srk news
Climate Change

Changing with the climate: perspectives from the mining industry

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Manage and mitigate climate change risk by developing and implementing effective strategies meeting regulatory requirements

Miners are responding to evolving standards on sustainability and climate change action and communicating their progress to their investors, regulators, customers and relevant communities. Decarbonisation is currently dominating miners' discourse on climate action but adaption in response to physical risks are equally important.

Decarbonisation now features in the strategies of mining companies, influencing acquisitions and divestments, as well choices of exploration targets, project stage-gate decisions, investments in existing operations and closure planning. Many mining companies have committed to achieving net-zero Scope 1 and 2 emissions by 2050 and have set ambitious mid-term targets. Today's investors want to know how the strategies will meet these targets and how they are accounted for in annual reports and financial models.

Engineering of climate adaptation solutions requires a site-level focus and a multi-disciplinary set of skills. The spotlight on climate adaptation risk is expected to increase; it will no longer only be framed from the perspective of physical risks and financial consequences, but also in terms of impacts on humans and ecosystems.

Standards and legislation relevant to mine design and closure planning are steadily introducing requirements for the prediction of changing conditions in response to climate change, both during the life of a mine and post closure.

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Changing with the climate: perspectives from the mining industry *(continued)*

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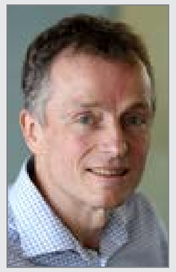

Tony is a water management specialist with over 33 years' professional experience. He has extensive experience in mine water management, with expertise in evaluating water issues in the context of the wider objectives of a mining project. Tony helps identify, manage and mitigate risks in mine water management while also highlighting opportunities through innovative thinking and taking a whole-of-project approach.

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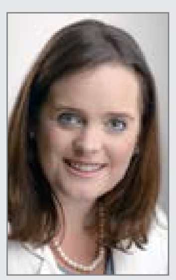

Philippa is an associate partner and principal scientist in SRK's Durban office. She holds a BSc Hons in Environmental Science and many qualifications in the field of climate change. She has 19 years of experience in integrated environmental management with more recent specialisation in air quality and climate change. She focuses on the identification of risks and opportunities in the project life cycle to inform design and operational optimisation to achieve clients' sustainability goals.

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This is particularly relevant to infrastructure such as dams and mine waste facilities. For example, climate change is identified as a key consideration in the Global Industry Standard on Tailings Management.

This issue of SRK News explores all these elements of the climate change agenda as relevant to the mining industry which is currently experiencing many positive developments. SRK is supporting and advising our clients through what is a complex interplay of technical, financial and business factors, not to mention perception and market reputation ones.

Deep, global cross-discipline experience across every aspect of mine evaluation and development allows meaningful and pragmatic contribution to the challenges of climate change, as demonstrated in the following articles.

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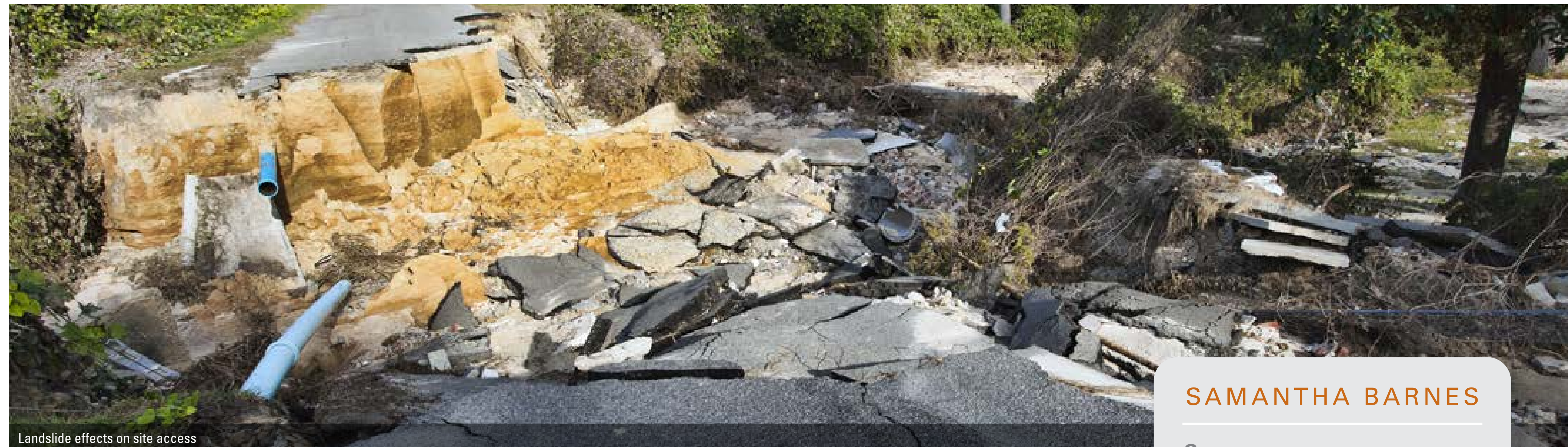
Addressing climate change risks requires cross-discipline considerations in decarbonization and climate risk

Enabling climate resilience with climate change physical risk assessments



Landslide effects on site access

The mining industry is facing a shift in reporting requirements, including a stronger need to identify and evaluate climate-related risks and adaptation actions. For example, the Global Industry Standard on Tailings Management (GISTM), released in 2020, lists climate change projections and their associated uncertainty as an integral requirement of the tailings infrastructure knowledge base. In addition, the Climate Disclosure Standard from the International Sustainability Standards Board (ISSB) was modelled on recommendations made by the Task Force on Climate-related Financial Disclosures (TCFD); these standards require companies to disclose significant and material sustainability risks and opportunities related to climate. The increasing need to understand and improve climate resilience across the industry is clear.

The first step in building this understanding is to compile and evaluate the potential changes in conditions caused by climate change. SRK has been developing climate forecasts internationally for over a decade and continues to improve its approach using the latest model projections. These results are translated into workable statistics and indicators that operators and decision-makers can integrate to infrastructure and systems. This leads to the next important step in enabling climate resilience: a climate change risk assessment.

SRK recently developed a climate change risk assessment framework for an international mining company. The framework, which follows ISO climate change standards along with jurisdictional guidance, is being applied across the company's operations in Australia, South America and Africa. This work includes a detailed climate characterisation for each site and the development of indicators in order to relate climate change projections to the occurrence of potential physical hazards such as droughts, fires and floods. The risk assessment framework provides an understanding of the range in conditions that may be expected in the near- to long-term future. Results inform miners of the effect of these projected changes on operations. Projections are developed in a consistent and transparent process that can be shared with stakeholders and investors.

Climate risks to infrastructure and processes are identified using standard consequence and likelihood tables; risks consider potential losses to the environment, human safety, reputation and costs. The risks are then ranked according to the owner's risk tolerance and priorities. This risk assessment matrix enables mine operators to plan the future by making informed decisions that enhance their resilience to climate change and meet international standards and requirements.

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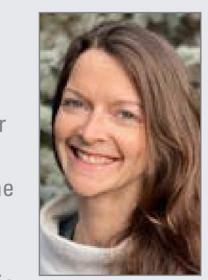

Samantha is a senior consultant in SRK's Vancouver office. She is a water resources engineer with expertise in mine water management. Her work includes performing hydrologic characterisations of historical and future climate and streamflow, developing hydraulic calculations for civil infrastructure and tailings management, and preparing mine site water balance models.

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Decarbonisation in mining

High-angle conveyor, Muruntau gold mine, Uzbekistan

DAVID PEARCE

David is a mining engineer with 35 years' experience. He spent 11 years working on world-class mining operations, both coal and hard rock, in various roles, before joining SRK. With SRK, David has led technical studies, due diligence reviews for acquisitions, stock exchange listings and project finance, and project optimisation studies. David's current focus is on helping mines improve their efficiency services through using mining technology as well as helping clients develop effective strategies for reducing carbon emissions. David has first-hand experience of designing trolley assist and IPCC solutions.

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Mining is responsible for 1–2% of global carbon emissions, with a further 4% approximately attributed to methane released by coal mining and approximately 8% attributed to smelters that convert concentrates into metal. The amount of energy used in mining, the emissions produced and the associated challenges of energy transition are all significant.

Many miners have set themselves demanding targets to reduce their Scope 1 and 2 emissions by as much as 30–50% by 2030. This represents an unprecedented rate of change. However, this rapid transformation is not without its challenges and this article will explore some of the promising technologies being explored by the mining industry.

Switching energy supply from a fossil-fuelled to a renewable source is a significant step towards reducing emissions, especially where electricity is currently being generated by burning coal or gas. Some mines in Australia are reporting that they can generate up to 60% of their power from renewable sources and are targeting increasing this to 80–95%.

Truck haulage can represent 30–50% of emissions in open pits through the diesel consumed. Electrifying haulage via technologies such as trolley assist, and in-pit crushing and conveying (IPCC) systems represents an area of opportunity. These technologies can reduce diesel consumption by 60–80%. However, installing systems with fixed infrastructure requires careful planning so as not to negatively affect operating efficiencies.

Switching to cleaner fuels is another area being investigated, with the world's first hydrogen-powered haul truck recently commissioned at a mine in South Africa. The electricity required to electrolyse the hydrogen will be generated using a 100 MW photovoltaic plant located on the mine site.

Underground mines have long used electrical power for powering equipment due to its benefits in reducing ventilation requirements. Recently, many mines have adopted battery power for LHD units and trucks as the haul distances underground are usually short and gradients low to flat. Studies by SRK have demonstrated that battery-powered haulage is economically competitive; it also provides additional benefits such as improved working conditions and reduced ventilation requirements, further reducing energy consumption.

A renewed focus on capturing methane in advance of mining is required at coal mines. This includes developing safe solutions for capturing, using and destroying the methane produced. Technologies exist to capture the methane for use in energy generation, thus reducing energy demand. SRK has applied hyperspectral methane monitoring technology for the identification of methane sources to assist in management, capture and monitoring of methane.

Further reductions in emissions will require a more holistic approach. For example, blasting to finer particle size would require less energy for crushing and grinding; increasing the grade of concentrates would reduce smelter emissions. Investing in alternative technologies such as pre-concentration and switching from conventional crushers and semi-autogenous mills to high-pressure grinding rollers will also reduce energy demand and associated emissions but will only be feasible at the outset of a new project or expansion. Finally, improving efficiencies through measures such as designing and maintaining haul roads to minimise rolling resistance and travel distances will reduce fuel consumption and thus emissions.

While emission reductions are critical, opportunities for carbon sequestration are also very attractive. SRK is currently involved in research and development into carbon sequestration in tailings.

In summary, the mining industry is embracing the challenge to reduce greenhouse gas emissions. Identifying suitable solutions and designing operations around the requirements for these solutions requires innovative thinking but also extensive experience in the mining industry to ensure that technologies are practical and sustainable. SRK is leveraging its global experience in various facets of the mining industry to partner with clients on this journey.

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Many miners aim to reduce scope 1 and 2 emissions by 30-50% by 2030

Meeting the expectations of the next generation of mining professionals

The environmental and social profiles of mining companies are more important than ever, both in managing the companies' reputations as well as enabling them to recruit and retain young talent and ensure the long-term sustainability of our industry.

In fact, the perception of poor performance of one mining company can – and does – impact outsiders' views of the entire industry. It is becoming increasingly difficult to recruit students into university mining programs, as most major programs report declining enrolment in recent years.

Mining students and young professionals are increasingly selecting their disciplines of study and employers of choice based on environmental and social branding and no longer solely on traditional metrics such as financial rewards and job stability. New recruits will be unlikely to opt for a mining company which has been singled out for its poor environmental and social performance.

Young professionals are also keenly aware of the impacts of climate change and the need to better protect the environment. Because of this, those who do select mining-related fields are more inclined to take an interest in 'green' technological developments and lower carbon alternatives to existing processes, such as climate change risk management and adaptation, electrified hauling fleets for mining and hydrogen-based steel products for steel production, for instance.

SRK has taken a lead in a diverse range of disciplines aimed at addressing these key issues; from using advanced data tools to help develop risk profiles and mitigation strategies for mining projects[1], to helping our clients develop and articulate their focus on water stewardship[2], to developing tools to facilitate increased transparency in carbon emissions of mining activities[3], to supporting decarbonisation efforts in mining[4]. These are well-articulated in the articles in this publication. The result is attractive career paths for prospective mining professionals in the climate change era.

To encourage the next generation of professionals to enter the industry and to promote the long-term sustainability of the mining sector, the mining sector needs to strengthen its brand, making a greater effort to emphasise metals' necessity and showcasing its work in adopting more transparency and climate-friendly policies.

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1 See articles by Victor Munoz and Samantha Barnes, and by Desana Stambuk

2 See article by Lindsay Shand and Fiona Sutton

3 See articles by Ben Lepley and Sean Kautzman, by Dhiren Naidoo, Jane Joughin and Tony Rex and others

4 See article by Andrew van Zyl and others

Dark clouds on the horizon if the industry cannot improve its environmental profile

GISTM requirements to address climate change

Table 1:
GISTM Climate Change requirements

REQUIREMENT	CLIMATE CHANGE RISK IDENTIFICATION	MODELLING OF CLIMATIC CHANGES	MONITORING AND ADAPTATION
TOPIC I Resource rights and risks to public safety	X		
TOPIC II Site climate and breach analysis		X	X
TOPIC II Enhance resilience to climate change	X	X	X
TOPIC II Include climate change uncertainties in design	X	X	
TOPIC II Updates required for changing conditions		X	X
TOPIC III Water Management including CC impacts		X	X
TOPIC V Requirement 6.5: Change Management System			X

Climate change mitigation has traditionally focused on the reduction of greenhouse gases, an approach now considered insufficient in light of the inevitability of climate change. Mitigation approaches now include climate change adaptation: measures required to adjust to the changing climate to avoid significant risks. These risks may include increased or decreased rainfall and increased temperatures with resulting increased prevalence of hazards such as floods, drought, heat waves and fires, competition for resources, changes in disease vectors, greater demands on infrastructure, and associated social impacts.

The risks and associated impacts of climate change are far reaching and cross sector. The GISTM has included requirements for addressing climate change risks as they apply to tailings. The requirements address five topics (I-V) as shown in Table 1 and include three main responses: 1) climate change risk identification, 2) modelling of climatic changes, and 3) monitoring and adaptation. The first two relate to planning and operation requirements for monitoring and adaptation will extend throughout the life of the tailings storage facility (TSF), from operations through to closure and post-closure.

The sixth assessment report released by the United Nations Intergovernmental Panel on Climate Change (IPCC) provides global models that can inform the identification of risks. The GISTM, however, requires site-specific modelling to inform TSF design. It is further recommends that site-specific models be used to inform water balance, assessment of impacts and enhancement of resilience.

Best practice guidelines inform this approach as the GISTM provides principles and requirements but does not prescribe how to achieve these goals. Because these models have limitations, monitoring and ongoing adaptation are essential to ensure that risks are addressed. It is critical that monitored information is analysed to ensure trends are highlighted to inform required adaptation. The table illustrates how this will be implemented through the requirements of the GISTM.

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Ashleigh is a principal scientist in SRK's Johannesburg office. She has an MSc in Biochemistry and 13 years of experience in the mining, water, climate change, energy and infrastructure sectors. She focuses on the integration of climate change into mine and infrastructure design to ensure that related risks are addressed in the early planning phases.

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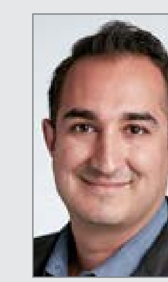
MICHAEL DABIRI



Michael is a senior water resources engineer in SRK's geoenvironmental group, based in Vancouver. Michael specialises in mine water and tailings management, with experience in development, operational support and closure of mines throughout North and South America, Europe, Australasia and Africa. Michael is also an adjunct professor at the University of British Columbia's Norman B. Keevil Institute of Mining, and is teaching mining environmental practices.

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Counting the cost of carbon


Wind farm in South Africa

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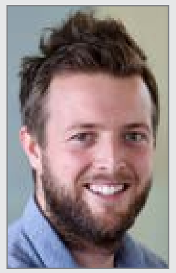

Ben is an environmental consultant with 13 years of international exploration and mining experience. Ben has recently transferred to the environmental, social and governance (ESG) team having formerly specialised in resource geology. As part of the ESG team, Ben works on environmental and social impact assessments along with audits and reviews of ESG studies as part of Mineral Resource and Mineral Reserve reporting.

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SEAN KAUTZMAN

Sean is a principal consultant (mining engineer) with SRK's Sudbury office. Over the course of 22 years within the mining industry he has amassed experience in engineering, operations and project management. Prior to joining SRK in 2018, he worked for multiple mining companies in the US and Canada. His specialities include underground mine design, design and execution of operational improvement projects, incorporation of new technology, systems and processes as part of the Mining 4.0 transition, and due-diligence studies.

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The cost of emitting carbon dioxide has been a financial and material consideration for manufacturing and energy industries, but the relatively small contribution of the mining industry means it has not had to face the same fiscal burden as other industries - until now. Mines that do not include pyrometallurgical processes generally fall below the threshold of schemes such as the EU emissions trading schemes (ETS). The introduction of carbon trading schemes in key mining jurisdictions, including Canada and Kazakhstan (see Sandy Abdizhalelova's article on page 13), and the agreement by many other signatories to the 2015 Paris Agreement to initiate similar legislative steps have set the stage for carbon costs to make their mark on mining.

Carbon pricing schemes have been operating in Canada for several years, but approaches vary between provinces. In 2018, the federal government announced the 'Output-Based Pricing System' (OBPS) to set an escalating minimum carbon price per tonne of carbon dioxide equivalent (CO_2e) emitted across the country. While the individual provinces and territories have differing carbon pricing approaches, the OBPS sets a minimum carbon pollution price. For 2023, this has been set at C$65/t, increasing by C$15/t per year until 2030.

Carbon pricing has forced mining companies to evaluate the impact carbon taxes will have on their existing operations and future projects. The mine's jurisdiction can have significant impacts on the magnitude of applied carbon pricing: a study by the Mining Association of British Columbia indicates that due to variances in carbon pricing structure, a mine in British Columbia will incur carbon price costs 10–13 times higher than an equivalent mine in Ontario.

Carbon taxes now must be considered at the earliest stages of mine planning. As mine plans and designs become increasingly detailed as the projects progress, energy and fuel data can be used to build Scope 1 and 2 emissions inventories along with associated carbon pricing. This calculation can help predict the potential economic impact of the project-related emissions and promote decarbonisation strategies.

Prior to reporting mineral/ore reserves, a company must demonstrate that its project is economically and technically viable under current and near-term conditions. International best practice resource/reserve reporting codes, such as the CIM and JORC guidelines, use the concept of 'reasonable prospects for eventual economic extraction', which must include a preliminary assessment of economic viability. To better withstand scrutiny by financial institutions and other external stakeholders, it is therefore critical that companies use shadow carbon pricing when evaluating their projects.

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Climate change disclosure reporting

Climate change represents a financial risk to mining companies. The recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) are becoming industry standard for reporting on climate risks and mitigation strategies. Many mining majors have published climate disclosure reports aligned with the TCFD recommendations in the last year and they will continue to update these annually, concurrently with their annual financial reporting.

Climate disclosure is voluntary in most jurisdictions, but there is a trend towards mandatory disclosure. Many stock exchanges are considering enhanced climate disclosure obligations for listed companies according to the Sustainable Stock Exchange Initiative, and several stock exchanges have issued guidance on this. The U.S. Securities and Exchange Commission has proposed rules to enhance existing climate disclosure requirements by certain listed companies. The Canadian Securities Administrators is proposing that public companies make climate disclosures from 2024. Premium-listed companies on the London Stock Exchange are already obliged to make climate disclosures.

The four pillars within the TCFD recommendations (governance, strategy, risk management, and metrics and targets) provide a robust and consistent structure. These are the preferred reporting frameworks for miners to explain to investors and other stakeholders how they factor climate change into their company strategies, operations and project planning. Many investors now seek climate disclosures and commitments from businesses.

The standards for climate disclosure are rapidly evolving, with the IFRS International Sustainability Standards Board consulting on its draft standard as of mid-2022. The draft standard is based on the four TCFD pillars, but with increased specificity and clarity on disclosure requirements.

SRK helps clients develop their TCFD disclosures and climate change adaptation solutions. Clients rapidly see the value of the process. Raising climate change awareness to senior management and board of directors puts climate change issues on the strategic planning agenda. Clearly defined financial commitments and tangible stakeholder engagement demonstrate the business responsible governance.

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Dhiren has 15 years' experience in air quality and GHG accounting. His project experience has been gained in Africa, Middle East, Europe, North America and Australia across 21 countries for the following industries: mining, various industrial operations, energy, development and planning and oil and gas. His expertise includes GHG accounting/carbon footprinting, climate change risk assessments, decarbonisation strategies, air quality impact assessments and managements plans.

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JANE JOUGHIN

Jane has 28 years' experience providing environmental, social and governance (ESG) consulting services to the mining industry. Extensive experience undertaking permitting and auditing of mines, coupled with a thorough understanding of ESG concepts and standards, enables Jane to provide clients with pragmatic and forward-thinking ESG advisory services. Jane has a high level of interest in legislation pertinent to ESG and mining, supporting achievement of compliance with legal obligations and assisting clients to maintain and gain social licence to operate.

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Renewable energy grids

The mining industry uses three principal sources of energy: diesel, grid electricity and explosives. Diesel and electricity consumption contribute substantially to the mining industry's GHG emissions. There has been a global shift in the mining industry to incorporate sustainability goals into business plans.

Strategies to reduce high energy consumption include moving towards renewable grid power, implementing renewable hybrid onsite microgrids, electrification of process equipment, and use of low-carbon mining equipment.

The Australian Renewable Energy Agency (ARENA) provided grant funding for renewable projects under the Advancing Renewables Program.

Gold Fields Australia secured an ARENA grant to invest in renewable energy microgrids at its Agnew gold mine in the Yilgarn region of Western Australia.

The Agnew gold mine was the first mine in Australia to be powered by a wind, solar, battery and gas microgrid. It is Australia's largest hybrid renewable energy microgrid and the first in the country to use wind generation on a large scale at a mine site.

The microgrid has a 56 MW capacity and is expected to deliver 50-60% of the Agnew mine's regular energy requirements and up to 85% during ideal conditions. It will reduce the mine's carbon emissions by about 40,000 tonnes of CO_2e per year.

Gold Fields is adopting innovative operational practices such as dynamic load shedding, renewable resource forecasting and IPP-controlled load management to maximise renewable energy use.

Gold Fields has started rolling out renewable energy grids and battery storage across its sites in Australia and Chile, including at Granny Smith in 2020, Gruyere and South Deeps in 2022, St Ives in 2023 and Salares Norte in 2024. The Agnew project paved the way for the adoption of renewable energy in the mining industry and provides a blueprint for other companies to deploy similar off-grid energy solutions.

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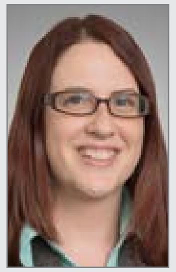

Danielle is a principal consultant with over 20 years' experience in the mining industry, specialising in mine closure cost estimating. She has in-depth experience working within the Australian regulatory requirements, provisioning for closure and collaborating with multi-disciplinary teams on closure options analysis and closure planning. Danielle's understanding of the future of mining evolved as a result of working extensively on mine closure aspects. She has developed a keen interest in the development of government regulations, corporate social responsibility related to reaching sustainability goals and reducing carbon emissions.

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Agnew mine's renewable energy microgrid

Water stewardship's role in climate change

Surface water sampling in Laguna Santa Rosa, Chile

Climate change refers to long-term shifts in temperatures and weather patterns. The changes have been accelerated by human activities since the 1800s. Climate change affects every country on every continent, causing changes to weather patterns, rising sea levels, and more extreme weather events.

The impact of climate change is mostly felt in relation to water, and climate change is essentially becoming a water story. The Paris Agreement, which was adopted in 2015, aims to strengthen the global response to the threat of climate change.

Climate change has heightened global awareness of the effects of these weather changes. Addressing the cause of climate change is vital to slow its effect on people and the world economy; however, these changes are unlikely to result in immediate alteration or improvement to the effects of climate change already being felt globally. Since we have limited immediate means of improving the effect of climatic changes, we need to build resilience into our lives, businesses and economies.

The primary risk of climate change relates to the accessibility to fresh water. In recent years, drought, floods and other water-related risks have threatened the sustainability of businesses, demanding a strategic and systemic approach to the management of water needs and sources. Many of the systemic water risks faced by businesses cannot be adequately solved through company operational measures.

The concept of water stewardship, a process whereby companies work collaboratively with other partners to manage shared water resources, is proposed as an effective response mechanism.

Water stewardship promotes and fosters the sustainable and equitable management of freshwater resources. Water stewardship practices range from water use efficiency at an organisation's own operations, to engagement with suppliers, to long-term multi-stakeholder river basin projects, and beyond. Water stewardship helps ensure that water users not only manage their own risks and seize opportunities related to water (e.g., ensuring businesses have the water they need to continue production processes), but also promote long-term water security for all.

There is a strong business case for companies to better understand and manage their water risks and seize related opportunities. In implementing water stewardship, companies can build more resilient operations and suppliers, protect their licence to operate, save money, promote workplace productivity, strengthen brand value, and more. Water stewardship is about the responsible planning and management of resources and moving into the 21st century sustainably.

Climate change poses a serious immediate risk to water resource quality and quantity. By adopting a water stewardship programme, a business can build resilience in relation to water use and discharge into its operations. Water stewardship therefore provides a mechanism to contextualise a site within a catchment, encouraging appropriate water use management and mitigation of impacts on water resources. Taking responsibility for its water helps improve the business's resilience to the effects of climate change by providing a better understanding of the catchment (basin scale) water system in which a business operates, and mechanisms to manage and mitigate impacts.

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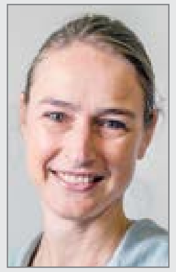

Lindsay is an associate partner, a registered principal environmental geologist and an AWS credentialed specialist with SRK's Cape Town office. Lindsay has over 20 years' experience in environmental water management, relating to baseline monitoring, water stewardship, and environmental site assessments and remediation of sub-surface contamination. Lindsay has managed a broad range of projects with particular experience in long-term surface and groundwater monitoring projects related to groundwater abstraction and monitoring of the implications thereof.

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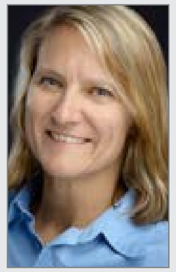

Fiona has over 25 years' experience in environmental management and has worked largely in the water and waste management and industrial sectors. Through her water stewardship knowledge, she has managed and compiled several Water Use Authorisations (WUAs) and water quality monitoring programmes. Her expertise includes water use licence applications for industrial, mining and linear developments; water quality management programmes for baseline assessments, water use licence compliance auditing and corporate responsibility; site contamination assessments; waste management, including waste stream classification, waste site licensing and strategic waste management planning.

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INSIYA SALAM

Insiya has over 10 years' experience working on sustainable livelihoods projects and undertaking social assessments, with expertise in ESG reviews of mining projects and operations. Resilience building and sustainable development planning and implementation, participatory consultation processes and human rights-based approaches are all at the heart of Insiya's work. She takes the time to understand the vulnerability context that frames the external environment in which people exist and any inequalities (often multiple and intersecting) that undermine the agency of people as holders of rights.

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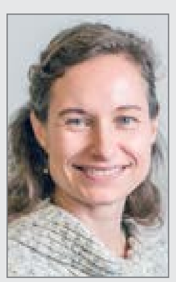
SUE REUTHER



Sue is a principal consultant with more than 19 years of experience. Sue undertakes socioeconomic assessments for a range of projects, including mine (closure) and renewables, in Africa, South America and Asia. She also manages ESIAs, ESDDs and E&S Lender reviews in Africa, South America and the Middle East. She has two years of experience in strategy and financial research. She holds a BSc (Hons) in Economics from University College London and an MPhil in Environmental Management from the University of Cape Town.

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Community resilience and climate change adaptation

Informal artisanal and small-scale gold mining as a livelihood strategy

The global community is facing a 'triple crisis': the interdependence of people, poverty and inequality; the changing climate and extreme weather patterns; and the natural world and its degradation. As climate changes, the highest rates of nature decline are in areas with high levels of poverty and where human security is increasingly threatened. The consequences of the triple crisis do not affect everyone equally. Many of these areas have mining operations and the poorest and most vulnerable people associated with these operations may suffer the most.

A shock within the context of community livelihoods is an unexpected event that can destroy assets or affect people, households or communities. As the impacts of climate change manifest, the prevalence of natural disasters (shocks), like extreme weather events, floods or longer periods of drought, is predicted to increase. The environmental or socioeconomic impacts of mining may result in further shocks.

To deal with shocks, communities resort to short-term coping strategies. Vulnerable communities with limited resources tends to have inadequate capacity or capability to respond effectively, and the strategies adopted are often negative, like changing food consumption patterns or having to use household savings.

Adaptation strategies refer to longer-term approaches by households to respond to adverse events. When adaptation strategies are successful, households become less prone to crises over time, and their resilience improves. A key pillar of the Paris Agreement is to reduce the vulnerability of countries and communities to climate change by increasing their ability to absorb shocks and remain resilient.

Mining companies seeking to understand and mitigate their own impact on existing vulnerabilities will be better placed to ensure their socioeconomic development initiatives are appropriate and successful.

Companies that look at climate change adaptation options without considering the socioeconomic, cultural or political context of the communities whose lives and livelihoods depend on the local environment will fail to generate shared benefit and to deliver positive outcomes.

To tackle the triple crisis, the global community must work together to reduce vulnerability, build resilience and tackle the root cause of complex social issues. There is a huge opportunity for mining companies to form partnerships with local or regional government bodies and development actors in the countries where they operate and work together towards the central transformative promise of the UN's Agenda 2030 and its sustainable development goals to ensure no one is left behind.

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The role of economic valuation in climate change decisions

Very few regions will escape the impacts of climate change. Climate risk vulnerability assessments identify these impacts, but whether, how and where to intervene are complex decisions. Economic valuation supports decision-makers in government, industry and financial institutions by considering various factors:

- cost of the climate change impact versus the cost of interventions – *whether* to respond
- cost effectiveness of solutions and interventions – *how* to respond
- economic sectors, regions and infrastructure facing the largest economic risk – *where* to respond.

Examples of economic valuation demonstrate its usefulness in addressing these fundamental questions:

Whether to respond: In 2021, SRK quantified climate change risks to the Eastern Cape province of South Africa to guide policy and expenditure allocation. The greatest costs were associated with interruptions to water supply and increased cost of maintaining public infrastructure, each estimated at US$2 billion over 25 years, followed by reduction in agricultural production (US$1 billion) and damage to coastal infrastructure and reduced tourism (US$600 million).

The principle of 'just transition' also warrants the comparison of societal costs of transitioning with costs of climate change impacts to identify appropriate replacement strategies and ensure that any transition or intervention is fair.

How to respond: Many solutions can mitigate climate change risks. Economic analysis helps select interventions by comparing costs and effectiveness, such as whether a client should reduce Scope 1 or Scope 3 emissions, reduce or sequester emissions, and relocate residents and infrastructure or improve stormwater management.

Where to respond: Socioeconomic impacts differ across regions, depending on the expected climate change impacts, population density and concentration of economic activity. Economic analysis can identify high-impact regions or sectors for focused interventions.

Resource economic analysis can also value traditionally unvalued impacts of climate change, such as loss in indirect use value from changes to ecosystems.

In each instance, economic valuation was the key to navigating climate change decisions.

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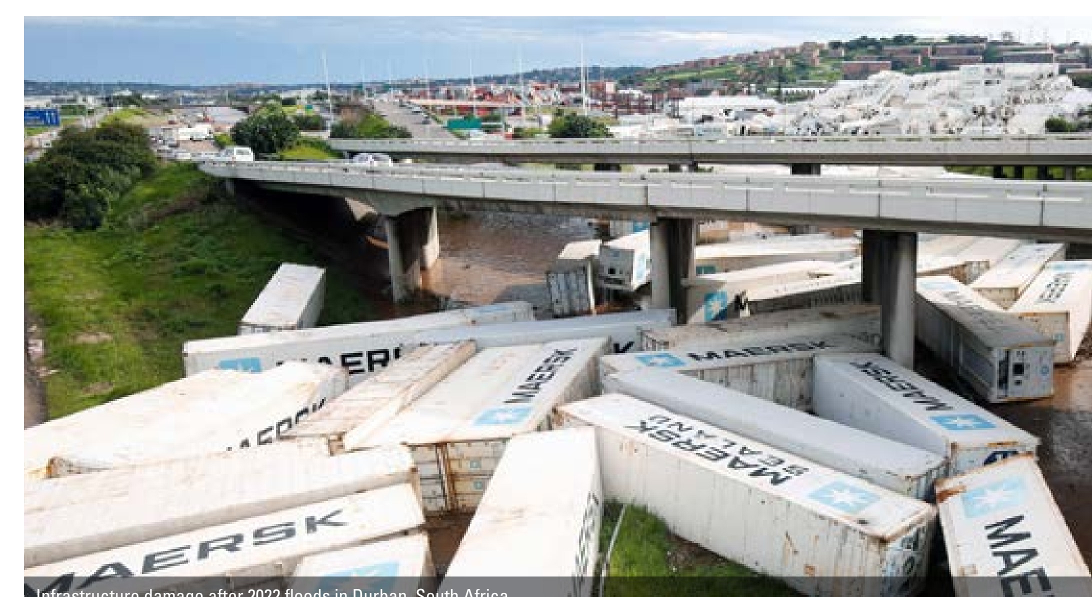


Infrastructure damage after 2022 floods in Durban, South Africa

Using R and data science to analyse site-specific climate change

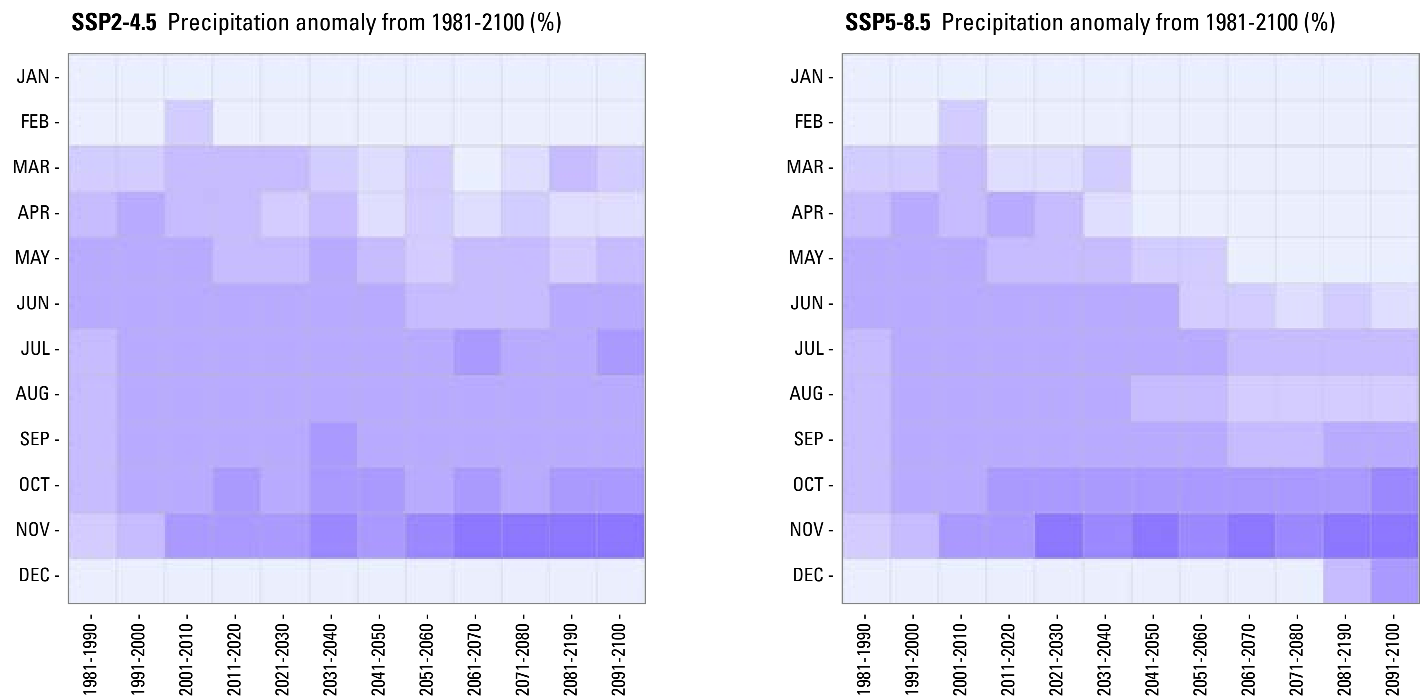
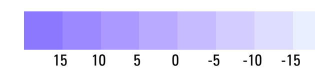


Figure 1: Heatmap of the projected precipitation anomaly



DESANA STAMBUK

Desana is a senior civil engineer whose interests lie in water resources management, hydroinformatics and civil design. She is experienced in hydraulic modelling, design and design management of large-scale drainage system, flood risk assessments and flood mitigation strategies. She focuses on mining water infrastructure and implementing data science in hydrologic studies and climate change.

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Climate considerations in tailings management have been highlighted by the publication of the *Global Industry Standard on Tailings Management* (GISTM) in 2020. The standard states that the knowledge base related to tailings facilities should 'capture uncertainties due to climate change'.

One of the parameters included in climate change analysis is precipitation and precipitation trends. Short-duration, high-intensity precipitation events have become more frequent across the globe.

SRK has been developing site-specific climate estimations based on general circulation models (GCMs) that are normally used for weather forecasting and projecting climate change. Data are derived from the NASA Earth Exchange Global Daily Downscaled Projections dataset comprising global climate scenarios from 35 GCMs.

Many future climate change implications will depend on actions of the global community. For this reason, the Intergovernmental Panel on Climate Change (IPCC) has established shared socioeconomic pathways (SSPs) which correspond to different hypothetical geopolitical responses. For example, SSP1-1.9 assumes a rapid transition away from fossil fuels, whereas SSP3-7.0 assumes a continuation of the current global emissions trend.

SRK's product uses state-of-the-art models to assess future changes under two pathways: SSP2-4.5, a mid-case emissions future that assumes climate protection measures being taken by all nations, and SSP5-8.5, a worst-case scenario. The data span the globe with approximately 25 km spatial resolution using historical data from 1950 to 2014 and climate projections from 2015 to 2100.

Climate change modelling is conducted through compiling available GCMs and completing an analysis with a purpose-built script using R, a programming language for statistical computing. The analysis provides the estimated change of different climatic parameters for a specific location.

SRK's R script captures daily climate parameters until 2100, and further review is done for mine-specific time periods. For example, the first assessment period covers the period from 2020 to 2049, representing the operational mine phase. Climate changes during this period are most likely to influence operational design and management. The second assessment period in the table represents the period from 2070 to 2099, which predicts the climate that may influence closure design and post-closure monitoring.

One key output of the analyses is statistical representation of all the GCMs for defined time periods, including the median value and the possible range of change for various parameters. The results can also graphically represent seasonality to understand monthly projected changes by decade (Figure 1). This can inform water balance and mine infrastructure design, which is vital for mine sites that rely on stormwater.

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Carbon accounting in Kazakhstan's new Environmental Code

The Global Climate Agenda is one of Kazakhstan's top priorities. Kazakhstan is one of the largest sources of greenhouse gas (GHG) emissions in the world, ranking among the top 30 global GHG emitters.

In 2016, Kazakhstan signed and ratified the Paris Agreement and proposed a Nationally Determined Contribution (NDC) target of a 15% reduction of GHG emissions by 2030. At the 2020 Climate Ambition Summit, Kazakhstan expressed its commitment to become carbon-neutral by 2060. A long-term Carbon Neutral Development Doctrine was published in 2021, including an updated NDC and additional measures needed to achieve carbon neutrality by 2060.

Kazakhstan is revising its environmental legislation to facilitate the transition to a green economy. Its new Environmental Code, adopted in 2021, contributes to this. Chapter 20 of the new Environmental Code lays out the structure of an emissions trading scheme (ETS) called the KAZ ETS, which regulates about half of Kazakhstan's domestic GHG emissions. The KAZ ETS establishes a cap of carbon credits to be distributed to equipment with annual emissions exceeding 20,000 tonnes of carbon dioxide equivalent (CO_2e), termed installations. Mining and metals companies make up some 23% of these installations.

From 2018 to 2020, 485.9 million tonnes CO_2e of free carbon credits were allocated. The National Plan for 2021 significantly reduced the free quotas to 159.9 million tonnes CO_2e. Any installations that emit more than their free allocations must buy the difference.

The price for Kazakh credits in November 2021 was US\$1.12/t CO_2e. It is expected to increase to US\$16.9/t CO_2e in 2023–2025 and up to US\$50.8/t CO_2e in 2026–2030. In addition, Kazakhstan plans to reduce free quotas by an average of 5.4% per year until 2025.

The KAZ ETS shares many similarities with the EU's ETS and there are plans to align it even more, especially in light of mechanisms that may add cost to EU imports in high carbon sectors such as the EU's Green Deal and its Carbon Border Adjustment Mechanism. Additionally, a carbon tax is being considered to cover the industries and emissions not included in the KAZ ETS.

The KAZ ETS and carbon tax will both have material implications on Kazakhstan's mining and metallurgical sector. This example shows the importance of considering these schemes at the start of mine planning and consider their impact on meeting the 'reasonable prospects for eventual economic extraction' (RPEEE) criterion.

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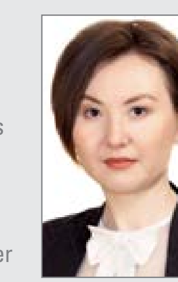

Sandugash is a sustainability consultant in Kazakhstan. She has a Master's degree in Environment and Sustainable Development and over 10 years' experience (industrial and consulting) working in environment and sustainability space including mining operations in Kazakhstan. Sandugash provides environmental and social input to multi-disciplinary projects starting from exploration through to development, operation and mine closure. She has also previously managed international projects in the field of integrated water resource management in Central Asia under the UNECE Water Convention framework.

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Mainstreaming climate change considerations in public sector policy

Climate change remains a critical risk to a wide variety of sectors and many international protocols and agreements have been established to manage climate change and set internationally binding emission reduction targets. While it is important to understand and manage GHG emissions and their contribution to climate change impacts, it is equally important to recognise the impact climate change will have on existing and proposed infrastructure.

Climate change risks need to be identified and adaptation strategies developed. This to ensure the sustainability of communities and that climate change risks do not pose an unacceptable risk to human life, livelihood and wellbeing. But the development of adaptation strategies cannot be done in isolation. Rather, the identification of risks and the development of adaptation strategies needs to form part of all public sector department policies, strategies and day-to-day operations. This ensures that adaptation strategies are identified by those who have the practical experience to develop feasible solutions, and will be responsible for the implementation.

SRK was recently involved in mainstreaming climate change into both economic and environmental policies of a provincial government in South Africa. This included the review of the policies to identify the extent to which climate change had been considered in the policies. Climate change scenarios and risks were developed to inform the identification of gaps in the policies. The scenarios, risks and gaps then formed the basis for stakeholder engagement where, to build capacity and awareness, public sector officials were educated on the potential risks, which then informed the development of action plans to address the gaps and opportunities. The opportunities in these instances largely related to economic opportunities associated with renewable energy, sustainable tourism and a transition to carbon neutral manufacturing. Given that the public sector itself does not invest in business, the action plans aimed to identify and support the enabling infrastructure required for these businesses to be successful.

This mainstreaming was supported by an economic valuation of the risks versus the investment required to implement the action plans. This provided a basis to prioritise action plans that achieved the greatest value at the lowest economic cost. It also enabled officials to motivate for funding for action plans based on potential financial losses estimated for the climate change risks identified. While not comprehensive, the approach provided valuable insights to the economic implications of inaction as it pertains to climate change, and the mechanisms to build resilience.

On the whole, the cost of implementing action plans to build resilience and realise opportunities was an order of magnitude lower than the potential financial implications of climate change; this highlights the need to consider climate change at all levels of decision making. The key to success is in sourcing available information to empower individuals working outside the climate change space and then work collectively to identify solutions that are based on defensible scenarios and experience in various sectors.

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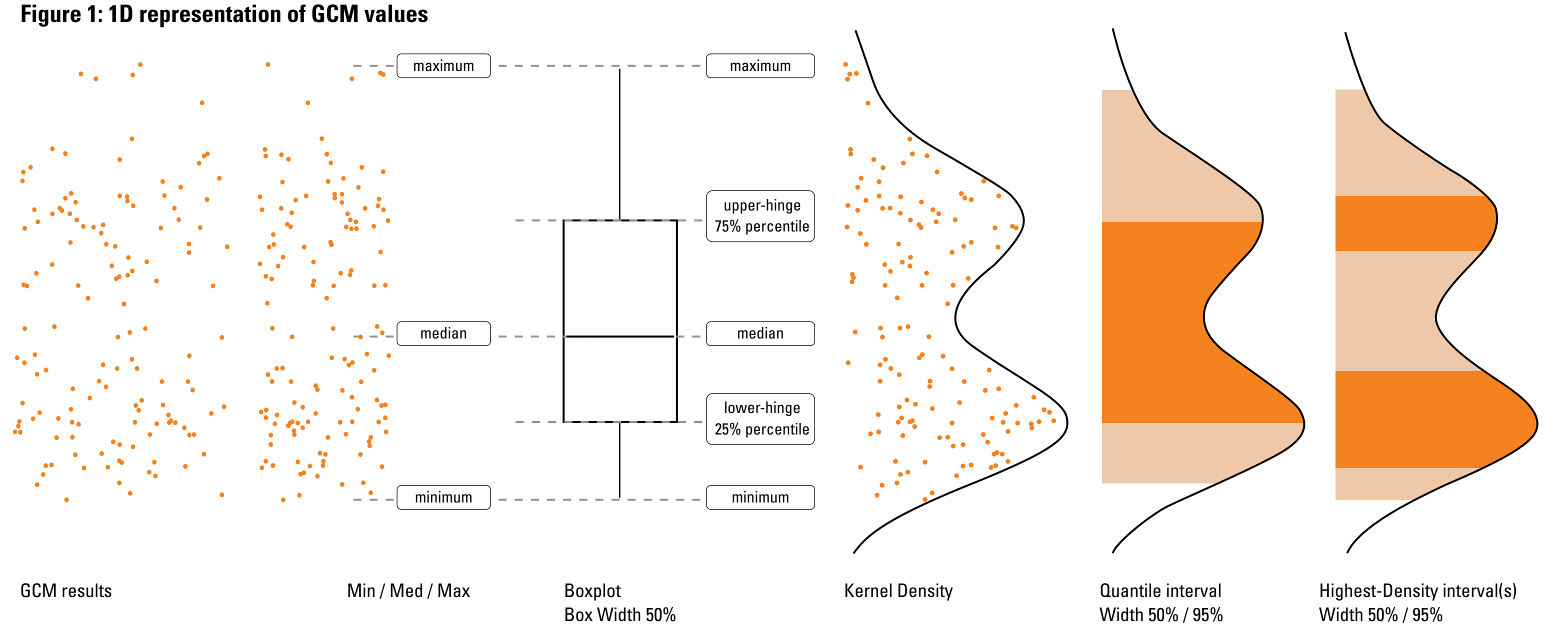
Dealing with uncertainty

Figure 1: 1D representation of GCM values



Uncertainty refers to epistemic situations in which there is incomplete or unknown information. It applies to predictions of future events, existing physical measurements, and to what is not known. Uncertainty arises in partially observable or stochastic randomly distributed environments, as well incomplete knowledge. A relevant example of uncertainty is the worldwide climate projections provided by general circulation models (GCMs).

The Intergovernmental Panel on Climate Change (IPCC) publishes assessment reports (ARs) every 5–8 years. AR1 to the most recent AR6 (2021, 2022) include GCMs which present the historical past and projected climatic worldwide conditions, including meteorological parameters such as precipitation and air temperature (up to 2100); however, there is inherent uncertainty in the data used.

The most recent assessment report, AR6, includes more than 30 GCMs, each of which is tested according to different emission scenarios or atmospheric boundary conditions projected up to year 2100; these conditions define possible climate futures. All these alternatives (+100) are currently applicable and are considered valid projections.

There is no consensus in the literature related to model selection or even to recommendations for following specific emission scenarios. These GCMs and emission scenarios display possible paths, and while our future may not follow any of these projections exactly, these projections highlight expected ranges which consider the best known to science (by IPCC) and therefore should be evaluated and considered.

Explaining this uncertainty is one of the most challenging issues for climate change projects. This is contrasted with the civil design approaches where structures are 'sized' for a specific event, such as 1:100 years, but this fixed value definition loses significance in climate change concepts where most of the design values are in fact ranges defined by every GCM and every possible meteorological projection.

Figure 1 presents some alternatives about how a single meteorological parameter, such as mean annual air temperature, can be presented. In this example, the one parameter (1D) display variability is represented by valid points ranging in number from 30 to more than 100.

To simplify the point-cloud, one of the most frequently used approaches (although not necessarily the most appropriate) is to consider only the point-cloud median (1 point), or maximum, median and minimum values (3 points), or even a boxplot representation (5 points). However, none of these simplifications may always be representative of the parameter variability; in this case, as a multimodal distribution (more than 1 peak), most of the points are aligned around the boxplots extreme values, which differ significantly from the point-cloud median.

Other approaches are based on kernel density distributions, where values are represented by a single smooth density estimation. Using this interpretation, quantile intervals can be also seen (as with the boxplot) and highest density intervals (HDIs) highlight the most credible values (even in multimodal distributions).

Today's GCMs involve an impressive variability of results which contrast with the typical single-value design required by civil engineers. The simplification to 1D representation of GCM values (from point-cloud to median/HDI) typically depends on: 1) relevance of the meteorological parameter; 2) actual impact of the variability on the design; and 3) the status of our own knowledge as project managers/clients to understand this uncertainty problem. The modeller should be included in these decisions/representations/simplifications to assess and present the uncertainty related to GCMs.

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VICTOR MUNOZ

Victor is a civil engineer and principal consultant with 20 years of experience. His well-developed combination of academic pursuit and experience includes a focus on hydraulics, hydrology, water management problems, data science/mining (in R), and climate change in areas related to analysis modelling, design and construction. In addition to experience gained at SRK's offices in Vancouver and Cardiff, Victor has worked on mine sites in Canada, US, Mexico, South America, Europe, Kazakhstan, Russia, Africa and Australia.

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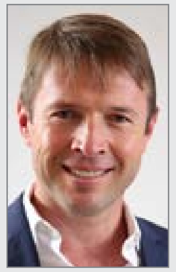
Overcoming decarbonisation challenges for the mining industry

Meeting committed targets relies on rapid roll-out of technologies

ANDREW VAN ZYL



Andrew specialises in valuing metals and minerals assets, including iron ore, manganese, chrome, copper, coal, gold and the platinum group metals. Andrew was elected chairperson of the South African Mineral Valuation Code (SAMVAL) committee in 2019, is a member of the International Mineral Valuation Committee (IMVAL) and on the council of the Southern African Institute of Mining and Metallurgy (SAIMM). Andrew has broad knowledge of a range of current interventions being pursued to reduce the carbon footprint of mining. He is currently managing the SRK team that is part of the EU Re-sourcing Project, an EU-funded project where SRK is facilitating stakeholder engagement in Asia and Africa on behalf of the project. He has also worked on a global SRK project to outline decarbonisation interventions in mining for a state fund.

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Most of the major mining houses have made commitments to achieve carbon neutrality by 2050 and set ambitious mid-term (2030) targets. As these commitments form part of company's investor reporting they are binding. Mining houses therefore need to ensure they meet the commitments or face penalties.

Several technologies provide the capacity to achieve the reductions; these include renewable energy (solar, wind, thermal, cogeneration etc.), electric, hydrogen or hybrid vehicles, as well as energy-efficient processing options, equipment, ventilation and conveying. Beyond technology, policy level changes can reduce carbon footprint including for instance a focus on local or carbon neutral suppliers, transport alternatives, offsetting and waste management strategies.

Decarbonisation technology is increasingly available and is being tested in the mining industry; however, implementing this technology is no simple matter.

Transitioning to this new technology meets the following challenges and risks:

- Performance and availability at scale with the potential to increase supply based on demand
- High capital and operational costs
- Timeframes for overhaul and the associated costs
- After-sales service and skilled maintenance workforce to effectively maintain the equipment

Time factors and stricter regulations remain significant challenges to this transition.

Implementation of new technology is hampered by the timeframe needed to test, adapt and troubleshoot the technology to an acceptable level of assurance, traditionally 10 to 15 years. Technologies are also often not off-the-shelf products. To be effective, solutions need to be tailored to site conditions, type of mine, and specific objectives of the installation. A typical mine life of about 10 to 15 years is therefore too short to implement many aspects of decarbonisation technology.

Investment into new mines is further limited by stricter regulatory limitations imposed, for example, by national power regulators. Although partnerships with Independent Power Producers (IPPs) offer opportunities, IPPs typically require 20–30-year contracts, an impractical commitment when most mines are usually established before a 20-year life is confirmed.

Furthermore, the permitting requirements in some jurisdictions for new technology (like renewable energy) remain uncertain. Without the benefit of previous experience, authorities are often unable to make quick decisions; this adds to the costs and timeframes of implementation of new technology.

Nonetheless, miners and investors have set ambitious transformation targets and are working proactively to address assurance issues to facilitate this transition. Mining companies and technology providers can be commended for their actions to increase the likelihood of meeting the stated targets. However, the extent of the technological transformation required is unprecedented. Supply chains and maintenance support systems that have developed over decades will now have only years to adapt to new technologies.

SRK recognizes the challenges in implementing decarbonization technologies but understands that a rapid roll-out is needed to meet commitments. SRK has adapted and grown it's skills in the engineering fields of mining, civil, environmental and mineral processing engineering to effectively identify alternative technologies while maintaining practical considerations tailored to specific mine sites.

SRK is engaging with a range of industry participants to understand and facilitate ongoing progress by identifying and working to eliminate areas of regulatory and technical uncertainty.

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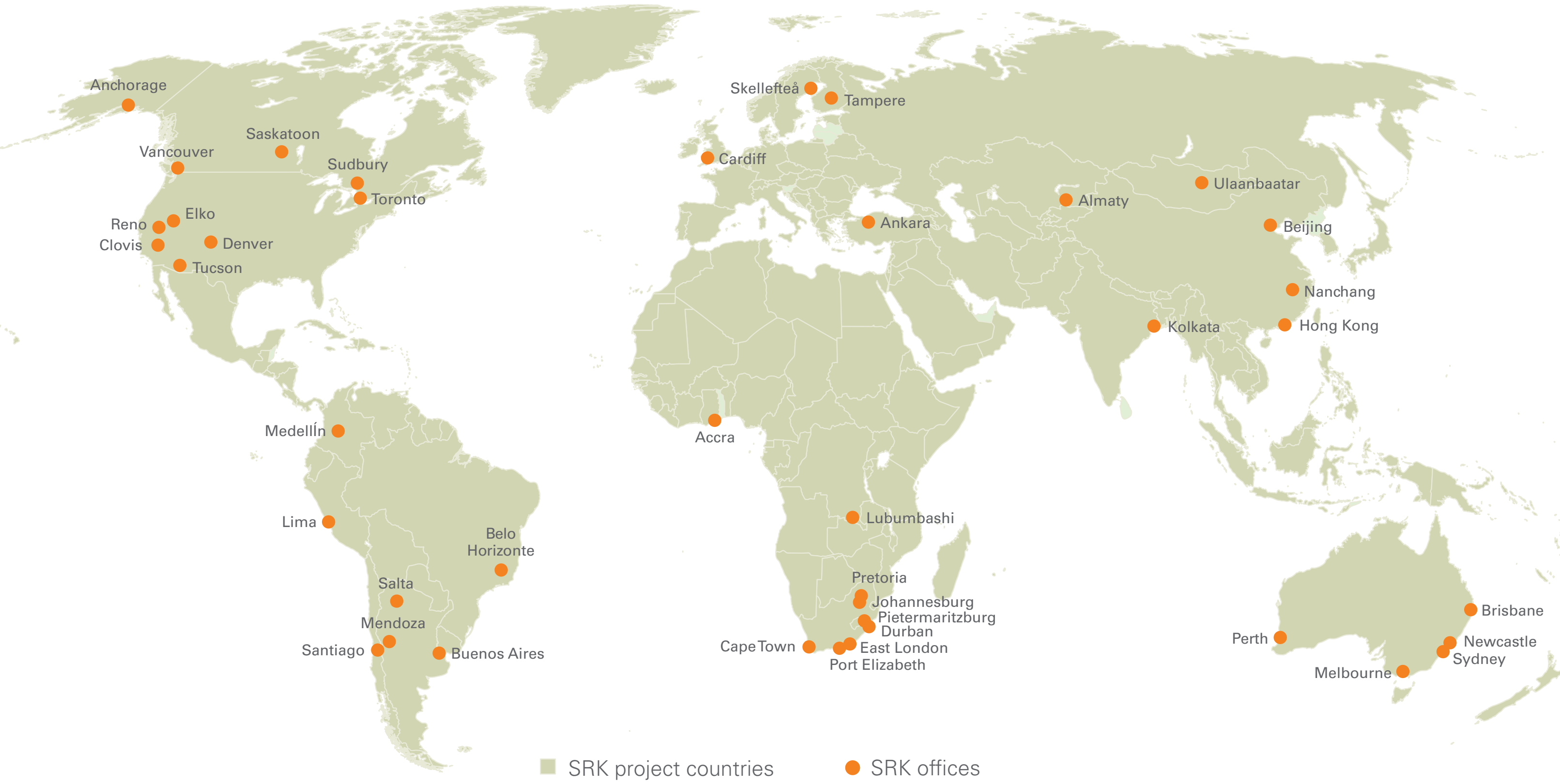
Cambambe spillway, Angola



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