data on pollutant emissions from major industrial facilities (ETC-EEA, 2017) show that metal production is a major contributor to the release of heavy metals such as lead and nickel, while mining releases significant volumes of heavy metals such as lead, copper and zinc. Most copper and zinc originates from underground mining and related operations. The release of substances is generally concentrated in a small number of facilities, especially for some pollutants in mining facilities. Paper and wood production industries are the second largest industrial contributors to the release of total organic carbon (TOC) to water, plus significant amounts of zinc.

Pollutant releases from the metals industry have decreased overall, except for an increase in nickel (Figure 39), which can originate both from (coal-based) power generation and from metal processes themselves. For the mineral industry, emissions have increased overall (especially for copper in Eastern Europe, from open-cast mining), yet they show very variable trends. Paper and wood production showed very stable trends for nutrient releases, and overall decreasing trends for heavy metals - except for arsenic, which can for example originate from the burning of fossil fuels. This trend took place in the context of generally decreasing trends for lead, zinc, nickel and TOC for the whole set of major industrial facilities (as reported to E-PRTR[148]), and increasing trends for copper.

[148] http://prtr.eea.europa.eu/#/home

Figure 39. Release of pollutants from metal production, the mineral industry, and the paper and wood industry over the period 2007-2014, according to E-PRTR data.

Data refer to values relative to 2007 and cover the eight most reported pollutants in E-PRTR. E-PRTR facilities classified as mineral industry include mining and manufacturing in some cases.



Source: ETC – EEA (2017).

The implementation of industrial and water policies has already led to significant improvements in terms of water reuse and the control of wastewater discharges by industries. Simultaneously, these policies have also led to limitations, for example on some mining activities, since a site cannot be moved to a different location when local water-related issues arise.

In the mining sector, the prevention of water contamination is an important part of mine operation and closure. At many mines, control systems have been implemented, as required by regulation. However, many of the water impacts from mining may occur post-closure. In fact, 'abandoned and historic mining' is one of the water pollution sources listed in the Water Framework Directive inventory of emissions, discharges and losses.

3.6.6 Seabed mining and dredging

Increasing attention is being paid to marine and deep-sea mining. This type of mining refers to the extraction and processing of abiotic resources in the seabed, for instance minerals, metals or aggregates such as limestone or gravel. It also encompasses the extraction of minerals dissolved in seawater.

The exploitation of mineral resources from the ocean is already taking place, and is one of the focus areas of the EU Communication on Blue Growth (EC, 2012). While current activity focuses on shallow water, minerals other than sand and gravel have just started to be exploited and mined from the sea. The Communication states that by 2020, "5 % of the world's minerals, including cobalt, copper and zinc could come from the ocean floors. It may also become economically feasible to extract dissolved minerals, such as boron or lithium, from seawater."

Deep-sea mining, i.e. seabed mining in deep ocean areas, is thus seen as a potential source of minerals to ensure a secure supply for EU industries, since the ocean crust contains mineral-rich deposits and technologies for extraction are rapidly improving. Examples of valuable mineral deposits are cobalt-rich crust, polymetallic manganese nodules and polymetallic massive sulphides (JRC, 2018b).

Numerous organisations within the EU are engaged in seabed mining activities, both as technology providers and as mine operators, yet the sector is still small. The European Commission is considering this practice for areas located under national jurisdiction but also outside it, since most opportunities are in non-EU waters. In this context, the International Seabed Authority[149], which is responsible for monitoring all mineral-related activities, is finalising the adoption of rules that will permit states or organisations to extract minerals in areas outside their national jurisdiction.

The environmental impacts of deep-sea mining are still under study (see ECORYS-GEOMAR, 2014) and subject to debate. Impacts will depend on the typology of the deposit and the extraction techniques put in place. Some of the expected impacts are those associated with pollution by ships onto surface water, and from the dewatering of slurry on board, where the excess water will be returned to the water column at a predetermined depth. To this regard, and following the precautionary principle, the EU Biodiversity Strategy for 2030[150] states that, in international negotiations, "the EU should advocate that marine minerals in the international seabed area cannot be exploited before the effects of deep-sea mining on the marine environment, biodiversity and human activities have been sufficiently researched, the risks are understood and the technologies and operational practices are able to demonstrate no serious harm to the environment". The European Commission is engaged in the development of studies (EC, 2007b) and projects aimed at gaining a deeper understanding of the possible benefits and drawbacks of this deep-sea mining.

Dredging is another practice affecting the quality of water bodies. It is defined as the removal of sediments or contaminated deposits from the bottom of water bodies (lakes, rivers), harbours, etc. In the EU, the main volume of sediments is dredged from coastal areas, most of which are not contaminated. The associated mobilisation of materials, which may include hazardous substances, can have significant impacts on aquatic ecosystems. There are numerous guidance documents to prevent this and other types of impact, such as Dredging Management Practices for the Environment[151].

3.6.7 Water data sources

Although not fully complete, Eurostat collects and harmonises data on water use by the industry[152], based on data reported by Member States, which cover some raw materials sectors. These data has been used for the analysis of water use in the 2018 Raw Materials Scoreboard[153]. More complete data series are available directly from national

[149] https://www.isa.org.jm/
[150] COM/2020/380 final
[151] https://www.iadc-dredging.com/subject/environment/management-practices-environment/
[152] http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_use_in_industry&oldid=196127
[153] See indicator 22 in the 2018 Raw Materials Scoreboard, http://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/ind/22

statistical offices and/or competent bodies. In addition, the European Pollutant Release and Transfer Register (E-PRTR)[154] provides data on pollutant emissions to water from major EU industrial facilities, which also include the raw materials industry. In the case of mining, the International Mine Water Association (IMWA)[155] gathers research from worldwide experts in the field.

Private companies also disclose some water-related data, although reporting schemes and studies are still highly heterogeneous. Examples include disclosures on water withdrawal, consumption and discharges in the Global Reporting Initiative[156] and the CDP water programme[157], both of which also cover raw materials production companies.

Water use in the sector is also approached from a life cycle perspective[158], through water footprinting[159] in line with ISO water footprint guidance[160]. This approach considers not only direct water used onsite, but all water used along the production chain (from extraction to transport and production). Materials associations such as the World Steel Association[161] or European Aluminium[162] have also undertaken life cycle studies, with figures provided on water inputs and outputs.

Finally, the EU major accident reporting system (MARS)[163], established by the EU's Seveso Directive[164], provides data on major accidents, near misses, etc. aggregated by type of economic activity. However, the completeness and sectoral aggregation of the information limits the usability of these data for monitoring the sector.

3.7 Land use by extractives activities

Access to land is essential to raw materials production, especially to establish extractive activities where deposits can be exploited. Fostering the sustainable supply of raw materials from EU sources, including granting access to land, is the aim of the second pillar of the EU Raw Materials Initiative (RMI).

At the same time, the management of the impacts derived from land uptake and land use associated to raw materials production is one of the key environmental challenges of the sector. The sector's land uptake often involves competition with other possible uses of the land. It can also lead to soil loss and degradation, with the subsequent deterioration of soil functions (ecosystems support, agricultural production, water retention, carbon sequestration, etc.).

While both extractive and manufacturing activities can lead to impacts on land and soil, impacts from extractives industries are usually more severe. Extractive industries' impact on land starts with the prospection of mineral occurrences and continues even after mine closure. In fact, impacts on land from abandoned mines can be large. Reclamation activities can partly mitigate these impacts. However, reclamation often does not take place in optimum conditions. Indeed, legacy mines are considered among the main concerns related to the environmental impacts of mining worldwide (STRADE, 2016).

In most European countries the management of mining activities is connected to land use planning, under conditions that largely vary across countries. While in some regions/countries mines are protected or designated as mining areas, other countries' regulations consider only the use of the land for mining when there is a permitting request (Minatura, 2016a).

[154] https://prtr.eea.europa.eu/#/home
[155] https://www.imwa.info/
[156] https://www.globalreporting.org/Pages/default.aspx
[157] https://www.cdp.net/en/water
[158] http://eplca.jrc.ec.europa.eu/?page_id=43
[159] http://www.wulca-waterlca.org/footprinting.html
[160] https://www.iso.org/standard/43263.html
[161] https://www.worldsteel.org/
[162] https://www.european-aluminium.eu/
[163] https://minerva.jrc.ec.europa.eu/en/emars/content
[164] http://ec.europa.eu/environment/seveso

3.7.1 Land uptake

Land uptake by mining starts with the prospection of mineral occurrences, which may require access to a large area of land (sometimes tens of square kilometres) (COM(2000)265). Land uptake continues with the operation of the facility and upon the expansion of the mine. The uptake of new land stops with mine closure. The level of invasiveness of the exploration techniques depends on whether existing roads and infrastructure are used or new ones need to be developed for e.g. exploratory drilling (ICMM, 2011). These activities can create new openings in areas that were not so accessible previously for other uses of the land such as logging or agriculture. Therefore, they can indirectly lead to further occupation of the surrounding land (ICMM, 2011). Invasiveness depends also on the type of deposit. For instance, exploration for metallic minerals and high quality industrial minerals can demand broad areas of land (COM(2000)265).

After exploration, exploitation itself requires a more limited land area, usually measuring a few hectares (COM(2000)265). However, impacts from land uptake are more intense, including clearing of vegetation, building of the site facilities and infrastructure (roads, pipelines and electricity lines), etc. Different mining typologies can have very different land footprints (Spitzley et al., 2008). Large-scale open pit mining can be responsible for most of the destruction of agricultural land and ecosystems while underground mining typically has a relatively small land footprint associated (ICMM, 2011). Open pits tend also to deepen and widen progressively, but can also offer more possibilities for progressive rehabilitation (ICMM, 2011). Similarly to exploration activities, land uptake during exploitation can also indirectly lead to further land uptake by other uses that can benefit from the infrastructure created (ICMM, 2011). This can also include human settlements where new workers may establish.

Once mining finishes, rehabilitation activities, also referred as reclamation, are to be put in place to return the disturbed land to a stable and productive condition (ICMM, 2019) (see chapter 3.7.4 below).

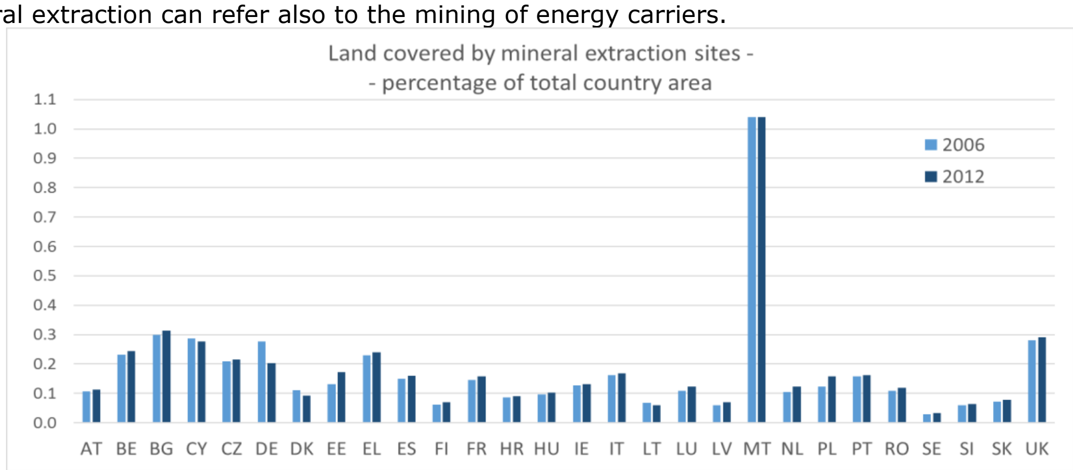
3.7.2 Land competition

Compared to other activities, such as agriculture, mining activities have a relatively small demand for land – 0.15% of total area in 2012 (average for the whole EU, see Figure 40 for a breakdown of the data by country, more). Mining activities can be perceived as positive since it can create income and jobs, and synergies with other manufacturing activities in the region. However, competition for land can also have relevant negative impacts at the local level, compromising the ability of local land to meet other needs (agricultural production, tourism, housing, etc.). This might also lead to problems for the mining activity itself, which may face problems obtaining the Social License to Operate[165].

[165] http://rmis.jrc.ec.europa.eu/?page=social-licence-to-operate-b86e6d

Figure 40. Land covered by mineral extraction sites by EU country.

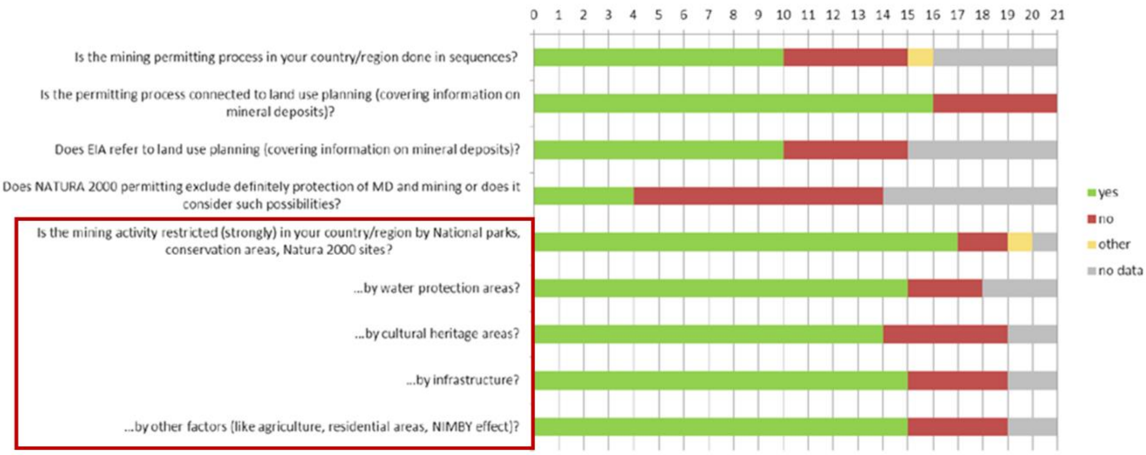
Mineral extraction can refer also to the mining of energy carriers.



Source: JRC elaboration based on European Environment Agency, CORINE land cover[166], 2006 and 2012.

Limitations to mine permitting may be linked to the protection of environmental, social or economic assets: from nature protection to the protection of water resources, cultural heritage and/or infrastructure (Figure 41).

Figure 41. Questions and answers concerning permitting.



Source: Minatura (2016a).

Three typical land uses that can compete for land with extractive activities are nature protection areas, agricultural land and human settlements. Among these three, the existence of nature conservation areas is the main factor restricting mining activity (Minatura, 2016a). Nature protected areas in the EU include the Natural 2000 network[167] and the Nationally Designated Areas[168]. Possible restrictions to the development of extractive activities in these areas depend on the level of protection, where permits can be still granted under specific conditions.

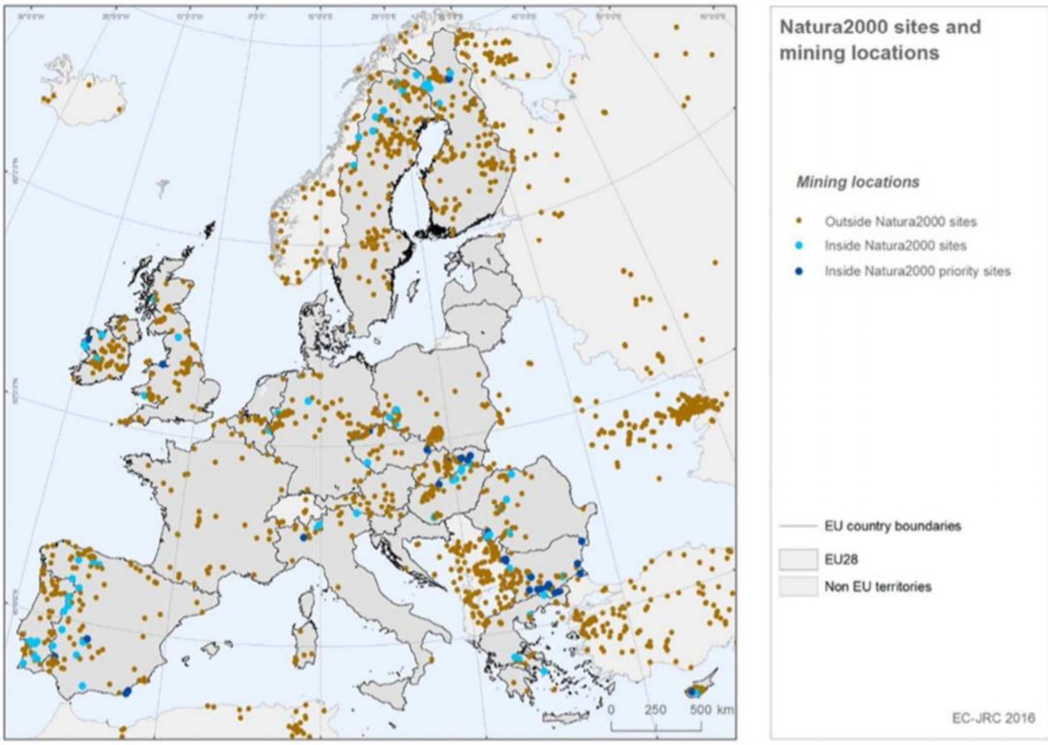
Currently, many mining sites are located within a Natura 2000 site (around 10% according to 2016 data) and almost 72% of are in close proximity (within a 5 km radius) of these protected areas. These data refers to both producing mines and not operational mines. This situation highlights the fact that often extraction is compatible with conservation on the one hand. On the other hand, it highlights that production in many areas shall undergo the limitations established by nature conservation objectives.

[166] https://land.copernicus.eu/pan-european/corine-land-cover
[167] http://ec.europa.eu/environment/nature/natura2000/index_en.htm
[168] https://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-15

Obtaining a mining permit within NATURA 2000, although not impossible, usually involves restrictions and a complicated procedure (Minatura, 2016a). Moreover, almost 30% of the mining sites located within Natura 2000 fall within the boundaries of a protected area classified as "priority site', which implies that regulation and criteria applied for permitting human activities are more stringent (according to the Habitats directive[169] and the Birds directive[170]).

In addition, around 70% of mining locations (again based on 2016 data) are in close proximity (within a 5 km radius) of these natural protected areas, which might limit the expansion of the mine. Indeed, a relevant share of mineral deposits are located within a Natura 2000 site (Figure 42). This situation was highlighted as a possible influence to raw materials' supply risk in the study to support the 2017 list of critical raw materials (EC, 2017b). However, the biggest share of sites falling into Natura 2000 areas are actually not operating anymore (abandoned or exhausted).

Figure 42. Location of mining sites (total) with respect to Natura 2000.



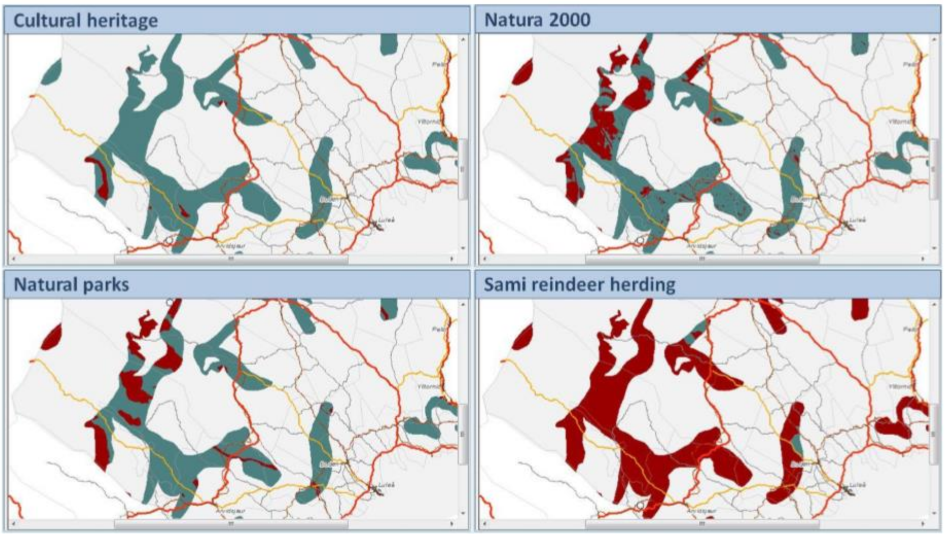
Source: EC (2017b). The figure is based on SNL Metals & Mining (mining sites, 2016) and European Environment Agency (Natura 2000 network). Data include both active mines and mining sites currently not operational.

On an EU scale, the Minatura project[171] has analysed the location of the main mineral deposits and its possible competition with other current land uses and future demands for land (Figure 43). Considering also forecasts of materials demands, the project has identified a set of potential protected areas that suit a set of selected safeguarding criteria (Minatura, 2016b) in selected case study countries. The European Commission has also edited guidelines on extraction to provide clarity on how to reconcile extractive activities in or near Natura 2000 are also available (EC, 2011).

[169] Council Directive 92/43/EEC
[170] Amended in 2009, it became the Directive 2009/147/EC
[171] https://minatura2020.eu/

Figure 43. Example of mineral resource constraints for the Norrbotten area (Sweden).

In red, areas of land use competition between mineral deposits and other restricting land uses.



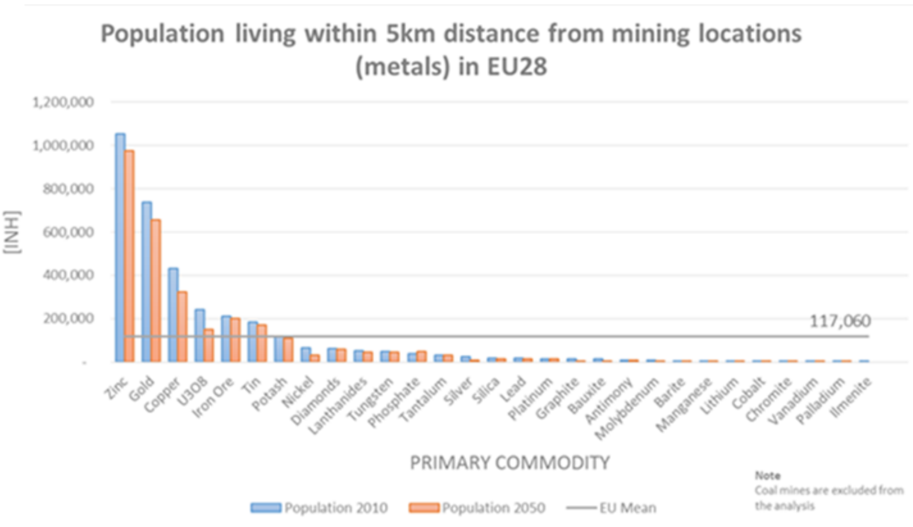
Source: Minatura (2016c).

Beyond protected areas within the EU, the study by Murguia et al. (2016) considers all ecosystems worldwide and shows that mines and deposits are not randomly located but concentrated in intermediate and high (plant) diversity zones).

Regarding competition for land in the vicinities of urban settlements (Figure 44) and agricultural land, specific regulations, usually at regional and/or local level, may restrict the development of extractive activities. In such cases, in addition to the possible legal restrictions, uses such as agriculture or urbanization might be more profitable or sufficiently profitable while socially more accepted than extractive activities. However, mining activities can be also perceived as positive, especially in areas with limited income sources – a mine creates jobs and therefore attracts people –, or in areas where mining can establish synergies with other manufacturing activities in the region.

Figure 44. Population density in proximity to metals mining locations in EU-28, for the years 2010 and 2050.

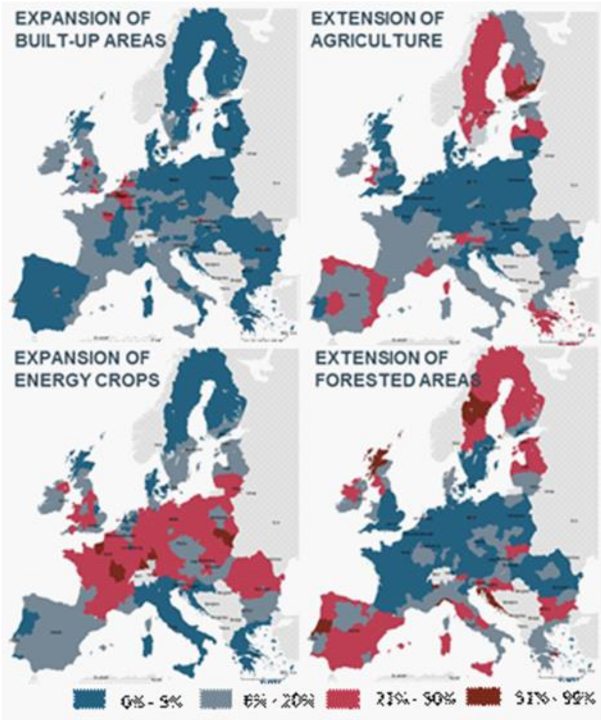
The units are number of inhabitants living within a 5km radius from the mines.



Source: EC (2017b). Data comes from on SNL Metals & Mining (mining locations, 2015) and LUISA platform simulations - EU Reference Scenario (population density maps) – partially based on Baranzelli et al. (2014).

In the future, both urban and agricultural areas are expected to expand in the coming years in the EU. This is also the case of other uses, such as energy crops and forest areas (Figure 45).

Figure 45. Estimated expansion of land uses potentially competing with extractive activities. Data refers to percentage increase as compared to the baseline.



Source: EC (2017b). Data simulations of the LUISA platform (Baranzelli et al., 2014).

3.7.3 Impacts on soil loss

Soils provide essential support to ecological and human systems, and have been under pressure due to the intensification and expansion of human activities. In fact, the majority of the world's soils are in fair, poor, or very poor conditions (FAO, 2015).

Extractive activities can lead to soil loss, to mechanical degradation due to e.g. compaction, and to soil contamination, with the subsequent temporary or permanent damage to soil functions. In addition, modifications of the land spatial pattern can also have relevant impacts on the connectivity of ecosystems, which is often key to safeguard nature. While soil contamination can be improved with remediation measures, damages such as soil compaction are nearly irreversible (Bide et al., 2019). The type of mining and processing practices, and the features of the soils, will determine the extent to which soil can be impacted by mining activities.

Impacts on soils can be much more critical and difficult to quantify in the case of accidents such as tailing dam failures, which still occur under certain circumstances. Tailings dam failures are among the events with higher environmental impacts (STRADE, 2016). Indeed, after the tailings dam failures in Aznalcóllar (Spain) and Baia Mare (Romania) in 1998 and 2000, mining’s environmental impact gained attention in EU environmental policy and resulted in the Mining Waste Directive regulating new mines in 2006 (STRADE, 2016) and linked to that, the update of the BAT Reference Document for the Management of Waste from Extractive Industries (EC, 2018a).

The European thematic strategy for soil protection[172] identifies as main threats to soils in the EU some of the pressures coming from the extractive sector (e.g. erosion, compaction and sealing). The proposal for a Soil Framework Directive[173] from the European Commission aimed to establish a common, harmonised approach for the protection and sustainable use of soils in Europe. However, the proposal was pending for several years and ultimately withdrawn.

Individual EU countries have national legislations about soil conservation, but the majority of EU countries are just starting to introduce basic regulations on the topic (Bide et al., 2019). Several national approaches establish indicators and threshold values for pollutant concentration, depending on the use of the land. Other countries establish values for point pollution (Bide et al., 2019).

3.7.3.1 ***Soil loss and mechanical degradation***

Mining practices lead to soil loss and mechanical degradation due to sealing and compaction, which generally are irreversible. Soils can be directly removed, which causes soil loss by deforestation: surface mining removes vegetation and soil on the surface, and underground mining involves digging and tunnelling to reach deep mineral deposits (Bide et al., 2019). The establishment of infrastructure causes soil sealing. Further, the use of heavy machinery causes soil compaction, as well as the leave of pits and heaps of waste material from underground and surface mining. The loss of macro porosity and pore continuity reduces the ability of the soil to conduct water and air, and subsequently, reduces soil fertility (Bide et al., 2019).

In addition, erosion by wind and water can be accentuated by mining activities that can reduce soil particle size such as crushing and milling (STRADE, 2016).

3.7.3.2 ***Soil contamination***

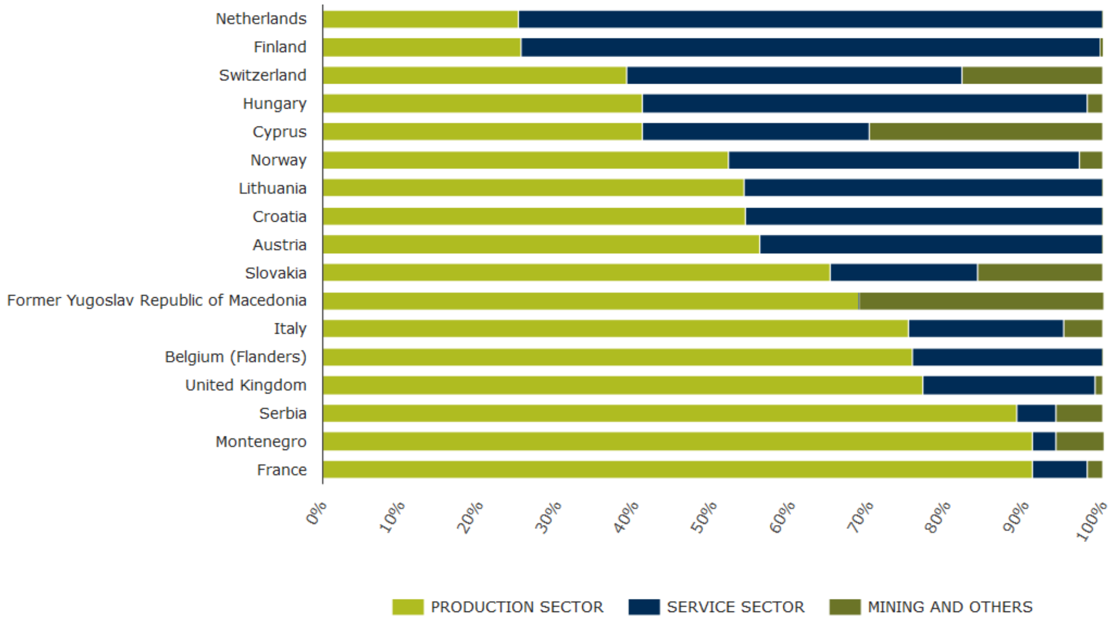
During mining and processing, pollutants coming from the deposit mined itself as well as from the chemicals used for the extraction and onsite processing are emitted and can be leached to soils. Spills, and leaks of hazardous materials, and deposition of contaminated dust can lead to soil contamination (Bide et al., 2019). Pollutants can include heavy metals, saline chemicals, etc., which can degrade the quality of the soil. The use of different mining techniques and chemicals (e.g. cyanides) can have differential impacts on soil quality (STRADE, 2016). Pollutants may also originate from fuel combustion and from specific industrial process, for instance metal smelting or casting. The presence of heavy metals in soils is a matter of particular concern because of their toxicity to humans and their persistence in the environment (Bide et al., 2019).

Acid mine drainage (AMD) can have extensive impacts on soil and water. AMD occurs when sulphide minerals react with oxygen and water, leading to the formation of sulphuric acid forms, which can dissolve e.g. heavy metals. In addition, chemicals used for processing such as cyanide or nitrogen-compounds, ore elements and tailings sludge can further contaminate soils and water (STRADE, 2016). The joint action of erosion, chemical leaks and AMD can have even more devastating effects (STRADE, 2016).

Mining and mineral processing operations are often the most serious local sources of soil contamination by metals and metalloids. Together with metal industries, mining is frequently reported to be an important source of contamination, particularly in some countries (EC, 2014; EC, 2018d) (Figure 46). In addition, soil contamination frequently leads to contamination of associated water associated water bodies, since pollutants can percolate into groundwater or reach surface water bodies (EC, 2018d).

[172] COM/2006/0231 final
[173] https://ec.europa.eu/environment/soil/three_en.htm

Figure 46. Breakdown of sectors responsible for soil contamination by EU country.

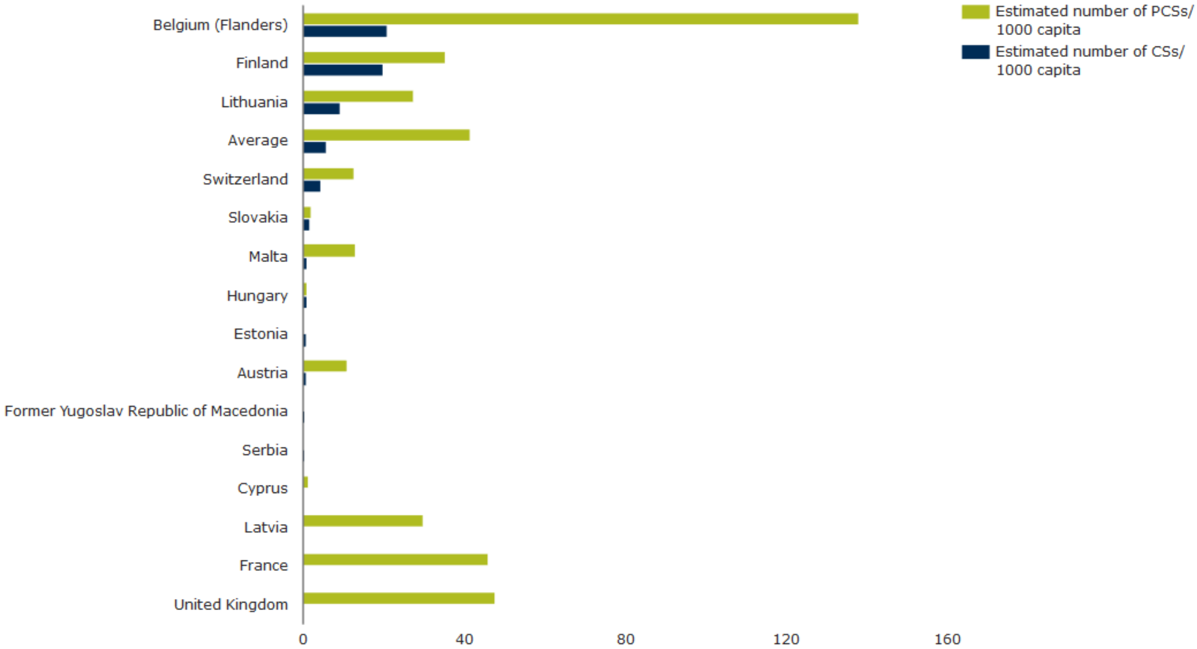


Source: European Environment Agency[174], based on data from Eionet NRC Soil data collection on contaminated sites provided by the JRC.

Nowadays, there is a high number of sites that are classified as contaminated or potentially contaminated (Figure 47). EC (2018d) provides a comprehensive overview of the status of identification and characterization of contaminated sites across the EU – they highlight that in some countries, a mapping of these sites is still lacking. The study provides data on the progress toward remediation of contaminates sites and the EU and national (sometimes sub-national) policy and regulation framework related to that. This includes also considerations on how to deal with historic contamination and 'orphan' sites, i.e. those sites where the polluter-pays principle cannot be applied since the polluter either has gone or is not financially able to support the intervention cost. The study states that criteria for addressing historical contamination vary across countries (and even within the same country) and are often laxer than criteria for new polluting activities.

[174] https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/assessment

Figure 47. Contaminated sites and potentially contaminated sites by EU country.



Source: European Environment Agency[175], based on data from Eionet NRC Soil data collection on contaminated sites provided by the JRC, and EUROSTAT Population on 1 January - Persons[176].

3.7.3.3 ***Soil contamination from extractive waste***

Diffuse emissions to soil and groundwater usually derive from extractive waste management activities, which includes waste generated from mineral excavation, mineral treatment and waste preparation for re-use and recycling EC (2018a). The rate of diffuse emissions depends on the waste characteristics, the water head, the basal structure, being the construction quality control and quality assurance systems essential EC (2018a). The BAT Reference Document for the Management of Waste from Extractive Industries provides indications about the main environmental concerns linked to extractive waste management (main pollutants, dangerous pollutants). It describes processes for a better handling of the waste along their processing stages. It provides also considerations for normal operation conditions, indications to improve the safety of the facility, and on how to operate in emergency conditions.

There is a substantial gap in consistent information on European level on 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 (Bide et al., 2019).

3.7.4 Mine closure and land rehabilitation

Impacts on land can be extensive after the closure of an extractive activity. Therefore, once the mining activity is ceased, mining companies are responsible for land rehabilitation (also called reclamation), i.e. the return of disturbed land to a stable and productive condition (ICMM[177]).

The level of rehabilitation that is possible varies from site to site. Returning the land to the pre-mining land use is not always possible, due to alterations of the socioeconomic

[175] https://www.eea.europa.eu/data-and-maps/indicators/progress-in-management-of-contaminated-sites-3/assessment

[176] http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&language=en&pcode=tps00001&tableSelection=1&footnotes=yes&labeling=labels&plugin=1

[177] https://www.icmm.com/en-gb/environment/mine-closure, consulted 2019.

context and the landscape, but should be evaluated. A wide variety of alternative uses for mined lands is available: post-closure landscapes adapted for forestry, agriculture, wildlife conservation or recreational areas.

In any case, there should be a clear plan for transitioning from operational to closure and decommissioning and, ultimately, post-closure (ICMM[178]). For some mines, this phase may last longer than its operational life. Closure activities can be carried out also during the operation of the activity, which is known as *progressive closure*. Indeed, optimally, the planning of mine reclamation should occur before the mining permit is granted.

Closure works should include engineering works (see Table 4), administrative works (e.g. transferring assets, demobilising the labour force, relinquishing agreements with governments and/or NGOs). It should also include due diligence monitoring and reporting on the post-decommissioning status of environmental and social aspects of the site (ICMM[179]).

Table 4. Some of the most common progressive closure works.

Closure works
• Soil management (e.g. stripping, stockpiling, and placement). • Strategic placement of uneconomic materials • Diversion of unimpacted waters • Revegetation • Stabilisation works • Cover placement • Demolition of unneeded infrastructure • Improvements to water management infrastructure • In-pit dumping of waste rock material • Capping or encapsulation of tailings waste rock material

Source: Adapted from ICMM (2019), Integrated Mine Closure - Good Practice Guide.

Ecological restoration and mine reclamation have become important parts of the sustainable development strategy in many countries. The International Council on Mining & Metals (ICMM)[180] has elaborated a good practice guide for Integrated Mine Closure (ICMM, 2019), which provides guidance on integrated closure planning, and includes successful examples and tools. Several national mining closure plans and recommended guidelines exits such as the Finish Mine Closure Handbook (Vammalan Kirjapaino Oy, 2008) and Swedish Guidelines. Several European countries have monitoring programmes on national level (Bide et al., 2019).

3.7.5 Legacy mines

So far, modernization of information technologies has made it possible to set up more efficient systems of environmental monitoring, and real-time monitoring. However, +abandoned mines and mines whose activity is based on old operations, which may not have worked according to modern environmental standards and which may lack environmental management plans, constitute the highest environmental risks of mining (Bide et al., 2019).

[178] https://www.icmm.com/en-gb/environment/mine-closure, consulted 2019.
[179] Ibid.
[180] https://www.icmm.com/

Europe has a huge legacy of abandoned mines; some abandoned mine sites and tailings ponds can still be found even close to residential areas (STRADE, 2016). This legacy was already highlighted by the COM(2000)265, which highlighted the existence of a legacy of abandoned mine sites and unrestored quarries in the EU, result of *unsatisfactory environmental performance of the industry in the past*, which impact *the landscape and can pose severe environmental threats due especially to acid mine drainage.*

Outside the EU, although current discussions on raw materials governance focus on active mines, environmental challenges from lack of remediation and legacy mine sites seem to be massive in many countries (e.g. in South Africa, Chile, Peru and Sub-Saharan countries) (STRADE, 2018)). This refers to both Artisanal and small-scale (ASM)[181] and to large-scale sites, with the exception of some mines from which secondary materials are recovered from old tailings (STRADE, 2018)). Sites under ASM practices, responsible for 15-20% of global mineral and metal production, are generally characterized by poor environmental management and very limited or absent reclamation or soil remediation, and impacts on land are more scattered in the territory than for regular mining.

3.7.6 Land use planning

A proper land use planning, from the start of the project until its closure, can help to mitigate environmental pressures on the land, and also reduce risks of negative impacts on soils, water, nature, climate, etc. (ICMM, 2011). This may also improve the relationship with the local communities. Table 5 suggests approaches to an improved land use planning for the different stages of mining.

Table 5. Approaches to reduce mining environmental impacts on the land.

Stage	Approach to reduce impacts on the land
Exploration	The use of technologies in exploration such as remote sensing or satellite imagery can reduce the need for invasive exploratory techniques; planning exploration around existing infrastructure can reduce the impact of roads on the forest
Activity (set up and expansion)	Environmental management systems and careful decision-making on infrastructure placement and mining area design.
Closure	As a mining operation approaches the end of its life, there should be a clear plan for transitioning from operational to closure and decommissioning and, ultimately, post-closure. This should optimally include: •Engineering works to decommission and dismantle infrastructure, complete rehabilitation, grade landforms for effective drainage, cap and cover tailings facilities, implement post-closure monitoring networks •Administrative works relating to transferring assets, demobilising the labour force, relinquishing agreements, and other government and NGO agreements •Due diligence monitoring and reporting on the post-decommissioning status of environmental and social aspects of the site.

Source: JRC elaboration based on ICMM (2011), and ICMM (2019).

[181] http://rmis.jrc.ec.europa.eu/?page=artisanal-and-small-scale-mining-a6f8a3

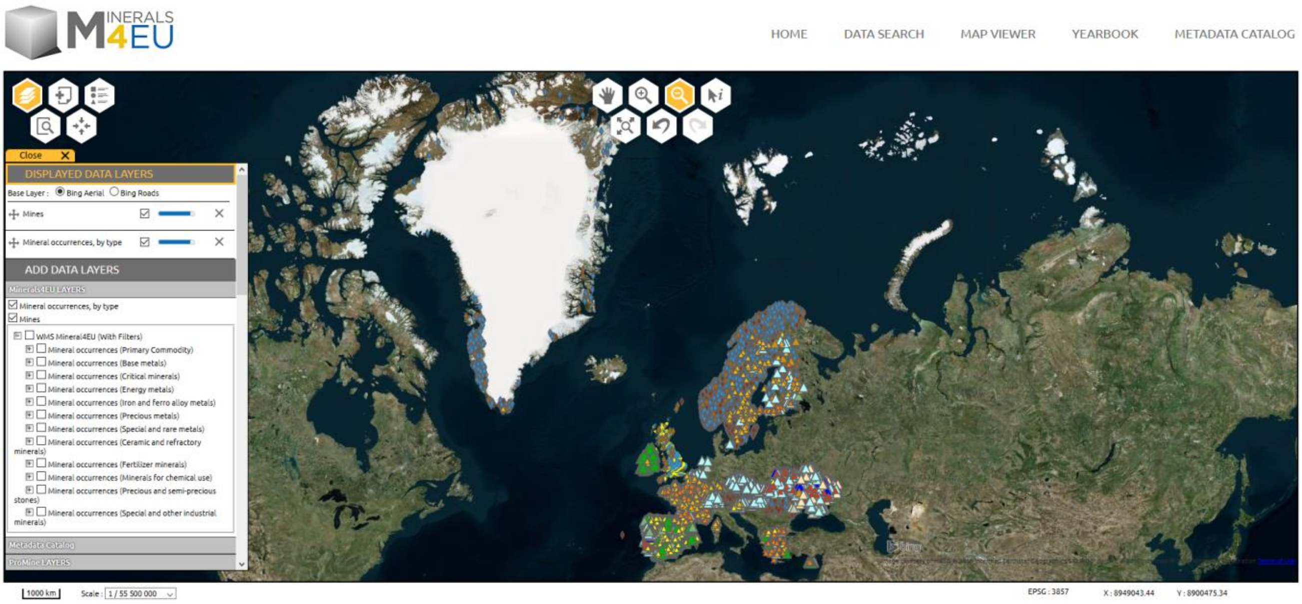
The European Commission (DG GROWTH) provides also guidance on best practices in the area of land use planning and administrative conditions for exploration and extraction (EC, 2010). This document gives an overview on regulatory framework for mining and explains specific case studies where e.g. land competition issues have arisen.

3.7.7 Data sources

3.7.7.1 *Mineral extraction sites*

Spatial data on the location of mining activities and mineral deposits is available from different sources. The Geological Surveys of Europe (EuroGeoSurveys[182]), within the Minerals4EU[183] project, compiled this type of data in a systematic way and provides a map viewer[184] where mines and mineral occurrences, among other information types, are displayed (see Figure 48). This map viewer provides also the location of mineral occurrences, which can be filtered by categories such as base metals, precious metals, critical metals, etc. Although the project attempted to build a comprehensive database of mineral extraction sites across Europe, significant data gaps exist for some countries.

Figure 48. Mines in the EU.



Source: Map viewer of the Minerals4EU project[185].

In addition, the viewer for the results of the Mintell4EU project[186], within the GeoERA action[187], also displays spatial data on mineral occurrences and mines. It also displayed background geological maps. Moreover, this portal allows the user to import the spatial data (both vector and raster layers).

At national level, many geological surveys collect and make publically available data for active mineral extraction. Table 6 gives an overview of geological survey data portals with information on the locations of mining and quarrying. However, these datasets are not harmonised across EU countries. These sources often do not capture small quarries, since they may be subject to different planning laws. For instance, publically available

[182] http://www.eurogeosurveys.org/
[183] http://www.minerals4eu.eu/
[184] http://minerals4eu.brgm-rec.fr/minerals4EU/
[185] http://minerals4eu.brgm-rec.fr/minerals4EU/
[186] https://data.geus.dk/egdi/?mapname=egdi_geoera_mintell4eu#baslay=baseMapGEUS&optlay=&extent=526650,1294900,6780610,4363970&layers=egdi_mines
[187] https://geoera.eu/

data in Finland only includes large mines, while small mineral operations are not registered (Bide et al., 2019)).

Table 6. European geological surveys with data portals containing information on the location of mines and quarries.

Country	Geological map portal
Croatia	http://www.hgi-cgs.hr/images/geoloska-karta-republike-hrvatske-1-300.jpg
Czech Republic	http://www.geology.cz/extranet-eng/maps/online
Denmark	https://eng.geus.dk/products-services-facilities/data-and-maps/maps-of-denmark/
Finland	https://www.gtk.fi/en/services/data-sets-and-online-services-geo-fi/map-services/
France	http://infoterre.brgm.fr/
Germany	https://geoviewer.bgr.de/
Ireland	https://www.gsi.ie/Mapping.htm
Norway	https://www.ngu.no/en/topic/map-viewers
Poland	http://geologia.pgi.gov.pl/arcgis/apps/MapSeries/index.html?appid=8d14826a895641e2be10385ef3005b3c
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

Source: updated from Bide et al. (2019).

At the global level, SNL Metals & Mining[188] provides, under licence, data on the location of mining activities and their production capacity, classified by main commodity and by mining stage. There are some initiatives, e.g. Cadaster Map Portals[189]**,** which provide detailed cadaster data for some non-EU countries.

3.7.7.2 ***Land cover and land use***

CORINE land cover[190] provides maps of a mixture of land use and land cover data, derived from the Copernicus network[191] of earth observation satellites and in-situ sensors. It includes a category for mineral extraction sites as one of the 44 classes that the dataset covers. However, this land class does not distinguish between the mining of different commodities. CORINE land cover is regularly updated, with data for 1990, 2000,

[188] https://www.snl.com/marketing/microsite/MEG/mm_pagetwo.html
[189] https://landadmin.trimble.com/cadastre-portals/
[190] https://land.copernicus.eu/pan-european/corine-land-cover
[191] https://www.copernicus.eu/en

2006, and 2012, and 2018 (expected at the end of 2019). Land cover/use changes between 2006 and 2012 are available here[192], and changes between 2012 and 2018 here[193].

Information on land cover/use from mining activities other than that coming from remote sensing is usually available at a local/regional planning level, yet harmonization of this data at EU level lacks.

The Land Use and Coverage Area frame Survey (LUCAS)[194] gives an EU wide breakdown of changes in patterns of land use. This survey is based on topsoil sampling on the ground, with points spaced 2 km apart covering the whole of the EU's territory (1.1 million different points), followed by statistical calculations that interpret observations in the field to derive full coverage land use data. LUCAS includes mining and quarrying as one of the land use/cover categories. However, LUCAS is more meant to monitor the effect of land management of soil characteristics (see chapter below on data on soils) than land use as such.

Other land cover data sources with a global coverage, such as the Copernicus Global Land Service[195]**,** do not distinguish mineral extraction sites as a land use/cover category.

3.7.7.3 *Soils and contaminates sites*

The European Soil Data Centre (ESDAC)[196] is the thematic centre for soil related data in Europe. It provides comprehensive data, maps and atlas on soil types, and soil properties and functions. It also publishes data on the vulnerability of soils to main threats such as compaction, contamination and sealing. It also provides point data[197] coming from e.g. the topsoil LUCAS survey (see description below). The ESDAC Map Viewer[198] allows to navigate many of these key soil data.

A dedicated section provides information about concentration of copper on top soils[199]. In addition, the sections on regional data and global data, links to soil datasets that can potentially be accessed and/or downloaded.

Hosted also within ESDAC[200], the LUCAS[201] samples topsoil properties across the EU with points spaced 2 km apart covering the whole of the EU's territory (1.1 million different points). It is meant to monitor soil properties and how they are affected by different drivers such as management practices. LUCAS results are hosted by Eurostat[202]. In addition, the European Environment Agency (EEA) hosts a LUCAS data viewer[203], showing also ground-level pictures. The LUCAS 2015 soil survey targeted physicochemical properties, including pH, organic carbon, nutrient concentrations and cation exchange capacity.

Within the section on soil contamination, the ESDAC publishes data related to the indicator for monitoring the progress in management of contaminated sites. Data cover contaminated sites and progress towards their remediation. This indicator is within the dataset used by the EEA to monitor the state of the environment in the EU, and it is based on official soil data provided by EU countries (and beyond) from the European Environment Information and Observation Network[204]. An important share of

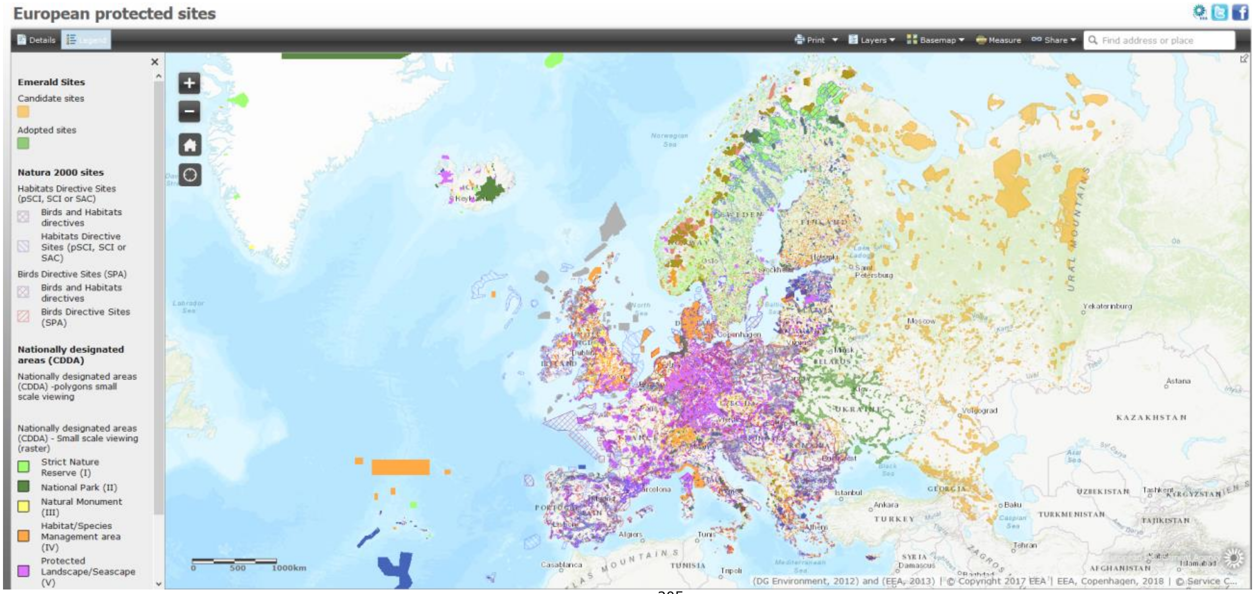
[192] https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2006-2012/view
[193] https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018
[194] https://ec.europa.eu/eurostat/statistics-explained/index.php/LUCAS_-_Land_use_and_land_cover_survey
[195] https://land.copernicus.eu/global/products/lc
[196] https://esdac.jrc.ec.europa.eu/
[197] https://esdac.jrc.ec.europa.eu/resource-type/soil-point-data
[198] https://esdac.jrc.ec.europa.eu/content/esdac-map-viewer
[199] https://esdac.jrc.ec.europa.eu/themes/copper-topsoils
[200] https://esdac.jrc.ec.europa.eu/
[201] https://esdac.jrc.ec.europa.eu/projects/lucas
[202] https://ec.europa.eu/eurostat/web/lucas
[203] https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/lucas-viewer-with-ground-level-pictures
[204] https://www.eionet.europa.eu/

contaminated sites are indeed mining sites, especially for some countries. The dataset shows some issues related to the heterogeneous interpretation of the concept 'contaminated site' across countries, and large uncertainties in terms of methodologies and data. There is a gap in industry specific data or data related to ground conditions, which hampers the possibility to work out causes of any contamination and soil degradation (Bide et al., 2019).

3.7.7.4 *Nature protection areas and biodiversity*

The EEA collects and displays through an online web mapping service data on European protected areas (Figure 49), covering Natura 2000 and nationally designated areas.

Figure 49. EEA interactive map on European protected areas.



Source: EEA[205].

At global level, the World Database on Protected Areas (WDPA)[206] is the most comprehensive global database on protected areas. It is a joint project between the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN). Protected Planet[207] is the online interface for the WDPA, which is also fed by text descriptions from Wikipedia[208].

[205] https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/european-protected-areas-1
[206] https://www.iucn.org/theme/protected-areas/our-work/world-database-protected-areas
[207] http://protectedplanet.net/
[208] https://www.wikipedia.org/

4 Other sections with environmental content

4.1 Raw Materials Scoreboard & monitoring

This RMIS section presents the information contained in the different editions of the European Commission´s Raw Materials Scoreboard, which is the tool to monitor the main challenges to a secure and sustainable supply of raw materials to the EU industries. The section provides also an overview of other monitoring schemes that relate to environmental considerations of the EU raw materials sector (Figure 50):

Figure 50. Location and structure of the ´Raw Materials Scoreboard & monitoring´ section within the RMIS.

Source: Adapted from the RMIS web page.

4.1.1 The Raw Materials Scoreboard

The Raw Materials Scoreboard (henceforth ´Scoreboard´) is an initiative of the European Innovation Partnership (EIP) on Raw Materials, included within its Monitoring and Evaluation Scheme[209]. It is meant to assess the progress towards the EIP on Raw Materials' objectives, which overall aim to contribute to the 2020 objectives of the EU's Industrial Policy and the objectives of the flagship initiatives 'Innovation Union' and 'Resource Efficient Europe', by ensuring the sustainable supply of raw materials to the European economy whilst increasing benefits for society as a whole.

This bi-annual publication is prepared in collaboration between DG Internal Market, Industry, Entrepreneurship and SMEs and the Commission's Joint Research Centre, in close interaction with an ad-hoc working group (AHWG) of public and private stakeholders and policy makers (around 30 experts representing a balanced range of interests).

The Scoreboard presents the best available data and indicators on the main challenges of raw materials production in the EU, with thematic clusters of indicators covering environmental (and social) sustainability considerations, as well as a cluster with data to monitor progresses towards a circular economy in the EU. The document covers also other topics: raw materials in the global context, competitiveness and innovation and framework conditions for mining.

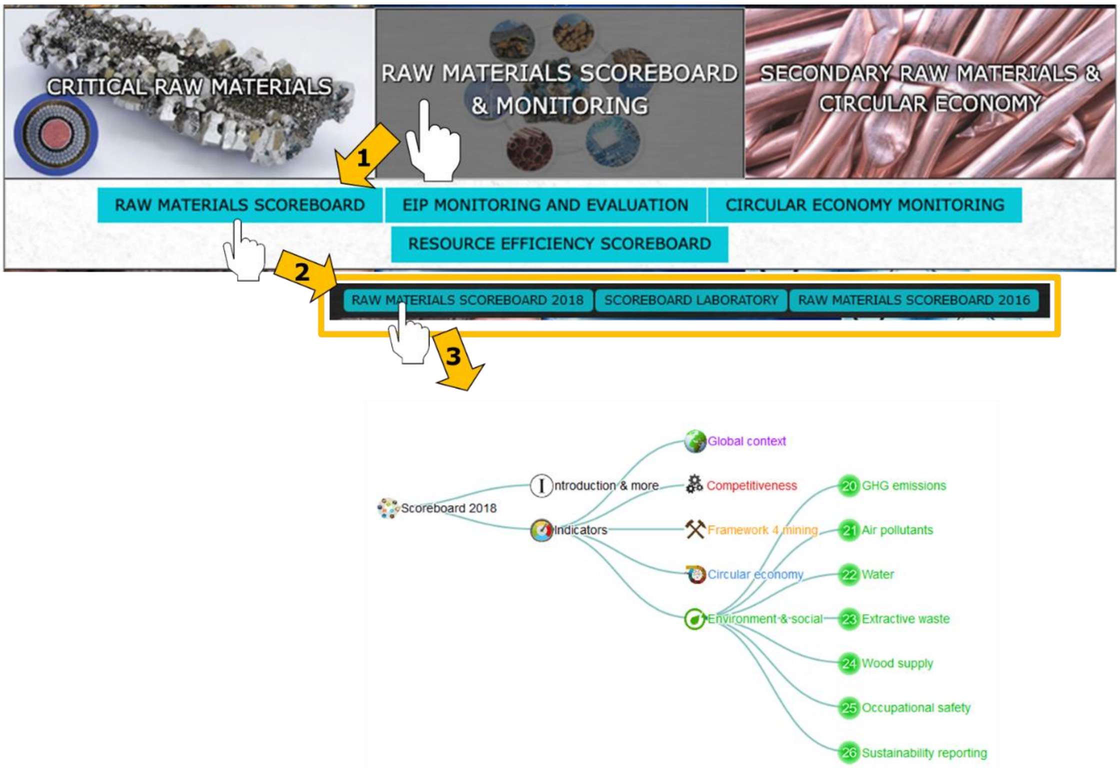
This RMIS sub-section presents the content of the 2016 and 2018 editions of the Raw Materials Scoreboard (see step 2 in Figure 51), implemented in separated online applications. It will also incorporate the 2020 edition of the document upon its release. In this sub-section, summarized versions of the content of each indicator are provided and links are given to access the complete version of all remaining information (full text of indicators, methodological notes, etc.).

In addition, this RMIS sub-section on the Scoreboard includes the so-called ´Scoreboard laboratory´. It consists of a collection of 1) background assessments, where alternative data options of indicators presented in the official version were evaluated for their

[209] Specifically used as an input for the development of its Strategic Evaluation Report.

possible inclusion in the Scoreboard; and 2) additional indicators, i.e. indicators that were considered for possible use but which were set aside mostly due to the present limitations of the data. The first sub-section includes additional data assessments for most environmental indicators: GHG emissions, air pollutants, extractive waste, water and sustainable wood supply.

Figure 51. Structure of the Raw Materials Scoreboard sub-section in the RMIS and entry point to the online application for the 2018 edition.



Source: Adapted from the RMIS web page.

4.1.2 Other monitoring schemes

The sub-section on other monitoring schemes covers the Circular Economy Monitoring Framework and the Resource Efficiency Scoreboard, which include relevant environmental information, partly related to the performance of the raw materials sector.

The Circular Economy Monitoring Framework[210] draws upon and complements the existing Resources Efficiency Scoreboard (see below) and Raw Materials Scoreboard, which were developed in recent years by the European Commission. The Circular Economy Monitoring Framework was put in place in 2018 as a commitment from the Circular Economy Action Plan (2015)[211]. This dedicated RMIS sub-section gives an overview of this framework and the indicators that are more relevant to raw materials production and consumption such as materials flows in the economy, materials´ recycling rates and trade of waste and scrap. These indicators are also relevant to the environmental performance of the raw materials sector. While the figures presented in this RMIS sub-section refer to the official documents COM(2018)29[212] and SWD/2018/017[213], the underlying datasets can be found at the Eurostat dedicated website[214].

[210] COM(2018)29 and its accompanying document SWD/2018/017, RMIS dedicated page at https://rmis.jrc.ec.europa.eu/?page=circular-economy-monitoring
[211] COM/2015/0614 final
[212] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A29%3AFIN

The Resource Efficiency Scoreboard[215], developed by DG Environment[216] and hosted by Eurostat in a dedicated website[217], provides a framework to monitor progress towards increased resource efficiency in Europe, with a view to decreasing pressures on our natural capital and shifting towards a circular economy. The underlying datasets, published by Eurostat since December 2013, present data from 2000. Indicators are categorised into three groups – 'lead', 'dashboard' and 'thematic' indicators: 1) the lead indicator is resource productivity; 2) dashboard indicators are arranged as materials (e.g. domestic material consumption), land (e.g. productivity of artificial land), water (e.g. water productivity) and carbon-related (e.g. share of renewable energy) indicators; and thematic indicators include sections on 'transforming the economy' (e.g. rate of wasted recycled and eco-innovation index), 'nature and ecosystems' (e.g. area under organic farming) and 'key areas' (e.g. pollutant emissions from transport).

4.2 Raw materials' profiles

This RMIS section gives access to quantitative and qualitative information along the supply/value chains of raw materials, in particular the material included in the 2017[218] and 2020[219] EU criticality analyses. It covers a variety of topics, including also environmental considerations (Figure 52). To access the environmental information, the user needs to follow the navigation path depicted in Figure 52.

First, for all materials (for which information has been uploaded online), data are provided on environmental considerations that may increase the risk of supply from some countries, i.e. environmental risk level in countries from which the EU sources materials. These data show how much share of a material comes from each producing country, covering EU producers and imports from non-EU countries[220]. The risk indicators considered include:

- risk and exposure to natural disasters, measured by The World Risk Report (2017)[221];
- risk linked to water scarcity, based on the Water Risk Index[222];
- risks linked to the environmental performance of a country, as estimated by the Environmental Performance Index (EPI)[223]. EPI measures how close a country is reaching its environmental quality targets, which reflects the risk of further development of environmental regulations which might limit some industrial activities.

When available, additional information is also provided on the conclusions from the Best Available Techniques Reference Documents (BREFs) and life cycle inventory data (validated data provided by relevant material associations).

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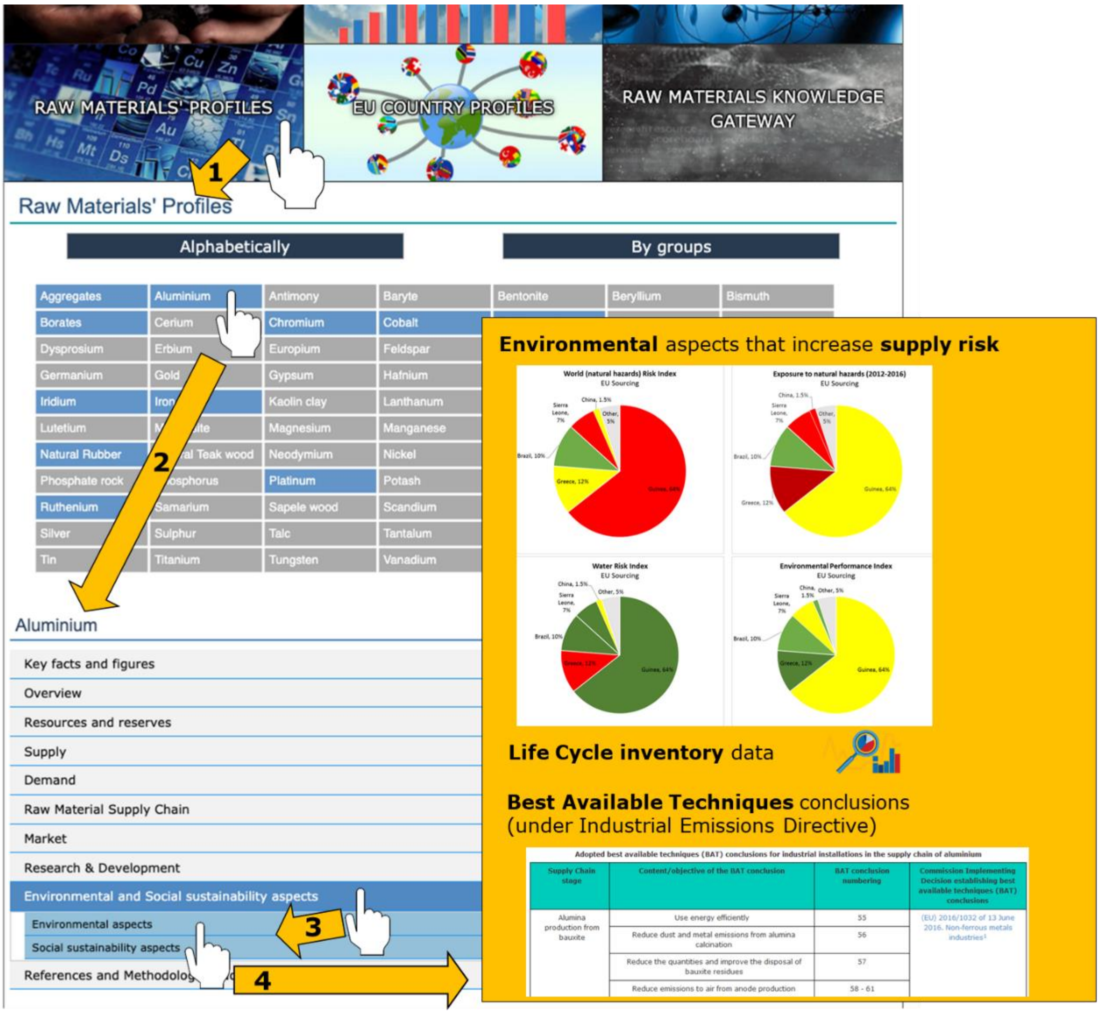
213 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2018%3A17%3AFIN
214 http://ec.europa.eu/eurostat/web/circular-economy/overview
215 http://ec.europa.eu/environment/resource_efficiency/targets_indicators/scoreboard/index_en.htm, dedicated page at the RMIS at https://rmis.jrc.ec.europa.eu/?page=resource-efficiency-scoreboard-8a9baf
216 http://ec.europa.eu/dgs/environment/index_en.htm
217 https://ec.europa.eu/eurostat/web/europe-2020-indicators/scoreboard
218 European Commission (2017), 'Study on the review of the list of Critical Raw Materials'.
219 European Commission (2020), 'Study on the EU's list of Critical Raw Materials (2020)'
220 Production data are taken from the 2020 Criticality Study, consisting of the average value the period 2012-2016
221 Bündnis Entwicklung Hilft, http://weltrisikobericht.de/english/
222 World Resources Institute, http://www.wri.org/our-work/project/aqueduct
223 Yale University and Columbia University in collaboration with the World Economic Forum, https://epi.envirocenter.yale.edu/

Figure 52. Environmental aspects with the RMIS section ´Raw materials´ profiles´.

The environmental content, highlighted within the orange box, is presented here in a different format as in the RMIS.



Source: JRC elaboration based on the RMIS web page.

4.3 EU country profiles

This section displays background information and data for EU countries (full coverage is not yet achieved), covering a variety of topics that can have an impact or be affected by raw materials production (Figure 53). This includes also data on the following environmental considerations:

— Land use: area occupied by mining activities and other land uses, taken from CORINE land cover 2012 and 2006[224];

— air emissions: emissions and emission intensity (i.e. emissions per unit of production, in monetary values) of greenhouse gases and particulate matter (PM2.5). Data taken from Eurostat, respectively, from ´Air emissions accounts by NACE Rev. 2 activity´ (env_ac_ainah_r2) and ´Air emissions intensities by NACE Rev. 2 activity´ (env_ac_aeint_r2);

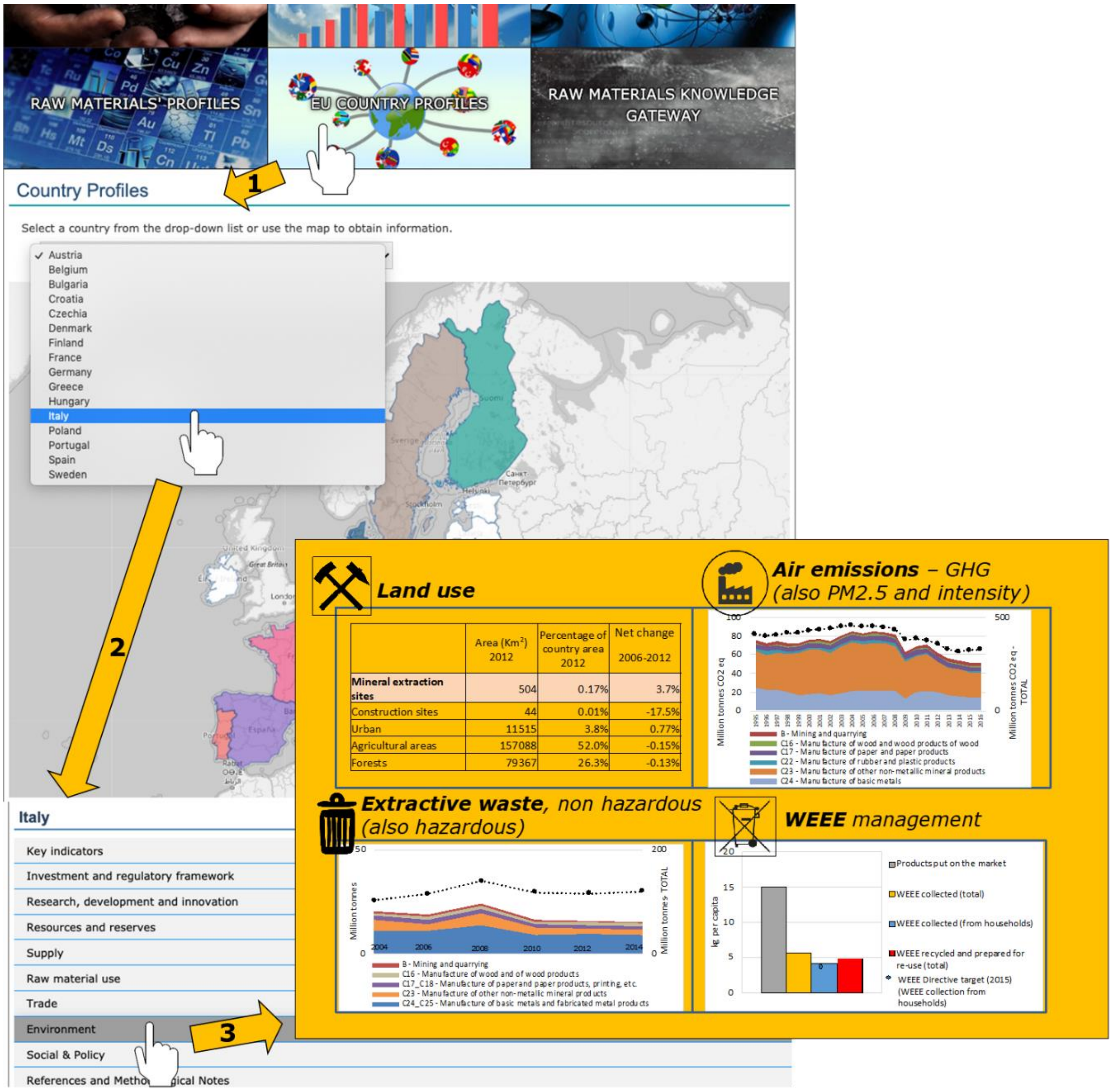
— extractive waste, taken from Eurostat ´Generation of waste by waste category, hazardousness and NACE Rev. 2 activity´(env_wasgen);

— a set of indicators of the management of electric and electronic equipment waste (WEEE), from Eurostat ´Waste electrical and electronic equipment (WEEE) by waste management operations´(env_waselee).

[224] https://land.copernicus.eu/pan-european/corine-land-cover

Figure 53. Environmental aspects with the RMIS EU country profiles.

The environmental content, highlight within the orange box, is presented here in a different format as in the RMIS.



	Area (Km^2) 2012	Percentage of country area 2012	Net change 2006-2012
Mineral extraction sites	504	0.17%	3.7%
Construction sites	44	0.01%	-17.5%
Urban	11515	3.8%	0.77%
Agricultural areas	157088	52.0%	-0.15%
Forests	79367	26.3%	-0.13%

Source: JRC elaboration based on the RMIS web page.

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- RMIS Artisanal and small-scale mining

Land use-related projects

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- Mineral Policy Guide (MIN-GUIDE) project
- Mineral Resources in sustainable land-use planning (MinLand) project

— Legal framework for mineral extraction and permitting procedures for exploration and exploitation in the EU (Minlex study)

Environmental perspective of land use and soil

— EEA, ´Land use´

— EEA, ´Land use data center'

— DG Environment, ´Soil´

— European Commission ad-hoc expert group, ´Exchange of best practices in the area of land use planning and administrative conditions for exploration and extraction´.

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