CARBON DISCLOSURE PROJECT

Carbon Disclosure Project Report Global Mining

Building business resilience to inevitable climate change

The Adaptation Challenge

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IBM Viewpoint

The mining industry has been an essential contributor to society and the economy for many years and has continually adapted successfully to changes. IBM believes this rate of change is increasing and many within the industry realise that the modern miner will need to work differently and work smarter.[1]

Several factors are driving this change such as volatile and emerging markets, new technologies, increased customer demands, a dynamic workforce and new business models. Increasingly the potential impacts from inevitable climate change resulting from past greenhouse gas emissions will need to be added into this mix, whether this takes the form of adapting to reduce risks or complying with regulations aimed at increasing energy efficiency or reducing greenhouse gas emissions. This is particularly true for mining companies where long term investment decisions have to be made.

Climate change is also affecting the costs of mining. Labour and energy are already major costs and are forecast to increase as operations move to harsher and more remote locations and energy costs continue to rise. Water and carbon costs are likely to become more significant as competition increases for scarce resources such as water, and pending legislation on carbon emissions comes into force.

The industry is already responding to these challenges. Leading companies around the world can provide examples of how they are changing their business models to become more fluid, flexible and agile so they can respond to the unpredictable. Also they are becoming smarter to increase efficiencies, reduce costs and take advantage of opportunities.

Mining companies will have critical choices to make about various aspects of their business. They must be considered in an holistic way and use technology widely as the enabler, investing for future success rather than supporting outmoded business models.

1.1 Potential for change

If there is one constant in the mining industry, it is constant change with unpredictability and complexity. Dealing with the impacts of inevitable climate change from past emissions will bring additional challenges around assets, operational procedures, waste management and the labour force. To adapt for success, mining companies will have to become fluid, flexible and agile enterprises and the business of mining must become smarter, perhaps by flipping the supply chain on its head, where the goal won't be to push product out of the ground to dump on the market, but to respond nimbly to sophisticated customer relationships and market dynamics.

To achieve this success, IBM believes an holistic approach is needed which considers nine characteristics of the future business of mining:

- People and work
  - Business model innovation, governance and workforce, collaboration
- Sustainability
  - Safety, energy and environment
- Operations and technology
  - Asset management, productivity, efficiency and cost reduction, information integration and visualisation, remote operations.

1.1.1 People and work

Improvements in mining must start with the most critical assets mining companies have: the intelligence, agility, and competencies of their people, strategies and endeavours.

Business model innovation – as unpredictability increases, not least because of climate change, a new, more agile business model is required where volatile customer demands and needs drive capacity and resource planning. The mine adopts a new production discipline, best practices and supporting metrics which enable the company to focus on maximising the throughput, efficiency and profitability of the entire process.

Example – one of the world's largest steel makers re-engineered its business model, synchronising its external and internal processes from suppliers through all divisions to customers, leveraging new end-to-end IT technology. This resulted in record delivery performance levels (95%) along with significant reductions in inventories.

Governance and workforce – a smarter mining company will need to improve its operational execution. Information and insight will become critical in managing fast changing demands and inefficiencies.

Collaboration – a new mode of operating with partners, customers and suppliers is required to build enterprise agility. Collaboration among individuals improves the sharing of knowledge and enables better decision-making; among customers and partners it drives innovation and effectiveness.

Example – using inter-company and inter-industry cooperative programmes to ensure the success of the member companies, a consortium of three major US auto manufacturers and four leading steel producers collaborates together on specific programmes that drive innovation, technology advancement and efficiency across the steel-auto manufacturing pipeline. Although the participating companies are clear competitors and rivals, they've realised that they can achieve more for the entire industry (and themselves) by working together.

1.1.2 Sustainability

Today, providing a healthy and safe work environment and protecting the environment are growing imperatives of corporate responsibility and must be integrated into a company's business strategy, operations and culture to drive business value, reduce costs and provide benefits for the business and society.

[1] IBM Corporation 'Envisioning the Future of Mining' 2009.

Safety is of paramount importance to any mining organisation. In the words of one CEO "We will not mine if we cannot mine safely". As mining operations take place in more hazardous and remote locations, safety needs are becoming ever more rigorous to meet the goal of minimising incidents. Technology can help by locating people in an emergency, preventing people straying into hazardous areas, helping to identify failing or stressed assets and helping to avoid collisions.

Example – one company, in the event of an emergency, can easily locate its employees in specific areas and avoid the need to conduct sweeps to search for unaccounted employees. Employees wear RFID tags linked to a visualisation engine providing a rich graphical view of employee locations and associated metrics.

Energy and environment concerns are increasingly high on the public's and politicians' agendas. To have a 'licence to mine', companies must demonstrate responsible use of resources and care for the environment. Companies are becoming serious about using technologies and programmes to manage pit to port costs that may be exacerbated by impacts of climate change, reducing greenhouse gas emissions and improving efficiency of water and energy use. The benefits include reduced costs, ability to adapt successfully to the challenges and an improved public image that can attract new talent and make substantial societal change at the same time.

1.1.3 Operations and technology

The 'heavy lifting' aspects of mining will improve in the future even whilst the core objective of unearthing product stays the same.

Asset management – the location and status of assets is essential information for an agile, smarter business particularly as assets may be stressed beyond their design points due to climate changes. Instrumented assets can now be tracked (thereby helping to reduce losses and optimise scheduling) and their performance monitored (thereby minimising outages and maintenance).

Example – a major heavy equipment manufacturer is outfitting their fleet with this new technology, shifting from a reactive 'health maintenance' mindset to one where equipment is viewed in its total contribution to 'production effectiveness'.

Productivity, efficiency and cost reduction – mining companies will need to increase productivity and reduce costs simultaneously without sacrificing customer service, safety, or operational flexibility. These improvements will be impacted by a company's ability to adapt to climate change in the future.

Information integration and visualisation – mining companies will need improved realtime information synthesised from a wealth of new data from instrumented assets and equipment, transportation, people, supplies, and plans. Decision-makers such as production and maintenance operations, analysts and field crew need a realtime view of their entire operation. Alerts, alarms and triggers enable the mine to be hyper-responsive to change and challenges and to be predictive rather than reactive.

Example – a Norwegian petroleum company uses realtime data from wireless sensors monitoring subsurface conditions (such as the pressure and temperature at different points in the field, as well as the movement of gas or oil deposits) to help the company's engineers to know when, where and how much to pump.

Remote operations – allow for more efficient use of resources and better access to experts. With all the challenges facing the industry, including potential impacts from climate change, remote operations will become more essential. But it is not simple as it requires the culmination of information, collaboration, smarter and leaner organisation, governance and workforce, visualisation, and business model innovation.

1.2 Opportunities to improve

The challenges facing mining enterprises today are pushing leaders to adapt the traditional ways of thinking about their business to discover and explore new practices that will improve the business of mining. The future of the mining enterprise is characterised in all aspects of the business, from improving people and leaders, to engaging new business models and processes, to employing new techniques in developing insight, knowledge and working remotely. Most of all, the mine of the future is smarter. It responds to change faster. It is agile and flexible.

Inevitable climate change is an additional challenge that mining companies will face. It brings an additional level of unpredictability to the equation which, again, a more agile and smarter company will be better placed to manage.

Jeremy Yoo
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Executive Summary

Over the last two years an unparalleled period of soaring commodity prices and economic growth collapsed and gave way to slowdown and recession. Although the outlook is now improving there remain difficult challenges for an industry with major capital investment needs and long lead-in timelines for new developments; operating in a market subject to periodic sharp declines in prices and demands and increasing costs. Companies are faced with strategic choices which may change their business models. It is clear however, that these are not the only challenges.

Climate change is underway. Whatever we achieve in reducing greenhouse gas emissions, we are now faced with further inevitable changes in our climate and in our social, economic and environmental systems. In our analysis of the responses made by mining companies to the Carbon Disclosure Project (CDP) and drawing on other published material and resources, it is clear that companies do not fully recognise the impacts (risks and opportunities) that are emerging due to the changes in our climate.

The sustainability of mining companies faced with delivering long term investment potential with increasing short term volatilities is challenging. Many of the challenges they face in managing boom bust, commodity price volatility, rising costs, geo-political risks, energy security, water resource availability, workforce issues, local community impacts and reputational hits are also under pressure from climate change. However it is clear that the effect of climate change on these challenges is not well understood, for example:

Only 34% recognised that climate change may create energy price volatility and security of supply challenges.

24% identified the risks due to rising sea levels, with 18% referring to potential problems due to their reliance on marine transport and port facilities.

19% recognised that land based transport systems could be vulnerable.

1.6% considered that climate change would have an impact on site remediation costs.

11% identified risks to essential utilities. Direct risks to supply chains were not identified (although these may have been included within the concerns raised regarding transport disruption).

19% considered that there may be an increase in disease risks, with 13% considering that they would be under more pressure from local communities. 18% reported that there would be reputational issues if they were not seen to be dealing with climate change.

No companies reported political instability as a risk driven by climate change.

Investors and the financial institutions are taking an increasing interest in the implications of climate change. They are exploring the implications for their investments, and for lending risk on project finance. The potential reputational implications arising from competition for water resources and the wider impacts on local communities will be placed under more intense scrutiny.

Most companies are tending to focus their risk management activities on extreme (acute) events and may not be recognising the risks posed by incremental (chronic) climate change. Disruptions from recent extreme events (for example, drought in Australia) serve to illustrate vulnerability to events greater than the industry's current asset design, engineering and operational standards. Chronic (incremental) changes however, are more subtle and their impacts on business models and assets may pass undetected until critical thresholds are breached (for example changes in precipitation and the impact on the design of tailing lagoons). The responses may result in 'step-changes' for a company, increasing operational costs beyond forecasts, unplanned capital investment and additional balance sheet financing to manage the consequences.

81% of companies reported that their physical assets would be compromised by extreme events.

No companies specifically recognised the risks associated with chronic changes to their physical assets and disruptions to essential infrastructure, utilities and supply chains.

Only 16% indicated that they were taking action on water management.

Although there is uncertainty in the knowledge we have about the extent and rate of future climate change, there is sufficient information to assess impacts on business models and enable robust decisions to be taken as a result. The existence of uncertainties regarding the business risks arising from climate change, should by itself act as a catalyst for companies to quantify the risks, monitor the impacts as they arise and be prepared for changes to their business models. The baseline climate is changing, and business decisions and practices will need to evolve as a result. Mining assets have been designed on the basis of historic climate data and a period of relatively stable weather. These design assumptions, together with those thresholds and margins set for regulatory, operational and financial performance requirements, may constrain the future effectiveness of assets to deliver under climate change.

Only 13% reported taking action to protect assets against extreme events.

Mining companies should consider acting now upon the clear signals that climate change is underway. A fully integrated approach to the challenges of reducing emissions **and adapting** to climatic change is required. Companies should use the lessons gained from the present financial crisis to avoid the even greater and entirely 'predictable surprise'[2] created by climate change. Acclimatise and IBM have jointly prepared a set of Prepare-Adapt questions on page 22 to help mining companies take the right steps towards building corporate resilience to inevitable climate change.

[2] M. Bazerman and M. Watkins (2004) 'Predictable Surprises: The Disasters You Should Have Seen Coming, and How to Prevent Them'.

Contents

1 Introduction

Climate change is underway. Whatever we achieve in reducing emissions of greenhouse gases (GHG) we still face inevitable changes in our climate and in our social, economic and environmental systems. If we fail to reduce emissions, then the changes in these systems will be even greater. In this report we explore the issues that mining companies are beginning to face in response to a changing climate and the actions being taken.

The mining sector has at times appeared reticent to recognise the climatic changes that are underway and the consequences for their business models. As recently as 2002, in a publication by the MMSD, WBCSD and IISD setting out future scenarios for the mining industry in North America, climate change (and its implications for both mitigation and adaptation) did not warrant any mention as a current or future change driver[3].

Mitigation efforts to reduce emissions are vital if we are to keep climate change from surpassing a dangerous, and rapidly approaching, threshold. This has been called avoiding the unmanageable. However, the effects of climate change are already upon us and are growing rapidly. A significant reduction in emissions is essential but we must also prepare for and respond to the impacts – we must adapt to manage the unavoidable.

The sustainability of mining companies faced with delivering long term investment potential with increasing short term volatilities is challenging. The present financial crisis, increasing costs, falling prices and demands have caused companies to suspend development activities. As the global economies begin to improve, mining companies will need to understand that their risk landscape is changing. For both new and existing mining assets it is essential that the likely impacts of inevitable climate change, examples of which are considered in this report, are assessed and managed.

In this report we explain why companies need to understand the implications of both extreme (acute) events and incremental (chronic) climate change and the direct and indirect effects operating through their business models. Acute events like continuing drought and water shortages in Australia grab the headlines, but are companies recognising the warning signs of chronic changes?

Given these impacts it is clear that there are potential financial risks to companies and to their investors. This report identifies areas where these risks may be significant, for example with regard to issues such as decommissioning and contingent liabilities.

Drawing upon an analysis of the responses from global mining and metals companies to the 2008 Carbon Disclosure Project (CDP), together with other published material and resources, this report provides an overview of some of the challenges that inevitable climate change brings. It also sets out clear guidance for senior executives on the business imperative to manage the unavoidable, and adapt their businesses to the impact of a changing climate.

Acclimatise and IBM have prepared a series of Prepare-Adapt questions on page 22 to help senior mining company executives identify the actions to build corporate resilience to inevitable climate change.

The Carbon Disclosure Project

CDP is an independent not-for-profit organisation which holds the largest database of corporate climate change information in the world. The data is obtained from responses to CDP's annual Information Requests, issued on behalf of 475 institutional investors, to more than 3,700 corporations across the globe. Since its formation in 2000, CDP has become the gold standard for carbon disclosure methodology and process, providing primary climate change data to the global market place. CDP plays a vital role in encouraging companies to measure, manage and reduce emissions and climate change impacts.

The CDP Information Requests include a series of questions seeking disclosure on the physical impacts of climate change on existing and future company performance and the management responses. (A copy of the questions is available on the CDP website: www.cdproject.net together with a list of the investors). The 2008 Information Request was sent to the world's largest 144 mining companies globally (based on market capitalisation) of which 43% provided detailed responses. Acclimatise has analysed the responses to assess the business resilience of companies to a changing climate.

Acclimatisation Index

The analysis of the responses to the CDP Information Request has been undertaken using our **Acclimatisation Index** methodology. This enables a semi-quantitative analysis of the responses recognising the scope of the questions. The Index can take into account information from other sources to provide a more comprehensive analysis.

The **Acclimatisation Index** has been used to analyse the resilience of global mining companies to climate change in response to questions contained within sections 1 and 4[4] of the CDP questionnaire.

[3] Learning from the Future Alternative Scenarios for the North American Mining and Minerals Industry 2002.
[4] Excluding question b 'Individual Performance' of section 4 which focused on performance towards GHG targets.

2 Climate change is underway

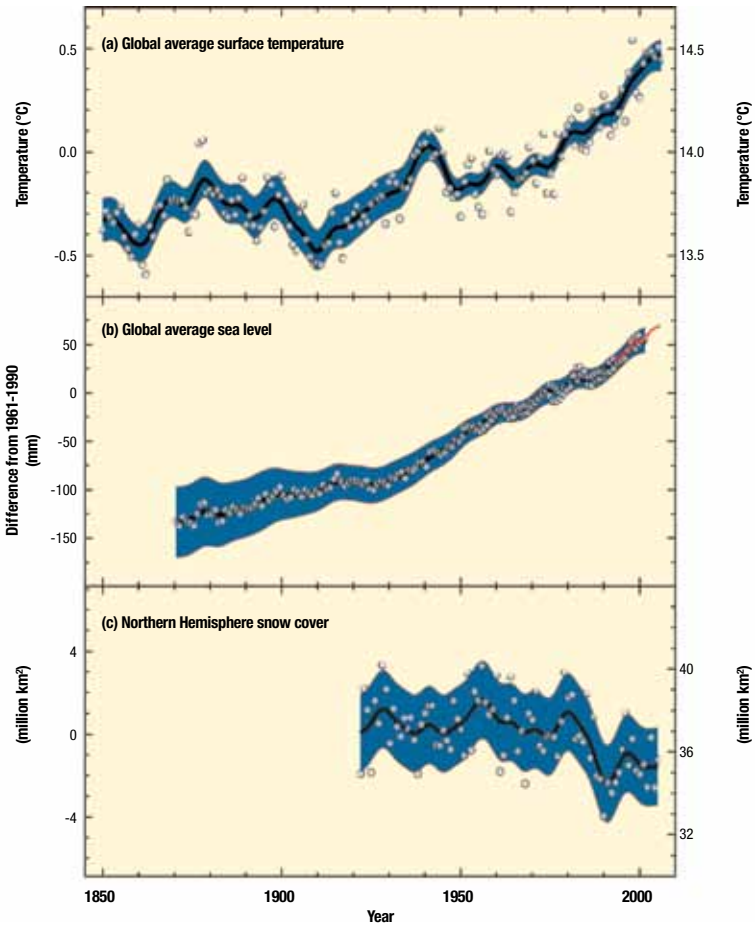
There is scientific consensus that the world's climate is changing due to human activity and that whatever steps we take to limit GHG emissions we are now faced with several decades of increasing global temperatures and a far longer period of rising sea levels.

In 2007, the Intergovernmental Panel on Climate Change (IPCC) – the most authoritative scientific body on climate change – confirmed the scientific evidence that climate change is already under way[5]. Figure 1 shows the observed changes in global average temperature and average sea level rise, together with northern hemisphere snow cover. The results from the climate models developed by governments and research institutions show a strong correlation with the observed changes. The IPCC states that:

- "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level"
- "At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones."

The IPCC has recommended that urgent action is required to limit the concentration of GHGs in the atmosphere and prevent global average temperatures rising above 2°C. A temperature rise above 2°C will be difficult for contemporary societies to cope with, and will cause major social, economic and environmental disruptions through the rest of the century and beyond. There are also concerns that increases above 2°C significantly increase the risk of large scale, irreversible system disruption[6].

Figure 1: Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data; and (c) Northern Hemisphere snow cover for March-April. All differences are relative to corresponding averages for the period 1961-1990[7]



[5] IPCC 'Climate change 2007: synthesis report'.
[6] *Scientific Symposium on Stabilisation of Greenhouse Gases – Avoiding Dangerous Climate Change Exeter February 2005* Executive Summary of the Conference Report.
[7] IPCC 'Climate change 2007: synthesis report'.

3 Sustainable mining: a long term investment with short term volatility

It is important that any consideration of the impacts of a changing climate is considered within the context of the challenges already faced by global mining companies. Creating and maintaining a sustainable business requires a comprehensive and detailed understanding of the risks and opportunities faced by a company and the social, economic and environmental conditions in which it operates. It also requires a view of how these conditions will interact with each other and change over time. The mining sector is a long term investment by the very nature of its financing requirements and operational activities, but it is subject to short term volatilities that require excellent management skills.

Over the last two years an unparalleled period of soaring commodity prices and economic growth has collapsed and given way to slowdown and recession. Mining companies have seen at first hand how recession bites hardest and quickest in those sectors providing the raw materials and commodities that build growing economies. Mining companies are now faced with balancing short-term responses with long-term strategy. This remains a difficult challenge in an industry with major capital investment needs and long lead-in timelines for new developments; operating in a market subject to periodic sharp declines in prices and demands and increasing costs.

Falling demand, tumbling commodity prices, high operating and capital costs and falling share prices; these are the characteristics of a mining sector suffering from the effects of a financial crisis. During 2008 and 2009 major international companies announced plans to stall or abandon new mining developments. Reviews of existing operations have focussed on opportunities for closures to minimise costs. Liquidity and managing cash flows and costs have become prime business objectives.

As the first signs of global economic growth become evident, there will be opportunities for some companies to make strategic acquisitions. Merger and acquisition activities are likely to increase in the mining sector as commodity prices increase and expectations rise of future growth potential.

Some of the key challenges the sector faces which show clear signals of the impacts of climate change are:

- Natural resource pressures
- Carbon management and emissions control
- Pollution and land contamination
- Reputation and brand
- Local community impacts
- Economic growth
- Workforce pressures
- Political stability and geo-political risks
- Supply chains and logistics, pressures on consumables
- Operating costs
- Energy
- Decommissioning and contingent liabilities
- Intangible asset value.

Marius Kloppers CEO BHP Billiton recently stated "We must recognise that the landscape has changed, and that we need to reinvigorate or focus on cost management and operational efficiencies. Importantly, efficient and predictable operations underpin our cash generation capability and establish the foundation to support further growth."

This report explores some of the implications for "efficient and predictable operations" arising from climate change together with the implications for investors. Later in this report the appropriate responses by senior executives will be considered.

"Climate change will place greater strains on natural resources such as land and water and contribute to deterioration in food security, political stability, health and poverty. These impacts will be particularly apparent in developing countries, where mining companies frequently have operations."

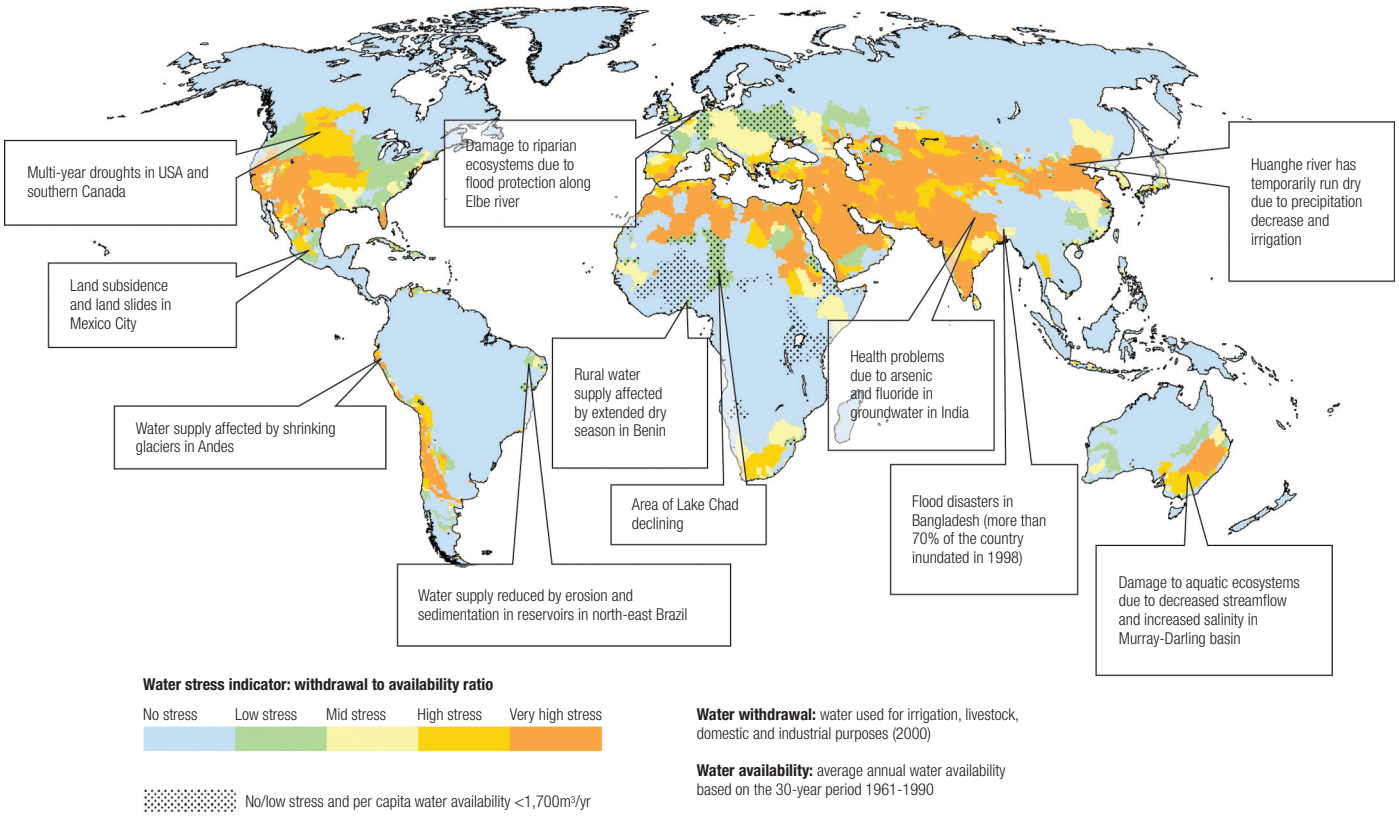
"It is increasingly important for mining companies to understand not only the direct impacts of climate change on their business, but also the indirect impacts associated with community and social adaptation. These pose a risk to their international reputation, their workforce and their local license to operate."

Ed O'Keefe, Director, Synergy Global Consulting

"The science has become more irrevocable than ever: Climate change is happening. The evidence is all around us. And unless we act, we will see catastrophic consequences including rising sea levels, droughts and famine, and the loss of up to a third of the world's plant and animal species."

Ban Ki-moon
Secretary-General of the United Nations, September 2009

Figure 2: Areas currently vulnerable to water stress[9]



Challenges

Natural resources under stress.

Global fresh water resources are under increasing stress. Less water, declining water quality, and growing water demand are creating immense challenges to the mining sector which is a major user of water. The sector has historically taken clean, reliable and inexpensive water for granted. These trends amplified by the effects of climate change are creating operational issues, restrictions on abstractions, more stringent water quality regulations, pressure to move towards full-cost water pricing, and increased public scrutiny of corporate water practices[8]. In Australia BHP Billiton is developing a desalination plant to secure operational water supplies. Water is becoming a major cost item for mining companies.

The IPCC Synthesis Report released in 2007 states[10]: "Climate change is expected to exacerbate current stresses on water resources from population growth and economic and land-use change, including urbanisation. On a regional scale, mountain snow pack, glaciers and small ice caps play a crucial role in freshwater availability. Widespread mass losses from glaciers and reductions in snow cover over recent decades are projected to accelerate throughout the 21st century, reducing water availability, hydropower potential, and changing seasonality of flows in regions supplied by melt water from major mountain ranges (e.g. Hindu-Kush, Himalaya, Andes), where more than one-sixth of the world population currently lives."

- Exxaro Resources Ltd has estimated the impacts of flooding, finding that it would lose $30 million if a 50 percent loss of production in one of its opencast mining operations occurs over two weeks due to floods[11].
- In Romania, heavy rains and a quick thaw caused by unusually high temperatures were partially responsible for the collapse of a tailings dam at Baia Mare spilling cyanide-contaminated wastewater into the Danube catchment[12].
- Heavy rainfall in Australia in early 2007 was blamed for an 8% decrease in gold production rates compared to the same quarter in 2006[13].

Reducing GHG emissions, a strategic challenge to business models.

Current actions to reduce emissions are insufficient to limit average global temperature increase due to anthropogenic (human activities) climate change to 2°C. Reducing the greenhouse gas (GHG) emissions arising from the use of fossil fuels is central to achieving a low-carbon economy and restricting global average temperature increases.

Mining companies are faced with strategic challenges to their long term business models. Companies, if they are to be sustainable in the long term, should plan for and actively manage the transition from fossil fuel dependent growth to one based on a portfolio of fuels and alternative sustainable sources. This involves the need to develop commercially viable technologies.

[8] Ceres, Pacific Institute 'Water scarcity and climate change: growing risks for businesses and investors' 2009.
[9] IPCC WG2, 2007.
[10] IPCC 'Climate change 2007: synthesis report'.
[11] Exxaro Resources response to Carbon Disclosure Project 2008.
[12] Report of the International Task Force for Assessing the Baia Mare Accident. December 2000. http://www.reliefweb.int/library/documents/eubaiamare.pdf.
[13] Sydney Morning Herald 27th May 2007 Gold production affected by rain.

Case study 1: Contaminated land and water resources

Research in the UK has highlighted the relationships between climate change, pollutant linkages and regeneration of contaminated land[1]:

- Proper management of contaminated land requires an understanding of the magnitude of the risk from climate change to current, and future, pollutant linkages between source and potential receptors
- Changes in environmental conditions and processes will inevitably affect the standards of remediation required to ensure receptors are not significantly impacted in the future
- Warmer conditions favour biologically-driven degradation of compounds amenable to degradation, while drier conditions are reported to have the opposite effect
- Heavy metal soil contaminants, whose movement is more related to issues of leachability, present less risk in higher temperature and drier climates due to increased soil speciation and pH
- Understanding the significance of the impacts of changing climatic conditions on contaminant speciation and adsorption will be fundamental to the development of sustainable risk management strategies – for example, drier soil conditions might lead to the oxidation of reduced metal species (which are generally insoluble) and increase their solubility
- Changes in climate are also likely to highly impact physical movement of contaminants through water erosion processes
- Changing environmental conditions also threaten the physical integrity of containment systems; engineered cover systems and stabilised/solidified soil systems have been shown to become extensively damaged under severe wet-dry and freeze-thaw cycles, significantly reducing their mechanical properties and hence effectiveness
- Over time, changes to the materials used in cover systems, slurry walls and geomembranes from temperature and moisture changes are likely to be significant.

[Source: SUBR:IM 2007]

Many diversified mining companies extract and produce coal, natural gas and oil, or they rely on these fuels for generating power for processes such as smelting. It is inevitable that the carbon costs arising from the use of these fuels will increase the costs to the user. Companies using fossil fuels for their own energy needs may find their costs increasing (and their margins being squeezed) when compared with other companies using renewable sources. In addition their use will over time be controlled by increasingly prescriptive regulation adding to costs of energy for mining. In 2005, the global iron and steel industry consumed over 900 TWh of electricity[14]. A large proportion of the energy for this came from fossil fuels which are becoming increasingly expensive. GHG emissions regulations and carbon costs will be an increasing important cost driver for mining companies.

Pollution and land contamination. Mining processes produce large volumes of wastewater, often contaminated with harmful chemicals. This is left to settle in tailings ponds or dams. These ponds, due to their long life spans pose risks to the surrounding environment and populations long after they have stopped being used by mining companies. Tailings pond spills can cause serious reputational and financial damage to companies as a result of the release of harmful chemicals into local ecosystems and water sources.

Legislation to control the design of these facilities and the consequences of any failures is being implemented. In Europe the EU Environmental Liability Directive (ELD) requires EU member states to implement a new liability regime for the prevention and remediation of environmental damage into their national laws. It has effectively extended the 'polluter pays' principle, and seeks to more clearly establish environmental liability for companies that cause damage to protected species and natural habitats, or contaminate surface waters, ground waters or land that leads to a risk to human health.

An example of how this will impact mining companies can be seen in the consequences arising from the burst tailings pond at the Aznalcóllar zinc mine in Spain in 1998. In this case, the Spanish authorities spent US$339 million on clean-up operations, whereas in the future, under the ELD regime, the operator of the mine will have to pay for the clean up[15].

Changes in precipitation, hydrology, ground conditions and soil-moisture content will have significant implications for the design and operation of facilities. Existing assets may no longer be able to meet original design parameters, leading to an increasing risk of dam failures and pollution. Regulatory provisions will need to be reviewed to ensure that impacts of climate change have been considered. It is inevitable that regulatory and consenting agencies will revisit pollution control consents (for example discharges to watercourses) given the inevitable changes in water quality and ecological status of receiving watercourses. Water treatment facilities may need to be upgraded to meet tighter consent standards.

Local community impacts. Climate change is likely to increase the vulnerability of indigenous peoples who may already be disadvantaged by being marginalised (see case study 2) and have low adaptive capacity. In seeking development benefits for indigenous groups, mining projects can look at opportunities to improve adaptive capacity (e.g. by increasing access to water, promoting or facilitating more climate-resilient sources of livelihood etc).

The impacts of climate change on development are already widely recognised and are expected to make it more difficult to achieve the Millennium Development Goals (MDGs). Many mining projects are providing health care, employment, educations, skills training, access to transport and energy, and improved water and sanitation systems. Mining companies can make a positive contribution to the achievement of MDGs. The risk is that failure on their part to recognise the impacts of climate change may compromise the ability of local communities to become more sustainable. Mining projects directly

[14] UN Data, 2009.
[15] Eriksson et al 2000.

Case study 2: Climate change fuels community conflict with mining operations in Chile

The plans of Barrick Gold Corporation to exploit gold, silver and copper reserves at Pascua-Lama have been severely affected by community opposition. The project is located high in the Andes, near glaciers which provide drinking and irrigation water to downstream communities in the Huasco Valley, where agriculture is the main source of livelihood.

Barrick believed that its operations would have no significant impact on water quantity and quality based on:

- Years of monitoring in the project area
- Operations that minimise the amount of runoff water coming into contact with mining operations
- Multiple barriers of active and passive protection against flooding, even in the case of extreme runoff events, during the life of the mine and after closure
- Avoiding operational discharges to the environment
- A comprehensive planned water quality monitoring and management programme providing realtime data.

In February 2006, the project's environmental impact study was approved by Chilean authorities, provided 400 conditions were met. Nevertheless, communities surrounding the mine feared that the dust generated by the mining activities would deposit on the glaciers and speed their melting, while the mine operation would contaminate and divert local water supply. Barrick stated that the glaciers have been receding because of climate change, and contend that the mining project would have only a minimum impact on any acceleration of the melting.

The IPCC predicts with high confidence that overcoming decades, Andean inter-tropical glaciers are very likely to disappear. Studies demonstrate that many South American glaciers are already retreating because of changes in climate.

or indirectly (for example through off site infrastructure finance) rely on organisations such as the International Finance Corporation, or the Asian Development Bank to contribute to their finance. These organisations have performance criteria linked to the MDGs; project under-performance due to unmanaged climate risks, may put these beneficial impacts at risk, and make mining companies less attractive as investments.

Reputation. The mining sector has faced significant reputational challenges over recent years. The profitability of mining projects has been hampered by community action, primarily due to the adverse environmental and community effects of mining operations. Climate change has the potential to create or exacerbate tensions that lead to reputational damage, by modifying the relationships between investments and their surrounding environments and local communities. It is also changing stakeholders' expectations, and in particular those that are sensitive to social and environmental impacts (for example NGOs, institutional investors and project financers, and most importantly of all, the local communities in which mining activities are located).

Facilities designed based on historic climate conditions may not perform as intended. Their demands, as well as those of local communities and the environment, for resources such as water, may change, increasing risks of conflict. Furthermore, because incremental changes in average climate conditions may go unnoticed for some time, mining activities may be held responsible for impacts, such as reduced water resources or water quality, which are actually the result of changes in climate conditions.

Investment banks, international finance institutions providing debt and equity finance, and investors providing equity finance are under ever-growing scrutiny. Community or government opposition to a specific mining operation, or public criticism of investment decisions are often relayed by the media or challenged through legal action or other forms of settlement.

The need for operational changes by mining companies to better manage the impacts of their activities and the relationships with local communities was highlighted by the Mining, Minerals and Sustainable Development Project in 2002 when it published its report: 'Breaking New Ground'. The mining sector is taking action and can be commended on the change in attitudes and its recognition that sustainable development is now critical to business success. However it is clear that far more effort is required.

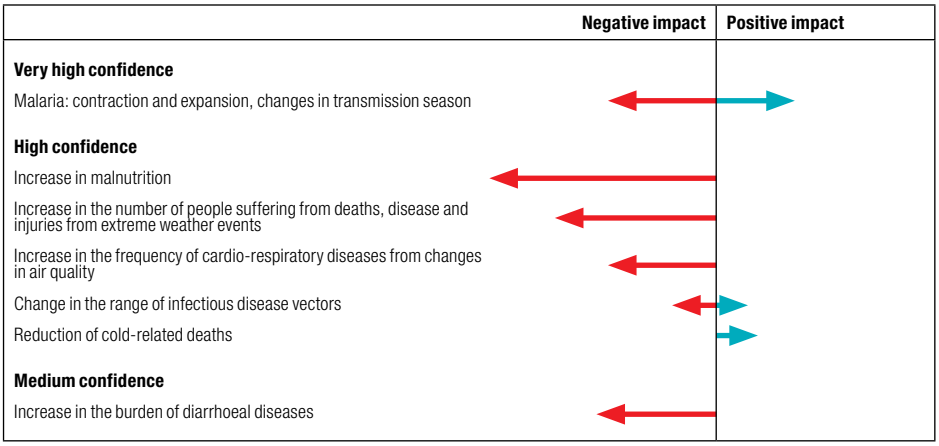
The potential risks to a company from reputational impairment are evident. Freeport-McMoRan Copper & Gold was excluded from the $300 billion Norwegian Government Pension Fund's investment portfolio on ethical grounds. Freeport's mining activities at the Grasberg mine in Indonesia were found to "involve an unacceptable risk of complicity in severe and irreversible damage to the natural environment"[16].

Workforce health. In parts of Sub-Saharan Africa companies are facing soaring costs from employee health care and training, as well as elevated rates of absenteeism from diseases. In South Africa an estimated 30% of all gold mining employees are HIV-positive[17]. Mining companies have calculated that HIV adds between $4 and $10 an ounce to production costs from South African mines[18]. Whilst there is no direct impact between climate change and HIV, there are potential indirect impacts, arising from increasing stress on social and economic systems.

Climate change will affect the health of the human capital upon which businesses rely, including staff, labour pools, sub-contractors and commercial partners. This will create additional costs for mining companies through lower productivity, compensation claims and disputes, and business interruption.

[16] Norwegian Government Pension Fund, 2006.
[17] World Gold Council, 2008.
[18] The Body, 2002.

Figure 3: Projected direction and magnitude of change of selected health issues because of climate change, with attached level of certainty[19]



Under a changing climate, risk of death, disease or injury from heat waves, floods, storms, fires and droughts for mining operatives will increase. These occupational risks will affect both indoor and outdoor workers. The safety and performance of buildings, structures and other assets that may not be climate-resilient could also translate into increased costs to ensure worker safety, comfort and productivity[20].

For example, warmer working conditions are a concern for health, safety and levels of performance. They can lead to diminished mental task ability, increased accident risk and, if prolonged, heat exhaustion or heat strokes. These can significantly affect the productivity of outdoor, production line and factory workers. In order to reduce impacts, it is likely that we will see regulations on maximum workplace temperatures with significant compliance cost implications for mining companies.

Economic growth. The effects of climate change on national economies, particularly emerging and developing states such as China, India and Brazil, may be significant. In general, developing countries and smaller economies face much larger output declines due to extreme (acute) events and incremental (chronic) change. These countries are less able to withstand the initial disaster shock and prevent further spill-overs into the macro economy. The potential impacts and costs are illustrated in case study 3. Mining companies operating in areas of the world where economies and future economic growth are under stress will face increasing pressures. The impacts for investment on essential infrastructure, health care, education, water, sanitation, transport and energy will in turn create problems for mining companies and increase their costs.

Political stability and geo-political risks. Mining companies operate in areas with varying degrees of political, legal and commercial stability. Administrative change, policy reform, changes in law or governmental regulations can result in civil unrest, expropriation, or nationalisation. The consequences of instability or changes could have an adverse effect on the profitability, the ability to finance or, in extreme cases, the operational viability of some mining operations.

The mining sector has traditionally found itself working in areas of the world where geo-political considerations can play a major role in shaping operational success. At a strategic level the implications for national and international security arising from climate change have been identified by a number of security 'think-tanks' and military organisations across the world. Military leaders and security advisors recognise that there are substantial security challenges arising from climate change that will feature increasingly in the planning of military defence and homeland security strategies.

"Due to the situation of the Aquarius mines within and close to the borders of Zimbabwe, Mozambique, Swaziland and Botswana, the area could experience an influx of refugees driven by famine and disease, which could lead to conflict situations as refugees compete with locals for limited resources."

"Climate change-induced conflict is anticipated to be prevalent in Sub-Saharan Africa through increased competition for resources and poor adaptation capacity."

"Whilst the levels of HIV prevalence amongst employees are not known, it can be assumed that these may be between 20 and 30% of employees based on data released by the state, NGOs and other mining companies."

Aquarius Platinum

"Assessing the implications of the impact of environmental dynamics on planned infrastructure is not a new science. Estimating and designing for the implications of extreme events – floods, droughts, seismic activity etc. – have been integral requirements of project planning, design and management throughout the lifecycle of all major projects."

"Anticipated climate change is not just a political fad, it is raising the stakes in risk analysis – both in terms of incremental changes and catastrophic events. No company can plan, operate, decommission or close facilities without factoring in the need for adaptation to anticipated changes in climate or the likelihood of climate induced events. Of particular concern will be the management of contingent liabilities associated with post mining legacy."

Jon Hobbs
Lead Advisor – Extractives Industries Policy – Department for International Development, UK and Chairman of the Inter Governmental Forum on Mining, Minerals, Metals and Sustainable Development

[19] IPCC WG2 2007.
[20] Bray et al 2007.

Case study 3: Effects of climate change on national economies

Natural hazards and GDP losses

A recent study by the Economics of Climate Adaptation (ECA) Working Group (McKinsey) has estimated how the changing incidence and severity of natural hazards could affect the GDPs of selected countries. The estimates, presented in Figure 4 are based on:

- An analysis of selected natural hazards (droughts, floods and tropical cyclones) within each country
- Estimates of changes in frequency and severity of natural hazards under climate change scenarios in the year 2030
- A 'natural catastrophe method', whereby the frequency and severity of past and future natural hazard events, the value of assets, incomes and populations exposed to the hazard, and their relative vulnerability, form the calculation of the expected loss per climate change scenario
- The combined losses from current climate-related factors, future climatic changes and future economic growth (which adds value to future damaged assets).

ECA's study is only indicative of the expected GDP losses because of climate change impacts. For instance, it does not account for future adaptation actions which may prevent some loss, and it makes simplistic assumptions about economic and population growth. ECA also used climate change projections from different global climate models, on the basis of a 'best-fit' approach for each country.

Future regional and country-specific costs of adaptation

The World Bank has recently published a report which provides estimates of adaptation costs per region, which illustrate how climate change risks may translate into different aggregated economic impacts across countries and regions in which IFC invests, with consequences for investment portfolio strategies.

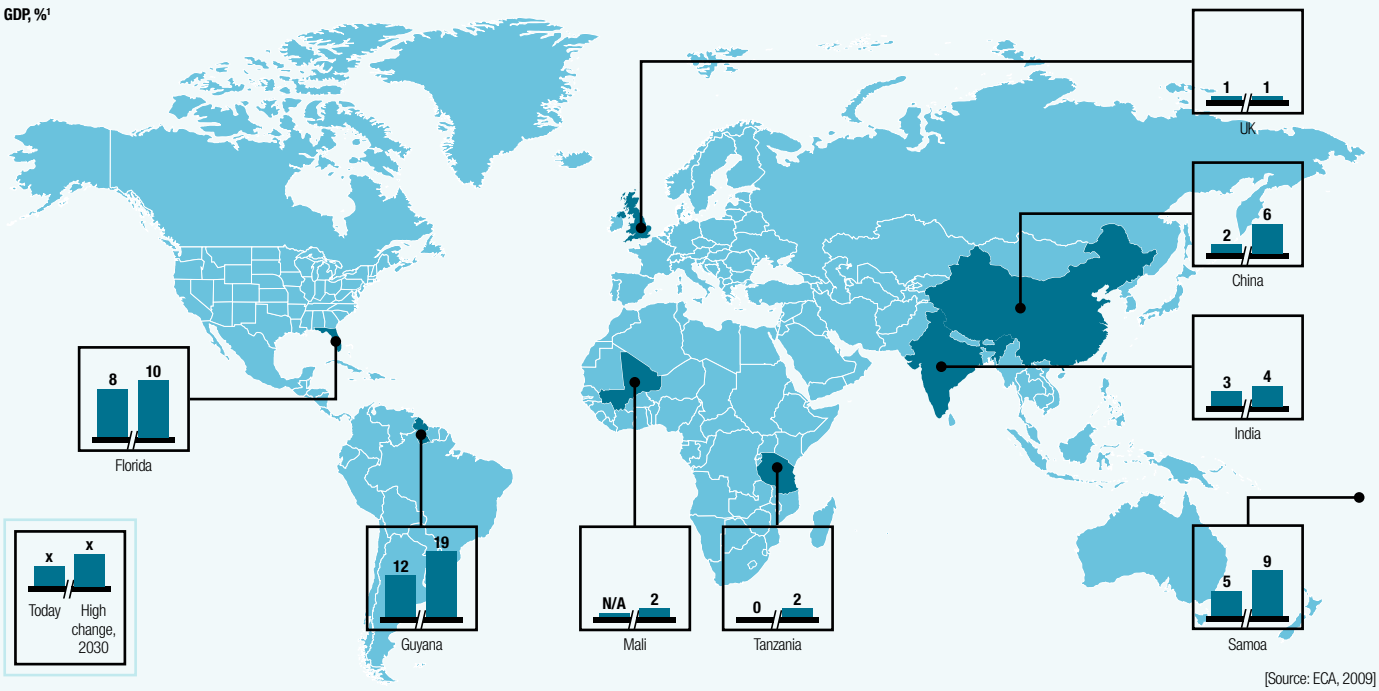
The study considers five sectors: infrastructure; coastal zones, water supply and flood protection; agriculture; forestry and fisheries; human health. It calculates the minimum cost of projects and programmes required to return each sector to its pre-climate change standard, such as level of service or nutrition value respectively for the infrastructure and agriculture sectors.

The World Bank used climate change projections based on two global climate models (GCMs) chosen because they provide extreme dry and wet projections of future rainfall (namely the Australian CSIRO model and the American NCAR model), as well as three GHG emission scenarios (A1B, A2 and B1*). Climate change impacts and adaptation costs were then estimated.

In this study, the East Asia and Pacific region had the highest adaptation costs because of high projected costs in infrastructure and coastal zone defence and management. The Latin America and the Caribbean and Sub-Saharan Africa regions are next, due to the costs in the water supply and flood protection and coastal zones sectors.

[Sources: ECA, 2009, World Bank, 2009]

Figure 4: Estimated losses from present-day natural hazards and from increased incidence of natural hazards by 2030, due to climate change, as a percentage of GDP for selected countries*



[Source: ECA, 2009]

The UN Security Council held its first ever debate on the impact of climate change on international peace and security in June 2007. This step recognised that climate change will have significant impacts on resources in many countries and that there are new threats arising from social, environmental and political factors that do not necessarily fall under conventional notions of military defence.

The scale of the potential problem is enormous. International Alert[21] identified 46 nations and 2.7 billion people at high risk of being overwhelmed by armed conflict and war because of climate change. A further 56 countries will face political destabilisation, affecting another 1.2 billion individuals.

In a recent report[22] it was found that there are strong historical linkages between civil war and temperature in Africa, with warmer years leading to significant increases in the likelihood of war. Using climate model projections the report estimated that there would be a 54% increase in armed conflict incidence by 2030, with an additional 393,000 deaths, if future wars are as deadly as recent wars. A 1°C increase in temperature 'represents a remarkable 49% increase in the incidence of civil war'.

The large majority of the poor in most African countries depend on agriculture for their livelihoods, and their crops are quite sensitive to small changes in temperature. When temperatures rise, the livelihoods of many in Africa suffer greatly, and the disadvantaged become more likely to take up arms. The research undertaken by the Institute for Environmental Security based in the Netherlands supports these findings. The Institute has noted that failure to recognise the conflict and instability implications of climate change and to invest in a range of preventive and adaptive actions will be very costly in terms of destabilising nations, causing human suffering, retarding development, and providing the required military response. The consequences for mining companies operating in Africa, and for global commodity prices are clear.

The current financial crisis. The mining sector has been one of the worst impacted by the financial crisis. The market capitalisation of the 40 largest mining companies decreased by 62%, nearly twice as much as the Standard and Poor's 500[23]. As commodity prices rose in recent years, companies aggressively expanded, with the cost of this expansion becoming a secondary concern[24]. This left them with large debts as the financial crisis struck.

One of the most significant impacts of the crisis is the increased cost of obtaining capital due to tighter debt and equity markets. This change in funding availability has an acute impact on a capital intensive industry such as mining. We can expect to see the cost of capital increase over time as the credit risk implications of a changing climate begin to be factored into project finance. The current analyses being undertaken by some banks in this area indicates the growing awareness of the potential risks (see page 18) and the implications for project finance.

Transport logistics. As minerals are often extracted from remote locations, companies face a logistical challenge in terms of how supplies, workforce and products are transported to and from the mine and onto the customer. Transport considerations, particularly cost containment and visibility, are vital components of any businesses supply chain. In a recent survey of executives, almost three quarters of supply chain executives positioned their supply chains as critical to cost containment for their overall businesses[25].

Disruption to supplies are notorious within the industry; in early 2008, climatic events such as snow storms in China, flooding in Australia and flooding related power outages in South Africa helped push up coal prices rapidly. An example of the impacts on transportation is provided in case study 4.

Transportation infrastructure and assets are extremely vulnerable to the impacts of climate change. Changes in sea conditions, coastal erosion, higher temperatures, melting permafrost, changing patterns and variability of precipitation, and increasingly frequent and intense extreme weather events, for example, will have impacts for navigation, materials handling and storage, and port, river, railway and road infrastructure.

These changes can all disrupt transportation infrastructure and networks, resulting in losses for businesses relying upon them and increased costs to the governments and companies charged with maintaining them. For example, South African mining company Exxaro Resources Ltd has estimated these costs, finding that two months of lost export opportunities occurring from transportation and/or infrastructure damage would cause revenue losses of $60 million[26].

As climate change impacts become more frequent and severe, businesses should expect and plan for disruptions to climatically vulnerable transportation systems and assets, as well as the subsequent economic and financial impacts.

Marine transport accounts for around 90% of world trade by volume and 70% of global trade by value. As a result, climate-related disruptions to maritime transport infrastructure and assets can have significant ramifications for the global economy, let alone individual businesses.

Ports and coastal areas are particularly vulnerable to numerous climate impacts, including coastal erosion, sea level rise, tidal flooding and storm surges. Heavy precipitation events (in conjunction with land use change) can contribute to sedimentation of ports, channels and other marine transportation routes, causing direct damages to infrastructure as well as disrupting transportation itself.

[21] International Alert (2007). A climate of conflict: the links between climate change, peace and war. London.
[22] Proceedings of the National Academy of Sciences Warming increases the risk of civil war in Africa (2009).
[23] PwC, 2009.
[24] Ernst and Young, 2009.
[25] IBM, 2009.
[26] Exxaro Resources. Response to the Carbon Disclosure Project 2008.

Case study 4: Impacts of permafrost thaw on the Qinghai-Tibet railway

On the Tibetan Plateau, warming of the climate and decreased depth of frozen soils is already occurring and threatens the stability of the US$4.2 billion railway line connecting Lhasa, Tibet, to the Chinese network in Qinghai, China, known as the 'highest' railway in the world. The railway will provide access to enable the extraction of significant copper, lead, zinc, and iron ore deposits together with rare earth elements.

The railway is built on 'warm' permafrost, with a mean annual ground temperature ranging from 0 to minus 1°C. Monitoring of permafrost along the railway confirmed that the soil beneath the rails is vulnerable: 'warm' permafrost (warmer than -1.5°C) is very sensitive to disturbances from engineering activities, which have an immediate and direct impact on its thermal and moisture regimes. Climatic changes will have more severe impacts on the stability and reliability of engineering infrastructures founded on 'warm' permafrost.

Permafrost on the Tibetan plateau has warmed by about 0.3°C over the past 30 years. Where human activity has disturbed the soil, such as during construction of the railway, the rate of warming is double, i.e. about 0.6°C. The area of the Southern Qinghai-Tibet highway with underlying permafrost decreased by 36% between 1974 and 1996, while the permafrost area of the Northern Qinghai-Tibet highway decreased by 12% between 1975 and 2003. Research indicates that the permafrost area on the Plateau may be reduced by up to about 60% by mid-century.

To manage the impacts of the changing climate, engineering techniques common in Alaska and Siberia were used to stabilise the ground by keeping it frozen well below 0°C: steel tubes containing ammonia were drilled into the soil to draw heat out of the soil. At the design stage, the use of this cooling technique added costs representing 1% of total project expenditure (i.e. $420 million).

Passive methods aimed at simply raising embankment height and insulating materials were considered ineffective.

The IPCC (2007) predicts an increase in annual average air temperatures in the region where the railway is located, of around 2-3°C by 2050. The railway was built to withstand rates of warming of about 0.2°C and 2°C for soil and air temperatures respectively, over the next 50 years. If the IPCC's higher end projections are realised, further capital investment and operational costs will be required to maintain the engineering integrity of the railway. Mineral operators may be faced with a call for them to contribute to these unplanned future capital and operational investment requirements.

[Sources: Cheng et al., 2008; Cheng, 2005; UNEP, 2007; Wu et al. 2007; http://news.xinhuanet.com/english/2009-08/17/content_11896656.htm]

For example, the total value of assets in port cities exposed to coastal flooding due to storm surge in 2005[27] was estimated to be US$3,000 billion, (around 5% of global GDP in 2005) the majority of which are found in the developed world. As climate change impacts become more frequent and severe, these figures are projected to increase substantially.

Climate change will not only pose risks to businesses relying upon marine transport infrastructure and operating within the transportation sector; it could also lead to opportunities. (See case study 5.)

Operating costs. As a result of the remote location of many mine sites and the amounts of heavy machinery used, companies are impacted by supply issues. A common delay for mining companies is finding spare parts for when an asset or piece of equipment breaks down[28]. Direct maintenance makes up a large proportion of expenditure; this ranges from 20% to 50% of total project costs[29], some of the highest levels in any industry.

As a result of the financial crisis, companies are taking a closer look at their operational costs.

The higher commodity prices pre-financial crisis masked the significant increases in operating costs which rose on average by 28% in 2008[30]. Rising production costs is a major pressure on the mining sector further eroding margins.

Many of the impacts identified in this report will place increasing stress on asset management and operating cost profiles.

Older plant and equipment can be less productive and can give rise to a number of other challenges and costs, including health and safety considerations. Equipment designed to historic climate conditions (for example pumps, compressors, generators) and nearing the end of their asset life may be required to work close to or exceed operating profiles, and in more challenging environments.

The equipment and asset design standards for existing assets may no longer be sufficient to meet the impact of a changing climate, for example, the capacity of tailing lagoons and surface water management systems may not provide sufficient risk headroom with changes in precipitation and storm conditions. The combined effect of asset age and a changing climate should be considered in operational and health, safety and environment risk assessments.

Asset maintenance and monitoring regimes should be reviewed in the light that the impacts of a changing climate may require:

- Changes in the frequency of maintenance and monitoring procedures
- New and/or revised maintenance and monitoring procedures.

The costs for asset depreciation and replacement due to climate change are asset and location specific.

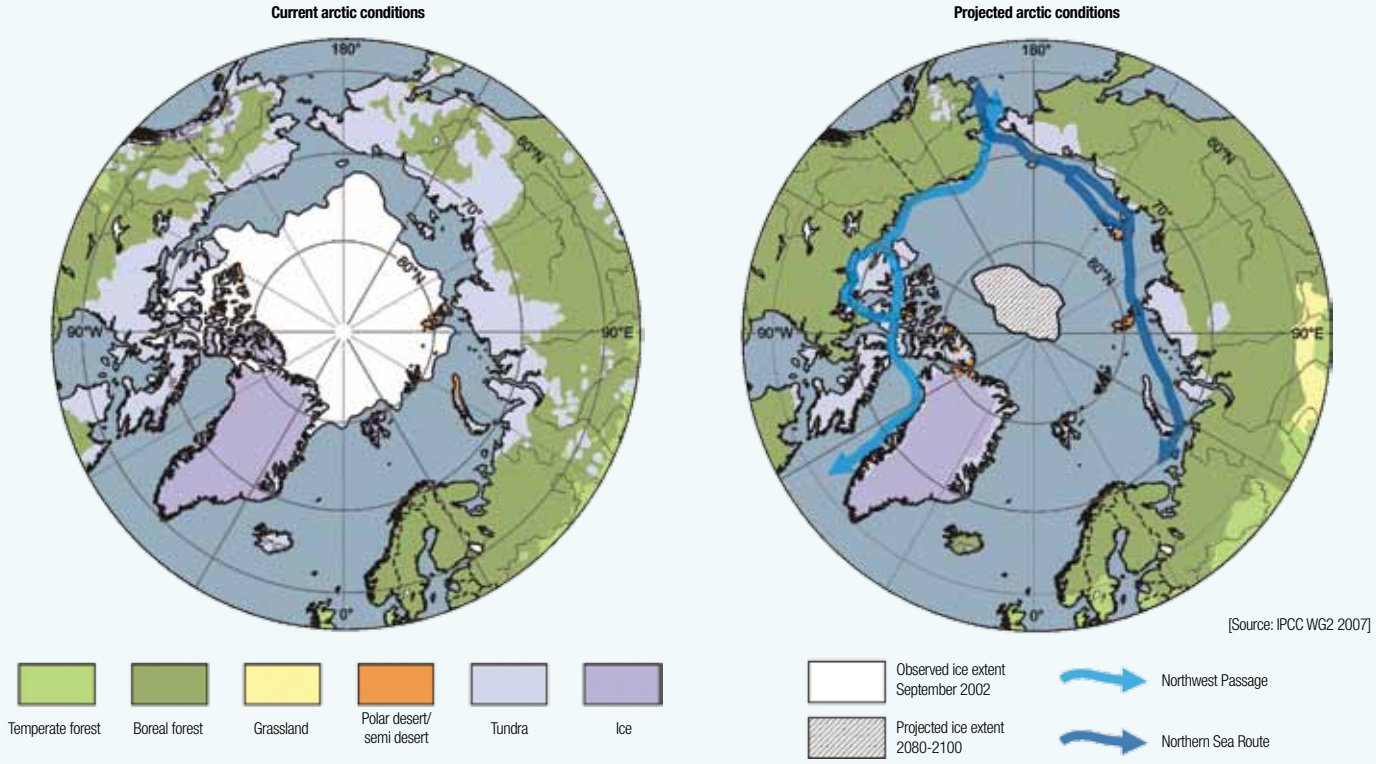
[27] Nicholls et al (2007).
[28] E.g. GMA Resources has recently experienced delays in receiving critical supplies at its Amesmessa gold mine in Angola. http://www.proactiveinvestors.co.uk/companies/news/6504/gma-resources-taking-further-steps-to-address-amesmessa-mine-supply-issues-6504.html.
[29] Campbell, 1995.
[30] PwC, 2009.

Case study 5: New maritime transport routes may open up

As sea and air temperatures increase, ice-restricted ports will find they have longer operation seasons as navigation routes become less restricted. In polar regions, new routes may become available as the area covered by sea-ice retreats creating new shipping lanes. Inland waterways in Russia, Canada and the USA will be ice free for longer and provide more reliable transport routes (subject to changes in river flows).

September 2009 saw the first ever commercial use of an arctic route from South Korea to Europe. Although there may be depth limitations that restrict the size of ships, it may provide an economic route for bulk cargoes given the significant fuel savings from the shorter routes. The routes may also enable the supply of materials and consumables to mining operations.

Figure 5: Projected Arctic ice melt by the 2080s



In the case of infrastructure in Alaska (see case study 6), the main climate risks affecting assets were thawing permafrost, increasing flooding and coastal erosion. Acknowledging differences in baseline conditions, future changes in climate and infrastructure asset value and composition; it can be estimated based on the Alaska analysis that mining companies operating in similar areas may require additional replacement costs on a similar scale, i.e. of the order of 10% to 15% by 2030. It is likely that on shorter timescales the percentage increase in costs might also be significant.

Energy and security of supplies. Most businesses rely on a secure source of energy for the continuity of their operations. Some industry sectors have critical logistics or operations for which even a short-term disruption in energy supply creates significant losses and lower revenues. Mining is one such sector where disruptions and increases in energy costs can challenge the financial viability of operations.

In Ghana in 2006 the Volta River Authority was forced to ration power supplies on a scale not seen since 1983 due to impacts of changes in rainfall on hydro-power. The crisis threatened mine closures due to electricity outages and led to increases in operating costs. As a result of energy disruptions, four mining companies have collaborated to build a new 80MW dual fuel thermal power plant at an estimated cost of US$45.5 million to ensure energy security[31].

In South Africa gold mining companies' production fell by almost 20% on a year-on-year basis in the first quarter of 2008[32] due to electricity shortages.

In Brazil (where approx. 80% of electricity is generated through hydropower) during 2001, reservoir levels were at 30% storage capacity due to drought. The effects resulted in the government taking severe measures to reduce electricity consumption by 10-35%. The usage reduction quotas

[31] Onyango. J Production costs rise with regular power cuts. Business Daily Africa 13 July 2009.
[32] Commodity Online, 2009.

"The most significant physical risk from climate change to Northam is anticipated to be water scarcity resulting from a decrease in rainfall. Northam used 18.1 million m^3 of water in 2007… Supply of water by the bulk utility, Magalies Water, is not yet a constraint but may become one in the near future."

"Should water restrictions be imposed due to severe water shortages this would impact the hydropower supply to Northam significantly, and have cost implications for accessing the alternatives described above."

"Northam's current infrastructure has been developed to utilise hydropower, which required a very high capital investment. Extreme water shortages resulting in a discontinuation of this technology would be highly expensive for the company."

Northam Platinum Ltd

Case study 6: Infrastructure and assets wear out more quickly and require additional capital expenditure under a changing climate

Wear and tear on assets and infrastructure will increase due to climate change. Research in Alaska has estimated the additional impact of climate change on capital depreciation for the State's infrastructure by:

- Calculating the baseline replacement costs for public infrastructure based on documented life-spans of various asset classes and standard financial techniques for calculating depreciation
- Applying annual engineering depreciation rates and percent changes in temperature and precipitation, based on asset class, topography and proximity to floodplains.

The study investigated two scenarios – one in which adaptation is undertaken when climate change leads to a loss in useful asset life of 20% or more, with an additional associated cost of 5% and allowing full asset life to be regained.

Under the second, 'without adaptation' scenario, public agencies simply react as conditions change: they continue to design and construct infrastructure taking into account historic climatic conditions but not projected changes; they find solutions as problems develop rather than anticipating and planning for trends in climate change and future infrastructure vulnerabilities.

The study found that, under the 'with adaptation' scenario, climate change will add between US$3.6 and 6.1 billion (NPV, using a public sector discount rate of 2.85% per year) to the costs of wear and tear between 2006 and 2030, across a range of climate change projections. These figures equate to between 9 and 15% of total asset value ($39.4 billion at 2006 replacement costs). Without adaptation, the costs of climate change are in the range $5.6 to $6.7 billion.

[Source: Larsen 2007]

"As a global mining and metals group, Rio Tinto operates mines and smelters in a wide spectrum of climates, ranging from tropical and temperate to arctic and desert. Since 2006 the Group has used high resolution climate modelling to predict the physical impact of climate change on many of our operations and projects. The results of this modelling are being incorporated into risk management processes, water management strategies and project development."

Peter Cunningham
MD Energy and Climate Strategy
Rio Tinto

affected some industry sectors more than others and those that did not comply were fined or eventually had their power supply cut off. The impact of Brazil's electricity rationing was national: it is estimated that the drought led to a loss of approximately US$20 billion, the equivalent of about 2% of Brazil's GDP[33]. (See case study 7.)

Contingency and decommissioning liabilities. Loss contingencies may need to increase as the risks of climate change become more likely and quantified. Loss contingencies typically cover risks which can be exacerbated by climate change, such as loss of or damage to assets through droughts, storms, heatwave and fire risks, and pending or threatened litigation. They are accrued on clients' income statements[34] as probable[35] losses for which the amount of loss may be reasonably estimated. Other climate-related risks which may fall within the scope of loss contingencies include supply chain disruption. Insurance costs for these risks are likely to increase over time.

Loss contingencies are recorded as footnotes in a company's balance sheet. Losses which are probable or have a reasonable possibility of occurring should be *disclosed* in financial statements, indicating the nature of the liability and an estimate or range of possible loss. The probability of losses due to disruptions is likely to increase over the life of a mining asset. The return periods for extreme events are decreasing for example, in 2003 the European heat wave was estimated to be an exceptional, '1 in 500' year event. Due to rising temperatures, by 2040, the UK Met Office predicts that summers as hot as 2003 will have a return period of 1 in 2 years, and by 2060 a '2003' type hot summer will be considered as a relatively cool summer. Such dramatic increases in the probability of damaging events and their impacts on business are within the requirements for disclosure. (See case study 8.)

[33] Cashmore et al 2006.
[34] Only remote liabilities do not deserve mention in financial statements (see footnote below).
[35] 'Probable' means 'more likely that not', or with chance of occurring greater than 50 percent. 'Reasonable possibility' means 'more than remote but less than 50 percent'. 'Remote' means the chance of the future event or events occurring is 'slight'.

Case study 7: Australian drought leads to significant reduction in energy generation and mining production

Tarong Energy (TE), a state owned enterprise in Queensland, owns the Tarong Power Station (TPS) and partly owns the Tarong North Power Station (TNPS). TE also own an adjoining coal mine which supplies the coal required for electricity generation at both stations. The ownership of the mine changed from Rio Tinto to TE in 2007. The power stations and mine jointly draw a substantial proportion of local resources from the region and provide employment opportunities for approximately 500 people, most of who reside within the boundaries of the region. The current mining activities at Meandu Mine are purely dependent on power station demand.

The financial performance of TE in 2006/07 was significantly affected by the 2007 drought in South East Queensland (SEQ), with the Corporation posting a loss for the first time in its history. In TE's Annual Report 2006/07, losses of AUS$68.6m (after tax) were reported, due to reduced generation due to the drought, a change to the Australian International Financial Reporting Standards (AIFRS) and write down of investment in TNPS.

The cooling system at TPS alone requires about 600 litres of water per second to make up the evaporation losses in its two cooling towers. Water required for the cooling towers is obtained through a purpose-built 96 kilometre pipeline from Boondooma Dam. The power stations normally required approximately 35,000 ML of water per annum. However, the worsening drought conditions over 2006/07 led to restrictions on water use and a significant reduction in the stations' output. This adversely impacted on the neighbouring farming community because of the limited release of water for irrigated farming. Prior to the drought, water released by the power stations was used for irrigation by farmers along Meandu and Barkers Creeks.

The cut in power station outputs had a direct impact on upstream supply chains. In 2007, Rio Tinto were reported to have halved production of coal and cut 160 jobs at its Tarong mine in south-eastern Queensland due to the cuts in power station output. Coal production was reported to have dropped from 605,000 tonnes per month to 300,000 tonnes.

The drought also lowered water levels at hydro-electric power station dams in the Australian states of New South Wales, Victoria and Tasmania. It was reported that wholesale electricity prices were up to four times higher than usual for the time of year because the drought had reduced supply at hydro-electric and coal-fired power stations.

TE responded to the drought by introducing a sustainable generation profile plan and a variety of water efficiency measures, such as recycling water from the ash dam, capturing and harvesting storm water, coordination of recycled water use between the power stations and the mine, reducing wastages through leaks and water use restrictions, and commissioning a reverse osmosis plant to provide potable water on site. Crucially as a safeguard against the affects of drought, the stations became connected to the SEQ Water Grid in June 2008.

[Sources: Delpachitra, 2008; www.theage.com.au/news/business/rio-to-cut-coal-jobs-as-drought-bites/2007/05/16/1178995236604.html (accessed 20/08/2009)]

Intangible values. A mining company's stock market valuation is not merely a function of its assets, reserves, costs, revenues, and profitability. Investors recognise the importance of a company's intangible assets and the contribution they make to overall value. Many of the intangible assets held by mining companies have the potential to be seriously affected by the direct and indirect impacts of inevitable climate change. Examples have been provided in the preceding sections. (See case study 9.)

"A changing climate is an important operational consideration for Rio Tinto, which already experiences weather related disruptions."

"Changes to climate may affect operations, especially our longer life assets (up to and beyond 50 years in some cases)."

"Water availability is a significant design issue for many operations, and is affected not only by climate change but also by increased competition where local population and industrial development is on the increase."

"Increased frequency and/or intensity of extreme events such as cyclones and other types of storms have the potential to cause disruption and damage."

"Sea level rise may affect coastal facilities, including power stations and ports. In some regions a change in health risks (e.g. malaria and dysentery) could affect both the workforce and local communities."

"Changes in temperature and rainfall could also affect land rehabilitation programmes and the security of our operations."

Rio Tinto

Case study 8: Decommissioning liabilities

A recent report from Standard and Poor's sets out concerns regarding disclosure by mining companies of their future decommissioning liabilities. The report refers to the lack of information provided by companies. An assessment of leading companies indicates that decommissioning provisions (which are treated as additions to debt) equate to around 40% of a company's reported debt. Decommissioning provisions represent a significant part of these companies' financial risk because the majority of cash flows occur at the end of the project's life.

The accounting rules for such provisions under IFRS (IAS 37) and the new Financial Interpretation 47 (FIN 47) require a company to recognise a liability as soon as the decommissioning obligation is created, which is normally at the time a mining project is commenced. Standard and Poor's found that the scale of decommissioning provisions tends to be based on management judgement rather than third-party appraisals.

There is no evidence that the new standards and principles that have been implemented and accepted by the mining sector contain any reference to the impacts that climate change will have on the costs of decommissioning their existing and planned assets. If this is correct then it is possible that companies may be underestimating their future debt liabilities and failing to meet reporting obligations.

There are new and emerging risks to be considered; examples of which are provided in this report. Many of these have the potential to create challenges for the decommissioning of assets, for example:

- Rising groundwater levels may create new source-pathway-receptor relationships increasing risks associated with contaminated land
- Increasing flood levels will result in enhanced risks to decommissioned sites requiring higher levels of flood protection
- Environmental site protection and reinstatement plans agreed during the licensing and consenting process may not be appropriate in view of the changes in species and habitats during the life of the project.

Each asset type, the area in which it is located, and the intended after-use of the site, will have to be examined and the decommissioning costs reassessed. In many cases legally binding obligations, linked to consents and licences to operate, may have been given regarding the decommissioning and restoration of a site and its future use, which may no longer be achievable. These obligations may need to be re-negotiated.

Robust climate change information is available to help assess the impacts on asset decommissioning costs. Failure to do so raises questions regarding the corporate governance credentials of individual companies and their fiduciary responsibilities to their shareholders. It also questions their reporting procedures and compliance with IAS 37.

[Source: Standard & Poor's 2007]

Case study 9: Client reputational damage linked to climate change may result in decreased return on equity

It is acknowledged that threats to reputation – whether real or perceived – can damage an image or brand. On the balance sheet, reputation value is considered as an intangible asset and is accounted for under 'goodwill' or 'intellectual capital'.

More and more studies demonstrate that reputation affects stock market values and contributes to explaining the difference between company market capitalisation and book value. Some experts estimate that reputation can account for much of the 30 to 70% gap between the book value and the market capitalisation for publicly-listed companies. A study comparing market value to book value of 3,500 U.S. companies over a period of two decades shows the dramatic upward rise in intangible value. In 1982 the value of intangible assets was significantly less than the tangible assets, by 1999 tangible assets only accounted for 16% of the market value.

Investors will continue to increase their interest in the management of intangible assets, particularly if these assets are at risk from climate change. Mining companies can expect to see pressure for disclosure about their understanding of the impacts of climate change, their risk management processes, and their strategies to maintain intangible asset value.

[Sources: Tergesen, 2002; Regester et al., 2002; Daum, 1999]

4 What are the impacts for the mining sector?

Successful mining companies already cope with historic climate risks, ranging from day-to-day and seasonal changeability in weather and extreme events. Assets have been designed to operate within historic thresholds and margins to:

- Meet the climatic differences across the various regions in which they operate
- Maintain social, environmental and health and safety regulatory requirements
- Deliver against financial performance standards
- Meet operational performance and service delivery standards.

Most companies have practical strategies in place to manage climate uncertainty and minimise disruption, including for example, taking out insurance, maintaining updated contingency plans, and investing in employee education and healthcare.

These strategies continue to be important in coping with natural climatic variability. However, the baseline climate is changing, and business decisions and practices will need to evolve as a result. Mining assets have been designed on the basis of historic climate data and a period of relatively stable weather. These design assumptions together with those thresholds and margins set for regulatory, operational and financial performance requirements will constrain the future effectiveness of assets to deliver under climate change.

Companies should recognise that climate change will have both direct and indirect impacts across their value chains. It is vital that companies do not limit their risk assessments to the direct physical impacts of climate change. The compound impacts are likely to reverberate through a company's business model – creating a 'pinball machine effect' as the impacts in one area rebound and have consequential impacts elsewhere within a company's business systems, for example:

- Access and availability of natural resources and raw materials
- Procurement supply chains and logistics
- Asset design and construction
- Asset operation, performance and maintenance
- Markets and customers
- Workforce
- Local communities and the environment.

Most reports on climate change impacts focus on direct climate hazards and environmental effects due to extreme events. They concentrate on analysing a one-to-one mapping of hazard to impact, for example, flood risk. This oversimplifies the complex cause and effects that exist as the climate hazards and environmental effects manifest themselves within a company's business systems. It also ignores the effect of incremental climate change and under-estimates the potential costs of the impacts and the adaptation responses by the company and by its stakeholders.

Extreme (acute) events and incremental (chronic) climatic change

Both 'acute' and 'chronic' climate change effects will impact the bottom lines of mining companies by influencing, for example:

- Operational performance as a result of degraded site conditions, damage to assets, decreased efficiencies of operations, reduced availability and quality of raw materials and natural resources, effects on workforce health and safety
- Social performance because of increased competition with local communities for access to climate-sensitive natural resources and changes in socio-economic conditions
- Environmental performance through changes in habitats, flora and fauna, impacts of discharges and use of natural resources.

Disruptions to mining extraction processes from recent extreme events (for example, the drought in Australia) serve to illustrate the vulnerability of assets to events greater than the industry's current asset design, engineering and operational standards.

These events, combined with the availability of increasingly sophisticated climate change models, have generated greater interest in planning for more severe and frequent climatic events. In contrast the 'creeping' average changes are much harder to recognise and are more likely to be overlooked.

Figure 6 illustrates the importance of identifying climatic sensitivities and critical thresholds for assets and business systems. These provide the boundaries between tolerable and intolerable levels of risk. Information and data on current and future climate conditions can then be assessed against the asset thresholds, to evaluate the likelihood of their being exceeded.

Acute (extreme) events. Setting the critical thresholds for asset design and operation is essential, but there is always an event greater than that for which protection has been provided. Climate change (as indicated by figure 6) is predicted to increase the risk of extreme events exceeding critical thresholds. Companies should assess their risks and develop strategic plans to expand the 'coping range' of their assets through adaptation measures. Business continuity and crisis-management responses are appropriate to manage the impacts of extreme events but have little relevance to incremental change. The latter requires companies to carry out fundamental reviews of their business models and check that processes are resilient to the new operating conditions created by climate change.

"Extreme weather events and changes in weather patterns affect project and region-specific issues and require a collaborative approach to identifying and implementing solutions. Extreme weather events and changes in weather patterns can affect our operations."

"Warmer winters can mean a shorter winter drilling season for our Canadian Conventional operations. As a result, companies may be challenged to complete drilling and other operations when conditions are amenable. Our North Sea operations may be affected by changes in climate and related storm patterns and sea conditions."

Canadian Natural Resources

"The mining industry has historically been early adopters of new technology to improve our operations, and this continues that tradition."

"It also represents a potential opportunity to obtain long-term and more secure sources of energy."

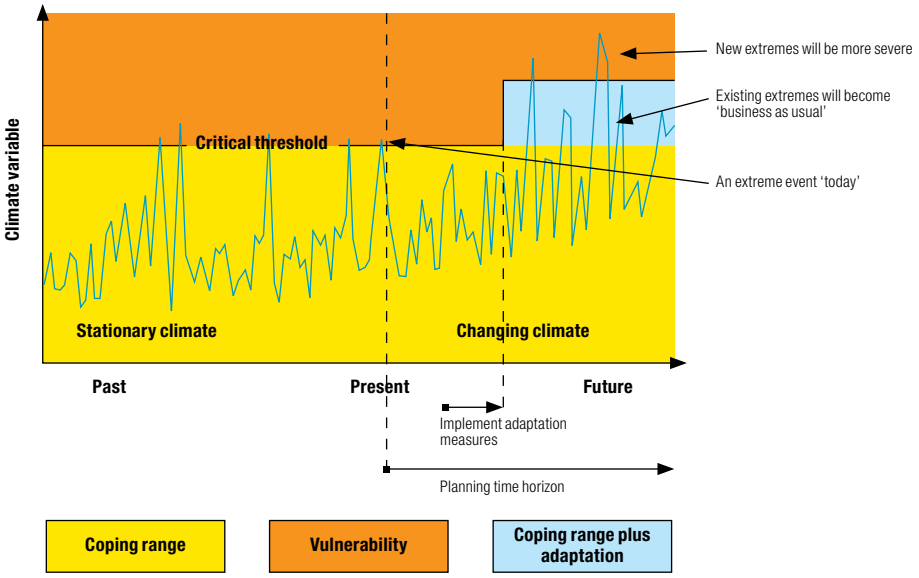
"By committing to investigating strategies to reduce or optimise energy usage we can reduce operating costs, increasing our competitive position within the industry."

Inmet Mining

Chronic (incremental) changes. These changes to our climate are more subtle and their impacts on business models and assets may pass undetected until critical thresholds are breached (for example changes in ambient air temperature affecting asset performance). The responses may result in 'step-changes' for a company, increasing operational costs beyond forecasts, falling revenues, unplanned capital investment and additional balance sheet financing to manage the consequences.

Assets and operational processes designed without an appropriate allowance for incremental change may fail to meet design criteria, operational performance targets, key performance indicators (KPIs) and future regulatory standards. Understanding the incremental changes in the climate and a company's current thresholds, sensitivities and vulnerabilities are significant issues to be considered in any analysis of a company's future financial performance. They should feature in corporate assessments of strategic, operational and project risks. This is a particularly important area for companies to focus on when undertaking asset and capability optimisation actions.

Figure 6: Impact of extreme events and incremental change on critical asset (or business system) thresholds[36]



[36] Willows and Connell, 2003.

5 Mining companies need to recognise growing investor concerns

Regulatory and legal drivers

Although new regulatory provisions are being developed in many countries in response to these challenges, there remains a great deal of uncertainty regarding the scope, content and format of future legislation. Greater certainty about the future regulatory landscape is required to encourage companies to invest. New regulatory pricing structures will be required in some countries to encourage greater energy efficiency and demand management measures.

As the impacts of climate change become more direct we are likely to see governments resort to prescriptive regulation and statutory controls to ensure that mining companies take appropriate action on adaptation.

The wealth of information on the impacts of climate change from the scientific community, academia, research institutions, government, trade associations, and NGOs is so great that no company or director, senior manager or professional advisor could claim ignorance. As the financial impacts of climate change are further recognised, we are likely to see litigation being used to address failures in risk management due to changes in our climate and the impacts on the mining sector.

Some lawyers are beginning to acknowledge that there is now sufficient information available on climate change to take it into account in both strategic and operational decision-making. Reasonable forseeability is likely to be established based on the existence of 'knowledge points' from which it was reasonable to consider that the impacts of a changing climate should have been taken into account. Potential 'knowledge points' that could be used to challenge decisions may include (without being limited to):

- The scientific evidence established, recognised and widely available since the IPCC First Assessment Report (published in 1990), the Stern Review (2007) and other landmark expert reports
- The increasing evidence of climate change business consequences across sectors and the positions being taken by some companies, providing evidence of best practice
- Professional institutions and trade associations providing guidance to their members. The recent report from the ICMM[37] recognises that "comprehensive and sustained global action is required to reduce the scale of human-induced climate change and to adapt to its impact". The ICMM council comprising the CEOs from 19 of the largest mining companies have reviewed the policy which now includes specific actions on adaptation for member companies to follow (case study 10).

Case study 10: ICMM policy on climate change

Extracts from the ICMM policies specifically relative to adaptation are set out below.

Policy 2: As major consumers and producers of energy, ICMM members have direct equity in a global policy approach to managing climate change that:

- Promotes the development and dissemination of technologies that build the capacity to adapt to climate change, particularly in developing countries.

Policy 3: ICMM Member responsibility

- Within the industry, and in support of a global agreement, ICMM members accept their responsibility to:
  - Promote technical innovation and creativity in low greenhouse gas emissions technologies while enhancing energy and resource efficiency
  - Ensure efficient use of renewable and non-renewable natural resources
  - Develop appropriate adaptation strategies specific to our operations
  - Contribute to the sustainable development of local communities and societies in adapting to the impacts of climate change.

Policy 7: Investment and co-operation in low emission technologies and adaptation

- ICMM members consider it is essential that governments and industries continue to co-operate in the development, deployment and funding of low emissions technologies in all energy sources, abatement related to land uses and in building collaborative efforts both within and between countries to build the capacity to adapt to the impact of climate change.

[37] ICMM (2009) Policy on climate change.

Increasing regulation and litigation will both add to the costs and liabilities that mining companies will have to manage. In an industry with an already increasing cost profile, investors will be concerned that the impacts will have detrimental effects on returns. It is in the interest of mining companies to manage these risks by engagement with regulatory authorities on the development of policies and regulations. Companies need also to consider their contractual relationships and ensure that they provide sufficient certainty and protection against potential claims.

Stakeholder pressure to disclose risks and address issues

Investors and other stakeholders, including governments and regulatory agencies, consumers, local communities and NGOs, have started to place much greater pressure on mining companies to address climate risks and opportunities. The status of climate risk disclosure and management is changing, moving from a voluntary to a mandatory requirement. These changes supplement the duty that company directors already have, to disclose future material risks to their shareholders, to regulatory investment authorities and to their insurers[38].

The issue of disclosure is of increasing interest to investors. For example, the United Nations Environment Program Finance Initiative (UNEP FI) has considered this issue in two landmark reports on fiduciary duties and environmental, social and governance (ESG) issues: the 'Freshfields Report' of 2005[39] and its follow up report in 2009[40]. These reports consider, in the context of investment and asset managers, that the inclusion of ESG considerations (which include climate change impacts) into investment analysis is compatible with the duties fiduciaries owe their beneficiaries, and indeed is arguably required in all jurisdictions.

- *"Fiduciaries must recognise that integrating ESG issues [among which UNEP FI includes climate change risks] into investment and ownership processes […] is* ***necessary to managing risk and evaluating opportunities for long-term investment****"*
- *"Fiduciaries will increasingly come to understand the materiality of ESG issues and the systemic risk it poses, and the profound long-term costs of unsustainable development and its consequent* ***impacts on the long-term value of their investment portfolios****"*

Climate change impacts are increasingly recognised by the financial community as a business risk issue with financial, credit, environmental, social and developmental consequences. This is demonstrated through various initiatives:

- The Carbon Disclosure Project (CDP) represented in 2009 a total of 475 institutional investors across the world holding US$55 trillion in assets under management. CDP sends out annual requests for information about management of climate risks, on behalf of its members, to the world's largest listed companies on climate change risks.
- Investors increasingly raise questions over climate change adaptation risks. There are many examples of investment funds undertaking research on the implications of climate change for future investment value.
- In 2009, members of the Equator Principles, as well as the Climate Change Working Group of the United Nations Environment Program Finance Initiative (UNEP FI), began discussing the need for climate risk management principles to be included into financial institutions' guidelines, including the Equator Principles.
- In September 2009, a statement on the urgent need for a global agreement on climate change, including "support for adaptation to unavoidable climate change impacts", was produced by the Institutional Investors Group on Climate Change (IIGCC), the Investor Network on Climate Risk (INCR), the Investor Group on Climate Change Australia and New Zealand (IIGCC Australia/New Zealand). Signed by 181 investment institutions with assets of US$13 trillion, the statement called for clear, credible long-term policies on climate change to be agreed in Copenhagen in December 2009, and stated that: *"As investors we recognise that the physical impacts from climate change will have far-reaching consequences, such as rising costs of insurance and scarcity of key resources, including water scarcity risks. At present, both government and private sector investment in adaptation is inadequate across the globe."*

Banks are looking at the lending risks associated with project finance. The International Finance Corporation (IFC), the European Bank for Reconstruction and Development (EBRD), the African Development Bank, the Asian Development Bank, Barclays, HSBC and Westpac are all assessing the implications. The EBRD has launched a twelve-month assignment with the objective of developing a methodology for understanding these risks, and their likely impacts on its operations, so that projects can be made climate resilient where appropriate. This assignment will develop guidance and practical tools for integrating climate risk assessment and climate change adaptation into EBRD's project cycle management. In the future companies approaching the EBRD for project finance will have to satisfy the bank that their project is resilient to the impacts of climate change[41]. It can be expected over time that other banks will follow the lead taken by the IFC and EBRD.

[38] Companies will need to uphold their duty of utmost good faith to their insurers regarding disclosure of any risk assessments they may have undertaken (or those undertaken by their suppliers, customers or the governments of countries in which they operate).
[39] UNEP FI AMWG 2005.
[40] UNEP FI AMWG 2009.
[41] Emerging work on climate change adaptation at EBRD, July 2009. Briefing note prepared by EBRD.

6 How are companies responding?

Companies are beginning to identify risks

Respondents most often identify both 'acute' and 'chronic' climate risks to assets and natural resources. Risks around water and energy, as well as assets being damaged, make up the top three most identified and assessed risks. These risks are understandably important to companies considering the large physical asset base and extreme working conditions of mining companies.

Damage to assets from extreme events is a risk identified by a number of companies. Xstrata state that there is "evidence that climate change will increase the severity and frequency of… extreme weather events, potentially disrupting operations and damaging infrastructure and equipment".

81% of companies reported that their physical assets would be compromised by extreme events, and 51% reported that they had suffered damage.

Companies often operate in areas that are prone to water shortages or areas where water issues will be increasingly tied with local communities. African Rainbow Minerals, for example noted that "Drought is a risk in terms of availability of water, especially in operations that rely on abstraction from rivers and aquifers opposed to supply from municipalities".

Potential water stress and restrictions were reported by 53% of companies.

34% recognised that climate change may create energy price volatility and security of supply challenges.

The fact that energy price volatility and security of supply is one of the most recognised risks is unsurprising as many companies are already facing electricity supply shortages. This situation is expected to get worse in the near future. According to Barclays Capital, "energy availability in the next 10 years is going to be a very important issue to the mining sector. We see these as structural changes, not cyclical changes"[42].

Table 1: The most frequently mentioned risks identified by companies and those that are being addressed

Top risks identified	Top risks assessed
1. Limited water availability	1. Limited water availability
2. Assets compromised by extreme events	2. Assets compromised by extreme events
3. Operations affected by energy price volatility and energy security issues	3. Operations affected by energy price volatility and energy security issues
4a. Assets damaged due to rising sea levels 4b. Onshore transport affected by extreme events	4a. Assets damaged due to rising sea levels 4b. Marine transport and port facilities affected by extreme events 4c. Raw materials not minable due to extreme events, potential loss of equipment
5a. Increased disease incidence among workforce 5b. Problems with reliance on marine transport and port facilities 5c. Reputational issues amongst customers if the company is seen to fail to deal with climate change	5a. Increased forest fire risk 5b. Climate change will mean more health and safety issues among the workforce (e.g. increased disease incidence) 5c. Higher temperatures lead to increased energy use for cooling 5d. Risk to own energy production capabilities
6a. Raw materials not able to be mined due to extreme events with potential losses of equipment 6b. Increased pressure from local communities	

Transport related issues (land and sea) featured in a number of the responses.

24% identified the risks due to rising sea levels, with 18% referring to potential problems due to their reliance on marine transport and port facilities.

19% recognised that land based transport systems could be vulnerable.

It is interesting to note that there was limited recognition of the effect of climate change on decommissioning and mine closures and regeneration issues.

Only 1.6% considered that climate change would have an impact on site remediation costs.

Supply chain and essential utility disruption together with consumable costs are already acknowledged as issues. It is perhaps surprising that the numbers recognising that these risks would be affected by climate change was not higher.

11% identified risks to essential utilities. Direct risks to supply chains were not identified (although these may have been included within the concerns raised regarding transport disruption).

The reputational problems many mining companies have experienced in recent years, often associated with workforce conditions and impacts on local communities, is a key issue.

19% considered that there may be an increase in disease risks, with 13% considering that they would be under more pressure from local communities. 18% reported that there would be reputational issues if they were not seen to be dealing with climate change.

It was surprising that no companies identified potential impacts on political stability and geo-political risks.

[42] Bloomberg, May 5 2009.