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Case Study 2 Report: Mining

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Summary

The mining sector’s attributes suggest it ought to be a prime consumer of climate services, such as its reliance on long-term large fixed assets and involvement with often complex processes and supply chains. Despite these attributes, studies have shown a lack of strong demand for climate services among all but a small proportion of the sector (EBI, 2015) indicating there is strong potential for growth in mining climate services. This study investigates this potential, bearing in mind changes the sector will undergo over the coming years to 2030. This case study indicates there is strong potential for growth of the use of climate services in the mining sector. Understanding the climate services needs of this sector will also help elucidate the potential needs of other important sectors such as the oil and gas sector, which has similar attributes as the mining sector. This document is a working draft, and a final draft will be uploaded upon review of delayed MARCO deliverables.

Approval

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Executive Summary

The mining sector’s attributes suggest it ought to be a prime consumer of climate services, such as its reliance on long-term large fixed assets and involvement with often complex processes and supply chains. Market research conducted in the MARCO project and elsewhere (EBI, 2015) indicate that the mining climate services market is established and provision is well under way. This case study provides colour to this market research, indicating the mining climate services market has not yet reached its potential. This is because apart from a small number of mining majors, current climate service use in the sector appears to stem from the need to comply with environmental regulation rather than deep understanding and proactive response to perception of climate risks facing operations.

The mining sector, worth 59.5 billion euro in 2015, is comprised of mining of coal and lignite, mining of metal ores, other mining and quarrying, and supporting services to these sub-sectors. Extraction of oil and gas was excluded in this case study. Mining operations are particularly exposed to climate due to the reliance on lived and capital-intensive assets, and on regions that are some of the most vulnerable to climate change. Climate-related impacts most often mentioned by stakeholders involved water management, ranging from concerns around excessive rainfall and flooding through to concerns around droughts or water scarcity. This background information on the mining sector is provided in Section 2.

Stakeholder mapping in Section 3 indicates strong presence of sector associations who are an important entry point for information flowing into the mining sector, with established groups at international through to local levels. The value chain analysis points out that climate services are needed in all stages of a mining project, that these climate services are typically advisory services-related, but also that there is a strong opportunity for the provision of climate and earth observation data, as well as the use of weather / climate-related insurance as a risk transfer mechanism. Climate service use cases, including a review of the Mining Climate Assessment (MiCA) data tool, and of the use of climate data in environmental impact assessments give a flavor of the mining climate services market. These case studies, found in Box I and Box II respectively, highlight how providers can be public and private actors, as well as how European climate service providers, public and private, often serve international actors.

The mining climate services market comprises 17% of the overall European climate services market, at 367.6 million euro in 2015-16 (MARCO deliverables 3.1, 3.2, 4.2, 4.3). There are a range of current climate services needs, including datasets on core climatic variables to climate model projections. Important gaps in the provision of climate services include datasets which are not readily available/easily produced at present such as those around intensity of rainfall. Section 4 provides analysis on current supply and demand of climate services in the mining sector.

An extensive review of framework conditions facing the sector’s use of climate services reveals how the governance landscape has shaped the mining climate services sector, found in section 5. Changes in this landscape, including the emergence of the Task Force on Climate Related Financial Disclosures (TCFD) are covered, as this will be an important driver to the growth of the mining climate services market by 2030. The review also finds the network of stakeholder associations could be a key factor in improving the sector’s currently low perception of climate risk – a persistent barrier to the uptake of climate services (see sections 6 and 7).

In this first known attempt to document and study the climate services market in the mining sector, a strong potential for growth both now and out to 2030 is discovered. This potential is summarised, and recommendations for increasing the use of climate services is provided in section 8. The study finds the establishment of a climate services observatory will benefit the sector greatly. Mining companies are expected to soon progress beyond compliance-based use of climate services, where a one-off study is produced and forgotten, and begin to actively analyse, manage and plan for climate impacts.
1 Introduction

1.1 MARCO project

This study forms part of MArket Research for a Climate services Observatory (MARCO), a research project funded through the European Commission’s Horizon 2020 Research and Innovation Program under Grant Agreement 730272. With growing appreciation of the risks that climate change presents, climate services are helping organisations to mitigate, adapt and become future-resilient. However, relatively little is known about the climate services market, with unaddressed gaps existing between supply and demand. MARCO endeavours to understand these gaps by providing a 360° view of Europe’s climate services market, endowing suppliers and users alike with the insight to predict the sector’s future direction and growth.

This deliverable (D5.3) is part of work package 5, which undertakes qualitative and quantitative analyses of the existing and future demand for climate services through the completion of 9 case studies. Each case study is associated with a key economic sector in Europe.

This study presents an investigation into the demand, supply, and decision-making processes relating to climate services in the mining sector in Europe and beyond. The mining case study is inclusive of most types of mining and quarrying across the 28 European Union (EU) Member States, though the study recognises the international nature of the sector. There are several mining majors who are headquartered in Europe, though carry out the majority of their actions on other continents such as Africa, Australia, or North America, for example. Lessons from these actors are included in this case study.

The study is based on 20 stakeholder interviews and desk-based background research. The identities of stakeholders are kept anonymous per their request. As such, when stakeholders are referred to, it is in a general sense. Attributes of the stakeholders such as sector, NACE code, user status, and gender are provided in Table 4 (Section 11.1).

1.2 Definition of climate services

In its consideration of their uptake in the mining sector, this study uses the EU Roadmap to Climate Services definition of climate services:

‘the transformation of climate-related data together with other relevant information into customised products such as projections, trends, economic analysis, counselling on best practices, development and evaluation of solutions and any other services in relation to climate that may be of use to society at large’ (European Commission, 2015).

Climate services, then, refers to the translation of in-situ or satellite observational data into information which can inform strategic decision making. It is the information needed for both day to day management of climate risks, and for longer term planning purposes. Climate services can therefore include raw datasets on climatic variables through to processed and refined climate data, delivered by third-party actors such as consultants. Sections 3 and 4 provide concrete examples of climate services in the mining sector.

2 Background on the Mining Sector

2.1 Definition of the sector

The mining sector in this case study refers to organisations which carry out the following activities: mining of coal and lignite; mining of metal ores; other mining and quarrying; and specialised technical services provided to aide these activities such as exploration services and geological observations. The mining sector
includes ‘crushing, grinding, cleaning, drying, sorting, concentrating ores…’ or similar activities that involve bringing materials to market (Eurostat, 2008). The scope of this case study only considers activities involving the extraction of solid materials, and excludes extraction of liquid or gaseous materials, such as crude petroleum and natural gas. The case study therefore only includes those activities which fall under European NACE1 Rev. 2 Classification Code Section B (mining and quarrying), sub-sections 05, 07, 08, and 09. Sub-section 06, ‘Extraction of crude petroleum and natural gas’, is not within scope for the purposes of this study. See Examples of activities and materials considered within scope

Table 5 provides further information on types of materials and activities included within scope.

Table 5 (page 39) for examples of activities and materials considered within scope of this case study (British Geological Survey, 2016; Eurostat, 2008).

The petroleum and natural gas extraction market is excluded from this study as it is separate and different to the markets involving extraction of solid materials in three key ways. First, the equipment and infrastructure are similar amongst activities involved in solids extraction. Second, there are separate sector associations for organisations involved in solids vs liquid or gaseous material (c.f. Euromines, or International Council on Mining and Metals (ICMM) in comparison to Eurogas, or the International Association of Oil and Gas Producers). Third, rarely do organisations operate in both solids and liquids/gaseous extraction.

Other excluded activities are: further processing of extracted material, using and crushing other earths, rocks and minerals not carried on in conjunction with mining and quarrying. Smelting and refining of imported ores to Europe and concentrates or refining semi-processed materials from other continents is also excluded.

### 2.1.1 Geographical scope

For the purposes of the sector economic profile, the mining climate services market quantification (Section 3), and the output of other MARCO deliverables (Section 4) the above listed activities were totalled for the 28 Member States of EU only. This case study does, however, recognise the presence of mining majors who are headquartered in one of the EU Member States, though primarily operate outside of the EU. This often results in a transboundary provision and procurement of climate services in the sector. The authors felt this case study of the European climate services market would benefit from the lessons provided by stakeholders and actors from outside the EU. As such, mining stakeholders from all locations were welcomed to participate. This primarily influenced the analysis around framework conditions and user preferences. Stakeholders outside of the EU included those from Canada, Australia and South Africa.

### 2.2 Economic profile of the sector

The review of the European mining sector’s economic profile shows that an important mining sub-sector in Europe is the ‘Other mining and quarrying’ sub-sector (NACE code Section B, sub-section 08). This is the largest employer and producer, both in terms of volume of material produced and value. The ‘Coal and lignite’ sub-sector (NACE code Section B, sub-section 05) is the second largest in terms of production and employees.

#### 2.2.1 Employment

The mining sector as defined in this study included 17,711 enterprises in 2015, employing 414,938 persons. The gender breakdown is not known in Europe thought worldwide it is rare to find companies with higher

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1 Nomenclature des Activités Économiques dans la Communauté Européenne.
than 10% female employment, with many being less than 5% (Eftimie, Heller, & Strongman, 2009). While around 92% of all firms were categorised as ‘Other mining and quarrying’, this sub-sector employed just over 46% of the workforce. ‘Mining of coal and lignite’ is the second largest sub-sector of mining workers in Europe, at about 38%, though in just 255 firms. See Figure 1 for a detailed breakdown of persons employed by the mining and number of firms, in 2015 (Eurostat, 2016).

![Figure 1: European mining sector size by employment and enterprises, 2015](image)

### 2.2.2 Production

The European mining sector was worth 59,501 million euro in 2015, in terms of sales (production value), and produced over 631 million tonnes of raw material (European Aggregates Association, 2015; Eurostat, 2016; Reichl, Schatz, & Zsak, 2017). Figure 2 below shows the production value of the mining sector, on the left axis (blocks), and the production of raw materials on the right axis (line), by sub-sector\(^2\). Charting the value and weight production figures shows they generally track against each other. The ‘other mining and quarrying’ sub-sector is the most productive, for example, in terms of both sales and weight. This sub-sector makes up 63 % of sales, and around 82 % of tonnage. The mineral fuels sub-sector makes up about 20 % of the production value in Europe, at 11,836 million euro, and about 18 % of tonnage. The metals sub-sector is worth 16 % of sales, and is the smaller producer by weight, as less than one percent of weight produced is metals. Related supporting activities is small in relation, worth 949 million euro, making up the remaining two percent of sales.

\(^2\) NB: Weight production figures, provided by the World Mining Congress, are organised slightly differently than the NACE code which Eurostat uses, as the World Mining Congress groups all energy-related minerals together.
2.3 Overview of mining sector climate risks

Climate change poses numerous significant risks and opportunities for the mining industry (see Appendix 11.2). These arise from both efforts to minimise greenhouse gas emissions (mitigation) as well as coping with inevitable climatic changes (adaptation). Climate change will have a significant bearing on the risk profile of operations and assets across three key areas:

1. Physical risks: For example, water scarcity, storms and extreme temperatures all hold risks to assets and operations.
2. Demand-side risk: The mining sector could experience some shifts in demand both over time and geographically e.g. increased demand for products required to support mitigation such as metals for renewable power technologies and adapt climate change (i.e. increased need for construction materials for flood protection structures).
3. Regulatory and investor risks: Investors are increasingly calling for businesses to account for and report on their climate risk exposure and actions to manage these risks.

This section provides the scientific evidence of climate change, presenting information on observed and current climate changes as well as observed trends in extreme climate events. This is followed by a discussion on the ways in which the mining sector is particularly exposed to climate change, as well as a general indication of risks the sector is facing.

2.3.1 Global climate change: observed and current changes

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, indicates that man-made warming of the global climate system is ‘almost certain’. This is supported by long-term worldwide measurements of surface air temperatures (See Figure 3, changes are relative to the mean of 1961–1990) (Stocker et al., 2013a). However successful the global community are with climate change mitigation, all sectors of the economy, including mining, will be faced with many years of unavoidable climate change. Decisions and projects that do not take the impacts of climate change into account will not perform as intended over their lifetimes.
The largest contribution to this continues warming is the increase in the atmospheric concentration of carbon dioxide (CO$_2$) since 1873 due to industrialisation (Figure 4; The black line represents this historical relationship) (Stocker et al., 2013a). CO$_2$ concentrations in the atmosphere are higher now than at any time during the past 650,000 years (Stocker et al., 2013a). During 2016, the average global CO$_2$ concentration exceeded 400 parts per million (PPM) for the first time (up from 278 ppm in the pre-industrial era) (NOAA, 2016). The 2013 IPCC Working Group I Summary for Policymakers states:

“...Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased...” (Stocker et al., 2013b).

In addition to changes in temperature, there have also been recorded changes in the global water cycle. Some areas of the world have seen an increase in precipitation (e.g. the mid latitude northern hemisphere) whilst others a decrease. Trends in how precipitation has changed are less clear than with temperature.

Figure 3: Observed global mean annual and decadal surface temperature changes between from 1850 to 2012
(NB: top is global mean annual and bottom is decadal surface temperature changes)
2.3.2 Observed trends in extreme climate events

In addition to ‘gradual’ changes in temperature and precipitation (as well as other climate variables such as sea level and ice extents), there have been observed changes in extreme climate events since at least 1950 (Stocker et al., 2013a). There is, however, variation in the current understanding of how much anthropogenic (human induced) climate change has contributed to these trends (see Table 1). A growing body of work is emerging which works to attribute extreme events to climate change, which is starting to be compiled and mapped in Carbon Brief’s project ‘Attributing extreme weather to climate change’ (Carbon Brief, 2018).
### Table 1: Extreme weather and climate events: Global-scale assessment of recent observed changes, human contribution to the changes and likelihood of further changes

<table>
<thead>
<tr>
<th>Extreme weather or climate event</th>
<th>Assessment that changes occurred (typically since 1950 unless otherwise indicated)</th>
<th>Assessment of a human contribution to observed changes</th>
<th>Likelihood of further changes</th>
<th>Early 21st century</th>
<th>Late 21st century</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer and/or fewer cold days and nights over most land areas</td>
<td>Very likely</td>
<td>Very likely</td>
<td>Likely</td>
<td>Virtually certain</td>
<td></td>
</tr>
<tr>
<td>Warmer and/or more frequent hot days and nights over most land areas</td>
<td>Very likely</td>
<td>Very likely</td>
<td>Likely</td>
<td>Virtually certain</td>
<td></td>
</tr>
<tr>
<td>Warm spells/heat waves. Frequency and/or duration increases over most land areas</td>
<td>Medium confidence</td>
<td>Likely</td>
<td>[not formally assessed]</td>
<td>Very likely</td>
<td></td>
</tr>
<tr>
<td>Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation.</td>
<td>Likely (over land)</td>
<td>Medium confidence</td>
<td>Likely</td>
<td>Very likely</td>
<td></td>
</tr>
<tr>
<td>Increases in intensity and/or duration of drought</td>
<td>Likely</td>
<td>Low confidence</td>
<td>Low confidence</td>
<td>Likely</td>
<td></td>
</tr>
<tr>
<td>Increases in intense tropical cyclone activity</td>
<td>Likely in some regions, since 1970</td>
<td>Low confidence</td>
<td>Low confidence</td>
<td>Likely</td>
<td></td>
</tr>
<tr>
<td>Increased incidence and/or magnitude of extreme high sea level</td>
<td>Likely in some regions, since 1970</td>
<td>Likely</td>
<td>Likely</td>
<td>Very likely</td>
<td></td>
</tr>
</tbody>
</table>

### 2.3.3 Exposure of the sector to climate change

In 2013 an Australian report (Mason et al., 2013), produced by the National Climate Change Adaptation Research Facility, indicated that relevant extreme events for the mining sector include flooding, drought, and extreme temperatures. In Europe, relevant extreme events to the mining sector include extreme precipitation, and abnormal variability (stakeholder interviews, 2017). Fluctuations in temperature such as extreme lows in winter and higher temperatures earlier in the spring have meant high snow melt at unexpected times for stakeholders in Northern Europe.

The extreme events and incremental changes which can be expected will create new and evolving risk profiles for the mining sector in Europe and internationally. These will include impacts on mining company’s physical assets, their operations, on their workforces, as well as their local operating environment. Mining companies are particularly exposed to climate impacts for the following reasons:

- They are reliant upon long-lived and capital-intensive assets;
- The majority operate in regions that are the most vulnerable to climate change, including fragile and remote environments and developing countries;
- They have extensive product transportation networks and rely on deep and complex supply chains, both of which make operations vulnerable to disruption;
- In developing countries, they depend on workforces and communities that are geographically and socio-economically vulnerable to a changing climate; and
The legacy of pollution left by historical activities is a major environmental issue for the mining industry, and there is the potential that climate change-related environmental impacts will increase pollution risks and make fragile environments even more stressed.

2.3.4 General climate risks and impacts

It is not possible to determine the vulnerability and risks of the European mining sector in its entirety due to the scale of the sector and the time limitations of this case study. The sector will have widely varying degrees of adaptive capacity to mediate to the risks it faces. There is, however, evidence of current and potential future climate change risks and impacts facing the mining sector. This is being reflected in the small but growing number of reports produced over the last 10 years by, and on behalf of, the industry. In 2010, for example, the International Council for Mining and Metals (ICMM) published a report which addressed issues such as why it is important for the mining sector to understand the impacts of a changing climate, what the relevant risks and opportunities are, and what options are available for the sector to adapt. The report identifies broad impacts to the mining sector, for example, risks to inputs to operations such as water and energy supplies, and on their workforces. Additionally, indirect impacts will include, for example, supply chain disruption and changes in markets (Acclimatise, 2010; ICMM, 2013).

2.4 Similar sectors and regions

While key differences in production exist, as referenced in section 2.1, the oil and gas sector remains as one of the most similar to the mining sector in Europe and internationally with regards to activity and climate sensitivities. The sector is worth almost double the mining sector, as defined in this study, with production value at 94,470 million euro in 2015 (Eurostat, 2016). The European oil and gas sector employed 77,025 persons in 2015, in around 460 firms.

Oil and gas production in Europe primarily takes place in the UK, Netherlands, Denmark, Germany, and Poland. Around 32,000 employees are located in the North Eastern Scotland region, where the North Sea oil and gas fields are, and around 36,000 were employed in the Norwegian region of Agder of Rogaland (Eurostat, 2016). These employment figures indicate, perhaps, that these regions are the most active in Europe in terms of production.

Oil and gas extraction, though reliant on different extraction technologies, has similarities with the mining sector which could mean lessons learned in either of the sectors around the provision of climate services could extend to the other. Similarities include the fact that oil and gas also has a reliance on fixed long-term assets, often in regions subject to extreme conditions, and both tend to have a lack of transparency around analysis and disclosure of climate related risks. Reputation management is perhaps even more active in the oil and gas extractives sector than the mining sector. This means that while it is safe to assume that the oil and gas sector has notable demands for climate services, it is not always possible to determine these or locate examples. The two sectors are also facing similar pressures from investors and insurers around climate risk analysis and disclosures, with the Task Force on Climate-related Financial Disclosure (TCFD) recommendations on climate-risk reporting aimed at both sectors (see Framework Conditions, section 5 for further discussion).

One important difference between these two sectors, which may influence the growth of the climate services market, is the growth trajectory. While both the mining sector and the oil and gas sector have slowed production in terms of production value in recent years, the oil and gas sector has done so at a quicker pace. For example, production value dropped 39.6% between 2012 and 2015, from 156,373 million euro in 2012 to 94,470 million euro in 2015. In the same period, the mining sector, as defined here, dropped 26.5%, from 15,935 million euro in 2012 to 11,718 million euro in 2015. The presence and growth of alternatives to conventional energy sources, as well as declining fuel resources have helped in the
decline of the oil and gas sector, two trends which will certainly continue through to 2030. What this decline means for climate services demand in the oil and gas sector remains to be seen, though could be a noteworthy impediment to expansion of climate services in the sector in Europe.

The international scope of this case study does not lend itself to comparison of similar regions.

3 Characterising the Mining Climate Services Market

3.1 Stakeholder mapping

This section maps out stakeholders in the mining sector, with particular attention to groups which could be interested in climate services. Figure 5 provides a simplified view of these stakeholders and is inclusive of actors who may not have participated in this study.

One group of stakeholders are the mining companies and supporting actors (such as service companies who provide ‘Other mining and quarrying’ services). There is notable diversity within this group, with a primary categorisation being the type of material extracted or service provided (mineral energy, metals, aggregates, exploration services), and a secondary categorisation being the size of the company. Larger size organisations typically correlates positively to the international status of the organisations.

Sector associations abound in the mining industry, and stakeholder mapping indicates these organisations are present at various geographical and sub-sectoral scales. At the global scale, the International Council on Mining and Metals (ICMM) is perhaps the most well-established and recognised sector association, representing mining and metals companies, as well as regional and commodities associations. At the European level, sector associations are typically organised by the sub-sector, or category of material produced. Euromines represents metal ores and industrial minerals sub-sectors, Euracoa represents the coal and lignite sub-sectors, and UEPG (European Aggregates Association) represents aggregate producers’ interests, for example. Sector associations at the global and EU-level are often comprised of state level sector associations. SveMin, the Swedish Association of Mines, Mineral and Metal Producers, for example, is a member of the European-level organisation, Euromines.

Sector associations are an important entry point for information flowing into the mining sector, be it climate or otherwise, as they provide an opportunity for organisations to share information around similar risks they may be facing, pooling resources to do so. ICMM, for example, allows members to directly access climate data and information by providing access to a web-based climate risk screening tool for its members which Acclimatise developed: the Mining Climate Assessment data tool (MiCA), as well as providing targeted training and reports on aspects of using climate data and climate change adaptation in the sector (c.f. ICMM, 2017). Euromines, while not yet a purveyor of climate services and information, bring in external speakers on topics of interest for their members, and maintain guidelines and positions papers one on various topics for their members such as energy and climate change. There is strong potential for these sector organisations to be a conduit for climate data and information, much as is the case with ICMM.

Public sector actors are another important overarching group of stakeholders. Various sub-groups within this group play a vital role in the uptake of climate data and information in the mining sector. Government agencies such as energy and environment agencies at the Member-State level implement Directives from the European Commission. Together with the Commission, these agencies provide the regulatory framework in which mining companies operate, determining to what extent and at what stages climate risks are required to be analysed and reported. The Framework Conditions section of this study discusses

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3 UEPG = Union Européenne des Producteurs de Granulats
governance issues in further detail. Other important public-sector actors are the meteorological and hydrological offices who are often the first point of call for both large and small mining companies for data needs around precipitation, for example. Finally, there are instances where publicly funded research organisations such as CSIRO in Australia, and universities are providing vital research around climate impacts to the sector (C.f. Loechel & Hodgkinson, 2014; Rio Tinto, 2016).

Specialist consultancies to the sector such as Acclimatise, Ecofys, or other firms providing environmental impact assessment (EIA) and closure planning services are stakeholders in the mining-related climate services market. These organisations often have long-standing relationships with mining companies and their operations and are a trusted source of expertise, often directly providing climate services to the sector.

Other groups which are notable for their potential, though are perhaps less active in driving current uptake of climate services, are non-governmental organisations (NGOs) and academics working in and around the sector. These groups also provide targeted research and information on, and to, the sector based on their needs, and many are conservation or biodiversity focussed. Related sectors are included in the climate services mining stakeholder map as well. There may be potential to share learning between the mining and the oil and gas sector with regards to climate impacts on large fixed infrastructure (e.g. energy or water management systems), and applications of climate data. Currently there is very little evidence that this sort of inter-sectoral sharing is occurring, and may only be limited to those few major companies that have both mining and oil and gas operations in their portfolios. Another related sector includes metals production, which involves the smelting and refining of metals into products, post extraction. Section 2.4 discusses the potential for climate services growth in related sectors.

Figure 5: Climate services stakeholder map in mining sector
3.2 Mining climate services market quantification

MARCO deliverable 4.3 (D4.3: ‘Quantitative analysis of global and EU market demand’) estimated the climate services market in Europe to total 6.28 billion euro in 2015-16 with growth expected to be 9.7-16% by 2021-22. This is based on procurement figures or sales. For mining, sales of climate services totalled 367.6 million euro in 2015-16. The sector ranked the sixth highest based on climate services expenditure in the EU in 2015-16, according to analysis in the deliverable. The highest value climate services applications for the sector are ‘actuarial evaluation for climate change’ for mines and quarries, at 10.2 million euro, and ‘geological services for climate change’ for mines and quarries at 9.3 million euro. As discussed in Section 4.1.2, (page 21) there is reason to believe these figures may be underestimated and more granular analysis could provide a better indication in the future.

3.3 Examples of existing climate services supply and use

Climate services in the mining sector are provided by both public and private actors. One private sector example, the Mining Climate Assessment data tool (MiCA) is highlighted in Box I. This tool was procured by ICMM, on behalf of its members, and works to bring together climate model outputs in one login-secured portal. Examples of public sector provision of climate services to the mining sector come from the UK Met Office, as discussed in their document ‘Mining case studies’ (UK Met Office, 2014). The Met office have conducted analysis on behalf of mining majors, as well as investors in mining operations, to determine a range of projections for snow and rainfall, among others, in Africa, South America, and Central Asia. While full details of the climate services provided by the UK Met Office is not provided in their case study document, various climate data types mentioned include precipitation datasets and climate model outputs. These examples indicate the transboundary nature of climate services in the mining sector: they are instances where European climate service providers have utilised the combination of European and international climate data to provide climate services to those in and outside of the EU. See Section 4 for further examples and discussion of the supply and demand dynamics of climate services in the sector.
Box I: Example of climate services use – MiCA data tool

<table>
<thead>
<tr>
<th><strong>Mining Climate Assessment data tool (MiCA)</strong> (Acclimatise, 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Benefits of use</strong></td>
</tr>
<tr>
<td><strong>Implications for other climate services</strong></td>
</tr>
<tr>
<td><strong>Demonstration</strong></td>
</tr>
</tbody>
</table>

![MiCA Climate Model Output](image-url)
### 3.4 Value chain analysis

The mining sector is comprised of a wide variety of specific-resource (e.g. aggregates, coal or bauxite) focused operators all of whom have distinctly different value chains. However, at a high level of generality a relatively standardised value chain can be conceptualised that helps orientate us to the important areas where climate services could add further value. Figure 6 shows a conceptual value chain for metalliferous mining (Lombe, 2011). Note that the last three steps, from ‘Smelting and Refining’ through to ‘Final product manufacture’ are not typically part of the mining value chain, however they are provided for completeness sake.

![Conceptual metalliferous mining value chain](image)

The challenge comes in understanding the way climate services can support a value chain as shown above. Firstly, the level of integration or ‘ownership’ of up and downstream value chain steps within a single organisation may vary significantly. Large multi-national mining companies may operate in the Mining step, through to the Smelting and Refining step, across multiple global locations. In this case, climate services may supply services tailored to the enterprise or portfolio-wide viewpoint, where mainstreaming climate risk considerations across the entire enterprise is a key objective. Conversely, smaller local/national companies may require a greater emphasis on asset-specific climate service support, with less emphasis on the mainstreaming or governance aspects of climate risk management.

To fully understand the role of climate services, a ‘one size fits all’ approach to service provision will not work well for the mining sector. Instead, it may be better to consider each of the value chain steps shown above in terms of their project or asset life cycle. With the exception of ‘Exploration’, all the above example value chain steps rely on large-fixed assets with strong dependencies on climatically sensitive inputs, such as water, power and labour. Each of these value chain steps will generally follow an asset lifecycle that starts, in engineering terms, with pre-feasibility and moves through to operation and ultimately decommissioning. Figure 7 shows a typical asset lifecycle for a mining value-chain related asset including potential climate service provision examples.
As shown above, there is a strong potential for climate services to be integrated into every step of the asset lifecycle. Although most of the examples provided are advisory services-related, there is also a strong opportunity for the provision of climate and earth observation data, as well as the use of weather/climate-related insurance as a risk transfer mechanism. More detailed research would be required for further expansion of this section, based upon further and more detailed stakeholder engagement. This could elaborate on examples where climate services have been successfully deployed in the value chain, and describe the actors involved, as well as the enablers and barriers to action.

### 4 Climate Services: demand, supply and use

Data produced for MARCO deliverables 3.1, 3.2, and 4.2 and 4.3, were used alongside stakeholder interviews to determine the existing climate services demand and supply in the mining sector. This section discusses current climate services needs, and current climate services provision. An initial attempt to reconcile the demand and supply is made.

#### 4.1 Existing climate services demand

**4.1.1 Climate service demands listed by stakeholders**

As reported in stakeholder interviews, mining companies typically have several main instances when they might need climate-related data and information:

<table>
<thead>
<tr>
<th>Goal</th>
<th>Establish preliminary scope and business strategy</th>
<th>Establish development options and execution strategy</th>
<th>Finalise scope &amp; execution plan</th>
<th>Detail and construct asset</th>
<th>Operate, maintain and improve asset</th>
<th>Decommission asset and manage on-going liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process/analysis</td>
<td>- Business model development</td>
<td>- Conceptual design</td>
<td>- Front end engineering design (FEED)</td>
<td>- Asset management</td>
<td>- Decommissioning planning</td>
<td>- Revised/ amended full EIA + Management Plan</td>
</tr>
<tr>
<td>- Pre-feasibility studies</td>
<td>- Site selection</td>
<td>- Cost estimating and financial/economic modelling</td>
<td>- Engineering Procurement and Construction Management (EPCM)</td>
<td>- Operations and maintenance</td>
<td>- Detailed engineering</td>
<td>- Insurance</td>
</tr>
<tr>
<td>Potential climate service provision</td>
<td>- Technology selection</td>
<td>- Full EIA + Management Plan</td>
<td>- Support of specific climate data, modelling and statistical analysis to support detailed engineering</td>
<td>- Insurname</td>
<td>- Enterprise risk assessment support</td>
<td>- Insurance</td>
</tr>
<tr>
<td></td>
<td>- Cost estimation</td>
<td>- Tier 1: Initial climate risk assessments</td>
<td>- Detailed financial/economic assessment for adaptation options</td>
<td>- Climate change advisory</td>
<td>- Climate risk mainstreaming and governance advisory services</td>
<td>- Insurance</td>
</tr>
<tr>
<td></td>
<td>- Environmental Impact Assessment (EIA) scoping</td>
<td>- Development of high level costs for adaptation options</td>
<td>- Supporting EIA with climate change advisory</td>
<td></td>
<td>- Organisational change and awareness raising</td>
<td>- Insurance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Provision of site specific climate datasets/earth observation</td>
<td></td>
<td></td>
<td>- Ongoing provision of climate data/earth observation to support operations and maintenance/upgrade priorities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Training/supporting engineering team on specific climate service aspects</td>
<td></td>
<td></td>
<td></td>
<td>- Climate risk assessments for long-term decommissioning</td>
</tr>
</tbody>
</table>

**Figure 7:** Typical mining asset lifecycle and potential climate services
• at the beginning of an asset’s planning – typically for permitting and integrating resilience into engineering design;
• for day to day operational management – some instances of activity, however more stakeholders indicated that shorter term weather services were used for these purposes more often than longer term climate services⁴.
• in case of climate and weather-related disasters – both before and after;
• corporate reporting and evaluation of the financial risks relating to climate change impacts (e.g. financial implications of increasing water scarcity at an asset, business unit or corporate level);
• during closure or decommissioning – typically for impact assessment and long-term management of tailing ponds and mining waste;

This section will discuss the types of climate data and services needed in the above-listed instances.

Precipitation forecasts and related data
Precipitation forecast data was a primary request among stakeholders, including those located in Northern Europe, Eastern Europe, South Africa, and Australia. This information is need for a variety of reasons: for planning and permitting stages of a new project, as well as in operational decision making. Apart from short term to seasonal forecasts of precipitation, additional medium to longer term forecast information around extreme rainfall events is needed, with interest expressed in rainfall duration and intensity. This information was primarily requested from public sector providers such as meteorological offices.

Related data needs often mentioned included river flow data for the purposes of managing discharges. This is not climate data, though interest in this data highlights motivations, and underpins the importance of precipitation data to the sector. Modelled, observed, and projected precipitation data could potentially help the sector understand their areas of concern such as river flow changes, as precipitation data could feed into hydrological modelling, for example. Other related data mentioned were short term drought forecasts which were listed as particularly important by organisations in Australia and South Africa.

Climate Scenarios
Stakeholders mentioned the need for climate scenarios from the Intergovernmental Panel on Climate Change (IPCC). For instance, IPCC’s Representative Concentration Pathways (RCPs) were used to feed into the development of a flood modelling tool for an analysis of potential climate impacts in a specific region, which resulted in a set of guidelines for designing new operations. The need for this information was mentioned by just one stakeholder, however, who suggested this proactive look at climate impacts in their region may not have happened if it were not for a joint research effort between public and private actors. In other words, climate scenarios may be used from time to time in the sector, for the purposes of analysing physical climate risk, though demand for this information may not yet currently be high.

Climate model outputs
The Mining Climate Assessment (MiCA) data tool (See Box I, Page 15) is a useful indication of climate service needs, as the tool was built to directly answer specific user needs. In its development, potential MiCA users requested one single place which brought together numerous climate model projections for core climate variables such as precipitation and temperature, among others. The Coupled Model Intercomparison Project (CMIP) works to help comparisons of climate modelling experiments, though there

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⁴ Weather data and services include forecasts in the short term, from hours to several weeks. Climate data and services include that with a timescale of several weeks out and further, though can also include historical observational data.
is still a need to navigate the outputs, as there are around 30 groups producing climate models (World Climate Research Programme, 2017).

Data needs for impact assessments

As discussed in the Framework Conditions analysis (See Section 5, page 25), EIAs are required for different aspects of mining projects in many jurisdictions including Europe. These assessments often require a multitude of climate-related data and information, climate modelling outputs, datasets on core climate variables such as temperature and precipitation, specialised studies relating to historical information on hazards, such as fire, flooding, extreme rainfall, as well as disaster modelling. The demand for climate services to inform EIAs is not currently large, largely due to the fact that physical climate risks are generally poorly assessed within in these assessments. It is expected that this demand will increase in the medium term, however. Box II explores a case study of various climate services needs stemming from an iterative EIA process associated with the decommissioning stages of a set of uranium mines in Canada.

Box II: Example of climate data needs in EIA

<table>
<thead>
<tr>
<th>Quirke and Panel Uranium Mines Decommissioning EIAs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
</tr>
<tr>
<td>The decommissioning of the Quirke and Panel Uranium Mines at Elliot Lake in Canada involved the construction of permanent tailing ponds to hold radioactive tailings. A complex design for the containment ponds was proposed, consisting of dams and dikes, which would prevent the generation of acid that would have resulted from the tailings’ exposure to air. EIAs were prepared for this work, as is required by Canadian law. Regulators required several iterations of assessment until they could be certain adequate considerations of climate impacts had been made. Reviewing this process showcases the various sorts of climate services necessitated by EIAs in the mining sector.</td>
</tr>
<tr>
<td><strong>Description of initial data needs</strong></td>
</tr>
<tr>
<td>In their first iteration of the EIA, preparers utilised drought and flood modelling to make estimations of the impacts associated with decreasing mean precipitation and increasing mean evaporation. Databases for evaporation, based on climate records of 55 years were consulted along with databases for precipitation, based on climate records of 18 years. Together, these allowed the project proponent to develop models for these two dynamics. Ultimately the regulator, Environment Canada, found the underlying assumptions in the models (that a 10% possibility of decreasing mean precipitation and increasing mean evaporation), among others, was not a sufficient consideration of climate change.</td>
</tr>
<tr>
<td><strong>Description of additional data needs</strong></td>
</tr>
<tr>
<td>The project proponent was asked to conduct further reviews of the potential impacts of catastrophic or accidental events as well. They were required to use climate model outputs to do this as ‘best estimates of long-term climate changes and their associated uncertainties’ were required (Lee, 2001).</td>
</tr>
<tr>
<td><strong>Implications for climate services providers or market</strong></td>
</tr>
<tr>
<td>As protective functions of tailing ponds are required for extended time frames, long after closure of mining activities, robust climate change considerations are essential for certain types of mining such as uranium. These design and analysis requirements indicate the demand for a range of climate services including input studies for flood modelling, the supply of historical observational data, and climate model downscaling for site specific requirements, as well as the translation of this information, in the EIA context. Kazakhstan, Canada, and Australian are the top three producing locations for uranium, with large recoverable reserves in Russia. Numerous European climate services providers are potentially well positioned to offer their services.</td>
</tr>
</tbody>
</table>
**Timescales**

A range of timescales for climate services are of interest in the mining sector. Stakeholder preferences for precipitation forecasts ranged between several days to seasonal. Longer term precipitation forecasts of up to one year were also noted as of potential interest, assuming their accuracy could be ensured. More generally, stakeholders indicated that in operational decision-making needs information of up to a one-year timeframe. Environmental permitting and planning needs require data and information of around 3-5 years. Longer term planning, e.g. to manage decommissioning liabilities, could necessitate information which spans decades, as is illustrated in the case of uranium mining in Box II.

**External analysis**

The majority of stakeholders indicated that expertise relating to climate data and its analysis was provided by experts outside their organisations. This is important to consider for climate service providers as it indicates the need for the translation of climate related data and information, rather than the sole provision of raw datasets. As one stakeholder put it: ‘[mining companies] are often not sure how to translate what data they do have into risk assessments.’ Consultants and advisory services continue to play an important translation role, and their services are in high demand in the mining climate services market.

### 4.1.2 Climate service demand analysis in other MARCO deliverables

MARCO deliverables 4.2 and 4.3 allow for climate services needs to be articulated in addition to the stakeholders’ expressed needs.

**Climate service applications and value**

MARCO deliverable 4.3 ‘Quantitative analysis of global and EU market demand’ (D4.3) finds the climate services demanded by the mining sector in Europe to be those listed in Table 2. This table also provides the estimated value of those sales for 2015-16 in million euro, where available. The highest amount volume of sales by expenditure was estimated to be in ‘actuarial evaluation’, at 10.2 million euro in 2015-16, followed by ‘geological services’ at 9.3 million euro for the year.

<table>
<thead>
<tr>
<th>Type of climate service</th>
<th>Value (million euro, 2015-16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuarial evaluation</td>
<td>10.2m</td>
</tr>
<tr>
<td>Geological services</td>
<td>9.3m</td>
</tr>
<tr>
<td>Coastal erosion research</td>
<td>4.6m</td>
</tr>
<tr>
<td>Water management</td>
<td>3.2m</td>
</tr>
<tr>
<td>Coastal erosion analysis</td>
<td>3m</td>
</tr>
<tr>
<td>Climate change data mapping services</td>
<td>2m</td>
</tr>
<tr>
<td>Insurance for impacts/risk of climate change</td>
<td>1.6m</td>
</tr>
<tr>
<td>Early warning systems</td>
<td>1.5m</td>
</tr>
<tr>
<td>Actuarial research services</td>
<td>12m (total all sectors analysed, not mining total)</td>
</tr>
<tr>
<td>Recording and analysis</td>
<td>No data available</td>
</tr>
<tr>
<td>Coastal erosion civil works</td>
<td>No data available</td>
</tr>
</tbody>
</table>
Emergency preparedness and support response | No data available  
---|---  
Infrastructure advice | No data available  
Special analytical services | No data available  
Water coursing | No data available  

Figures from D4.3, shown in Table 2 should be taken as an estimation and general indication, as D4.3 was the first attempt to quantify the climate services market, and there may be methodological limitations of that study (See D4.3 for further discussion). Apprehensions around this data are numerous. Certain services are believed to be underrepresented (e.g. low figures reported for insurance coverage), figures for total spending are unavailable for several of these applications, and only the total value or spending for all sectors is available for certain applications (e.g. actuarial research services). Additionally, these figures may be on the conservative side, given that a single detailed quantitative risk assessment with modelling can cost hundreds of thousands of euros. Definitions for these climate service applications were also not provided in the D4.3 analysis, making it impossible to clarify this terminology and unpack further meaning of the types of services they include. ‘Geological services’ for example, does not provide enough nuance to understand which types of exact services mining companies are demanding. Finally, the highest-ranking services, by value, (e.g. actuarial evaluation) should not be taken to indicate the highest amount of climate service demand. Data on number of transactions per climate service application is not available, so it is not clear if there is a high volume of actuarial evaluation or geological services demand, or if these services are simply more expensive than other applications.

D4.3 also provides sales breakdown for the mining sector in Europe, dividing demanded services into categories based on delivery platform: land-based, airborne, space services, mixed services, and marine in situ services. This indicated for the mining sector that the majority of climate service purchases were land based climate services at 36%, followed by airborne services at 30%. Mixed services, space-related climate services (e.g. earth observations), and marine in situ (e.g. water quality monitoring) services comprised about 10% each of sales respectively (see Figure 8). This division could indicate a strong demand for analysis such as flood modelling (land-based) and weather station-related services (airborne), though D4.3 does not provide adequate definitions of these data platform categories to draw these certain conclusions.

**Figure 8: Mining climate service sales split by data platform for 2015-16 (%)**

**Known purchasers of climate services in the mining sector**

MARCO deliverable 4.2 ‘Research into transactional data to identify purchasers and providers of Climate Services’ (D4.2) does not detail purchasers by sector, providing general figures on purchasers at the EU-level instead. D4.2 found there were 3,171 unique purchasing companies across the 28 countries of the EU. Malta was found to have the lowest number of purchasers at 60 and Poland the highest at 204. No public-sector purchases were included in the analysis. Further analysis is needed to determine known purchasers in the mining sector in particular.
4.2 Climate service activities supplied to the mining sector

4.2.1 Climate service supply analysis in other MARCO deliverables

Deliverable 4.2 builds on the transactional analysis of Deliverable 4.3 to provide an indication of climate services suppliers to the sector. A review of MARCO Deliverables 3.1 and 3.2 also indicated there are 17 well known firms that target and provide services to the mining sector in Europe. These are provided in Table 3.

Table 3 may not be a complete list, however. One additional provider is SRK, located in Cardiff, UK, who carry out future modelling of precipitation in design of tailings dams. There are also likely a number of other meteorological offices which provide climate services to the mining sector, such as those located in Northern Europe and the UK. As it stands, D3.1 indicates a majority of providers are in the private rather than public sector. Stakeholders indicated that the public sector, such as governmental agencies, are important sources of information, be it relating to climate or not. One stakeholder explains ‘Operations use geological surveys and ministries of environment, as mining is [often] linked to national government.’ Even when mining is privatised, national meteorological offices were also often mentioned as a first point of call for information. In Finland, for example, stakeholders referred to the use of data and information from the Finnish Environment Institute SYKE (Suomen ympäristökeskus) and the Finnish Meteorological Institute (FMI). In the UK, the UK Met Office is a provider to mining sector. Finally, another climate services provider is the non-profit organisation BSR. BSR are a global organisation with offices in Denmark, US, France, China, and Japan.
<table>
<thead>
<tr>
<th></th>
<th>Climate service provider known to serve the mining sector</th>
<th>Location (Headquarters)</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acclimatise</td>
<td>UK</td>
<td><a href="http://www.acclimatise.uk.com/">http://www.acclimatise.uk.com/</a></td>
</tr>
<tr>
<td>2</td>
<td>AllEnvi - Alliance nationale de recherche pour l'environnement</td>
<td>France</td>
<td><a href="https://www.allenvi.fr/">https://www.allenvi.fr/</a></td>
</tr>
<tr>
<td>3</td>
<td>Barcelona Supercomputing Center – BSC</td>
<td>Spain</td>
<td><a href="https://www.bsc.es/">https://www.bsc.es/</a></td>
</tr>
<tr>
<td>4</td>
<td>Climate Northern Ireland</td>
<td>UK</td>
<td><a href="https://www.climatenorthernireland.org/">https://www.climatenorthernireland.org/</a></td>
</tr>
<tr>
<td>5</td>
<td>Danish Nature Agency</td>
<td>Denmark</td>
<td><a href="http://eng.naturstyrelsen.dk/">http://eng.naturstyrelsen.dk/</a></td>
</tr>
<tr>
<td>6</td>
<td>DHI Group</td>
<td>USA</td>
<td><a href="https://www.dhigroup.com/">https://www.dhigroup.com/</a></td>
</tr>
<tr>
<td>7</td>
<td>EcoAct</td>
<td>France</td>
<td><a href="https://eco-act.com/">https://eco-act.com/</a></td>
</tr>
<tr>
<td>9</td>
<td>Jacobs (previously Enviros (aka SKM Enviros)</td>
<td>UK</td>
<td><a href="http://www.jacobs.com/">http://www.jacobs.com/</a></td>
</tr>
<tr>
<td>10</td>
<td>European Centre for Medium-ranged Weather Forecast</td>
<td>UK</td>
<td><a href="https://www.ecmwf.int/">https://www.ecmwf.int/</a></td>
</tr>
<tr>
<td>12</td>
<td>ICF</td>
<td>USA</td>
<td><a href="http://www.icf.com">www.icf.com</a></td>
</tr>
<tr>
<td>14</td>
<td>Previmeteo</td>
<td>France</td>
<td><a href="https://www.previmeteo.com/">https://www.previmeteo.com/</a></td>
</tr>
<tr>
<td>16</td>
<td>TERRA SPATIUM, Geo-information and Space Products &amp; Services S.A.</td>
<td>Greece</td>
<td><a href="http://www.terraspatium.gr/">http://www.terraspatium.gr/</a></td>
</tr>
<tr>
<td>17</td>
<td>Trinomics</td>
<td>The Netherlands</td>
<td><a href="http://trinomics.eu/">http://trinomics.eu/</a></td>
</tr>
</tbody>
</table>
4.3 Unmet needs

Unmet needs are difficult to summarise across the vast scope of this case study. Responses varied greatly between stakeholders. There is a notable gap in awareness and knowledge around physical climate risks and the benefits of using climate service in the sector. Instead, the sector tends to have a fixation with carbon risks, as discussed in Section 6 (page 31). As such many stakeholders were unable to express unmet needs, because they have not started using climate services. Several stakeholders who are further along in their use and understanding of climate data and information indicated they have sufficient access to what they need, and just a few were able to highlight examples of unmet needs.

The market research provided by other MARCO deliverables has not been presented in a format which makes analysis of purchases (demand) and provision (supply) easy to reconcile. This section would benefit further if definitions of climate service type or application in D4.3 were provided, for example. Nevertheless, several unmet needs were clearly highlighted by stakeholders, including:

- Short to medium term forecasts of extreme rainfall appear to be a persistent unmet need. In particular, stakeholders indicated at present they are not able to access sufficient forecasts on the intensity and duration of extreme rainfall events.
- Stakeholders also indicated there was a need for numerical values to be provided along with visualisations of seasonal forecasts, with uncertainty ranges included.
- Accuracy and uncertainty were recurring themes for datasets with longer time frames, such as seasonal forecasts through to climate model projections. One stakeholder stated, for example, ‘What would really change the playing field would be that we can say that the climate predictions are more certain than uncertain.’ Another pointed out that accurate one-year precipitation forecasts would be very useful.
- With regard to general feedback on the means for data provision, stakeholders were interested in a centralised portal where a variety of climate data and information on physical climate risks could be easily accessed, affordable, and in one location. One stakeholder mentioned an issue they perceive is keeping up to date with all of the new climate data and information, including climate model outputs, for example, and indicated the usefulness of a trusted current source of this information.

Despite this gap analysis lacking adequate data to provide a complete picture of unmet needs in the mining sector, there is an indication that the sector would greatly benefit from a Climate Services Observatory. Stakeholders highlighted the need for a centralised place for data to be published, where it could be verified that they have the latest information.

5 Framework Conditions

This section reviews provides and extensive review of sector-relevant factors which may be influencing the uptake of climate services in the mining sector - positively or negatively. This includes a range of conditions such as governance structures and strategies, technological developments, finance, capacity, knowledge and research, and normative conditions. See Section 12, (page 42) for a table summarising the analysis, including a list of which documents and evidence were reviewed.

5.1 Governance

5.1.1 Adaptation policies and climate risk strategies

At the international level, the 2015 Paris Agreement of the UNFCCC process (agreed at COP 21) has helped place climate change adaptation on the agenda, alongside a long-running focus on climate change
mitigation (UNFCCC, 2015; stakeholder interviews, 2017). Countries submitting Nationally Determined Contributions (NDCs) as part of that process are now often including elements on climate adaptation goals and targets. A recent study of climate legislation has found that around 65 countries have at least established frameworks for adapting to the impacts of climate change (Nachmany & Fankhauser, 2016). This growing body of adaptation frameworks provide the backdrop against which corporates now operate, at very least increasing awareness of the need to manage physical climate risks.

Many mining majors operate on a global scale, and therefore may not be uniformly impacted by these varying adaptation policies. Multi-national firms, have, however, begun to develop their own internal climate risk management strategies. For instance, Glencore has developed a framework to identify, understand, and ultimately manage climate-related challenges and opportunities facing their portfolio. Glencore’s framework includes considerations of government policy, energy costs, physical impacts, stakeholder perceptions, market impacts of climate change. Other majors such as BHP Billiton and Rio Tinto have shown leadership in this respect as well. While there are a few publicly-available instances of company-specific policies or frameworks on climate-risk management, which could indicate a growing demand for relevant climate services, the existence of these self-published frameworks should not always be taken as an indication that they have been implemented. These strategies are by no means standard practice across the sector, with major mining companies potentially more motivated and able to develop and implement such a framework, than smaller operations.

5.1.2 Climate risk disclosure frameworks

It is noteworthy, however, that Glencore’s above-mentioned framework is aligned with the Task Force on Climate-Related Financial Disclosure (TCFD) recommendations. Set up by the Financial Stability Board (FSB) in 2015, chaired by Michael Bloomberg, the TCFD published a framework for reporting both climate-related risks and opportunities that stem from both transition and physical climate risks in 2017\(^5\). The new TCFD recommendations are designed for use across all sectors, with special guidance provided for key sectors, including (TCFD, 2017). The intention is investors and financial institutions will use corporate disclosures to factor in climate risk in a more comprehensive way in their decision-making (IIGCC, 2017). Despite the TCFD recommendations’ voluntary nature, this initiative is an effective governance structure and will positively influence the uptake of climate services in the mining sectors, among others. The initiative builds on other voluntary disclosure schemes such as CDP (formerly the Carbon Disclosure Project) in its clarity and relevance for investors. While Glencore’s link to the TCFD recommendations is a positive sign that the firm is taking them seriously, reception of the TCFD recommendations among smaller organisations is not known. During stakeholder interviews, for instance, several of the smaller mining firms had not yet heard of the recommendations. This is expected to change as there is now widespread support for the recommendations.

Also, of note is the mandatory climate risk disclosure framework that has emerged in France. France is the first country to mandate reporting by financial institutions on (1) how they integrate environmental, social and governance (ESG) factors into their investment policies, and (2) how climate change considerations are incorporated (Rust, 2016; Sustainable Investment Forum - France, 2016). There is mounting evidence other European Member States such as Sweden and the UK may be eventually pursuing similar climate disclosure regulations in the near future. Together, voluntary and mandatory disclosure frameworks will be key drivers of climate services uptake in sectors across the economy, including mining.

\(^5\) The TCFD was established at the behest of G20 Finance Ministers and Central Bank Governors. It recommends that organisations analyse and disclose against the following four categories: Governance: Disclose the organization’s governance around climate-related risks and opportunities; Strategy: Disclose the actual and potential impacts of climate-related risks and opportunities on the organization’s businesses, strategy, and financial planning where such information is material; Risk management: Disclose how the organization identifies, assesses, and manages climate-related risks; Metrics and targets: Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
5.1.3 Mining closure and extractive waste management policies

Stakeholder interviews confirmed other legislation in Europe such as the Extractive Waste Directive 2006/21/EC\(^6\) could be influencing the use of climate-related data and information (though rarely were the terms ‘climate services’ used). The Directive is aimed at managing waste in both operational and closure stages of mining operations. It has been transposed into laws in Member States in various ways- including into environmental permitting regulations, which could require the use of climate information during the analysis, such as changing climatic conditions over the full lifecycle of an operation and its tailing ponds. The Directive does not directly imply that climate projections or climate data needs to be considered, however.\(^7\)

A 2017 study (European Commission, 2017a) on the implementation of the EWD indicated that despite it being integrated in the national legislation of EU Member States, there is not sufficient data to verify that waste management plans (WMPs) have the minimum content as set out in Article 5. There are also very few examples of national-level guidance documents for the preparation of WMPs. At Member State level, then, there appears to be patchy implementation of directives relating to the industry. Yet there is indication that several Member States have put forth strong governance structures/governance frameworks are at least in place. In Finland\(^8\), for example, an action plan published by a government agency (Ministry of Employment and the Economy, 2013) indicates mining companies must manage their operational risks to the environment in order to be in compliance with regulations, avoid liabilities and maintain a social license to operate.

Other examples of guidance on mine closure and mine closure planning include those from international organisations such as World Bank or the International Atomic Energy Association (IAEA, 1994; World Bank, 2010). At the national level, examples of guidelines include the Finnish Mine Closure Handbook or Swedish Guidelines (European Commission DG Environment, 2012b). In addition, larger mining companies have developed their own company-specific guidelines for mine closure planning, implementation and follow-up. As the environmental risks associated with extractive waste, both during operation and post-closure are extensive, good planning around these risks requires consideration of climate-related data and information. See Table 6 (Section 12.4) for more information on potential impacts associated with extractive waste and examples of potential climate services which could be used to manage these impacts.

5.1.4 Environmental Impact Assessments

EIAs are not necessarily mandated in all European countries, as the European Union’s EIA directive leaves it to the discretion of member states to determine if extractives operations and related waste management facilities need to conduct an EIA in planning stages (European Commission, 2017c; European Council, 2011). Regardless, stakeholders did express a need for climate services in the context of EIAs. There are numerous guidelines for the inclusion of climate considerations in EIAs, in Europe (McGuinn et al., 2013), in the US , and internationally (c.f. Columbia Law School, n.d.). Section 4 discusses this further.

5.2 Technology

The mining sector is not generally known for strong investment in innovation, nor a willingness to openly discuss new technological advances, perhaps due to the competitive nature of the sector, according to

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\(^6\) Also referred to as the Mining Waste Directive

\(^7\) Article 4 of the Directive states requires Member States to take ‘the necessary measures to ensure that extractive waste is managed without endangering human health and without using processes or methods which could harm the environment, and in particular without risk to water, air, soil and fauna and flora, without causing a nuisance through noise or odours’ and Article 5 sets out requirements for waste management plans (European Council, 2006).

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stakeholder interviews (2017). New technologies relating to climate change or the environment, where they can be found, have tended to focus on resource efficiency (EY, 2016) rather than on improving understanding of climate impacts on a mining operation.

The plethora of programmes and initiatives in the sector which seek to increase technological advancements and innovation are a prime example of the sector’s focus on resource efficiency. The Finnish action plan for sustainability in the extractive industry, which encourages technological advancements in the sector, for example, focusses on resource efficient behaviour and planning around water use by stakeholders (Ministry of Employment and the Economy, 2013). The European Technology Platform on Sustainable Mineral Resources exists to create sustainable mineral resource potential in Europe, and does this by participating in EU-funded projects relating to sustainable mining, and contributing to EU mining-related policies such as the Research and Innovation Roadmap 2050 for the European Raw Materials sector (ETP SMR, 2017). While this platform could indicate a potential venue for further of dissemination of climate data and information, most initiatives the organisation appears to be participating in involve technological developments around lowering the impacts of mines.

Many of the projects funded under the Horizon 2020 Societal Challenge on Climate Action, Environment, Resource Efficiency and Raw Materials 2016-17 work plan involve development of automated or modular technologies such as remote exploration devices, or portable equipment (c.f. the IMP@CT project, which develops modular mining plant) (European Commission, 2016; IMP@CT Consortium, 2017). Other evidence of technological advancements appear to relate to re-purposing of abandoned mines (Directorate-General for Environment, 2011) or reducing greenhouse gas emissions of mining operations such as carbon and methane (Smith, 2016). Perhaps overarching changes in exploration and extraction techniques, such as automation, could help shape the types of climate data and information needed, however, in the near and more distant future. In the broadest sense, for example, mobile equipment may face fewer climate-relate risks if it can be moved to a safe location during storm events.

Despite the presence of technological advancements and initiatives in the mining sector, there do not appear to be many technological factors directly driving the uptake of climate services in the sector at present. One exception is the MiCA data tool, as discussed in Box I (see Section 3). This software development has fostered a direct increased use of climate data and information, though this type of development is uncommon.

5.3 Finance

There is a growing awareness of climate risk associated with mining operations, by investors in and insurers to the sector. In 2016, for example, Rio Tinto’s shareholders, comprised of the UK’s ‘Aiming for A’ coalition (which includes the Local Authority Pension Fund Forum, members of the Church Investors Group and Hermes Investment Management) requested the board and shareholders to support a climate change resolution (MinterEllison, 2016; Rio Tinto Limited, 2016). The mining major published a supplementary report to its sustainable development report in as a partial response to the shareholder requisition (Resolution 17), setting out a commitment to analysis and disclosure of climate risks and impacts. This direct pressure from shareholders around environmental disclosure mirrors that seen in other sectors such as oil and gas, and indicates a growing demand for more climate risk analysis, which will certainly drive the need for climate services in the mining sector.

5.3.1 Climate risk disclosure regime for financial decision-making

Institutional investors with long term investment horizons, including pension funds, have long-since expected mining companies to adopt sustainable practices to mitigate and adapt to climate-change related impacts such as changes in water availability. Yet when determining a company’s value, analysts consider
economic and commodity cycles and valuation models do not presently account for the uncertainty in a mining company's ability to access adequate water resources. A production disruption, or temporary closure due to a lack of water resources, can drastically impact revenue, profit margins, future cash flow, and the ultimate valuation of a company (CDP, 2013). Disclosure of business-critical water-related information is not a uniform practice across the sector. The Task Force on Climate-related Financial Disclosures (TCFD) recommendations, as mentioned above as a governance framework condition, complements other disclosure initiatives which primarily focus on carbon reporting, such as CDP. The TCFD recommendations are expected to empower investors by providing them with a framework to ask for improved information around current and potential climate risks facing the mining sector (and others) (TCFD, 2017), and is expected to contribute to an upward trend in climate data and analysis in the sector.

5.3.2 Pressure from the insurance sector

Other financial services actors such as insurers and re-insurers are similarly placing pressure on the mining sector. Greater intensity and damage from extreme weather events has led to an exponential increase in weather related insurance and re-insurance costs over the last 50 years. Unmitigated climate change is forecast to contribute to continuing this trend leading to ongoing increases in insurance costs (Smith, 2016). Insurance companies have stated the terms and conditions of insurance contracts will change in response to climate change. This includes insurance premiums, exclusion clauses, and at times insurance availability.

5.4 Capacity

Mining companies will have differing capacity to either analyse internally, or procure external climate-related data and information and analysis. Several stakeholder interviewees discussed the wide range of actors present in the sectors, indicating that varying capacities available in the sector translates into varying access and to uptake of climate data and information. Mining majors may have staff familiar and competent in climate analysis, whereas there are parts of Europe with numerous small-scale rural operators with little to no staff available for this.

Stakeholders interviewed for this case study indicated that a majority of forecasting and planning analysis, where climate data and information is used, is external to their organisations due to lack of internal capacity to analyse this information. This may be due to the small and medium size of these organisations; larger firms may have more capacity for internal analysis. For more integrated or routine analysis of climate impacts in day to day operations/monitoring of impacts, it may be the case only larger firms have enough staffing resources. There is evidence of ongoing efforts to improve the capacity of mining organisations to utilise climate data and information including training and research programmes, as discussed in the next section.

5.5 Knowledge and research

The presence of existing knowledge infrastructures, as well as specific research relating to climate impacts on the sector indicate that there are many knowledge and research factors that are contributing to the uptake of climate services. The presence of long-standing infrastructures where information is disseminated, (climate-related or not), for example, indicate good potential for future dissemination of climate-related information. For example, the sector has well-established conferences where knowledge exchanges can occur, such as the annual Aachen International Mining Symposia (AIMS). Portals such as the Extractives Hub (Extractives Hub, n.d.) also indicate knowledge sharing efforts are present in the sector.
There are also numerous examples of knowledge and research specifically relating to climate impacts on the mining sector. ICMM’s programme of work focusing on climate change, established in 2011 has led to several detailed reports and analyses around climate change impacts and the mining sector (ICMM, 2011). The Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia and the Canadian Mining Industry Research Organisation (CAMIRO) also operate several research programmes involving climate impacts to the sector. While these are outside of Europe, the international nature of the sector, and the public nature of the knowledge produced means that lessons from those organisations may be transferring to European mining firms. Knowledge and information is also directly shared between Canadian and German and Australian firms, via the Canadian-German and German-Australian bilateral competence centres established there (Canadian German Chamber of Industry and Commerce, n.d.; German-Australian Chamber of Industry and Commerce, n.d.). Within Europe, sector associations at the European and national levels, as reported by stakeholders, hold frequent guest speakers on areas of interest for their members, which is an important potential channel of climate data and information. The stakeholder explains:

‘We arrange often 1-2-hour Skype meetings, where we bring an external expert to tell us about some topic. This way we bring information and knowledge to relevant actors around the country. This is professionals talking to professionals, but also marketing of the relevant information. May provide new insights and get the people in the field thinking that something is an issue to be solved.’

5.6 Normative

5.6.1 Minimising environmental impacts of the sector

A shared desire to mitigate environmental impacts has emerged. Euromines, the European Association of Mining Industries, Metal Ores & Industrial Minerals, for example, works to help minimise environmental impacts of the industry, also working to re-cast it as environmentally friendly etc. This could at very least put climate issues on the agenda for organisations, where they would not have been before. While it may have worked to place carbon management on the agenda, it is not clear if this has yet to place climate impacts or needs for adaptation on the agenda (and therefore climate services). The desire to reimagine the image of the sector, however, was mentioned by many of the stakeholders interviewed.

At the international level, ICMM has programmes directly related to minimising environmental impacts of the sector, as well as addressing both climate change mitigation and adaptation. In the lead up to COP 21, ICMM released a statement on climate change, where members publicly endorsed the notion that ‘climate change is an undeniable and critical global challenge, and its causes must be addressed by all parts of society. ICMM member companies are committed to ‘being part of the solution.’’ (ICMM, 2015).

At company level there is ample evidence among the mining majors, such as Rio Tinto, of a desire and commitment to mitigating environmental impacts. For example, Rio Tinto’s Sustainable Development Report includes a commitment to protecting the environment, which states ‘In planning and operating our assets, we seek to avoid, prevent, mitigate and remediate the environmental impacts of our activities. We work with our host communities and regulators to manage and monitor these and to comply with relevant regulations’ (Rio Tinto, 2017).

5.6.2 Social license to operate

The desire of the sector or mining companies to manage and maintain their social license to operate – or their ‘level of acceptance or approval by local communities and stakeholders of mining companies and their operations’ (Fraser Institute, 2012) could also be influencing mining companies’ use of climate services in the future. BHP Billiton’s 2016 report, Community: Our Requirements states, ‘We believe in developing
strong, mutually beneficial relationships with communities, regions and countries where we do business and contributing to their economic and social development. We also understand and minimise adverse social and human rights impacts from our activities’ (BHP Billiton, 2016). As mining operations are continuing to extend their focus on issues beyond of the fence line in order to consider the impacts of their operations on communities and ecosystems, this could mean more, or different types of climate-related information may be required.

5.6.3 Health and safety
Convergence on standards for health and safety is also a normative condition to consider. Strong health and safety concerns or a desire to proactively manage health and safety issue could be driving the uptake of climate data and information, both now and in the future. For example, climate-related risks include higher risks of more days over 35 degrees Celsius, coupled with high levels of humidity, or more intense rainfall events and flooding. These could lead to increased heat-related illness and decreased on-site employee safety, respectively (Smith, 2016). The sector’s desire to manage health and safety risks such as these could be potentially driving the uptake of information relating to heat waves or precipitation in turn.

6 Attitudes to Climate Risk

6.1 Varying perceptions by region
In Canada, climate change and its physical impacts were found to be perceived as a threat to operations (Ford et al., 2010). Another study (Delphi Group, 2014) builds on this work and indicates that climate change is not perceived as a high risk in the Canadian mining sector, with around one-third of companies designating climate change only as a medium- to low-level risk for their business operations. Despite this, climate change risks appear to be factored into infrastructure design for around half of the group in the study. This is perhaps due to other factors including regulatory requirements rather than perceived risk (ibid). Northern European stakeholders, confirmed many mining organisations in their region take climate risks very seriously; there appears to be a strong perception of climate risks in Northern Europe.

One Eastern European mining firm, on the other hand, confirmed they do not believe they have experienced any adverse physical impacts of climate change to their core operations. They believe climate change is incremental and are not concerned about the impact of these incremental changes or future extreme events to their primary location. When considering their satellite operations, which operate in drought-stricken zones in North and South America, the firm was also nonchalant about climate-related risks, saying these regions ‘have always been dry, they are used to this’, suggesting their international operations may already be well-equipped to handle impacts. The firm did confirm, however, that the decentralised management of these branches located outside of Europe may mean they are not certain about how these locations perceive climate risks.

In Australia, a set of Commonwealth Scientific and Industrial Research Organisation (CSIRO) studies found that while perception of climate risk may have increased in the few years between the studies, there appears to be a ‘decline in the perceived level of importance of climate change to the [study] respondents’ own organisation’ (Loechel & Hodgkinson, 2014; Loechel, Hodgkinson, & Moffat, 2013). So, while climate change is seen as a risk, it may not be leading to demand in climate services since the risk may not appear as material. Interesting to note in these Australian studies (Loechel & Hodgkinson, 2014; Loechel, Hodgkinson, & Moffat, 2013), however, is the gap between mining companies’ perception of risk and that of the local government jurisdictions affected by mining operations. Local governments were found to be much more concerned with physical climate impacts on their organisation than the mining companies were found to be.
A South African firm interviewed for this case study also put forth a hesitation about climate risks, citing uncertainty about the materiality of climate impacts. Their hesitation was that addressing climate change might require investment, and they were uncertain that investment in climate services would pay off. While they did perceive climate change as a risk to their operations, it was not yet perceived as material enough to warrant the needed investment.

6.2 Concerns around carbon risk and mitigation
Greenhouse gas emissions and climate mitigation was mentioned in all 20 stakeholder interviews, without prompting. This indicates that climate mitigation is a strong, clear, known risk in the sector, perhaps more than physical climate change risks. At least one mining firm explicitly mentioned their concern around carbon emissions as their main climate related consideration. For that stakeholder, the need for data and services are more to do with legislation relating to carbon emissions, and less to do with physical climate change impacts. There were no references to any synergies between climate mitigation and adaptation, or the management of carbon risks and physical climate risks. The fixation on carbon risks is an important barrier to the uptake of climate data and information in the sector.

6.3 Size of organisation
There are some indications that size of organisation could have an impact on perception of climate risk. There are different ways that an organisation’s size influences its perception of climate risk – size can influence capacity for analysing climate risks. As one stakeholder put it: ‘there are two groups of mining companies [in Europe], large international companies with departments that deal with environmental impacts, and smaller ones without manpower or capacity to think or address issues such as climate change’. Size of organisation would impact the perceived and actual climate risk, and perhaps need for climate services by extension. Alternatively, size of organisation can be a factor in determining which climate risks are critical. For example, one stakeholder confirmed: ‘Companies, especially smaller ones, might be interested in impacts to their supply chain, such as in the European transportation network, for example’. These smaller companies are less diversified, so the level of criticality is high for certain transportation routes, which could lead to more interest in climate data and information needed to determine potential impacts to these routes.

6.4 Extreme weather events
The occurrence of extreme weather events in recent years appears to influence perceptions of climate risk in mining companies: ‘companies that have experienced more extreme weather events over the last five years were more likely to assess climate change as a business risk and take actions to mitigate those risks’ (Delphi Group, 2014). Stakeholders from the Northern European region often mentioned the Talvivaara incident where flooded tailings ponds release large quantities of toxic discharge in the local environment, ultimately leading to the prosecution of executives for environmental crimes. The excessive flooding has been attributed to extreme rainfall in the region. One stakeholder stated ‘Talvivaara raised awareness, also within authorities. Everyone was made to think more about these issues. The risks are now analyzed in more detail.’

7 Obstacles and Drivers to Climate Service Take-up

7.1 Current key obstacles
The perception of physical climate change as a material risk is mixed in the sector and appears to be generally low overall. Other areas of climate risk, such as carbon risk, are still piquing more interest than physical climate change risk as well. For instance, all of the 20 stakeholder interviews included an
unprompted discussion of carbon management and climate change mitigation more generally, indicating transition and carbon risks are at the forefront of their minds. Mitigating greenhouse gas emissions is still the primary focus of the sector when it comes to climate, and overall climate services use is latent. In instances where climate change is seen as a risk in terms of potential physical impacts, there appears to be more concern around potential extreme events, and less awareness and interest in incremental climate change. That is to say, there does not appear to be a clear culture of managing physical climate risks in operations. This could be retarding current growth in the mining-related climate services market, as procurement of climate services on a regular basis may not be seen as necessary.

Capacity both to procure and to process climate data and information is likely inhibiting the mining climate service market. Cost of climate services data above and beyond what is required by regulations such as planning and permitting (as discussed below in section 7.2) appears to be of concern for stakeholders, who are facing pressure to justify data and analysis expenditures. Low risk perception comes into play here, as those who may regard their operation’s climate risk as low, despite evidence otherwise, may discount the value of climate services. Some organisations may simply not be able to afford data or analysis above the what is needed for planning and permitting, even if there is a strong perception of physical climate risk.

The confusion around the term ‘climate service’ may not be a complete barrier to the development of the mining climate service market, though remains an important point to consider for those interested in the market’s development. Most stakeholders interviewed for this study had never heard the term ‘climate services’ before our interviews. It should be noted that this study was not able to access and interview mining majors, who are likely more aware of this terminology and engaged in proactive physical climate risk management. This should not be taken to mean the sector is not procuring what can be categorised as climate services. As the MARCO deliverables 4.2 and 4.3 indicated, the sector is indeed purchasing climate services. The confusion around the ‘climate services’ term indicates there may be work to be done to improve understanding of this terminology – by both mining climate service providers, and by users themselves. It will be important for the providers of climate services, and any effort to measure or observe this procurement (such as a climate services market observatory) to be aware of this dynamic.

7.2 Current key drivers

The planning, operation, and long-term closure phases of mining facilities often necessitate impact assessments and permitting, which rely on a multitude of climate-related data, projections, and information. This is primarily due to statutory requirements, to the extent they exist, that govern mining waste management, environmental management, and water abstraction. There is evidence of new technologies which move beyond tailing ponds, which could eventually reduce or change the mining waste management (e.g. tailing ponds) regulatory requirements and therefore change this driver (c.f. Davies, 2011; Outotec, n.d.). It is, however, expected that permitting and impact assessments around water-covered tailing ponds will continue to help drive the need for long term climate analysis in the sector.

Previous climate-related disasters have raised awareness in mining companies to improve understanding of potential climate risks, and as such could be influencing the uptake of climate services. This was the case in Northern Europe after the Talvivaara disaster, for example. After that disaster, even mining companies who were not directly affected began to understand the need for analysis and planning around future hazards, leading to an uptake of climate data and information in that region (stakeholder interviews, 2017).

The presence of sector associations such as The International Council on Mining and Metals (ICMM) are also driving the uptake of climate services. The organisation’s public endorsements and commitments to climate action, and the way it provides mining companies an opportunity to pool resources for the procurement of climate services are allowing its members more readily access climate services such as
tools (e.g. MiCA), guidance and training. ICMM members include large mining majors, however, and may not be representative of the numerous smaller mining actors in Europe and beyond. These mining majors, however, are helping to set the tone in the sector, taking a leadership role, and acting ahead of governments in many cases, on climate action. Other sector associations also allow for important knowledge sharing to occur, by providing and maintaining education networks.

8 Conclusions and Recommendations to Enhance Climate Service Take-Up

8.1 Looking Ahead: Climate Service Demand 2030

Despite the current latent demand for climate services in the mining sector, there are clear indications the demand for climate services will increase by 2030. Climate science shows that despite efforts to mitigate climate change, we are on the path of unavoidable climate change, including both incremental changes and extreme events. The sector is particularly sensitive to these changes, and despite efforts to adapt, climate change will impact the sector. At the same time that climate change will likely continue to impact the sector, the need for raw materials will not likely decrease. Some mining has to be a local activity, due to high shipping costs, so despite political and market pressures which may slow the growth of coal or metals extractive sub-sectors, mining of aggregates and critical raw materials will continue in Europe out to 2030 and beyond. That continuity means at very least a potentially steady demand for climate data and information used in planning and permitting stages of those operations.

More important, however, are overarching changes to the way climate adaptation and physical climate risk is seen globally. Placing climate adaptation firmly on the agenda, COP 21 helped to crystallise efforts to analyse and manage all climate risks, not just carbon risks and climate mitigation. This conference and the Paris Agreement have helped crystallise private sector action on climate risk governance such as the TCFD recommendations (see section 5). These recommendations with their framework for climate risk and disclosure, including physical climate risk will eventually lead to better and more transparent analysis of physical climate risks in the sector, not the least because financers will come to expect these disclosures, and could do so as a condition of future loans. There will be number of years before corporates, including those in the mining sector, actively analyse and disclose climate risks via the, for example, TCFD recommendations, though this is expected to be well under way by 2030. All of this analysis will require a potentially considerable increase in the provision of climate data and information, so these changes in governance are crucial for the growth of the mining climate services market by 2030. Climate services are needed in all stages of a mining project and these are typically advisory services-related. There is also a strong opportunity for the provision of climate and earth observation data, as the sector’s interest in managing operational risks may grow.

8.2 Recommendations to Enhance Climate Service Uptake

This study has led to a set of recommendations aimed at governments, mining companies, and other stakeholders to encourage the growth of the mining climate services market, which are as follows:

1. Open up core climate data. Making data on climatic variables more accessible could encourage further analysis and development of products and services by climate service purveyors. This recommendation is aimed at governments and public bodies primarily.
2. Work to build up a business case for climate services, and then move to build internal capacity to take on board climate data and information. This will require internal awareness raising within mining companies, and perhaps prototyping the use of climate services for strategic facilities to prove the concept. Proof of concept should be used as the foundation of further capacity building that is needed to utilise and eventually integrate climate data and information into operations.
Governments should consider facilitating or incentivising prototyping and further training for end users of climate data.

3. Use existing networks and structures in the sector to further disseminate information around climate risk and best practices for utilising climate data for decision-making. Encourage coordinated education and action at the sector level through national and international sector bodies (e.g. Euromines, ICMM, or local-level bodies). Sector associations could consider how to be inclusive of smaller organisations. This may require creative solutions such as incentivisation or sponsorship of smaller mining companies.

4. Consider the perspective of end-users, including considerations of company risk management practices, key performance indicators, and framing questions in the sector’s terminology. The starting point could be less ‘how do I proactively manage climate risks’ and more ‘how do I plan for x amount of rainfall over the next year’ or ‘how would drought impact my ability to meet discharge consent limits that I manage’. Presenting information in local languages is also recommended where possible. There will potentially be many nuanced needs of each mining sub-sector, each region, and company. These diverse needs should not be overlooked by providers of climate data and information.

5. Tap into evolving governance trends in the sector. The TCFD recommendations, as discussed in the Framework Conditions analysis (Section 5), has set the stage for explicit climate risk disclosure in the mining sector. Mining companies will be increasingly expected to analyse and report their climate risks, for more than just a one-off instance as is the case with conventional regulation such as impact assessments. Climate service providers to the mining sector should orient their services toward this framework. Governments may soon be obliging their financial sectors to consider and disclose climate risk in order to prevent financial harm to investors or physical harm to society, as is the case in France currently. This could lead to increased engagement with the mining and other sectors by financial institutions on their climate risks, and therefore could drive climate services uptake.

8.3 Conclusion

This study is the first of its kind in assessing the mining climate services market and has is the first attempt to establish an approach to review and monitor this climate services market segment. Other efforts which provide case studies on climate services use (c.f. Climate Services Partnership, 2018) do not include the mining sector. This study has reviewed the sector, climate impacts it could face, examples of current demand and supply, and provided an in-depth review of factors such as governance, knowledge and research, and norms which allow for the sector’s motivations around climate services to be established. This has led to a number of conclusions about current drivers and barriers to use, as well as produced a set of recommendations to enhance climate service uptake in the mining sector.

This case study indicates that a Climate Services Observatory could be useful to mining climate service users and potentially providers. This study found there is already limited demand primarily through the purchase of climate information for statutory needs, and also by leading international mining companies that are already mainstreaming climate risk considerations and are making site-specific risk assessments. Stakeholder interviews indicated the sector would welcome a single location, such as an Observatory, which brings together an overview of a range of types of climate data and services that are available, relevant, and tailored to them. Users could benefit from seeing examples and case studies of climate service use. An Observatory might also further improve the sector’s understanding of the terminology ‘climate services’ as well as it would help focus attention on physical climate risks to the sector, helping to differentiate this from the carbon and energy transition risks. Beyond this, the observatory would help grow the climate services market by matching up users with providers beyond the hydrological and meteorological offices which might have been a typical first port of call.
9 Gender Dimensions in the Mining Sector and in this Study

The mining sector as defined in this study included 17,711 enterprises in 2015, employing 414,938 persons. The gender breakdown is not known in Europe though worldwide it is rare to find companies with higher than 10% female employment, with many being less than 5% (Eftimie et al., 2009). Stakeholder engagement in this case study attempted to achieve gender parity. Interviewees, however, were 80% male, and 20% female. 16 stakeholders from within the mining companies themselves were all men. The four women participants were all working for sector associations which serve different aspects of the mining sector. It is not possible to determine the gender makeup of climate service suppliers. An anecdotal example, however, comes from within Acclimatise – both the mining case study leader and supplier to the mining sector. Acclimatise have more than 50% women employees. The team conducting this research was led by a female, and was comprised of three females and three males. Interviews were conducted by both males and females.

10 Evaluation of Study

This case study took an inclusive approach in terms of scope, analysing the climate services potential in the European and some segments of the international mining sector. This approach may have overlooked nuances present in the sector, such as attitudes to risk or potential climate sensitivities, and ultimately climate service needs. These will be highly context specific, varying by attributes such as location, company size and commodity type. In aggregating information on the framework conditions facing the sector for the uptake of climate services, motivations to use climate services such as local level policy or local research and knowledge may not have been captured completely due to the case study’s wide scope. This high-level approach was adequate for a first attempt at looking at the climate services needs of the mining sector, especially as the sector is cross-boundary and international in nature. In future, however, it would be worth narrowing the scope to a smaller subset of countries, or type of mining (e.g. by commodity) and preferably those with sufficient transparency.

Another issue facing this case study, regardless of the scope, is the lack of engagement with this project in the sector. Generally, companies within the sector were not found to be responsive, or accessible for interview/engagement. More often than not, sector associations or those on the margins of the sector, such as academics, were more amenable to participate in the case study. As stakeholder engagement included a small number of mining companies, the findings of this study can only be taken to be a typical indication of the sector’s needs, rather than a full representative view. No mining majors were able to participate in this study, for example. The study was able to engage with ICMM, however, which generally represents the perspective of larger, more international mining firms.

There are notable concerns around the data provided on the mining climate services market, as discussed in Section 4. In future analysis of the mining climate services market, it is recommended to improve market quantification in a manner that allows for a more complete gap analysis of climate service provision to the mining sector.
11 Appendices

11.1 Stakeholders Interviewed

Stakeholders have preferred to remain anonymous in this study. General attributes of the stakeholders such as sector, NACE code, user status, and gender are provided in Table 4.

Table 4: Stakeholders interviewed

<table>
<thead>
<tr>
<th>Number</th>
<th>Sector</th>
<th>NACE Code</th>
<th>User/supplier</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Public research organisation</td>
<td>M72.1</td>
<td>User/purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>2</td>
<td>Mining-related consulting</td>
<td>M74.9</td>
<td>Supplier</td>
<td>Male</td>
</tr>
<tr>
<td>3</td>
<td>Mining-related consulting</td>
<td>M74.9</td>
<td>User/purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>4</td>
<td>Sector association (Mining)</td>
<td>S94.2</td>
<td>User/purveyor</td>
<td>Female</td>
</tr>
<tr>
<td>5 and 6</td>
<td>Sector association (Mining)</td>
<td>S94.2; P85.59</td>
<td>User/purveyor</td>
<td>Female</td>
</tr>
<tr>
<td>7 and 8</td>
<td>Mining company</td>
<td>B07</td>
<td>User</td>
<td>Male</td>
</tr>
<tr>
<td>9</td>
<td>Academia</td>
<td>M72.2</td>
<td>Supplier</td>
<td>Male</td>
</tr>
<tr>
<td>10</td>
<td>Re-Insurance</td>
<td>K65.2</td>
<td>User/purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>11</td>
<td>Academia</td>
<td>M72.1</td>
<td>Supplier</td>
<td>Male</td>
</tr>
<tr>
<td>12</td>
<td>Sector association (Energy)</td>
<td>S94.2</td>
<td>User</td>
<td>Male</td>
</tr>
<tr>
<td>13</td>
<td>Sector association (Mining)</td>
<td>S94.2</td>
<td>User/purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>14</td>
<td>Mining company</td>
<td>B08</td>
<td>User</td>
<td>Male</td>
</tr>
<tr>
<td>15</td>
<td>Sector association (Mining)</td>
<td>S94.2</td>
<td>Purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>16</td>
<td>Sector association (Mining)</td>
<td>S94.2</td>
<td>Purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>17</td>
<td>Mining company</td>
<td>B05-B08</td>
<td>User/purveyor</td>
<td>Male</td>
</tr>
<tr>
<td>18</td>
<td>Sector association (Mining)</td>
<td>S94.2</td>
<td>User/purveyor</td>
<td>Female</td>
</tr>
<tr>
<td>19 and 20</td>
<td>Mining company</td>
<td>B05-B08</td>
<td>User</td>
<td>Male</td>
</tr>
</tbody>
</table>
11.2 Climatically sensitive dependencies

- **Scoring**
  - **Red**: Highly dependent on Climatically Sensitive Infrastructure and Systems (CSIS) for majority of sector's core activities. Short term disruption could cause an interruption in business continuity.
  - **Orange**: Moderate dependency on CSIS for majority of sector/industry's core activities. Several aspects of the business's operations along the value chain are liable to be significantly interrupted.
  - **Green**: Low dependency on CSIS for the operation of sector's core activities; business continues to function during CSIS disruption.

---

- **Dependency on Climatically Sensitive Infrastructure and Systems (CSIS)**
  - Economic
  - Industrial Sector/Sub-sector or Activity
  - Large Fixed Assets
  - Transport
  - Water
  - Energy
  - Other (climatically sensitive raw)
  - Market Demand
  - Ecosystem

- **Economic Rank of Sector**
  - NACE
  - B05
  - B07
  - B08
  - B09

- **Mining Case Study**
  - June 2018
11.3 Definitions of World Mining Data Mineral Raw Materials

Iron and Ferro-Alloy Metals:
Iron, Chromium, Cobalt*, Manganese, Molybdenum, Nickel, Niobium, Tantalum*, Titanium, Tungsten*, Vanadium*

Non-Ferrous Metals:
Aluminium, Antimony*, Arsenic, Bauxite, Bismuth*, Cadmium, Copper, Gallium*, Germanium*, Lead, Lithium, Mercury, Rare Earth Minerals, Rhenium, Selenium, Tellurium, Tin, Zinc

Precious Metals:
Gold, Platinum-Group Metals (Palladium, Platinum, Rhodium), Silver

Industrial Minerals:

Mineral Fuels:
Steam Coal (incl. Anthracite and Sub-Bituminous Coal), Coking Coal*, Lignite, Natural Gas, Crude Petroleum, Oil Sands, Oil Shales, Uranium. NB: only figures for coals, lignite, and uranium have been included as per the definition of the mining sector for this study.

(Reichl et al., 2017)

* denotes this is a critical raw material (CRM) for the EU, 2017 list (European Commission, 2017b)

11.4 Examples of activities and materials considered within scope

Table 5 provides further information on types of materials and activities included within scope.

<table>
<thead>
<tr>
<th>NACE Code</th>
<th>Included in MARCO case study</th>
<th>NACE examples</th>
<th>World mining data examples</th>
<th>BGS examples</th>
<th>UEPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td>Yes</td>
<td>Mining of hard coal, cleaning, sizing, grading, pulverising, compressing coal; Mining of lignite; washing, dehydrating, pulverising, compressing of lignite to improve quality or facilitate transport or storage</td>
<td>Mineral Fuels: Steam Coal (incl. Anthracite and Sub-Bituminous Coal), Coking Coal, Lignite, Natural Gas, Crude Petroleum, Oil Sands, Oil Shales, Uranium. NB: only figures for coals, lignite, and uranium have been included as per the definition of the mining sector for this study.</td>
<td>Energy minerals</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>No</td>
<td>Not included in scope of case study</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction of crude petroleum and natural gas</td>
<td>Mining of iron ores; Mining of non-ferrous ores, including uranium, thorium, aluminium (bauxite), copper, lead, zinc, tin, manganese, chrome, nickel, cobalt, molybdenum, tantalum, vanadium; Mining of precious metals including gold, silver, platinum</td>
<td>Iron and ferroalloys: Iron, Chromium, Cobalt, Manganese, Molybdenum, Nickel, Niobium, Tantalum, Titanium, Tungsten, Vanadium</td>
<td>Metals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07 Mining of metal ores</td>
<td>Yes</td>
<td><strong>Non-ferrous metals:</strong> Aluminium, Antimony, Arsenic, Bauxite, Bismuth, Cadmium, Copper, Gallium, Germanium, Lead, Lithium, Mercury, Rare Earth Minerals, Rhenium, Selenium, Tellurium, Tin, Zinc <strong>Precious metals:</strong> Gold, Platinum-Group Metals (Palladium, Platinum, Rhodium), Silver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 Other mining and quarrying</td>
<td>Yes</td>
<td>(A) Quarrying, trimming, sawing of stone, sand, and clay including marble, granite, sandstone, limestone, gypsum, anhydrite, chalk, refractory clays, kaolin; (B) Mining of phosphates, potassium, sulphur, barium sulphate and carbonate, borates, magnesium sulphates; (C) Mining of guano, peat, salt, other materials n.e.c. including gemstones, graphite</td>
<td>Industrial minerals: Asbestos, Barite, Bentonite, Boron Minerals, Diamond (Gem/Industrial), Diatomite, Feldspar, Fluorspar, Graphite, Gypsum and Anhydrite, Kaolin (China-Clay), Magnesite, Perlite, Phosphates (incl. Guano), Potash, Salt, Sulphur, Talc (incl. Steatite and Pyrophyllite), Vermiculite, Zircon</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>World mining does not include aggregates</td>
<td>Industrial (non-construction) minerals, e.g.: feldspar, kaolin, salt, diatomite, bentonite, gypsum, talc, potash, magnesite, mica, barite, fluorspar</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Construction minerals, e.g.: Clay and shale, aggregates, limestone and dolomite, building stone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sand &amp; Gravel Crushed Rock Marine Aggregates Recycled Aggregates Re-Used on Site Manufactured Aggregates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 11.5 Potential Impacts from extractive waste facilities and associated climate services

Table 6 shows potential environmental issues associated with waste management from different extractive operations, indicating risks that may need to be planned for, which may require use of climate and weather data (adapted from European Commission DG Environment, 2012a).

**Table 6: Potential environmental waste issues associated with extractive operations, with associated potential climate services**

<table>
<thead>
<tr>
<th>Extractive operation</th>
<th>Overburden</th>
<th>Waste rock</th>
<th>Tailings/silt</th>
<th>Potential environmental issues</th>
<th>Associated potential climate services (Current / future projections)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregates</td>
<td>Tipped in heaps</td>
<td>Tipped in heaps</td>
<td>Tipped in heaps</td>
<td>Dust from exposed facilities</td>
<td>Current / future projections of wind direction and speed; air temperature data / consecutive dry days</td>
</tr>
<tr>
<td>Construction materials</td>
<td>Backfilled into void</td>
<td>Backfilled into void</td>
<td>Deposited in lagoons or TMFs</td>
<td>Contaminated seepages</td>
<td>Precipitation data and hydrological and groundwater modelling</td>
</tr>
<tr>
<td>Industrial minerals</td>
<td>Tipped in heaps</td>
<td>Tipped in heaps</td>
<td>Tipped in heaps</td>
<td>Dust from exposed facilities; Contaminated seepages; Leaching of process chemicals; Tip/slope failure; Failure of containment structures</td>
<td>Current / future projections of wind direction and speed; Precipitation data and hydrological and groundwater modelling; air temperature data / consecutive dry days; earth observations (of slope stability)</td>
</tr>
<tr>
<td>Salt/potash</td>
<td>Backfilled into void</td>
<td>Backfilled into void</td>
<td>Underground backfill/deep well disposal</td>
<td>Salinity of run off</td>
<td>Precipitation data and hydrological and groundwater modelling</td>
</tr>
<tr>
<td>Metals</td>
<td>Tipped into heaps</td>
<td>Tipped into heaps</td>
<td>Deposited in TMFs</td>
<td>Dust from exposed facilities; Contaminated seepages; Leaching of process chemicals; Tip/slope failure; Failure of containment structures; Acid Rock Drainage of both waste rock and tailings</td>
<td>Current / future projections of wind direction and speed; Precipitation data and hydrological and groundwater modelling; air temperature data / consecutive dry days; earth observations (of slope stability)</td>
</tr>
<tr>
<td>Energy minerals</td>
<td>Tipped in heaps</td>
<td>Tipped in heaps</td>
<td>Tipped in heaps</td>
<td>Dust from exposed facilities; Contaminated seepages; Leaching of process chemicals; Tip/slope failure; Failure of containment structures; Acid Rock Drainage of both waste rock and tailings; radioactive waste; spontaneous ignition</td>
<td>Current / future projections of wind direction and speed; Precipitation data and hydrological and groundwater modelling; air temperature data / consecutive dry days; earth observations (of slope stability)</td>
</tr>
</tbody>
</table>
11.6 Framework Condition Analysis

Per the guidance provided from the MARCO consortium, each source was scored based on list below (benchmarked green):

Green (8-10)
Amber (4-7)
Red (1-3)

+ Accessible climate tools, data, knowledge on climate risks pertinent to sector
+ Organised and comprehensive sector initiatives to improve climate response
+ Available cost-effective climate services pertinent to sector/region
+ Strong climate research (and development) ecosystem
+ Organised programmes for climate change pertinent to sector/region
+ Strong physical/technological infrastructure
+ High confidence in climate service (strong quality assurance/accreditation etc.)
+ Economic incentives for climate action
+ Strong and equitable enforcement of climate-related regulatory regimes
+ Strong and comprehensive climate change adaptation/mitigation plans
+ Tools and services available/used well adapted to sectoral/regional needs
+ Finance widely accessible that enables climate-related action
+ Support for production and uptake of climate services
+ Strong provision of climate insurance/resilience-enhancing services
+ Broad social consensus on need to address climate change
+ Regulatory support for innovation
<table>
<thead>
<tr>
<th>Source</th>
<th>Category</th>
<th>Mitigation/Adaptation/Both</th>
<th>NUTS 1</th>
<th>Score (Author’s discretion)</th>
<th>Positive Conditions</th>
<th>Negative Conditions</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making Finland a leader in the sustainable extractive industry - action plan</td>
<td>Risk Management</td>
<td>Mitigation and adaptation</td>
<td>Finland</td>
<td>2</td>
<td>Management of environmental impacts reduces risks to business operations. Mining companies must manage their operational risks to the environment in order to be in compliance with regulations, avoid liabilities and maintain a social license to operate</td>
<td>No specific mention of climate resilience or CS uptake however the broader sentiment of risk management is there</td>
<td>2</td>
</tr>
<tr>
<td>Adapting to Climate Change: A Guide for the Mining Industry</td>
<td>Comprehensive management system to address climate adaptation</td>
<td>Adaptation</td>
<td>EU and global</td>
<td>6</td>
<td>Leading companies have taken significant measures to adapt internal management structures in ways that facilitate proactive, adaptive, and integrated management of climate change impacts</td>
<td>A very small number of companies have adopted such an approach. In other words, this is not representative of the overall industry</td>
<td>6</td>
</tr>
<tr>
<td>Glencore - 2017 Climate Change Considerations for Our Business</td>
<td>Risk Management Framework</td>
<td>Adaptation</td>
<td>Global</td>
<td>6</td>
<td>Glencore has developed a framework to identify, understand and ultimately manage climate-related challenges and opportunities facing their portfolio. The framework is aligned with the TCFD recommendations on Climate-related Financial Disclosures. Risk framework considerations include; government policy, energy costs, physical impacts, stakeholder perceptions, market impacts</td>
<td>This process is in its early stages and the level of reliance on climate services is unknown</td>
<td>6</td>
</tr>
<tr>
<td>Climate Change and Mining, a foreign policy perspective</td>
<td>Force Majeure</td>
<td>Adaptation</td>
<td>Global</td>
<td>5</td>
<td>Climate change may lead to disputes surrounding contractual fulfilment. For example, a sudden water shortage could presently be classified as an 'unforeseeable circumstances outside reasonable control' however under climate change may become the ‘new normal’. Climate data and projections can be used to understand resource variability under climate change, and whether it may impact the contractual obligations of a party under contract</td>
<td>Force majeure definitions may be defined on a case by case basis, and in some cases not consider changing availability of a resource.</td>
<td>5</td>
</tr>
<tr>
<td>Mining Waste Directive, MWD (Directive 2006/21/EC on the management of waste from the extractive industries)</td>
<td>High level legal framework</td>
<td>Adaptation/other</td>
<td>Europe</td>
<td>7</td>
<td>European Union directive on disposal of mining waste. The Directive aims to prevent or reduce as far as possible the adverse effects on the environment and any resultant risks to human health from the management of waste from the extractive industries. The Directive sets out how to achieve this aim by providing for measures, procedures and guidance on how extractive waste should be managed. This has been transposed into laws in member states in various ways - including as a set of environmental permitting, which could lead to the use of climate information during the analysis.</td>
<td>Does not directly imply that climate projections or information needs to be considered, and there is no indication of the levels of implementation.</td>
<td>7</td>
</tr>
<tr>
<td>Supporting guidance to EU Member States on development of strategies in line with the MWD</td>
<td>Supporting guidance</td>
<td>Adaptation/other</td>
<td>Europe</td>
<td>7</td>
<td>Guidance on the overall strategy for rehabilitating closed and abandoned extractive waste facilities is provided in this document. It was developed with stakeholder input and presents a robust step-wise structure to follow for regulatory bodies and mining companies directly. It suggests a long-term outlook is taken and various risks including erosion, physical stability of the facility are considered. In practice this means the geotechnical or hydrological studies could potentially include analysis of different climate scenarios or climate projections to understand how the site would perform under varying conditions.</td>
<td>Does not directly imply that climate projections or information needs to be considered, and there is no indication of the levels of implementation.</td>
<td>7</td>
</tr>
<tr>
<td>Total – governance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Average - Governance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.8</td>
<td></td>
</tr>
</tbody>
</table>

Technology
## Mining Case Study

### Making Finland a leader in the sustainable extractive industry - action plan

<table>
<thead>
<tr>
<th>Action</th>
<th>Country</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological Innovation to improve resource efficiency</td>
<td>Finland</td>
<td>5 years</td>
<td>Effectively utilise technology to reduce environmental impacts of extractive operations; improved management of water balance, tailings and waste facilities at mines. Evaluate energy demands of these processes to not contribute to additional emissions. Conduct a water review to determine mine's water balance and develop a water management plan which must include monitoring and measurement. Investment in water technology development projects.</td>
</tr>
</tbody>
</table>

### Abandoned mines can be used as a geothermal energy source

<table>
<thead>
<tr>
<th>Action</th>
<th>Country</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal energy generation from closed and abandoned mining sites</td>
<td>Europe</td>
<td>4 years</td>
<td>Post-closure mines can be used for energy generation (heating and cooling) using the natural heat contained in the mine water. Geothermal energy systems could be implemented to extract heat using heat pumps, from both closed and potentially working mines. Other uses of the energy may include melting snow on icy roads (instead of using salt) or supplying heat for fish farms and greenhouses.</td>
</tr>
</tbody>
</table>

### Assessing Climate Change Risks and Opportunities for Investors

<table>
<thead>
<tr>
<th>Action</th>
<th>Country</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fugitive methane capture from coal mines degasification (including enhanced degasification) and ventilation air methane systems</td>
<td>Global</td>
<td>3 years</td>
<td>In some cases, it is possible to directly capture fugitive methane and burn it to produce energy and reduce overall global warming potential. During the initial stage of coal mining a highly concentrated stream of methane can be emitted.</td>
</tr>
</tbody>
</table>

### Total - Technology

<table>
<thead>
<tr>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total - Technology</td>
<td>12</td>
</tr>
</tbody>
</table>

### Average - Technology

<table>
<thead>
<tr>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average - Technology</td>
<td>4</td>
</tr>
</tbody>
</table>

### Finance

<table>
<thead>
<tr>
<th>Action</th>
<th>Country</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate related disclosure</td>
<td>UK-Australian (Rio Tinto), Global Operations</td>
<td>5 years</td>
<td>Investors, investor groups and NGOs are increasing interested in disclosure of climate change risk and resilience. Rio Tinto is working to understand how disclosure requirements are evolving and what they need to do to better inform stakeholders about climate risk and management actions.</td>
</tr>
</tbody>
</table>

### Rio Tinto - Climate Change Report

<table>
<thead>
<tr>
<th>Action</th>
<th>Country</th>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate related disclosure</td>
<td></td>
<td></td>
<td>Disclosure could potentially impact the cost and competitiveness of Rio Tinto's operations. Mining companies may be reluctant to disclose full details.</td>
</tr>
<tr>
<td>Rio Tinto - Climate Change Report</td>
<td>Carbon price</td>
<td>Mitigation</td>
<td>UK-Australian (Rio Tinto), Global Operations</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Assessing Climate Change Risks and Opportunities for Investors</td>
<td>Higher insurance premiums</td>
<td>Adaptation</td>
<td>Global</td>
</tr>
<tr>
<td>AXA Group</td>
<td>Investment</td>
<td>Mitigation/adaptation</td>
<td>France</td>
</tr>
<tr>
<td>Willis</td>
<td>Fines, penalties and assessments</td>
<td>Mitigation/adaptation</td>
<td>UK and global</td>
</tr>
<tr>
<td>Willis</td>
<td>Liability Insurance</td>
<td>Mitigation/adaptation</td>
<td>UK and global</td>
</tr>
<tr>
<td>--------</td>
<td>---------------------</td>
<td>-----------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Environmental risk including climate risk exposure to mine operations is becoming more complex and potentially expensive. Exposure to climate change liability will have to be factored into risk management strategies for vulnerable properties including refineries, smelters, crushing operations and mills but also open pit mines, which reduce forest and vegetative cover. Greenhouse gas emissions are very much at the forefront of the climate change debate.</td>
<td></td>
<td>Climate liability is nascent and difficult to parcel out from other environmental liabilities</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metals &amp; Mining: a sector under water pressure. Analysis for institutional investors of critical issues facing the industry</th>
<th>Investment in mining companies</th>
<th>Adaptation</th>
<th>UK</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutional investors with long term horizons, including pension funds and other large institutional investors, expect mining companies to adopt sustainable practices to mitigate and adapt to changes in water availability. The sector's high water demands, and polluting nature of wastewater, makes the sector highly exposed to water-related risks. Many mining operations take place in regions where corporate water usage faces intense scrutiny from the public and governments.</td>
<td>Disclosure of business-critical water-related information is not a uniform practice across the sector.</td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metals &amp; Mining: a sector under water pressure. Analysis for institutional investors of critical issues facing the industry</th>
<th>Water oriented valuation models</th>
<th>Adaptation</th>
<th>UK</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>When determining a company's value, analysts consider economic and commodity cycles. Valuation models do not presently account for the uncertainty in a mining company's ability to access adequate water resources. A production disruption, or temporary closure due to a lack of water resources, can drastically impact revenue, profit margins, future cash flow, and the ultimate valuation of a company.</td>
<td>Measuring, managing and disclosing water information is only practiced by select mining companies.</td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

| Total - Finance |                                    |           |       | 40 |
| Average - Finance |                                |           |       | 5 |

<p>| Capacity |</p>
<table>
<thead>
<tr>
<th>Top 10 Business risks facing mining and metals in 2016-2017</th>
<th>Lack of innovation capacity</th>
<th>Mitigation/adaptation</th>
<th>UK</th>
<th>2</th>
<th>Willingness to collaborate with other industries and sectors to spur innovation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining Case Study</td>
<td>Mining companies traditionally spend less than other sectors on innovation budgets. There is a skills deficit and a lack of an innovative culture in the industry, that impeded technological advances. Innovative initiatives that do take place are not transformational. That is, they provide short term benefits (i.e. cost saving, efficiency) but do not enable strong future growth.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessing and Addressing Climate Change Impacts in the Mining Sector</td>
<td>Climate change risk assessment training for mining professionals</td>
<td>Adaptation</td>
<td>Canada</td>
<td>7</td>
<td>Participants will have an understanding of climate trends, and be able to identify, understand and apply available climate data sources. They will develop an appreciation for the impacts that climate shifts have on mine operations and planning from diverse perspectives including investment, asset and risk management, financial planning and legal liability. Participants will have knowledge of frameworks and tools that can be applied to assess climate risks and identify resilience solutions.</td>
</tr>
<tr>
<td></td>
<td>Short nature of course may only serve as a primer for climate risk assessment and not offer participants with the skills and capacity to conduct further analysis.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapting to Climate Change: Implications for the Mining and Metals Industry</td>
<td>Climate Risk Assessment in consortium</td>
<td>Adaptation</td>
<td>UK and Brazil</td>
<td>7</td>
<td>Anglo American partnered with Imperial College London and the Met Office to develop a detailed climate change impact assessment of its Minas Rio Project (Brazil). Anglo American will use regional climate change modelling to develop business risk templates to incorporate adaptation actions into new and current operations. The result of this work will also feed into the company’s internal climate risk model.</td>
</tr>
<tr>
<td></td>
<td>Capacity of mining company alone to conduct this process (i.e. in the absence of a partnership) may be challenging. This is an example from a major and may not indicate behaviour or capacity of smaller companies.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total - Capacity</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Average - Capacity</td>
<td>5.33</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Research and Knowledge
<table>
<thead>
<tr>
<th>Title</th>
<th>Conference proceeding: The role of climate change in shaping the industry's future in Africa</th>
<th>Adaptation</th>
<th>South Africa</th>
<th>Acknowledgement of climate change material impact to mining and metals industry, and opportunities for innovation and strategic thinking. Long term view of business and policy planning</th>
<th>No explicit mention of climate services uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapting to Climate Change: A Guide for the Mining Industry</td>
<td>Recognition of climate risks</td>
<td>Adaptation</td>
<td>EU and global</td>
<td>Recognition of the impacts of climate change to the mining industry, primarily through four streams: • supply of critical inputs (water and energy) • employee health and safety • social license to operate • increased material risk</td>
<td>Not a reflection of standard mining practices across the industry but rather recognition by some companies.</td>
</tr>
<tr>
<td>Adapting to Climate Change: A Guide for the Mining Industry</td>
<td>Application of climate information</td>
<td>Adaptation</td>
<td>EU and global</td>
<td>Regional and site-level scientific modelling to identify and quantify physical risks and opportunities at the local level. Translation of global climate models into likely localized impacts is critical to adaptation planning in an industry whose facilities are spread over a large geographic region.</td>
<td>Application of scientific information differs on a company by company basis. No standardized approach among mining companies to understand best practices.</td>
</tr>
<tr>
<td>Norsk Hydro - 2017 Climate Change Information Request - CDP</td>
<td>Physical risks and opportunities driven by climate change</td>
<td>Adaptation</td>
<td>Norway / global operations</td>
<td>Climate risk assessments conducted in some regions where Hydro has operations to identify risks and opportunities. All major sites and operations that have experienced extreme events have been through local risk assessment. Opportunity: In Norway, increased precipitation has resulted in (and may continue to result in) increased water flows to hydropower reservoirs, thus increasing power output.</td>
<td>Risk assessment and management does not appear to be streamlined across all regions where Norsk Hydro maintains operations.</td>
</tr>
</tbody>
</table>
## Top 10 Business risks facing mining and metals in 2016-2017

<table>
<thead>
<tr>
<th>Access to energy</th>
<th>Mitigation</th>
<th>UK</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top 10 Business risks facing mining and metals in 2016-2017</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transition to renewable energy sources, particularly wind and solar, to secure reliable energy and decrease dependency on fossil fuels and hydroelectricity which are subject to price volatility and potentially unreliable supply. Renewables can generate financial, social and reputational benefits.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Renewable energy systems need to be built, financed and operated which have substantial up-front costs and need strong leadership to champion this. Operating margins are dependent on commodity prices and energy prices – investing in an energy transition project, while generating strong long-term benefits, may require significant up-front costs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resource and energy efficiency</th>
<th>Mitigation</th>
<th>Sweden</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sweden's Mineral Strategy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reducing carbon emissions by 20 % (and by 30 % if conditions permit), increasing the share of renewable energies by 20 % and increasing energy efficiency by 20 % Adopt greater resource efficiency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>No mention of adaptation.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mine Closures - Conference proceeding International Mine Water Association</th>
<th>Adaptation</th>
<th>Germany</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate Change and Mine Closures - A Practical Framework for Integrating Risk</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conceptual framework to incorporate climate considerations into mine closure from a risk management perspective. Utilizes the Koppen Geiger climate classifications, RCP scenarios and global dataset of long term precipitation and temperature records, adapted to future climate projections.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>High level, may be difficult to implement without expert guidance.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment of water availability across the mining life cycle</th>
<th>Adaptation</th>
<th>Europe</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A practical guide to catchment-based water management for the mining and metals industry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Risk management framework to understand the changing magnitude of water risk across the mine life cycle in consideration of climate change impacts (and other factors). Identification of risk and adaptive management plans for each phase of the mine cycle. Document references water indicators and tools based on climate services.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>A good primer but somewhat high level. Employees may lack the expertise to conduct these types of assessment in-house.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| Total - Research and Knowledge | | | 49 |
| <strong>Average - Research and Knowledge</strong> | | | 6.125 |</p>
<table>
<thead>
<tr>
<th>Adapting to Climate Change: Implications for the Mining and Metals Industry</th>
<th>Partnership and Collaboration</th>
<th>Adaptation</th>
<th>UK</th>
<th>2</th>
<th>Mining companies forge relationships with key stakeholders to advance the availability of tools, resources and the latest techniques focused on climate adaptation. Key partners may include trade and industry groups, standards developers, regulators, vendors and consultants, state and municipal governments, local communities, civil society groups and academics.</th>
<th>Extent to which companies collaborate is highly variable. Some companies may be reluctant to partner so as not to reveal competitive advantage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norsk Hydro - 2017 Climate Change Information Request - CDP</td>
<td>Consumer Ethics</td>
<td>Adaptation/mitigation</td>
<td>Norway</td>
<td>2</td>
<td>Consumer demand for products that are made with a lower climate footprint. Norsk Hydro can gain a competitive market advantage by developing low-carbon aluminium with the use of hydropower</td>
<td>The transition to lower carbon footprint products may not involve the long-term uptake of CS information</td>
</tr>
<tr>
<td>Euromines</td>
<td>Reputation</td>
<td>Adaptation/mitigation</td>
<td>Europe</td>
<td>2</td>
<td>Improve the image of the industry as more environmentally friendly, trustworthy and innovative</td>
<td>Not clear the extent to which the organisation encourages conducting environmental or climate change assessments to inform better practices</td>
</tr>
</tbody>
</table>
| Assessing Climate Change Risks and Opportunities for Investors | Health and Safety | Adaptation | Australia | 4 | • Higher risks of more days with temperature over 35° coupled with high levels of humidity lead to an increased risk of heat-related illness which can impact decision-making, affect productivity as a result of more accident, injuries and fatalities.  
• Higher risk of more intense rainfall events and flooding may affect employee safety on-site and on roads. | Climate-related risks must be analysed on a site-specific basis. |
Climate Change and Mining, a foreign policy perspective

<table>
<thead>
<tr>
<th>Community relations</th>
<th>Adaptation</th>
<th>Australia</th>
<th>4</th>
</tr>
</thead>
</table>
| Climate-change induced (mis)management may exacerbate tensions with local communities in the following ways:  
  • Tailing dam disintegration due to extreme flooding or sea level rise  
  • Heat and dust related stress among local residents  
  • Changes to water availability may lead to increased competition over water resources which risks affecting community relations and a mining company’s social license to operate  
  • Meeting community’s growing expectations from the industry to invest and be involved in local climate adaptation |
| Managing community needs may only involve stakeholder engagement rather than consulting climate information |

| Total - Normative | 14 |
| Average – Normative | 2.8 |
11.7 Bibliography


CDP. (2013). Metals and Mining: a sector under water pressure; Analysis for institutional investors of critical issues facing the industry. Retrieved from https://b8f65cb373b1b7b15feb-c70d8ead6ced550b4d987d7c03fdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/000/897/original/Metals-Mining-sector-under-water-pressure.pdf?1472052411


