IBRAM
BRAZILIAN MINING

RESILIENT MINING

A guide to adapting Mining
to Climate Change impacts

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PLANTAR CARBON

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December 2021

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LIST OF ABBREVIATIONS AND ACRONYMS

AR	Assessment Report
BACEN	*Banco Central do Brasil* (Central Bank of Brazil)
BSR	Business for Social Responsibility
CCAFS	Climate Change, Agriculture and Food Security
CDP	Carbon Disclosure Project
CMN	*Conselho Monetário Nacional* (National Monetary Council of Brazil)
CNI	*Confederação Nacional da Indústria* (Brazilian National Confederation of Industry)
COP	Conference of the Parties
FGV	*Fundação Getúlio Vargas* (Getúlio Vargas Foundation)
FPMAC	*Fórum Paraense de Mudanças e Adaptação Climática* (Forum on Climate Change and Adaptation of the State of Pará)
GAR	UN Global Assessment Report on Disaster Risk Reduction
GCM	General Circulation Models
GHG	Greenhouse Gas
GVces	*Centro de Estudos em Sustentabilidade da Fundação Getúlio Vargas* (Center for Sustainability Studies at the Getúlio Vargas Foundation)
GWP	Global Warming Potential
IBRAM	*Instituto Brasileiro de Mineração* (Brazilian Mining Association)
ICMM	International Council on Mining and Metals
IPCC	Intergovernmental Panel on Climate Change
IQR	Interquartile Range

ISO	International Organization for Standardization
LULUCF	Land Use, Land-Use Change and Forestry
MAC	Mining Association of Canada
MBC	*Plano de Mineração de Baixa Emissão de Carbono* (Low Carbon Mining Plan)
MCTI	*Ministério da Ciência, Tecnologia e Inovações* (Brazilian Ministry of Science, Technology and Innovation)
MDIC	*Ministério da Indústria, Comércio Exterior e Serviços* (Brazilian Ministry of Industry, Foreign Trade and Services)
MMA	*Ministério do Meio Ambiente* (Brazilian Ministry of Environment)
NAP	National Climate Change Adaptation Programme
NAPA	National Adaptation Programme of Action
NDC	Nationally Determined Contribution
PDCA	Plan, Do, Check, Act
PEMC	*Plano de Energia e Mudanças Climáticas de Minas Gerais* (Energy and Climate Change Plan for the State of Minas Gerais)
PNMC	*Política Nacional de Mudança do Clima* (Brazilian National Policy on Climate Change)
TCFD	Task Force on Climate-related Financial Disclosures
UKCIP	UK Climate Impacts Programme
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WG	Work Group
WRI	World Resources Institute
WWF	World Wide Fund for Nature

FOREWORD

The Brazilian Mining Association (IBRAM) presents the "Resilient Mining: A guide to adapting Mining to Climate Change impacts", a practical guide for mining sector businesspeople, with the objective of guiding the preparation of strategies aimed at reducing risks and exploring opportunities resulting from changes in our weather and climate.

The mining sector is essential for providing the natural resources that drive economic development and social welfare. And, in the light of the new demands of a changing society, the sector faces the challenge of rethinking how to create and share value with its stakeholders. The trend towards decarbonizing the world economy, and the energy matrix, points to new opportunities for the sector, especially with the supply of new materials. This ongoing change has enormous potential to alter the scale and composition of the global demand for minerals and metals.

The changing climate will, however, affect mining in a number of ways, both directly and indirectly. Extreme weather events, and long-term changes in climate patterns, have the potential to damage assets and disrupt supply chains.

For the mining sector, building operational resilience to climate change depends on a company´s ability to adapt to such changes, anticipate what might happen next, and absorb climate shocks when they happen. Especially in corporate reality, adaptation management should be seen as part of the strategy to manage specific and systemic risks, and there may also be sustainable improvement opportunities for those who know how to transform themselves better.

In this sense, and keeping its commitment to gradually broaden and deepen the climate change agenda in the mining sector, IBRAM publishes this guide, aiming at promoting business resilience, and integrating considerations on climate change into existing risk planning and management procedures.

The Association understands that, through qualified knowledge, it is possible to comprehend better the risks and opportunities related to the climate agenda, besides being in line with the growing concern, and worldwide awareness, about measures to monitor and implement mitigation actions for climate change adaptation-related risks.

Flávio Otoni Penido
CEO
IBRAM

Climate change is a scientifically proven reality, and a challenge that affects not only our productive activities, but the entire planet. Fighting the impacts of climate change is a strategic priority on Vale´s agenda. The company is committed to contributing to a more sustainable future, through a renewable energy matrix, the superior quality of our products, and the constant technological evolution together with innovation leaders of value chains. We have recently announced more ambitious goals towards low carbon mining, guided by scientific and practical references, and as defined in our global policy on climate change. In line with the goal of the Paris Agreement of limiting global warming to less than 2°C, we aim at reducing the emissions of Scopes 1 and 2 by 33% by 2030. This reduction will be measured from 2017 emissions, which totaled 14.1MtCO_2e.

In addition, our goal is a zero net emission balance for scopes 1 and 2 by 2050. For the challenge of scope 3, we are strategically positioned to help our customers reduce their carbon footprint. We are the first company in our industry to set a quantitative target for this scope´s net emissions: by 2035, we will reduce net emissions by 15% compared to 2018 levels. This reduction will be achieved both through our own initiatives, and partnerships and engagement with suppliers and customers.

It is also part of Vale´s strategy to assess Climate Change risks, opportunities and impacts on the resilience of business strategies and assets, in line with the Task-force on Climate-related Financial Disclosures (TCFD) recommendations. The publication of this Adaptation Guide, through this IBRAM initiative, enables the industry to identify the physical impacts of climate change, its operational and strategic vulnerabilities, and to be ready to prepare adaptation measures.

For Vale, contributing to mitigate climate change is an essential part of our purpose as an organization, that is, to improve life and transform the future, together. Guided by open and transparent dialogue, and the constant search for partnerships with our stakeholders, we are honored to have contributed to this important work developed by IBRAM.

Have a good reading!

Vivian Mac Knight
Climate Change Manager
Vale

The UK took over the presidency of COP26 at a key moment for the climate agenda. Science has evidenced that the effects of rising temperatures will become more frequent and brutal, and, unless we act urgently, we will witness a scale of global catastrophes never seen before. We are aware of the responsibility we have been entrusted with, and we wish to lead by example.

In 2019, we were the first major economy to legislate to zero net carbon emissions by 2050. Last year, we committed to reducing our emissions by 68% by 2030 and, last April, we announced the target of 78% by 2035, both from 1990 levels. This is the largest reduction target assumed by a major economy to date.

Mining is an important sector for the much desired energy transition and green economy. Therefore, the discussion proposed in this guide is of utmost importance to foster the debate about climate change adaptation in the sector. Mining has its own challenges to face towards a low carbon economy, whether in the commitment to mitigate carbon emissions and collaboration of the value chain as a whole, or in the management of tailings dams. Therefore, the creation of this guide indicates the openness of the sector to dialogue.

It is with great satisfaction that we support the "Resilient Mining: A guide to adapting Mining to Climate Change impacts", developed by IBRAM. We believe this document will be the first step to contribute to the change in the sector, in order that it adapts to having a lower impact on the environment, promoting development and innovation, and becoming increasingly transparent and responsible.

Nathália Gomide
Business Development Manager –
Mining UK Government

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1 Climate Change and Adaptation

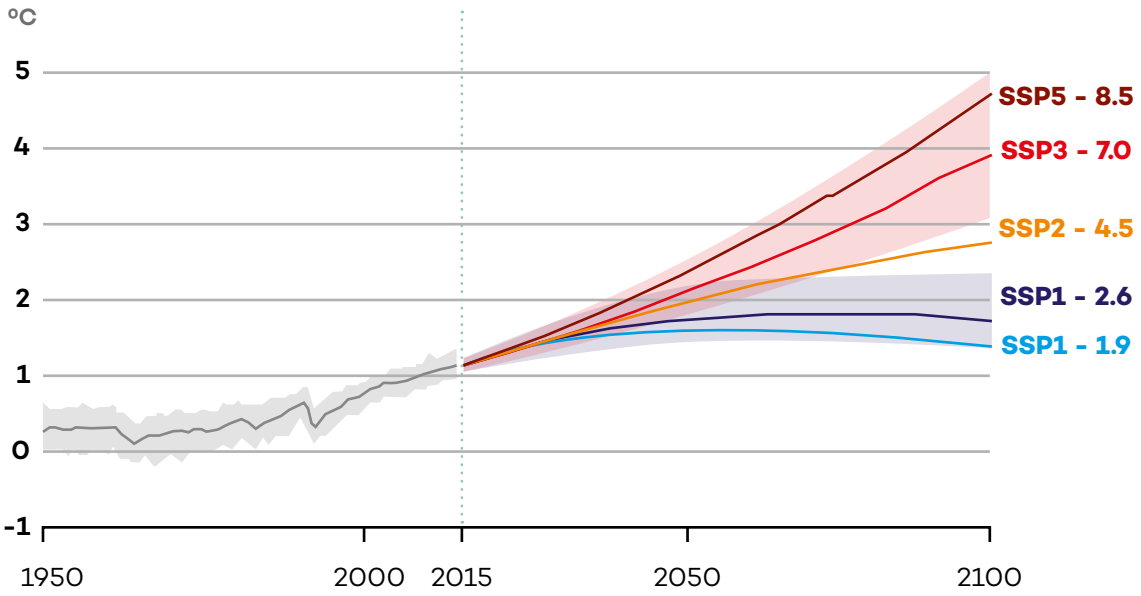
According to the Intergovernmental Panel on Climate Change (IPCC, 2007), climate change adaptation is the set of adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. The Brazilian National Policy on Climate Change (PNMC), Law 12187/2009, defines adaptation as initiatives, and measures, to reduce the vulnerability of natural and human systems to current and expected climate change effects.

Why addressing adaptation? IPCC points out, in its sixth Assessment Report (AR6), that the concentration of CO2 in the atmosphere in 2019, approximately 410ppm (parts per million), was higher than at any time in the last 2 million years. The report concluded that climate change led to an average increase of approximately 1.07°C in the planet´s temperature from 1850-1900 (pre-industrial periods) to 2010-2019.

If nothing is done, the 1.5°C increase limit, defined by the Paris Agreement, may be reached already by 2030, ten years earlier than previously predicted. However, there are still alternatives for humanity to mitigate the problem. The study shows that in scenarios where there are large reductions in emissions (e.g., net emissions equal to zero by 2050), after the average temperature increase reaches 1.5°C in 2030, it would fall to 1.4°C by 2100.

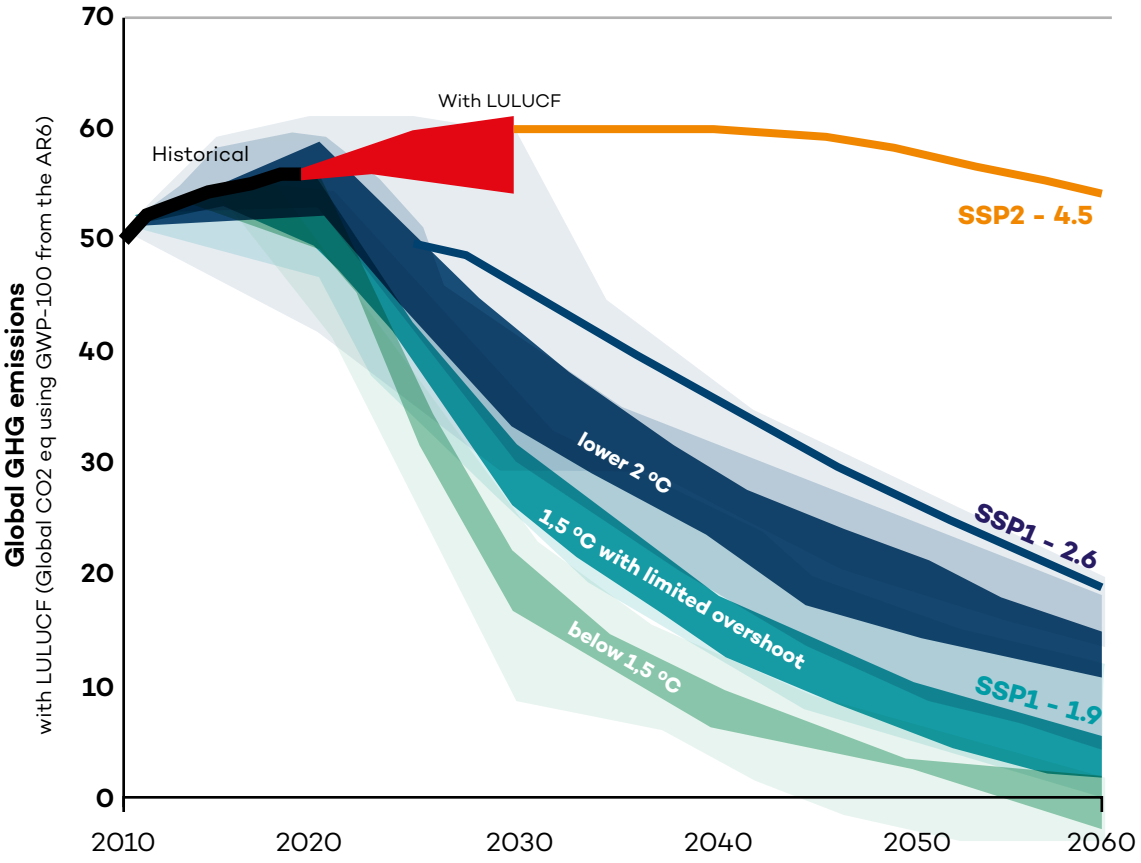
Although there is room to solution, the current situation is quite alarming. The United Nations Framework Convention on Climate Change (UNFCCC) has compiled all the targets defined by 191 countries in their Nationally Determined Contributions (NDCs) which, in practice, represent the emission reduction efforts already promised by each country. According to this study, even if all countries achieve their targets by 2030, the average global temperature increase will remain well above 2°C (Figure 2).

Figure 1: Global surface temperature changes between 1850-1900



Source: IPCC, 2021

Figure 2: Comparison of global emissions under IPCC-assessed scenarios with the total global emissions according to NDCs

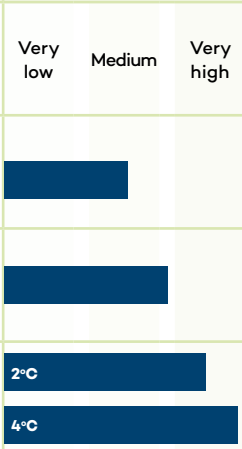
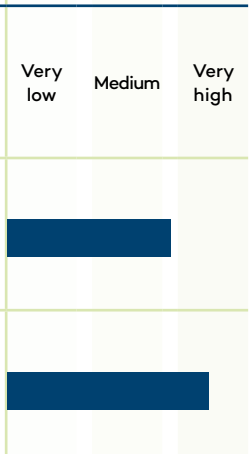
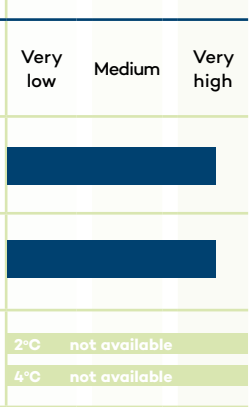


Source: UNFCCC, 2021

UNFCCC states that the world is already experiencing climate change effects, including average temperature changes, season changes, and increasingly frequent extreme weather events.

In this scenario, there are two ways to tackle climate change. The first and best known includes mitigation actions, which seek to fight the causes, reducing the concentration of Greenhouse Gas (GHG) in the atmosphere. The second includes **adaptation** actions, which address the consequences, reducing damage, and assessing risks and opportunities of effects that mitigation could not reduce. That is, even if great efforts to fight climate change are made from now on, droughts, floods, extreme temperatures (high or low), sea level rise, loss of agricultural productivity and biodiversity, among other occurrences will happen, due to the high concentration of GHG in the atmosphere. All these events bring severe consequences to humanity such as deaths, loss of quality of life, increase of diseases, damage to food production and infrastructure, among others. Figure 3 below illustrates the main damage that can be caused by climate change, according to the planet´s average temperature increase in Central and South America. (Figure 3).

Figure 3: Main regional climate change risks, and potential risk reduction through adaptation and mitigation

CENTRAL AND SOUTH AMERICA				
Main risk	**Problems and prospects for adaptation**	**Climate drivers**	**Period of time**	**Risk and potential for adaptation**
Water availability in semi-arid regions which depend on glacier melting, and in Central America; floods and landslides in urban and rural areas due to extreme rainfall (high confidence) [27.3]	• Integrated management of water resources • Management of urban and rural floods (including infrastructure), early-warning systems, better weather forecasts, better runoff forecasts, and control of infectious diseases		Present Short-term (2030-2040) Long-term (2080-2100)	
Reduced production and quality of food (medium confidence) [27.3]	• Development of new varieties of cultures more adapted to climate change (temperature and drought) • Compensation of impacts on human and animal health caused by the reduced quality of food • Compensation of economic impacts of changing land use • Reinforcement of systems and practices of traditional Indigenous knowledge		Present Short-term (2030-2040) Long-term (2080-2100)	
Propagation of vector-borne diseases in altitude and latitude (high confidence) [27.3]	• • Development of early-warning systems for disease control and mitigation based on relevant information on climate and other data. Many factors increase vulnerability • Definition of programs to increase basic public health services		Present Short-term (2030-2040) Long-term (2080-2100)	

Source: IPCC, 2014b

In addition to physical risks, climate change is associated with economic and financial risks, and can culminate in global economic crises. In 2019, the Carbon Disclosure Project (CDP), an international non-profit organization that assesses climate performance of companies and cities, estimated that 215 of the world´s largest industries would have incurred US$970 billion in losses due to additional climate change-related costs, and by 2024, they would have another US$1 trillion in losses.

Therefore, climate change adaptation is extremely important for the survival not only of the population, but also business. Especially in corporate reality, adaptation management should be seen as part of the strategy to manage specific and systemic risks, and there may also be opportunities for those who know how to transform themselves better.

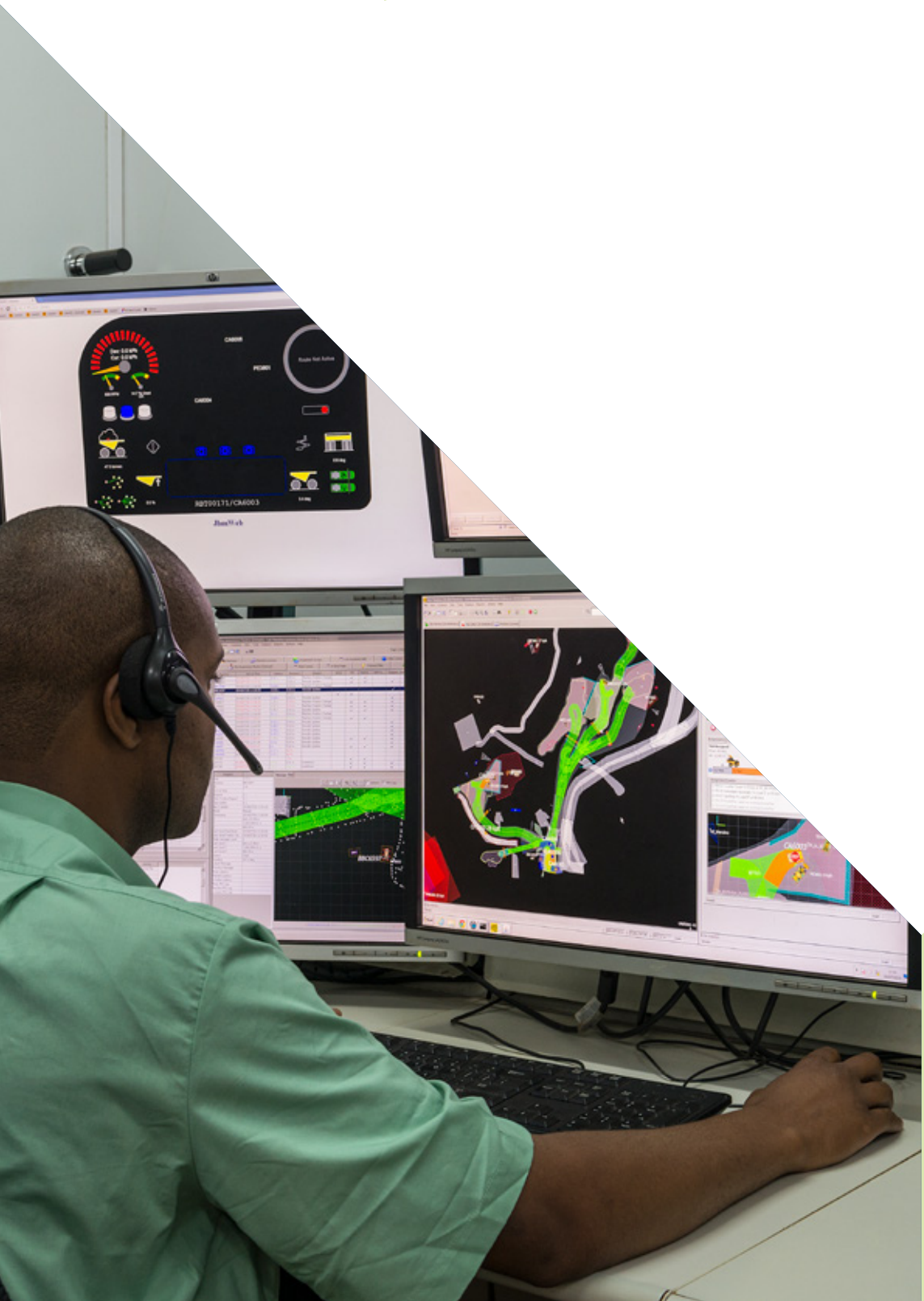
In addition to the adaptation concept, and for a better understanding of this guide, it is important to highlight other concepts related to the subject:

Tabela 1: Other adaptation-related concepts

Resilience	The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012).
Climate change-related risks	Risk of climate-related impacts results from the interaction of climate-related hazards, with the vulnerability and exposure of human and natural systems, including their ability to adapt. Risk refers to the consequences that may occur at a given location where some value attribute is exposed and when the outcome is uncertain. It is often represented as the probability of occurrence of hazardous events multiplied by the impacts if these events occur (IPCC, 2014).
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and the lack of capacity to cope with and adapt to the adverse effects of climate change (IPCC, 2014).

Source: Adapta Clima, 2021

2 Governance



Adaptation-related governance actions and instruments occur at various levels, whether in the public or private sector. Although, for now, there are no mandatory commitments to be met by companies in the adaptation area (unlike mandatory mitigation targets, for example), it is important that they consider the various adaptation governance initiatives in their macro environment. Besides serving as a structural reference for corporate strategies, those commitments can help companies map out specific actions that will require interface with external areas and stakeholders. By definition, a good corporate adaptation strategy depends on the ability of a company to act in coordination with the various external stakeholders, since risk management will not be only under the control of the company. This is even more evident in the mining sector, due to the risks that directly affect the core productive activity of companies.

In this context, the main international and local level adaptation governance initiatives, whether public or private, are shown below.

2.1 Public international level:

Under the UNFCCC, the major milestone of the adaptation agenda was COP16, held in 2010 in Cancun. Besides defining the National Adaptation Plans, the Cancun Adaptation Framework was created. In this framework, countries stated that adaptation actions should have the same level of priority as mitigation actions.

IPCC has a specific work group for studies on the Assessment of Impacts, Adaptation and Vulnerabilities related to climate change. Work Group II (WGII) assesses climate change impacts, from a global to a regional view of ecosystems and biodiversity, and of humans and their various societies, cultures, and settlements. It considers their vulnerabilities, and the abilities and limits of these natural and human systems to adapt to climate changes and, thereby, to reduce climate-related risks. It also includes options for creating a sustainable future for all, through an equitable approach integrated to mitigation and adaptation efforts in all scales. Since the creation of IPCC in 1988, the Work Group has contributed with several reports, most notably the "Global warming of 1.5°C" and the "AR 5 – Climate Change 2014: Impacts, Adaptation and Vulnerability" (IPCC, 2021).

2.2 Public local level:

In Brazil, the National Climate Change Policy (PNMC), of 2009, proposed policies related to the monitoring and implementation of sectoral mitigation and adaptation plans, which encouraged the creation of the Brazilian National Climate Change Adaptation Programme (NAP) in 2016. This NAP aims to promote the reduction of the national climate change vulnerability and manage the risks associated to this phenomenon.

In addition to NAP, the Brazilian Ministry of Environment (MMA) has created Sectoral Plans that, besides including a mitigation strategy, also include adaptation actions. Sectoral Plans for Climate Change Mitigation and Adaptation, including the Mining Plan (MBC Plan), were in force from 2013 to 2020, and included subsidies for actions by public authorities and society for planning, implementation and monitoring of public policies.

Besides actions by the federal government, some Brazilian states, and even municipalities, have made efforts in the adaptation agenda. The most prominent examples in the mining sector context are the states of Minas Gerais and Pará.

The State of Minas Gerais conducted two studies in the scope of the Energy and Climate Change Plan for the State of Minas Gerais (PEMC): "*Estudo de Vulnerabilidade Regional às Mudanças Climáticas de Minas Gerais*" (the Regional Climate Change Vulnerability Study of Minas Gerais) and "*Estratégia de Adaptação Regional às Mudanças Climáticas para Minas Gerais*" (the Strategy for Regional Climate Change Adaptation for Minas Gerais). In addition, the State created the platform *Clima Gerais*, which supports the municipalities of the state in both low carbon development and territorial adaptation using tools such as the municipal climate vulnerability map.

The State of Pará created the Forum on Climate Change and Adaptation of the State of Pará (FPMAC) in the scope of the State Policy on Climate Change of Pará (Law 9048/2020). The Forum aims at promoting cooperation and dialogue between different sectors of society, with the objective of tackling problems related to climate change, adaptation, and its socio-environmental and economic consequences.

2.3 Private international level:

Besides governmental actions, the private sector has also engaged in the subject. One of the main global initiatives of the mining sector in this agenda was the publication "Adapting to a Changing Climate: Building resilience in the mining and metals industry", led by the International Council on Mining & Metals (ICMM). Besides engaging the sector for the identification of relevant adaptation subjects, the publication has addressed risks and opportunities, bringing suggestions for building resilient businesses in activities connected to the mining chain.

Also seeking to guide organizations that wish to implement adaptation measures in their business, ISO published standards ISO 14090:2019 - Climate change adaptation - Principles, requirements and guidelines, and ISO 14091:2021 - Climate change adaptation - Guidelines on vulnerability, impacts and risk assessment, and constantly studies, through its work groups, the preparation of other standards on the subject.

Other relevant initiatives are: the Task Force on Climate-related Financial Disclosures (TCFD), which defines guidelines for the voluntary disclosure of risks and opportunities of climate-related and adaptation-related business, providing relevant information to investors, and; CDP, which besides engaging companies and governments in the disclosure

of climate management information, informs investors and society about actions aimed at the climate management of companies, including risks and opportunities.

Financial entities are also concerned about the risks associated with their operations. In 2002, the code of conduct "Equator Principles" was launched, defining voluntary social and environmental criteria for financial institutions around the world to assess the impacts of their financial products. Concerned with the issue, the Central Bank of Brazil published, in 2014, Resolution nr. 4.327, defining guidelines for financial institutions to adopt social and environmental responsibility policies. In addition, in 2021, the Central Bank of Brazil edited some resolutions (CMN 4.943, CMN 4.944, and CMN 4.945) that, besides replacing the generic concept of social and environmental risk, defined by Resolution nr. 4.327, by specific definitions of social risk, environmental risk and climate risk, have improved the management rules of these risks applicable to financial institutions. These measures promote investment in actions that are connected with climate change adaptation such as, for example, resilient infrastructure, renewable energy, restoration and conservation of native areas, among others.

Climate Finance

In the financial area, besides risk assessment, several sources of climate finance are available, both for mitigation and adaptation. A good reference for the private sector is the CNI publication: "***Financiamento para o Clima: Um guia para a indústria***" [Climate Finance: A guide for the industry].

Read the content in the link or QR Code below:

https://static.portaldaindustria.com.br/media/filer_public/51/fa/51fad9ce-242c-4dde-8c0e-7b5eff1f084d/financiamento_para_o_clima.pdf

RACE TO RESILIENCE

Race to Resilience is a global campaign (connected to Race to Zero) launched in 2021, and supported by UN, to catalyze a step change in the global ambition to climate resilience by putting people and nature first in the quest for a resilient word.

The key objectives of the campaign are:

By 2030: to catalyze actions by non-state actors and the private sector that build resilience for 4 billion people, including groups and communities that are vulnerable to climate risks.

By 2050: to live in a world where all communities thrive, even in the face of the many risks and uncertainties posed by climate change.

Through partnerships, Race to Resilience focuses on helping the most vulnerable communities build resilience and adapt to the physical impacts of climate change in three levels:

- **Urban:** Transforming cities, industries, and informal settlements into healthy, safe, and prosperous spaces that support resilient livelihoods and enable post-COVID-19 "green" recovery.
- **Rural:** Making small farmers, rural entrepreneurs, and agribusinesses adaptable and equipped to face climate change while protecting nature.
- **Coastal:** Protecting coastal and riverine cities, communities, and business through increased investment in adaptation, resilience, and protection of the natural ecosystems that support these livelihoods and economies.

RACE TO RESILIENCE

To learn more about **Race to Resilience**, visit

https://racetozero.unfccc.int/join-the-race-to-resilience/

3 Adaptation and Mining

The mining sector, like many other segments of the economy, is already feeling the effects of climate change in Brazil and around the world. IPCC states that climate change will affect exploration, extraction, production and transport in the mining industry. Increased climate-related risks (for example floods, windstorms, and forest fires) affect the feasibility of mining operations, and potentially increase operational, transportation, and decommissioning costs.

According to the International Council on Mining and Metals (ICMM), extreme weather events, and long-term changes in weather patterns, have the potential to damage fixed assets and disrupt the supply chains of the sector. In general, the main areas of concern for mining companies are water management, the performance of long-life facilities, and how climate change may impact dams, and mine closure and post-closure.

> “Most mining infrastructure has been built on assumptions of a stable climate and, therefore, is not adapted to climate change.”
>
> (IPCC,2014).

For the mining sector, building operational resilience to physical climate change depends on a company´s ability to adapt to changes, anticipate what might happen, and absorb climate shocks.

It is also important to understand the main stages involved in the “life cycle” of the mining activity, to help the planning of adaptation measures, and anticipation of risks that affect the productive chain. The peculiarities of each of these stages should be taken into consideration. Usually, this cycle consists of: planning, design, construction, operation, closure, and post-closure. These stages are rarely linear and planning, design, and construction are recurrent activities throughout the life cycle (MAC, 2019). Therefore, risks, opportunities, and priorities may be different for each stage.

Restrictions in the supply of relevant inputs for mining processes, such as water and energy, risks to health and safety of employees, difficulty in obtaining and maintaining a “social license to operate” in communities where climate change increases direct competition between the company and the population for resources, and difficulty in enabling projects with higher physical and non-physical risks are some examples of risks for the mining sector (BSR, 2009).

Table 2 (next page) shows some examples of impacts, risks, vulnerabilities, and adaptation measures for the mining sector.

Table 2: Impacts, risks, vulnerabilities, and adaptation measures for the mining sector

IMPACTS AND RISKS	
• Reduced water availability	• Damage to industrial, logistical, energy, telecommunications, and port infrastructure
• Risks of instability/disruption of infrastructure such as, for example, dams	• Oxidation of metal structures and equipment
• Increased incidence of floods	• Reduced availability of raw materials and inputs
• Production losses	• Increased operating costs
• Logistics impairment	• Increased harm to health and safety of employees
• Loss of competitiveness	• Less job creation
• Sea level rise	• Increased heat waves and heat islands
• Mine closure-related problems	• Increased incidence of fires in conservation areas of mining companies
VULNERABILITIES	
• Dependence on raw materials	• Susceptibility to landslides in steeper areas
• Susceptibility to floods in lower areas	• Vulnerability to sea level rise in coastal areas
• Diversity of energy matrix	• Low investment in adaptation and R&D
ADAPTATION MEASURES	
• Identification and monitoring of climate variables	• Access to monitoring and climate-alert tools
• Mapping of risk areas	• Rational use and reuse of water
• Rational use of energy and alternative sources	• Inclusion of climate risk in planning and decision-making
• Development and implementation of contingency plans	• Conservation and recovery of natural areas
• Creation of natural barriers, and recovery of mangroves in coastal areas	• Containment works in drainage slopes, and flood control
• Alert systems for natural disasters	

Source: Adapted from Adapta Clima, 2021

Companies will need to increase business resilience, integrating considerations on climate change into existing risk planning and management procedures. Risks can manifest in various ways, possibly impacting operations, production, and financial, social and environmental performance of mining companies.

Climate resilience permeates all components of mining activities and, thus, risk management tools are essential for a better understanding of the subject, and implementation of mitigation actions for risks, as shown in the next chapters..

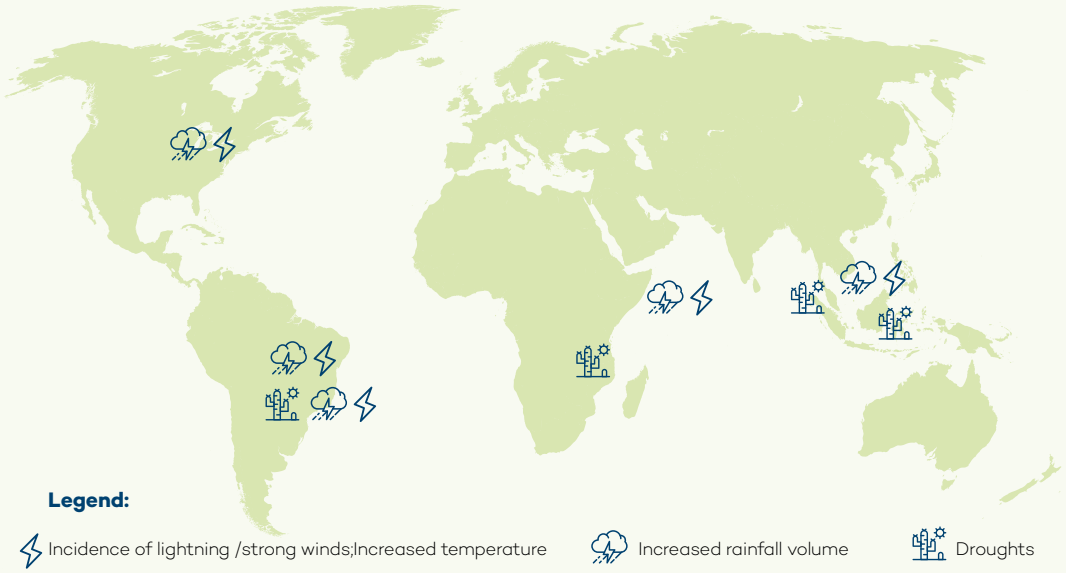
Sectorial Case – Vale

Vale is committed to leading the transition to low carbon mining, which represents opportunities and challenges, aiming to become a net-zero mining company by 2050. In addition to a portfolio for emission mitigation to achieve this goal, Vale has developed specific analysis methodologies divided into impacts resulting from the transition to a low carbon economy and physical impacts in line with the guidelines of the Task-force on Climate-related Financial Disclosures (TCFD), and has prepared a specific report with Vale´s analysis and actions to manage this subject.

The company has developed, together with Instituto Tecnológico Vale, a projection and mapping model for the possible physical impacts that pose risks to the operations of the company. The climate projection is conducted using a modeling system that allows future scenarios of temperature and rainfall. Therefore, it is possible to:

- Assess climate change-related risks, such as transition risks and physical risks, and their potential impacts for the company;
- Monitor and analyze the physical impacts that are already occurring as well as the long-term impacts.

Figure 4: Map of risk in Vale´s operations



4 Management of Climate Change-Related Risks and Tools

As shown in the previous chapter, there are several climate change-related risks in mining activities and, one of the ways of organizing the information, and assist decision-making on the subject is by the implementation of actions aimed at climate risk management.

Risk management of climate change-related adverse events should be done by determining measures that maximize the utility function, which is the average gain taking into account the aversion to the uncertainty of forecasts.

The aversion to the uncertainty is a measure of the magnitude of losses that cannot be tolerated by the company. For that, it is necessary to determine, quantitatively, the magnitude of the losses associated to each adverse event predicted due to climate change, and the probability of occurrence. As a corporate decision, the magnitude of losses that cannot be tolerated must be defined, and, therefore, the magnitude of the aversion to the uncertainty.

It is important to note that the objective of maximizing the gain in view of the probability of occurrence of adverse events, and taking into account the aversion to the uncertainty, does not mean adopting the best existing forecast as if it were certain, but rather considering the best forecast, its margin of uncertainty, and the aversion to the uncertainty.

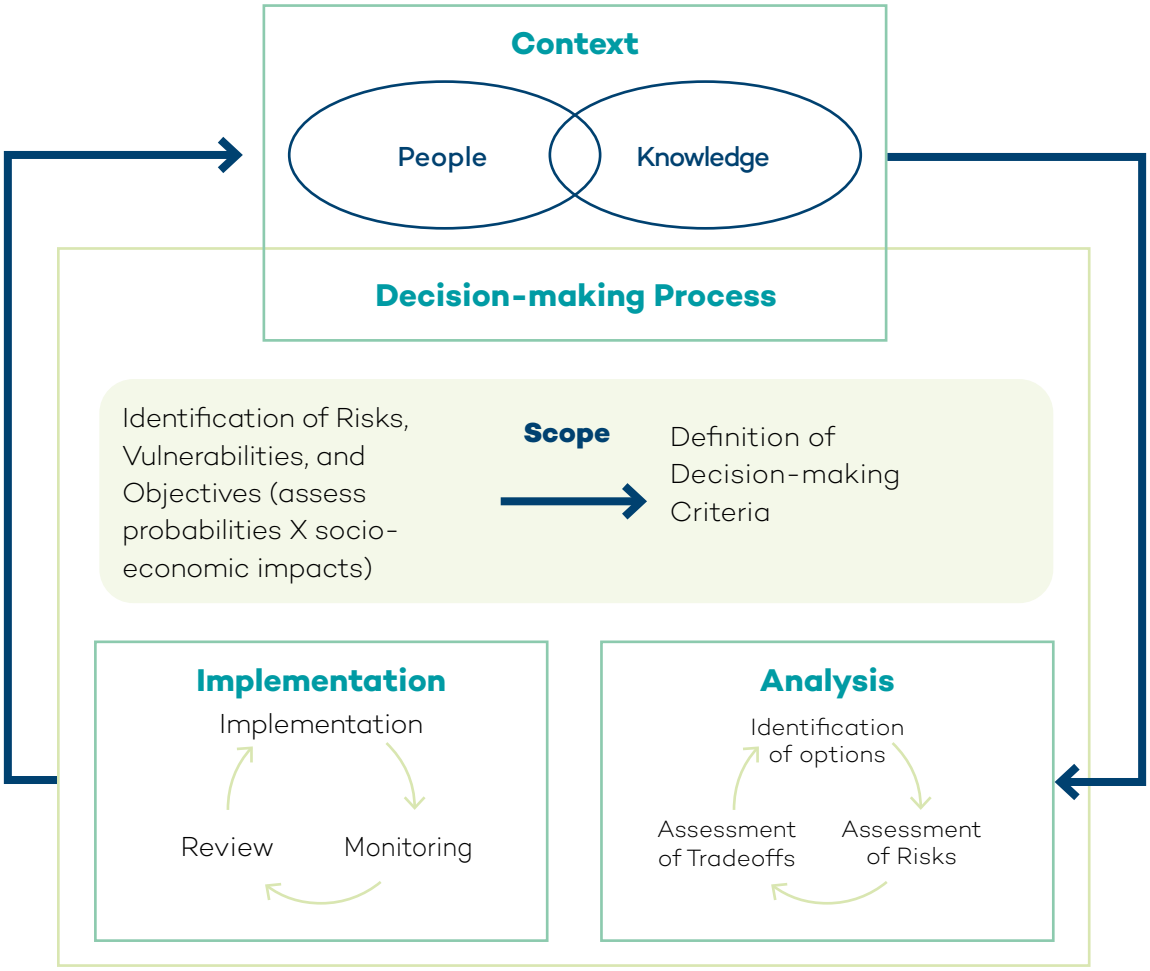
As the magnitude of climate change is increasing in time, and it is much cheaper to make modifications in the design of infrastructure than to make corrections after its construction, it is essential that the climate change predicted in the area of the project is taken into account during its design and construction stages. As an example, the size of culverts, height of bridges, and slope of backfills have to be modified due to predicted rainfall increase. Another example is the need to modify the design or operation of railroads to take into account the predicted temperature increase.

Iterative risk management, that is, risk management that is conducted repeatedly, is best suited in situations characterized by major uncertainties, long periods of time, with the potential for learning over time, and the influence of climate, and other socio-economic and biophysical changes. Complex decision-making contexts require a broad definition of risk and assessment of plausible future outcomes, and alternative risk management actions (robust evidence, medium agreement).

The intention is that people, and organizations, apply the decision-making processes of climate impacts, adaptation, and vulnerabilities in ways that meet their specific objectives (IPCC, 2014). Figure 5 (next page) illustrates the structure of iterative risk management.

Currently, there are several risk management tools focused on climate. In this chapter, we will show some examples of methodological approaches that are applicable to the mining sector, besides examples of tools that can be used in risk assessment and management.

Figure 5: Structure of iterative risk management



Source: Adapted from IPCC, 2014

4.1 SWOT Matrix

SWOT is an English acronym for Strengths, Weaknesses, Opportunities and Threats. SWOT analysis is a tool that can be used to assess businesses, companies, projects, processes, and even perform individual and personal analysis. It is most commonly used in the management area to assist decision-making because, by emphasizing the assessment of the four factors listed above, it facilitates the preparation of strategies that take into account internal factors (strengths and weaknesses), and external factors (opportunities and threats), besides positive points (strengths and opportunities), and negative points (weaknesses and threats) of a process (GAO et al., 2017).

Given its versatility, SWOT analysis can also be applied to climate risk management for companies of all sizes and sectors, with different levels of depth on the subject, and used as a basis for the preparation of adaptation plans.

Table 3 (next page) shows an example of SWOT matrix focused on climate adaptation in the mining sector.

Table 3: Example of climate adaptation SWOT matrix in the mining sector

CLIMATE ADAPTATION SWOT®		
	STRENGTHS	**WEAKNESSES**
Internal Factors (organization)	• Engagement of top management • R&D&I actions focused on monitoring and climate risks • Investment in resilient infrastructure • Rational use of water and energy • Conservation of native areas • Other	• Difficulty to engage internal areas of the company • Lack of resources for investment in adaptation actions • Low level of knowledge on the subject • Focus on mitigation actions • Focus on short-term measures • Other
	OPPORTUNITIES	**THREATS**
External Factors (environment)	• Development of new technologies focused on adaptation • Improvement of monitoring tools and climate database • Recognition by the market and customers of the company´s adaptation actions • Creation of policies to encourage adaptation • Funding sources for adaptation actions • Other	• • Floods • • Lack of water resources • • Damage to infrastructure • • Logistical difficulties • • Lack of raw material supplies • • Other

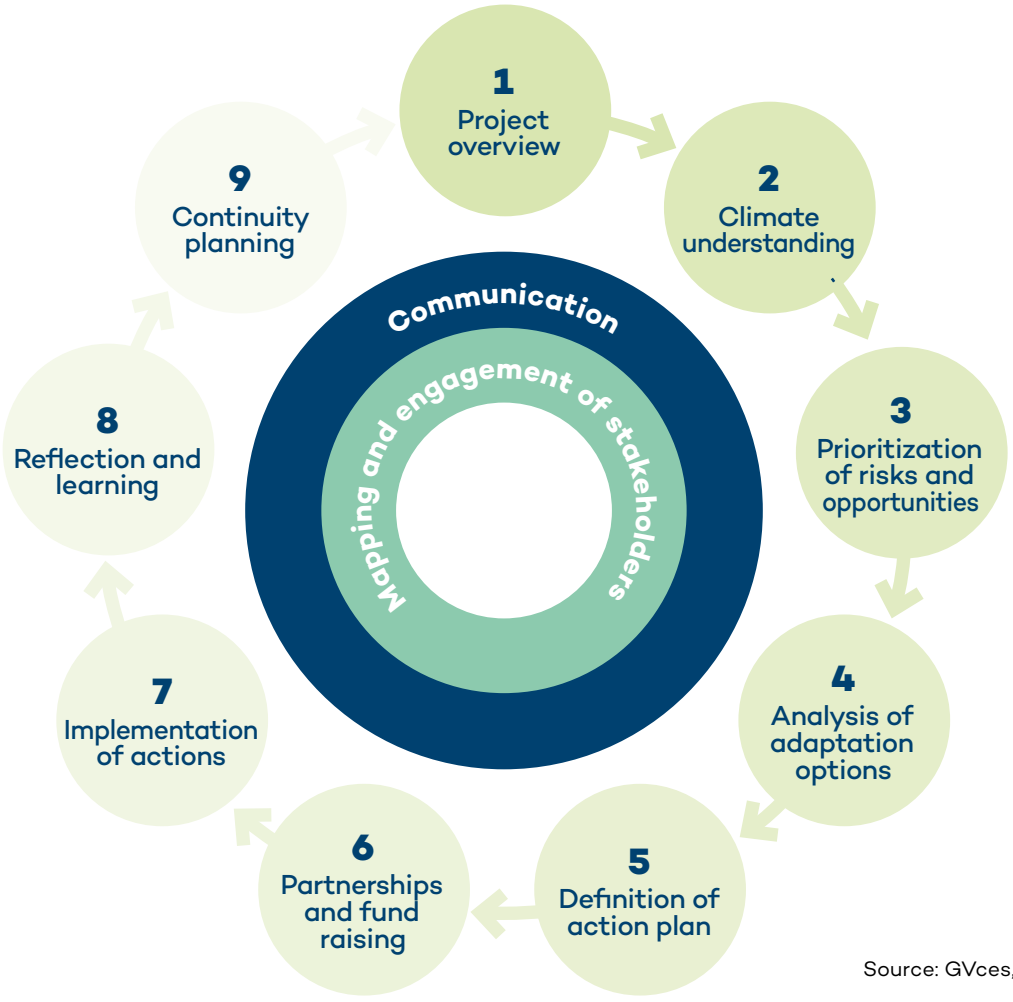
Source: Internal resources, 2021

4.2 Tool to Support the Preparation of Climate Change Adaptation Strategies for Civil Society Organizations

One of the main tools to facilitate adaptation management in Brazil was developed by GVces at FGV, based on the UKCIP methodology, by Oxford University. This tool aims to facilitate the management of processes and actions that increase resilience, and reduce vulnerabilities within civil society projects and programs. It consists of conscious, planned, systemic, and strategic actions that are coherent with the local reality, and seek to strengthen partnerships, develop cooperation relations and, therefore, optimize efforts.

The full cycle of the tool includes support for the organization, and systematization of the information needed to promote better understanding and management of the risks and opportunities of climate change. Its application facilitates the development of adaptation management plans, which can be used by companies of various sizes and sectors, including mining. Figure 6 below shows the structure of the cycle.

Figure 6: Cycle of the tools to support the preparation of adaptation strategies



Source: GVces, 2015

The expected result of this entire process is the preparation of a robust adaptation plan, and the learning about a planning approach that can be incorporated into the organizational strategic planning. As shown in the next chapter, this tool can also be conducted according to the PDCA cycle (Plan, Do, Check, Act).

In addition to the tools mentioned above, other tools can be used by mining companies. Table 4 shows some examples that include databases with local information on various subjects important for risk management such as, for example, water availability, frequency of natural disasters, biodiversity, changes in land surface temperatures, among others.

Access to the GVCes/UKCIP tool

To learn more about the "Ferramenta de Apoio à Elaboração de Estratégias de Adaptação às Mudanças do Clima para Organizações da Sociedade Civil" [Tool to Support the Preparation of Climate Change Adaptation Strategies for Civil Society Organizations], visit: http://mediadrawer.gvces.com.br/adapta/original/ferramenta_estrategias-em-adaptacao_sociedade-civil.xlsx

Guidelines to complete the form are available at: http://mediadrawer.gvces.com.br/adapta/original/ciclo-para-elaboracao--de-estrategias-de-adaptacao_sociedade-civil.pdf

Table 4: Tools to support climate risk management

Tool: Adapta Brasil **Entity:** MCTI **Link to access the tool:** https://adaptabrasil.mcti.gov.br	**Descrição** The Information and Analysis System on Climate Change Impacts (Adapta Brasil MCTI) has been created by the Brazilian Ministry of Science, Technology and Innovation and aims at consolidating, integrating and disseminating information that enables the advancement of the analysis on the climate change impacts, observed and projected in the Brazilian territory, providing subsides to the competent authorities responsible for adaptation actions. The platform contributes to the dissemination of knowledge through the analysis of increasingly integrated and updated information on climate, and the risks of impacts in Brazil, besides ensuring the accessibility of the main results to decision makers at all levels, as well as to researchers, civil society, and the private sector.

Tool:
Aqueduct Atlas

Entity:
World Resources Institute (WRI)

Link to access the tool:
https://www.wri.org/aqueduct

Description
Aqueduct´s tools map water resource-related risks, such as floods, droughts, and stresses, using open-source, peer-reviewed data. In addition to tools, Aqueduct´s team works one-to-one with companies, governments, and research partners to help promote best practices in water resource management, and enable sustainable growth in a water-constrained world.

Tool:
General Circulation Models (GCM) Downscaled Data Portal

Entity:
Research Program on Climate Change, Agriculture and Food Security (CCAFS)

Link to access the tool:
http://www.ccafs-climate.org/

Descrição
The CCAFS-Climate data portal provides high resolution global and regional climate datasets that serve as a basis for assessing climate change impacts and adaptation in a variety of fields, including biodiversity, agricultural and livestock production, ecosystem services, and hydrology.

Tool:
Global Risk Data Platform

Entity:
UNEP

Link to access the tool:
https://preview.grid.unep.ch/

Description
The Global Risk Data Platform seeks to share spatial data information about the global risk of natural disasters. Users can view, download, or extract data on previous hazardous events, exposure to human and economic hazards, and risks of natural hazards. It includes tropical cyclones and storm surges, droughts, earthquakes, biomass fires, floods, landslides, tsunamis, and volcanic eruptions. Data collection is carried out through a wide range of partners, and the platform has been developed as a support to the Global Assessment Report on Disaster Risk Reduction (GAR).

Tool: Google Earth Engine **Entity:** Google **Link to access the tool:** https://earthengine.google.com/	**Description** Google Earth Engine combines a catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers, and developers use the Earth Engine to detect changes, map trends, and quantify differences on Earth´s surface. Google Earth Engine´s public data archive includes more than forty years of historical imagery and scientific datasets, updated and expanded daily. It also includes specific databases for Earth´s Surface Temperature, Climate, Atmosphere, and Weather.
Tool: Think Hazard **Entity:** World Bank **Link to access the tool:** https://thinkhazard.org/en/	**Description** Think Hazard! provides an overview of hazards, for a given location, which should be considered when designing and implementing projects to promote climate resilience to disasters. The tool highlights the probability of occurrence of different natural hazards affecting project areas (very low, low, medium and high), and provides guidance on how to reduce the impact of these hazards, as well as where to find more information. The hazard levels provided are based on published data, released by a number of public, academic, and private organizations.
Tool: Water Risk Filter **Entity:** WWF **Link to access the tool:** https://waterriskfilter.panda.org/	**Descrição** With 32 watershed risk indicators, and over 12 high resolution country datasets, the tool offers a variety of risk map layers at different global-to-local scales. In addition, users can select different layers to facilitate a more accurate assessment, and allow the understanding of potential connections between water risks and other factors, such as protected areas, human footprint, etc.

Source: Adapted from Sitawi, 2020

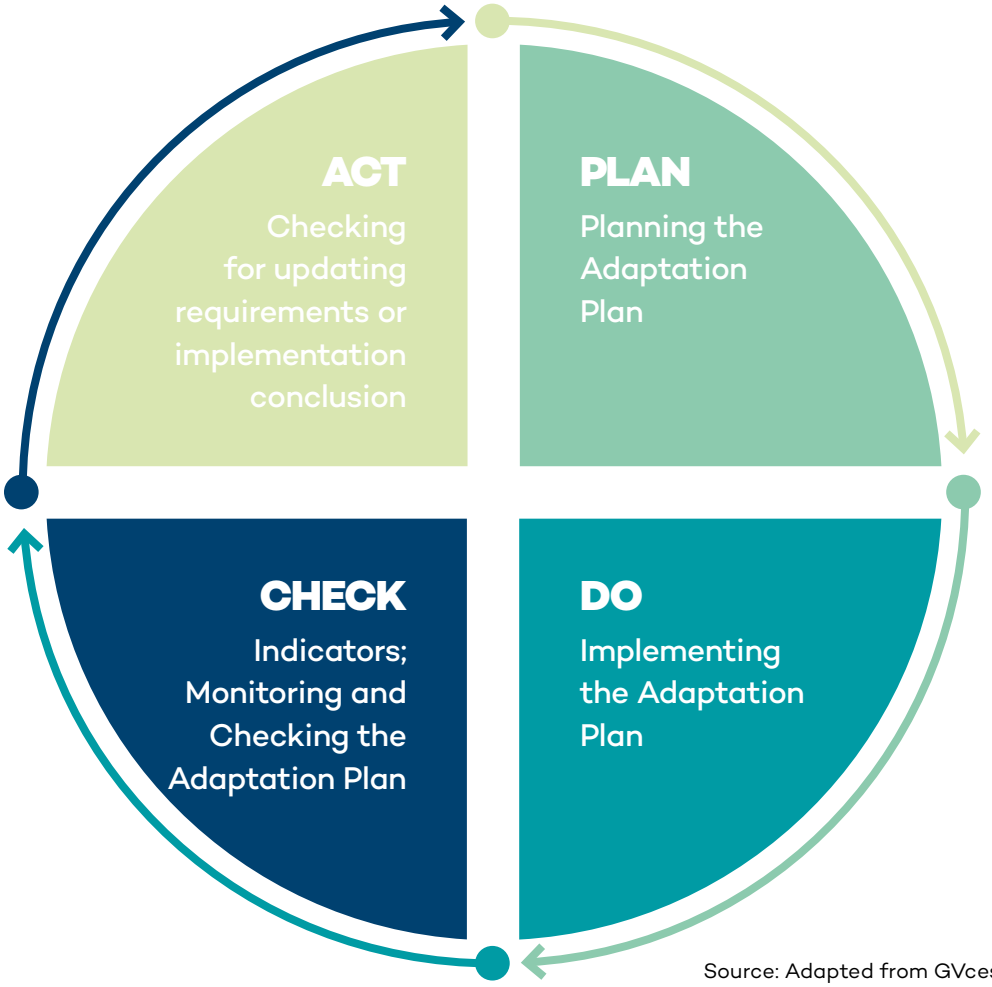
5 PDCA for Corporate Routine

One way of implementing a climate change adaptation strategy, and incorporating it into the business routine, is to use the PDCA cycle (Plan, Do, Act, Check). This method, widely applied in the management area, can be useful for companies that wish to start an adaptation plan.

PDCA allows companies to deepen their knowledge on the subject, providing important inputs about the reality of the places where their activities are inserted, and how they interact with the environment and society. The advantage is that this is a flexible method that can be updated according to the needs identified during the preparation and review process, allowing improvement opportunities to be incorporated throughout the development of the strategy. Figure 7 below shows the PDCA cycle, which will be detailed focusing on climate change adaptation.

Table 5 (next page)describes the stages of the PDCA cycle focused on the implementation of the Adaptation Plan for mining companies. It is possible to see that the use of tools, like the ones mentioned in the previous chapter, can help the implementation of several stages in the preparation of the adaptation strategy, facilitating the incorporation of PDCA in a company's day-to-day activities.

Figure 7: PDCA cycle for climate change adaptation



Source: Adapted from GVces, 2016

Table 5: PDCA stages to implement the adaptation plan in mining companies

Stage	Sub stage	Tasks	Suggestions
Plan	Preparation and engagement	• Define objective and scope. • Build and engage a work group to lead the process. • Engage and ensure support to leaderships. • Understand how the organization works, territory or population subject to the adaptation measure. • Clarify which approaches, materials, guides, and tools can be useful in the process, and how they can help. • Identify human and financial resources. • Map players that are relevant to be involved in the adaptation strategy.	This is a stage mainly focused on internal actions. For mining companies, we suggest the involvement of relevant areas such as, for example: Research & Development & Innovation; Marketing, Commercial, New Business, Supply, Regulatory (governance/risks/compliance/legal), Financial, Relation with Investors, among others, according to each company´s reality.
	Analysis of impacts and vulnerabilities	• Research climate events which have already occurred and their impacts on the region. • Define the need of technical partnership for the development and analysis of climate forecasts. • Analyze climate forecasts for the region. • Identify potential positive and negative impacts associated to climate forecasts. • Analyze the vulnerabilities of the organization, territory, or population. • Define criteria for risk analysis. • Prioritize risks.	This is one of the most important stages of the process, as it will provide relevant inputs for the construction of the Plan. Some of the tools mentioned in the previous section may help in this analysis such as, for example: the Global Risk Data Platform that can provide information on climate events which have already occurred, the Google Earth Engine that can help in climate forecasts, and the SWOT matrix that can be used for the analysis of vulnerabilities providing inputs for risk prioritization, etc. In the mining sector, there can be regions with activities conducted by more than one company under the same environmental characteristics. In this case, we suggest the exchange of information between these companies, and even joint analysis with more robust data and process efficiency.

Stage	Sub stage	Tasks	Suggestions
Do	Preparation of the Adaptation Plan	• List adaptation measures to mitigate/avoid more relevant risks. • Select adaptation measures in the light of pre-defined criteria. • Define concrete actions required for the development of the adaptation measures selected, and develop the action plan. • Raise enough resources to develop the plan. • Engage relevant players for this stage through agreements and partnerships.	This is the main stage of the process. The Adaptation Plan should comprehensive, however, the prioritization of the risks identified in the previous stage is essential. We suggest that actions that bring greater positive impact with lower investment are prioritized in the short term. The GVces/UKCIP tool, shown in the previous chapter, can be used especially in this stage, helping the preparation of the Adaptation Plan.
Check	Actions and monitoring	• Define process and result indicators to monitoring and assessing your plan. • Conduct the actions of the plan and record their progress, as well as the necessary adjustments. • Collect all data required for analyzing the indicators in the periodicity defined.	Process management is essential to the success of the adaptation strategy. We can also use the GVces/UKCIP tool to help this monitoring, organizing the information, and providing more accuracy to data monitored. In addition, it is extremely important to define indicators that are relevant, simple, and easy to be understood, to show trends.
Act	Assessment and adjustments	• Assess and review the implementation processes of the plan.	Given all the information generated during previous stages, this is the moment to decide whether or not to discontinue a specific action. This is a very important stage to focus future efforts on actions that are bringing positive results. In addition, communication is important to show transparency to stakeholders.
	Communication	• Prepare the communication of results and learning, target audience, formats, and media.	

Source: Adapted from Adapta Clima, 2021

6 Final Comments

Climate change adaptation has become increasingly relevant. This has mainly occurred due to the consequences of the average global temperature increase, already experienced by the whole society, and also the mining sector.

The Glasgow Climate Pact, created at COP 26, recognized and reinforced the relevance of the subject, emphasizing the need for financing from developed countries for the implementation of adaptation measures in developing countries.

The implementation of adaptation measures in the mining sector, as suggested in this guide, is necessary to avoid even greater damage, mitigating risks, and bringing opportunities for companies of all sizes and activities within the sector. The use of the various tools available, and the access to climate finance opportunities, can help catalyze this movement towards climate resilience in the sector.

In addition, the monitoring of regulations, initiatives, and actions at public and private levels, both nationally and internationally, can open space for organizing the sector around this subject, bringing benefits to the entire mining chain and, consequently, to society.

IBRAM plays a fundamental role in mobilizing and sensitizing the Brazilian mining sector on this subject. Besides informing and training companies on the need to adapt to climate change, the Association seeks to present the sector´s vision to regulatory bodies, helping the construction of a regulatory framework that brings sustainable development for the country. This guide is just an initial step to create a more resilient mining industry in Brazil.

REFERENCES

United Nations Framework Convention on Climate Change - UNFCCC. **Nationally determined contributions under the Paris Agreement**. Available at: https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf. Accessed on: Oct 26, 2021.

BRASIL. Ministério da Indústria, Comércio Exterior e Serviços - MDIC. **Plano setorial de mitigação e adaptação à mudança do clima para a consolidação de uma economia de baixa emissão de carbono na indústria de transformação.** Brasília: MDIC, 2013. 30 p. Available at: https://www.mma.gov.br/images/arquivo/80076/Industria.pdf. Accessed on: Dec 26, 2013.

BRASIL. Ministério do Meio Ambiente - MMA. Grupo Executivo do Comitê Interministerial de Mudança do Clima. **Plano Nacional de Adaptação à Mudança do Clima**. 2015b. Available at: https://www.mds.gov.br/webarquivos/arquivo/seguranca_alimentar/caisan/Publicacao/Caisan_Nacional/PlanoNacionaldeAdaptacaoaMudancadoClima_Junho2015.pdf. Accessed on: Jan 8, 2020.

IPCC AR4, 2007

Política Nacional de Mudança do Clima - PNMC

IPCC AR6, 2021

UNFCCC: https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean

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https://agenciabrasil.ebc.com.br/internacional/noticia/2019-06/clima-gera-prejuizo-de-us-1-trilhao-grandes-empresas

http://clima-gerais.meioambiente.mg.gov.br/

https://www.semas.pa.gov.br/diretorias/meteorologia-e-hidrologia/fpmc/

http://adaptaclima.mma.gov.br/glossario

ICMM - ADAPTING TO A CHANGING CLIMATE,2019

MAC, 2019 – Mining Association of Canada

IPCC, 2021 -https://www.ipcc.ch/working-group/wg2/

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