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# Methodology for the assessment of climate-related risks in Private Equity investment portfolios

**Supervisors**
Prof. Giovanni Andrea Blengini
Prof. Claudia Baranzelli
Company Supervisor Umberto Del Gobbo

**Candidate**
Lorenzo Canepa

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Lorenzo

**Abstract**

Climate change, driven by human activities, poses profound challenges to our planet. Its impacts, including rising temperatures and extreme weather events, are undeniable and far-reaching. The urgent need to mitigate these impacts and transition to a sustainable, low-carbon future has never been clearer. While climate change was initially viewed primarily as an environmental concern, it has evolved into a significant financial issue.

Investors and financial institutions now recognize the importance of assessing and managing climate-related risks to protect their investments. This thesis focuses on the Private Equity sector, characterized by longer investment horizons and direct influence over Portfolio Companies (PCs). Private Equity asset managers face both higher exposure to climate risks and to the opportunity of driving mitigation actions within their portfolios. Investors increasingly demand comprehensive and accurate information to make informed decisions regarding climate-related risks. This demand has led to greater transparency and disclosure requirements for asset managers, impacting PCs, including small to medium-sized enterprises (SMEs).

This thesis presents a methodology developed by Environmental Resources Management (ERM), a sustainability consulting firm, to address the most technical climate risk disclosure expectations within the Private Equity landscape. The methodology is applied to case studies, critically reviewed, and evaluated for its potential applicability to inform policymakers' funding decisions for companies most vulnerable to climate change.

Challenges related to the application of the methodology are provided as well as insights on how to possibly overcome them. Strengths of the methodology are also highlighted, such as its framework encompassing the analysis from portfolio to individual PC level, and weaknesses, such as the lack of transparency in the disclosure associated to the in-depth analysis.

In conclusion, this thesis contributes to climate-related risks disclosure by proposing a methodology to quantify climate-related risks and opportunities within the Private Equity sector. Further testing, refinement, and broader application are needed. Acknowledging the inherent uncertainties and evolving nature of climate-related risks analysis is crucial. Flexibility and adaptability will be essential for effective risk management in the ever-changing landscape of climate change.

# Contents

# Chapter 1

# Introduction

Climate change refers to the long-term alteration of Earth's average weather patterns and global temperatures due to human activities, primarily the emission of greenhouse gases (GHGs) like carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) into the atmosphere. The Sun irradiates the Earth with ultraviolet radiation, which is partially absorbed by the Earth and re-emitted back in the form of infrared radiation. These gases are "transparent" to the ultraviolet rays while trap the infrared radiation, creating a "greenhouse effect" that leads to an overall warming of the planet. The consequences of climate change are diverse and far-reaching, encompassing rising global temperatures, melting polar ice caps and glaciers, more frequent and severe weather events such as hurricanes and droughts, disruptions to ecosystems, and the endangerment of various species. Scientific consensus on climate change is well-established, with organizations like the Intergovernmental Panel on Climate Change (IPCC) [10] presenting extensive evidence and projections based on decades of research by climate scientists. Urgent global action is required to mitigate the impacts of climate change and transition to a more sustainable, low-carbon future to safeguard the planet for future generations.

Climate change is not anymore only an environmental concern but also a financial one. Investors and financial institutions are increasingly recognizing the need to assess and manage climate-related risks to protect the financial profitability of their investments, as multiple scientific studies related to the economic losses that climate change may potentially generate are published [17].

Private Equity investments are characterized by longer time horizons, chance to have a direct influence over Portfolio Companies (PCs) and they are dependent on investor commitments. On one hand, the Private Equity sector has an inherent higher exposure to climate risks. On the other hand, it has a wider operational range in promoting the implementation of mitigation actions for the PCs highly exposed to climate risks.

For these reasons, in the context of the Private Equity sector, concerns have been increasing among investors regarding the imperative need for more comprehensive and accurate information to facilitate well-informed investment decisions concerning climate-related risks. In response to these mounting apprehensions, Private Equity asset managers, also referred to as SGR (Società di Gestione del Risparmio), have faced pressure to enhance transparency and provide a more extensive disclosure related to the climate risks associated to their portfolios. As a consequence, this push for greater transparency requested to asset managers has impacted PCs, including both large corporations and small to medium-sized enterprises (SMEs). PCs, regardless of size, have found themselves compelled to conduct robust and reliable assessments of climate-related risks.

To ensure that the assessment was conducted, institutional bodies published supervisory expectations to force asset managers in performing this activity. To support the financial entities in disclosing their exposure to climate risks, reference frameworks were made available.

However, a gap between climate-risk policy expectations and the disclosure practices that companies actually follow has been observed. While the percentage of companies disclosing climate-related risks according to the reference framework increased over time, the sections technically complex to handle, such as the analysis of climate risks and opportunities in the context of future scenarios and the quantification of their financial impacts in terms of operational expenditure and capital expenditure, are poorly managed [11]. The scope of the Thesis is to present the methodology designed by a consulting company specialized in operationalizing sustainability, Environmental Resources Management (ERM), to deal with the toughest disclosure expectations within the Private Equity landscape. The methodology is tested with its application to case studies, allowing a critical review supported by evidences from the literature. Additionally, the range of applicability of the methodology is investigated by trying to understand whether policymakers would benefit by such methodology to provide fundings for the companies potentially most impacted by climate change.

The dissertation is structured with an introductory chapter, an overview of the reference frameworks and the normative context, a focus on the reference framework applied to the Private Equity sector, a description of the methodology, the application of the methodology to case studies, a critical review of the methodology and the conclusions.

## 1.1 Background information

The Private Equity sector is a subset of the financial industry that involves taking ownership stakes in businesses that are not publicly traded on stock exchanges. Private Equity firms (i.e. asset managers) raise capital from various sources, such as institutional investors, high-net-worth individuals, and pension funds, and then use this capital to acquire or provide financing for private companies through investments. Asset managers allocate the collected equities into funds, and the list of companies in which investments are directed, along with the respective percentage of Assets Under Management (AUM) invested, is referred to as portfolios. The AUM represents the total value of assets in the fund. The percentage can be related to the to the total AUM of the fund or to the AUM invested until that time only, excluding the assets that have not already been traduced into investments. Asset managers can manage multiple funds at the same time, which differ based on the commitments taken by the investors, which directly affect the investment strategy. Asset managers aim to generate returns for their investors by improving the performance and value of the companies they invest in and eventually selling them at a profit.

The scope of the proposed methodology is to assess whether the exposure to climate related risks and opportunities is potentially material for companies in present times or will be in the future. "Materiality" is a very important concept in the context of investment decisions: it refers to the idea of significance of a financial information, which can influence the decision-making of investors, analysts or other stakeholders. However, the assessment of materiality related to climate risks and opportunities is dramatically complex, because it presents unprecedented challenges. High uncertainties are inherently embedded in the analysis: climate science involves complex systems and models, which are linked to uncertainty in predicting the exact impacts of climate change. Uncertainty is also associated to a behavioural and market trend: consumer behaviour, market sentiment and government policies are difficult to predict. Furthermore, there is a mismatch between the long-term nature of climate change and the time horizons considered traditionally for financial reporting of investments: the materiality assessment is delicate because financial investments and climate change impacts are evaluated under different temporal scales. The limited availability of data constitutes another barrier for the analysis. The datasets' spatial resolution required for a proper assessment is generally high. Finally, the nature of climate change imposes that the analysis is carried out in terms of non-financial metrics, and at the last step only a conversion into financial metrics occurs. This task is performed by implementing models that link financial to non-financial metrics, which requires the collection of additional data and its specificity does not allow the development of a general framework, rather it is a case-by-case approach. For these reasons, it is complicated to perform.

## 1.2 Literature review

The related work reviewed poses as evidence the availability of several tools to perform climate-related risks and opportunities assessments [15]. However, in general the tools are not contextualized into an operational framework and applied to case studies. Nevertheless, among the tools, ClimateWise, developed by the University of Cambridge's Institute for Sustainability Leadership (CISL), aligns comprehensively with the reference recommendations to support the insurance sector. It provides well-structured frameworks to address both physical [22] and transition risks [23], whose definitions are provided in subsection 2.2.1.

Regarding the application of the methodology to case studies, no ones have been detected related to a comprehensive methodology that, within the Private Equity sector, evaluates the climate-related risks and opportunities from portfolio to asset level, regardless the economic sector in which PCs operates and including the whole spectrum of risks and opportunities associated to climate change. Fragmentations have been found out, such as a portfolio screening of a few physical risks in the real estate sector [12] and a detailed climate-related financial risk assessment of debt investments in the energy infrastructure sector [16].

# Chapter 2

# The normative context and reference frameworks

## 2.1 Overview of the evolution of the regulations

The regulation that nowadays requires financial entities to disclose on the climate risks associated to their financial products in Europe is the result of 50 years long international negotiations regarding policies to mitigate and adapt to climate change. The EU's recognition of the financial risks posed by climate change has evolved over decades, driven by scientific evidence, global agreements, and the growing awareness of the economic consequences of inaction.

The beginning of this journey can be associated to the publishing of the first Environmental Action Programme (EAP) [25] by the European Commission in 1973. The strategic direction taken was already sharing many elements with what will be called in a later stage Sustainable Development. Indeed, the claim that economic growth, prosperity and environmental conservation are all linked was already made in this program, as well as the acknowledgment that the preservation of the environment is a duty of the community. Moreover, the EAP set the groundwork for the definition of directives for the regulation of the quality of environmental matrices (i.e. water and air). Nevertheless, the impact of such policies on the European economy was not mentioned. Starting from the Third EAP [26] (1982-1986) a significant shift in the policy-making approach was experienced: a strong focus on the potential risks and opportunities that environmental policies could generate within the Internal Market of the EU was posed. Furthermore, environmental policies started concentrating on the reduction of $CO_2$ emissions rather than focusing solely on the quality of the environment [29].

The same position was taken at the United Nations level, in 1997, with the negotiation of the Kyoto Protocol, during the third Conference of Parties (COP) of the countries signatories of the United Nation Framework Convention on Climate Change (UNFCCC). In addition, the Kyoto Protocol was the first international environmental agreement to use market-based tools, considering climate change as a negative externality. In order to internalize it, GHG emission allowances were converted into a commodity to be traded between developed countries [21]. This operation can be considered the first alarm bell related to how climate change could become a source of risk in financial terms, by assigning a price for damaging the environment.

In 2001, the Intergovernmental Panel on Climate Change (IPCC), published the Third Assessment Report (TAR) [30], a collaborative effort by hundreds of climate scientists and experts from around the world to compile and evaluate the most current scientific knowledge on climate change. Among the others, it provided key insights on the risks posed by extreme weather events and their implications for economic sectors and financial systems. It highlighted that the increasing frequency and severity of extreme events due to climate change could have significant consequences for businesses, insurers, investors, and financial institutions.

In 2006, the Stern Review on the Economics of Climate Change [35], led by the British economist Nicholas Stern, had a profound impact on the EU's understanding of the financial risks associated with climate change. The Stern Review emphasized the economic consequences of inaction on climate change and the benefits of early and ambitious climate policies. The report highlighted that the costs of mitigating climate change were significantly lower than the potential damages resulting from inaction. It presented a compelling economic argument for taking decisive action to reduce greenhouse gas emissions and build climate resilience.

In 2015, the Paris Agreement was unanimously embraced by 196 Parties during the UN Climate Change Conference (COP21). It was the first legally binding global accord addressing climate change. Its central objective was to curb "the rise in the worldwide average temperature to a level significantly below 2°C compared to pre-industrial times" and endeavor to "constrain the temperature increase to 1.5°C above pre-industrial levels" [38]. The EU's effort in respecting the commitment led, in 2019, the launch of the European Green Deal, a comprehensive and overarching policy framework to make the EU's economy sustainable and climate-neutral by 2050. Within the European Green Deal, several initiatives related to sustainable finance were developed, including the Sustainable Finance Action Plan (SFAP). One of the key components of the SFAP is the introduction of the Sustainable Finance Disclosure Regulation (SFDR) [27], which requires financial market participants to publish information regarding their policies on the integration of sustainability risks within their investment decision-making processes. Moreover, they must provide details about how they incorporate sustainability risks into their investment decisions and share the outcomes of evaluating how these risks might affect the returns of the financial products they offer in their pre-contractual disclosures. Part of the SFAP is also the EU Taxonomy Regulation [34], introduced in 2020. It is a classification system developed by the European Union to define what economic activities can be considered environmentally sustainable. Its primary purpose is to establish a common language and set of criteria for identifying activities that make a substantial contribution to environmental objectives, including climate change mitigation and adaptation. Included in the Green Deal, emanated in 2022, was also the introduction of the Corporate Sustainability Reporting Directive (CSRD) [33], for which the interested companies will need to submit a report aligned with the new directive in the beginning of the 2025, for the financial year 2024. The CSRD aims to overhaul and expand existing sustainability reporting regulations, compelling a wider range of companies, including listed SMEs, to disclose comprehensive environmental, social, and governance (ESG) information in line with international standards. It promotes materiality-focused reporting, digital formats, integration with financial reporting, and auditing to ensure data reliability.

In parallel to the Green Deal, the European Central Bank (ECB), responsible for the European financial stability, published in 2020 its first guide on climate-related and environmental risks [18], outlining the supervisory expectations for financial entities in addressing these risks. This guide provides a framework for financial organizations on how to consider climate risks in their risk management processes. Bank of Italy, the supervisory body of Italian financial institutions at the national level, under the authority of the ECB, received the supervisory expectations and distributed them to small banks and financial intermediaries operating in Italy (i.e. "Aspettative di vigilanza sui rischi climatici e ambientali") [20].

Unfortunately, a questionnaire distributed to a sample of non-bank financial intermediaries [31] revealed limited alignment with the expectations. Despite significant attention to ESG issues by top management, widespread deficiencies were observed in many cases, with delays in implementing structural changes across various business aspects:

- Regarding business models and strategies, weaknesses were found in assessing how environmental and climate risks could impact the competitive and regulatory landscape. Intermediaries often linked business model sustainability only to the presence of "green" or "socially responsible" products in their offerings, lacking measurable sustainability objectives in their strategies.

- For governance and organizational systems, variations in adherence to expectations were observed. While many showed attention to sustainability, some lacked involvement of governance bodies and had limited competency in climate and environmental matters. Expectations necessitate an active and knowledgeable role of the board of directors in climate and environmental risks and recommend enriching boards with ESG-specific expertise.

- In the risk management sphere, challenges included the scarcity of reliable data for risk measurement, underscoring the importance of data governance strategies and integration into informational systems. Expectations urge systematic integration of sustainability risks into risk management, complete mapping of climate and environmental risk events, setting acceptable exposure levels, and creating effective monitoring and reporting systems.

Thus, the task of aligning with the requirements posed by national and international initiatives aimed at regulating and supervising climate risks and opportunities has been difficult for financial institutions, included the ones operating in the Private Equity sector. For this reason, while at first it was a non binding framework, in April 2022

Bank of Italy required financial entities to submit an action plan on how to align with the supervisory expectations by March 2023.

The next paragraphs will explore more in detail the frameworks upon which ERM's methodology is built on to fulfill Bank of Italy's expectations.

## 2.2 TCFD recommendations guidelines

Climate-related risks are becoming a significant concern for various participants in the financial markets, including Private Equity investors, who demand transparent and reliable information in relation to their investments. However, current understanding of the financial risks posed by climate change is still in its early stages. Existing climate-related disclosure standards focus on emissions and sustainability metrics, lacking information on financial implications, which is an issue, since inadequate information can lead to mispricing of assets and misallocation of capital, raising concerns about financial stability.

To address the problem, the Financial Stability Board (FSB) established the Task Force on Climate-related Financial Disclosures (TCFD) in 2015. The TCFD's goal is to develop recommendations for consistent and voluntary climate-related disclosures that can inform financial decision-making. These disclosures would help stakeholders understand climate-related risks, carbon-related assets, and financial system exposures to climate risks. Aware of the inherent issues characterizing the matter at hand, the TCFD aims to balance the needs of users with the challenges faced by preparers and draw from existing frameworks where possible.

### 2.2.1 Climate-related risks and opportunities

Improved disclosure of climate-related risks and opportunities is essential for conducting robust analyses of potential financial impacts of climate change. While various climate-related disclosure frameworks exist, there is a need for a standardized framework to promote alignment and consistency across existing regimes and G20 jurisdictions. The Task Force worked on this topic by categorizing climate-related risks and opportunities into two major types: physical and transition [24].

#### Physical Risks

Physical risks refer to the financial impacts arising from the actual and projected physical changes resulting from climate change. These risks can manifest in both acute and chronic forms:

- Acute Physical Risks: Acute physical risks are sudden and event-driven climate-related events, such as hurricanes, cyclones, floods, wildfires, and extreme weather events. These events can cause direct damage to physical assets, induce business interruptions, disrupt supply chains, and result in increased costs due to recovery and rebuilding efforts.

- Chronic Physical Risks: Chronic physical risks are long-term changes in climate patterns, including rising average temperatures, sea-level rise, and prolonged droughts. These changes can gradually impact business operations and profitability. For example, water scarcity may lead to reduced agricultural productivity, increased water costs, and supply chain disruptions for industries dependent on water-intensive processes.

#### Transition Risks

Transition risks refer to the financial and operational risks that arise from the process of transitioning to a lower-carbon economy. As described in the previous section, as the world is taking steps to address climate change and moving towards more sustainable practices, significant changes in policies, regulations, technology, and market dynamics occur. These changes can have various impacts on organizations, depending on the nature, speed, and focus of the transition. Potential transition risks are the following:

- Policy and Legal Risks: Policy actions related to climate change can have far-reaching implications for businesses. Governments may implement carbon-pricing mechanisms, impose emission reduction targets, or introduce regulations that affect certain industries more than others. Organizations that heavily rely on fossil fuels or produce a significant amount of GHG emissions may face financial and operational challenges if new policies restrict their operations. Moreover, the risk of litigation or legal actions against companies for not adequately addressing climate risks can result in financial liabilities. As an example, as of April 2023, 23% of global GHG emissions are covered by carbon pricing initiatives, such as emission trading schemes and carbon taxes, and over 2500 companies have implemented an internal carbon pricing or plan to do so[1] [19].

- Technology Risks: Technological advancements and innovations are central to the transition to a lower-carbon economy. The development and adoption of renewable energy sources, energy-efficient technologies, and carbon capture solutions can disrupt traditional industries. Organizations that fail to adapt to emerging technologies or invest in sustainable practices may lose market share and competitiveness.

- Market Risks: Climate change considerations are increasingly influencing consumer preferences and investor decisions. As awareness about climate risks grows, demand for sustainable products and services rises. Organizations that fail to align with evolving market trends may face reduced demand for their products or services, potentially leading to declining revenues.

[1] It involves applying a theoretical price per unit of emissions which is taken into account during company's decision making. The income generated by activities subjected to these fees is partially used to fund initiatives aimed at reducing emissions.

- Reputation Risks: Public perception of a company's commitment to sustainability and climate action can significantly impact its reputation. Consumers and stakeholders are increasingly holding companies accountable for their environmental impact. Failure to demonstrate responsible environmental practices could result in reputational damage and loss of trust.

**Opportunities**

It is important to note that many of the risks mentioned in the previous paragraph can indeed present opportunities for organizations if they adopt a strategic approach to the transition to a lower-carbon economy. Climate-related risks can often be managed and turned into opportunities by embracing sustainability and proactively adapting to changing market demands and regulatory landscapes. The following list points out the opportunities that can arise:

- Resource Efficiency: Organizations can reduce operating costs and curb emissions by improving efficiency across production and distribution processes, buildings, machinery, and transport. Innovations in technology, such as energy-efficient solutions and circular economy practices, can contribute to cost savings.

- Energy Source: Shifting energy usage toward low-emission sources like wind, solar, hydro, and other renewables can potentially save on annual energy costs and align with global emission-reduction goals.

- Products and Services: Innovating and developing new low-emission products and services can improve competitive positions and appeal to environmentally conscious consumers. Examples include carbon footprint-focused marketing and energy-efficient producer goods.

- Markets: Organizations can diversify their activities and position themselves for a lower-carbon economy by proactively seeking opportunities in new markets or collaborating with governments, development banks, and community groups to transition to greener economies.

### 2.2.2 Climate risks financial impact

Understanding and disclosing the financial impacts of climate-related risks and opportunities on organizations is a crucial objective of the Task Force's work. Investors, lenders, and insurance underwriters need to gain insights into how climate-related factors will affect an organization's future financial position, as reflected in its income statement, and balance sheet. Climate change's effects vary significantly depending on the sector, industry, geography, and the strategy adopted by the organization regarding the management of climate related risks (i.e. mitigate, transfer, accept, or control).

There are four primary categories (i.e. revenues, expenditures, assets and liabilities, capital and financing) spread into two main financial areas (i.e. income statement and balance sheet) through which climate-related risks and opportunities can influence an organization's financial position.

### Income Statement

The income statement is a financial report that provides a summary of a company's revenues, expenses, and net income over a specific period, typically a quarter or a year. It can be impacted by climate-related risks and opportunities in the following aspects:

- Revenues: Changes in climate conditions and policies can lead to shifts in demand for an organization's products and services. It is crucial for organizations to assess potential impacts on revenues and identify opportunities to adapt or develop new revenue streams. Additionally, the emergence of carbon pricing as a regulatory mechanism should be carefully considered, especially for industries directly affected by such policies.

- Expenditures: An organization's response to climate-related risks and opportunities may hinge on its cost structure. Organizations with cost-efficient suppliers may demonstrate more resilience to changes arising from climate-related issues and possess greater flexibility in addressing these challenges. Providing transparent information about cost structures and adaptability can offer valuable insights to investors when making decisions. Moreover, disclosing capital expenditure plans and funding sources, along with their resilience, will help enhance access to capital markets and improve financing terms.

### Balance Sheet

A balance sheet is a financial statement that presents a snapshot of a company's financial position at a specific point in time. It outlines the company's assets (what it owns), liabilities (what it owes), and shareholders' equity (the residual interest in the company's assets after deducting liabilities). Climate-related risks and opportunities can significantly impact on it in the following ways:

- Assets and Liabilities: Supply and demand changes related to climate change, policies, technology, and market dynamics can influence the valuation of an organization's assets and liabilities. Special attention should be given to long-lived assets and reserves, as they may be particularly affected by climate-related issues. Organizations are encouraged to disclose potential climate-related impacts, especially concerning existing and committed future activities, investments, and restructuring decisions.

- Capital and Financing: Climate-related risks and opportunities may alter an organization's debt and equity structure. Increased debt levels may be necessary to compensate for reduced operating cash flows or to fund new capital expenditures and research initiatives. Organizations may face challenges in raising new debt or refinancing existing debt, and changes to capital and reserves could result from operating losses, asset write-downs, or the need for additional equity to support investments.

There are several challenges that organizations encounter in identifying and assessing climate-related financial impacts, among which: limited knowledge of climate issues, a focus on short-term risks over long-term risks, and difficulties in quantifying financial effects. To address these demanding tasks, organizations are encouraged to undertake both historical and forward-looking analyses when considering the financial impacts of climate change. The unprecedented nature of climate change responses necessitates a greater focus on forward-looking analyses. Scenario analysis is recommended as a valuable tool to incorporate into strategic planning and risk management practices. It enables organizations to understand potential future scenarios and their implications on financial performance.

### 2.2.3 Recommendations and guidance overview

In 2017, the TCFD published the set of "Recommendations" [24] aimed at providing uniform and optional disclosures related to climate matters. They are structured around four main themes: governance, strategy, risk management, and metrics & targets. In general terms:

- Governance focuses on how the top management oversees climate risks and opportunities, including board involvement and monitoring progress.
- Strategy involves disclosing how climate factors impact the organization's plans for adaptation or mitigation, by applying forward looking tools (i.e. scenario analysis).
- Risk management addresses processes for identifying, assessing, and managing climate-related risks in comparison to the organization's broader set of traditional risks.
- Metrics and targets includes disclosing measurable indicators and goals for assessing climate impact and performance.

For the financial sector, the Task Force offers additional guidance tailored to four major industries: banks, insurance companies, asset managers, and asset owners. This guidance intends to facilitate early assessment of climate-related risks and opportunities, enhance risk pricing, and enable more informed capital allocation decisions. This dissertation, focused on the Private Equity sector, dives deep into the guidance provided for asset managers. In addition, the supplemental guidance for non-financial industries is also explored, because, as anticipated in Chapter 1 and extensively explained in Subsection 3.2.2, individual PCs may be required to perform climate risks analyses on their business. The focus is on those industries contributing significantly to greenhouse gas emissions, energy and water usage. These industries are categorized into four groups: energy, materials and buildings, transportation and agriculture, food and forest products. The selection of these groups is based on their susceptibility to climate-related financial impacts, assessed primarily through GHG emissions, energy usage, and water usage.

### 2.2.4 Supplemental guidance for asset managers

Asset managers are individuals or entities that are engaged by clients to manage investments on their behalf. Notably, the outcomes (positive or negative) of these investments rightfully belong to the client. Consequently, the possible transition and physical risks to which their investments are subject fall primarily on the clients who hold the underlying assets. At the same time, the opportunities for returns that potentially can rise due to a shift towards a low-carbon economy can create opportunities for returns for the clients.

Clients who entrust their assets to asset managers rely on the information provided in reports to comprehend how climate-related factors are being navigated within their portfolios. The supplemental guidance provided by the TCFD is tailored to maximize the effectiveness in communicating climate-related information to their clients (no additional advice provided for what concerns the pillar "Governance"):

- Strategy: Asset managers should elaborate on how they integrate climate-related risks and opportunities into their investment strategies. This involves describing how climate factors influence the selection of investment opportunities, asset allocation, and long-term investment goals. Asset managers should focus on demonstrating the alignment between their investment strategies and climate-related considerations.

- Risk Management: Asset managers need to disclose their processes for identifying, assessing, and managing climate-related risks in the context of their investment decisions, including the methods and resources used. Moreover, they should outline their efforts to engage with companies they invest in, aiming to promote improved disclosure and practices concerning climate-related risks. This engagement aims to enhance the availability of data and subsequently, the asset managers' capacity to evaluate climate-related risks.

- Metrics and Targets: Asset managers should provide relevant data on key indicators that measure the climate impact of their investment decisions, such as carbon emissions, energy usage, and water consumption.

### 2.2.5 Supplemental guidance for non financial entities

Supplemental guidance is available for non-financial groups on recommended disclosures about strategy and metrics/targets:

- Strategy: Organizations should delve into how climate-related risks and opportunities impact current decision-making and strategy formulation. This includes considerations like research and development, existing and future activities, planning assumptions around legacy assets, GHG emissions and physical risk exposures in capital planning, and flexibility in capital allocation. Organizations with over $1 billion annual revenue should engage in thorough scenario analysis to test strategy resilience against various climate scenarios. While conducting forward-looking analysis, it is important to thoroughly discuss and transparently disclose the consequences of policy and technology assumptions, economic trends, energy pathways, input parameters, and analytical choices within scenarios. This should be accompanied by the presentation of outcomes, which include the organization's hypothetical exposure to climate risk and the potential financial impacts, according to the baseline and future projections.

- Metrics and Targets: Organizations should present historical patterns and prospective forecasts for pertinent metrics, taking into account the nation/jurisdiction, business sector, or asset class. It is important to be transparent about the metrics used to assist strategic planning and scenario analysis. To address the financial aspects of changes in demand, expenditures, asset value, and financing costs, key metrics concerning GHG emissions, energy, water, physical risks exposure, land usage, and investments in climate adaptation and mitigation should be included.

## 2.3 Bank of Italy's expectations

Bank of Italy has outlined a set of expectations for financial intermediaries under its direct supervision regarding climate and environmental risks [20]. These expectations promote independent evaluation of thematic relevance, allowing businesses to tailor their risk strategies. The autonomous application of solutions, considering factors like business type, size, activity complexity, and organization structure, ensures a nuanced and effective risk mitigation approach. This approach acknowledges the uniqueness of each business while striving for coherent and tailored risk management solutions. The 12 expectations are:

- Board Involvement: The board of directors is expected to play an active role in integrating climate and environmental risks into the corporate culture, strategy, risk appetite framework, and risk limits. A comprehensive action plan should be approved to guide these efforts.

- Strategic Consideration: Intermediaries must identify and comprehend climate and environmental risks that could impact their business. These risks should be factored into the strategy to enhance resilience and inform development prospects.

- Proportional Adaptation: The board of directors should proportionally adjust organizational and operational processes based on materiality assessments of climate and environmental risks, ensuring consistency and coherence.

- Risk Mapping: Intermediaries are expected to map potential events arising from physical and transition climate and environmental risks. These identified risks should be integrated into the risk management system, considering prudential implications.

- Data and Metrics: Comprehensive and high-quality databases related to climate and environmental risk profiles need to be established. This data should be integrated into information systems to develop robust metrics for risk assessment.
- Capital and Liquidity Adequacy: Climate and environmental risks should be integrated into internal capital and liquidity adequacy assessment processes, alongside risk limits systems. For non-subject intermediaries, risk limits should be adjusted to account for risks' impact on portfolio value and operational volumes.
- Ongoing Review: Due to the dynamic nature of climate risks, intermediaries are expected to establish a program for periodic review and updating of methodologies and tools used for risk assessment.
- Credit Process Integration: Climate and environmental risks should be seamlessly integrated into all stages of the credit process, including policy adjustments in line with relevant regulatory guidance.
- Investment Pricing: Intermediaries must consider potential climate and environmental risks when pricing investment instruments, aiming to minimize the risk of financial loss.
- Operational and Reputational Impact: Consideration of climate and environmental risks should extend to potential impacts on operational continuity, reputational risk, and legal obligations.
- Liquidity Risk Management: Integration of climate and environmental risks into liquidity risk management processes is crucial. This involves estimating potential liquidity deterioration resulting from various risk factors.
- Communication and Disclosure: Intermediaries should establish the necessary infrastructure, data, and processes to transparently communicate how environmental risk drivers are integrated into the business strategy, internal organization, risk management mechanisms, and disclosure practices.

These expectations underscore the Bank of Italy's commitment to ensuring that financial intermediaries effectively identify, assess, and manage climate and environmental risks within their operations. By adhering to these expectations, intermediaries contribute to sustainable and resilient business models while aligning with global sustainable finance objectives.

# Chapter 3

# Methodology for the evaluation of climate-related financial risk

This chapter delves into the pragmatic approach embraced by ERM to evaluate climate-related risks and opportunities within the context of a Private Equity portfolio. As elucidated in Chapter 1, the pivotal factors underpinning the significance of this endeavor in the market encompass: the exposure of Private Equity investors to substantive risks arising from both the physical impacts of climate change and the transition toward a low-carbon economy; the evolving regulatory landscape that mandates heightened reporting obligations concerning climate-related matters; and the escalating investor demand for transparency from Private Equity fund managers regarding their strategies to tackle climate change. These imperatives necessitated the adaptation of the TCFD recommendations to align with the unique structures and investment cycles of asset managers [7]. Within this chapter, the initial segment delves into the process of tailoring the TCFD guidelines to cater to the requirements of asset managers. Subsequently, the ensuing section elaborates on the conceptual stages inherent to ERM's methodology in executing this undertaking. The third section employs illustrative case studies to implement ERM's approach. Lastly, the fourth section critically reviews the methodology, based on literature analysis and the outcomes obtained in the application of the methodology to case studies.

## 3.1 Adaptation of the TCFD recommendations guidelines to the Private Equity sector

The literature reviewed [7] suggests a practical approach for Private Equity General Partners (GPs)[1] to address the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). It emphasizes actions required to align with the TCFD

[1]The Private Equity firm that oversees a Private Equity fund is referred to as General Partner.

framework's four pillars rather than focusing on reporting mechanisms. A three-phase action plan incorporates the measures to be taken (Table 3.1, Table 3.2, Table 3.3).

Table 3.1: TCFD Implementation Plan - Phase 1

| **TCFD Pillars** | **Objectives** | **Practical Steps** |
|---|---|---|
| Governance | Increase climate-related understanding across the business | • Provide education to partners, investment directors, and analysts<br>• Attend workshops on integrating climate change across industries |
| Governance | Design a climate-focused governance system | • Define the board and executive level duties for climate oversight<br>• Define the board's and management's responsibility for climate assessment and management |
| Strategy | Design a more straightforward implementation strategy | • Through sector and scenario analyses, identify macro-level risks and opportunities<br>• Establish an implementation plan |

Table 3.2 describes the second phase, which accounts for the TCFD pillars "Strategy" and "Risk management". In this context, the first centers on what are the methods employed by asset managers and necessitates reporting on what climate risks affect investment strategies and products. The suggested scheme to follow to develop a climate strategy for asset managers operating in the Private Equity sector is:

1. Recognize how climate risks and opportunities can impact PCs.
2. Evaluate PCs exposure through materiality analysis.

Table 3.2: TCFD Implementation Plan - Phase 2

| **TCFD Pillars** | **Objectives** | **Practical Steps** |
|---|---|---|
| Strategy<br>Risk Management | Perform materiality analysis on current portfolio holdings to identify climate risk exposure | • Introduce climate evaluations within pre-acquisition due diligence<br>• Define portfolio holdings with the highest exposure and conduct in-depth analysis |
| Strategy<br>Risk Management | Identify key climate performance indicators for each portfolio holding | For the portfolio holdings most exposed to climate-related risks and opportunities, perform engagement activities with the management to design an action plan to improve climate resilience |

Table 3.3: TCFD Implementation Plan - Phase 3

| **TCFD Pillars** | **Objectives** | **Practical Steps** |
|---|---|---|
| Risk Management<br>Metrics and Targets | Integrate climate aspects within the whole investment process | Integrate climatic factors that influence valuation based on relevant climate indicators under various scenarios |
| Risk Management<br>Metrics and Targets | Provide portfolio holdings with tools and recommendations to deal with climate risks | When material risks are found, set portfolio-level climate targets (such as risk exposure, resilience, carbon footprint, and 2°C alignment) |
| Risk Management<br>Metrics and Targets | Perform periodic reviews of the investees to evaluate progress towards climate targets | Integrate climate commitments for the least vulnerable enterprises, during pre-acquisition and after climate due diligence |

3. Perform in-depth analysis in case the exposure is material.
4. Implement tailored action plan to enhance climate resilience.
5. Guarantee ongoing sustainability through vendor due diligence.

On the other hand, risk management focuses on how the methods are implemented: within the investment cycle, there is not a universal procedure to address climate risks and opportunities. Figure 3.1 faithfully represents the investment process, encompassing the corresponding transaction phases and delineating the climate risk assessments applicable at each juncture.

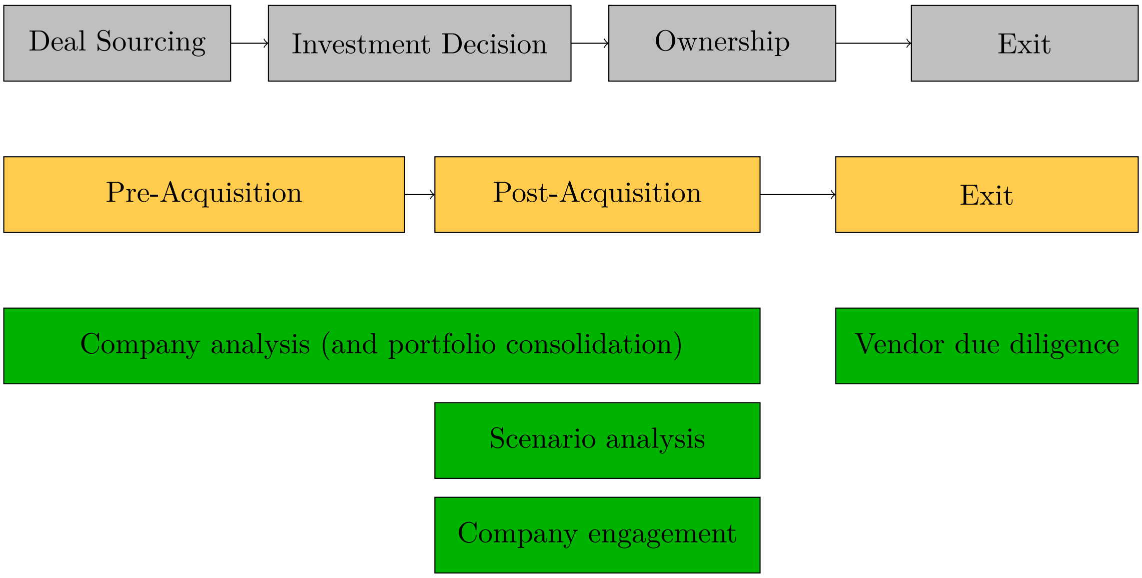



Figure 3.1: Climate risk management in relation to the stages of a financial transaction. The grey boxes represent the investment cycle of an asset, the yellow boxes represent the stages of a financial transaction, the green boxes represent the climate risk analyses usually performed for each transaction phase. In particular, the company analysis, can be conducted on an individual asset level (e.g., during a new acquisition) or on a broader portfolio level (e.g., ,merging of diverse portfolios).

### 3.1.1 Company analysis

The evaluation of the company's exposure to climate-related risks and opportunities can be conducted at two distinct stages: during the pre-acquisition phase, encompassing climate due diligence, and also during the post-acquisition phase. The depth and breadth of this analysis are contingent upon the significance of climate risk to each specific investment product. For this reason, typically, a climate due diligence initiates with a comprehensive assessment of materiality concerning climate-related risks, in order to systematically categorize and prioritize climate-related concerns by GPs. Practically, the materiality assessment involves the critical inquiry of whether climate change is reasonably expected to exert a significant impact on a PC's operational facets, including supply chains and market dynamics. Typically, the analysis revolves around several key factors, including the industry sector, company size, geographical location, and the regulatory framework within which each PC operates. The GPs must take into account the footprint of a PC's operations, its market presence, and supply chain intricacies. By concentrating on these data, GPs can pinpoint potentially severe climate-related risks and formulate a coherent strategy for addressing them.

Certain GPs opt for a more profound emphasis on the analysis of climate-related physical and transition risks as part of their materiality assessment. This approach allows them to ascertain the potential financial implications associated with climate risks, thus ensuring a more precise understanding of their relevance.

Regarding physical risks, to enhance the transparency of the analysis, open source databases to map the exposure of the assets can be used, given their location. The asset-level analysis is then aggregated at portfolio level.

For what concerns transition risks, the TCFD offers a valuable breakdown, allowing for a meticulous examination of each sub-risk concerning every PC. Each of these risks can be evaluated based on its likelihood of occurrence and its potential impact on the company's operational landscape. Subsequently, these risks can be aggregated and used to benchmark PCs against one another.

### 3.1.2 Scenario analysis

The recommendations put forth by the TCFD assign considerable significance to climate scenarios. These scenarios are instrumental in assessing a company's economic resilience across varying climate conditions. Scenario analysis serves as the conduit through which one scrutinizes the potential impact of physical and transition risks on a company, contingent upon different climate trajectories.

For GPs, ensuring that their PCs exhibit resilience across diverse scenarios becomes paramount. While only a few GPs have ventured into the development or utilization of intricate climate models, there is a growing trend of pragmatically addressing scenario analysis.

The process of conducting scenario analysis typically involves four key steps:

1. Defining Time Horizon and Scenarios: Establish a specific time horizon and identify the relevant scenarios to be considered. Publicly available scenarios, such as those generated by organizations like the International Energy Agency (IEA), International Renewable Energy Association (IRENA), Potsdam Institute for Climate Impact Research (PiK), and The Inevitable Policy Response (IPR), can serve as valuable references.

2. Describing Impact Factors: Describe the factors, such as energy prices and resource access, that are likely to exert an influence on the PC's various facets, including sales, operations, and supply chains, with respect to each identified physical and transition risk.

3. Matrix Development: Construct a matrix that enables the analysis of how the materiality of each factor evolves across the selected scenarios.

4. Financial Linkage: Establish the connection between climate risks and opportunities and the company's financial performance. This is achieved by scrutinizing the effect of changes in each factor's evolution on the company's sales, operating expenses (OPEX), and capital expenditures (CAPEX).

These steps collectively form the foundation for a rigorous and comprehensive scenario analysis, helping investors gain valuable insights into the potential implications of climate risks and opportunities on their PCs. For those companies whose climate risks are assessed as material, a mitigation action plan can be created.

### 3.1.3 Company engagement

The post-acquisition phase of a climate strategy involves translating the assessment of climate risks into actionable and pertinent plans while fostering engagement with the acquired companies. These action plans are custom-tailored to each investment, and there is no universally prescribed approach for their development. Nonetheless, GPs have established formalized procedures to efficiently devise action plans for their PCs and to equip them with the requisite knowledge, tools, and support concerning climate risk.

To effectively engage with PCs, GPs collaborate closely with the company's management to comprehend the measures already in place and to determine the most effective way to implement an action plan. A preliminary step may simply involve initiating a discussion on climate risks and opportunities with the PC's management, employing fundamental scenario-based queries. Below are reported some of the questions that GPs can pose to portfolio and potential investee companies regarding climate change impact and awareness:

- What are the potential legal, financial, and commercial implications of climate change on your business?

- Which existing and forthcoming laws and regulations pertaining to climate change are you aware of that may affect your business? How do you stay informed?

- Do you have, or should the company have, a designated officer or employee responsible for climate change or environmental measurement and reporting?

- What is the direct and indirect carbon footprint of your business? Have you established objectives and targets to reduce carbon emissions?

- Are you cognizant of any measures your competitors are taking to address climate change? How do your actions compare with those of your peers?

- Have you assessed the impact of increasing climate-related costs on the business? Could rising costs significantly affect profitability, and if so, what mitigation strategies have been considered?
- What steps are you taking to manage identified climate-related risks? Have you formulated a climate risk mitigation policy and strategy? Do you explore opportunities associated with climate change?
- Which departments within your organization are responsible for climate change or environmental measurement, management, and reporting?

Once GPs have heightened climate awareness among top management, they can proceed to develop tools and action plans in collaboration with the company to evaluate and monitor climate risks. During this phase, GPs primarily serve as facilitators, offering support and knowledge-sharing on climate policies, implementation tools, and contributing as co-developers of the PCs' climate change strategies.

### 3.1.4 Vendor due diligence

Climate considerations have yet to gain widespread prominence in the divestment processes employed by Private Equity firms. During interviews conducted for guide preparation, the prevailing sentiment was that climate change risks rarely feature in sell-side due diligence reports. This absence is particularly noticeable unless certain regulatory frameworks, such as carbon taxes or cap-and-trade systems, apply to sizable corporations. Respondents also expressed apprehensions regarding the potential adverse effects on company valuation if extensive climate risk disclosures were made.

Conversely, on the buy-side, an increasing number of GPs concur that, especially when investing in environmentally sensitive assets, they seek a deeper understanding of how companies might navigate various climate scenarios. Consequently, it is plausible that vendor climate due diligence will become more prevalent in the years ahead. A streamlined approach to implementing such due diligence during the divestiture of a company would involve structuring the report in alignment with the TCFD framework. This framework ensures comprehensive coverage of critical climate-related aspects. The primary objective of vendor climate due diligence would be to furnish potential new investors with a forward-looking report on the company scheduled for divestment. This report would encompass scenario planning and action plans where deemed necessary.

## 3.2 ERM methodology for climate-related financial risk assessment in the Private Equity sector

The materiality analysis performed by ERM is composed by two levels, in which the level of detail of the assessment increases progressively as well as the time required to conduct the evaluation. At first, a high level screening on all the PCs is conducted. For those most exposed to climate risks, the materiality is better assessed by engaging with the companies. The reason is to focus resources and expertise on the assets for which climate risks are material, avoiding waste of time. This aspect becomes particularly relevant when considering large portfolio investments. Whether the potential materiality of climate risks is confirmed, the analysis considering future climate projections (i.e. climate scenarios) and the financial quantification of the identified risks can be conducted.

### 3.2.1 High-level portfolio's exposure screening

The objective of the first high-level screening is to map the portfolio's climate risk exposure for both transition and physical risks. The methodology adopted to perform this task is based on readily available information, such as site location and the NACE code[2] of the activities carried out. At this stage, the SGR is accountable for completing this activity. Data are collected at both PC level and operating site level.

#### Data collection

Information regarding PCs includes:

- The percentage AUM, the total market value of assets managed by the fund, invested by the fund in the PC. the metric is used to quantify the exposure of the fund to climate risks.
- The percentage of Ownership of the company by the fund, to assess the SGR's influence on the company's decision-making.
- The revenue of the company, as indicator of the company's size.
- The NACE Code of the company, to know the economic sector in which it operates.

These details are sufficient to evaluate the companies' exposure to transition risks. For physical risks exposure, however, a bottom-up approach is adopted, in which the analysis is conducted at a more profound level (i.e., operational site level), then aggregated at company level. The data collected at the operational site level falls into two categories. The first category pertains to an overview of the asset, while the second focuses on its location (i.e., region, province and address). The overview-related data includes the percentage of AUM associated with each asset, assumed to be the company's invested AUM evenly distributed among each company asset. Additionally, it encompasses the property type, with prioritization for owned assets over the leased ones, and the type of activity. In the analysis, only industrial sites are considered, as offices are presumed to have limited materiality, assuming that a physical event impacting offices would potentially generate only damage to the equipments, considering no business interruptions occurring because the activities can potentially be kept going from home. Moreover, to

[2]statistical classification of economic activities in the European Community

their typical urban location is associated a minimal exposure to physical risks. Lastly, the area of the industrial site is included to provide context regarding its spatial scale in relation to the spatial resolution of the datasets used for screening physical risks.

### Physical risks exposure assessment

To estimate the risk associated to several climate hazards, the assessment is performed using updated databases and maps, displayed in table 3.4.

Table 3.4: Databases used to assess the physical risk at high level. For some risks (i.e., Extreme Heat and Landslide) two databases are consulted based on the geographic location (Europe or rest of the world). Since most of the assets analyzed by ERM are in Europe, the databases delivering information from this region are more accurate. For landslides risk, the first option is more accurate, however it presents a limited availability of data. In case of missing data for the location of interest, the second option is used.

| Category of risk | Chronic | | Acute | | | | |
|---|---|---|---|---|---|---|---|
| Type of risk | Extreme heat | Water Stress | River flood | Coastal flood | Landslide | Wildfire | Cyclone, Storms |
| Database used | Europe: Urban Adaptation Viewer | Acqueduct | Acqueduct | Acqueduct | Option 1:WESR Database | Europe: Copernicus | Hurricane tracks |
| | World: IPCC Interactive WGI Atlas | | | | Option 2: Think Hazard | World: Think Hazard | |

The technical features of each database are described in the following list:

- Urban Adaptation Map Viewer [9]: It considers as metric the "projected number of extreme heatwaves". The reference period is between 2020 and 2052, under the RCP 8.5 scenario. This scenario represents a future emissions pathway in which GHG concentrations continue to rise unabated, leading to a high level of global warming (approximately 4°C to 6°C above pre-industrial levels) and environmental change by the end of the century. The model adopted to perform the simulations is the Coupled Model Intercomparison Project Phase 5 (CMIP5). Daily maximum temperatures are interpolated to match 1.875° grid resolution (approximately 200 km $\times$ 200 km). The data are used to build the Heat Wave Magnitude Index (HWMI), which is computed by applying the following steps: firstly, for each cell of the grid a daily threshold is calculated using data from the reference period (1981-2010). Heat waves are identified as consecutive days with temperatures above this threshold. Each heat wave is then broken down into subheat waves, each consisting of three consecutive days. A statistical approach is then used to determine the magnitude of a subheat wave. The magnitude of a full heat wave is calculated as the sum of its subheat waves, and the HWMI is defined as the maximum magnitude among all heat waves in a given year.

For a HWMI higher (or equal) than 4, the heat wave is considered as "extreme". The metric adopted in the extreme heat risk assessment is the number of extreme heatwaves occurred within the reference period.

The qualitative risk classes have been delineated according to the following thresholds: from 0 to 1 extreme heat waves has been associated a low risk, from 1 to 2 a medium risk, from 2 to 6 a high risk, for more than 6 a high risk.

- IPCC Interactive WGI Atlas [5]: It refers to "number of days, within a year, with maximum temperature above 35°C". The time period considered is between 2021 and 2040, under the IPCC scenario RCP2.6. This scenario considers that GHG emissions are strongly reducing, limiting the temperature rise by the end of the century to 1.6°C. The model adopted to carry out the simulations is the Coordinated Regional Climate Downscaling Experiment (CORDEX) for the non-Europe regions. To standardize information across different fields and to optimize the size of the resulting ensembles, all the available simulations for each specific CORDEX region (including both the standard 0.44° CORDEX and the finer 0.22° CORDEX-CORE) have been resampled to a shared and consistent 0.5° -resolution grid (which is approximately 55 km $\times$ 55 km grid size).

  The metric has been used to derive qualitative risk classes according to the following thresholds: from 0 to 12 days with maximum temperature higher than 35°C has been associated a low risk, from 13 to 24 days a medium risk, from 25 to 35 days a medium-high risk, for more than 35 days a high risk.

- Acqueduct [6]: This database provide for the physical hazard "water stress", and for the physical risks "river flood" and "coastal flood". The method used to compute the risk score is the product between hazard (a potentially harmful event or situation, such as a flood or water stress event), exposure (characteristics of the elements or factors that exist within the area affected by the hazard), and vulnerability (it reflects how well or poorly these exposed elements can withstand or recover from the hazard).

  – Water stress: the indicator is computed at hydrological sub-basin while the temporal resolution considered is the annual one. Water stress is a metric that assesses the balance between the total demand for water and the quantity of renewable surface and groundwater resources that are accessible. This demand encompasses various uses like residential, industrial, agricultural, and even the needs of livestock, both for consumption and other purposes. When evaluating available renewable water resources, it accounts for factors like the influence of upstream water consumption and the presence of large dams on downstream water availability. Elevated values of this metric indicate increased competition and demand for water resources among users.

- Riverine flood risk: the indicator is computed at hydrological sub-basin while the temporal resolution considered is the annual one. Riverine flood risk is a measure that estimates the percentage of the population likely to be affected by riverine flooding in an average year, while considering existing flood protection standards. This assessment takes into account several factors, including the hazard of flooding (caused by river overflow), the population residing in flood-prone areas (exposure), and the vulnerability of these exposed populations. Additionally, the analysis incorporates the level of flood protection already in place. It's important to clarify that this indicator does not represent the worst-case scenario but rather the expected impact in an average year. It combines the impacts of both rare, extreme flood years and more frequent, less severe flood years to calculate the "expected annual affected population." Higher values for this indicator indicate that a larger portion of the population is anticipated to be affected by riverine floods on an annual basis.
- Coastal flood risk:the indicator is computed at hydrological sub-basin while the temporal resolution considered is the annual one. Coastal flood risk is a metric that gauges the percentage of the population likely to be affected by coastal flooding in an average year. This assessment takes into consideration the existing flood protection measures in place. It encompasses several factors, including the hazard of coastal inundation, the population residing in flood-prone coastal areas (exposure), and the vulnerability of these exposed populations. Additionally, it factors in the level of coastal flood protection that already exists. It's important to emphasize that this indicator doesn't reflect the worst-case scenario but rather the anticipated impact in an average year. It combines the impacts of both infrequent, extreme coastal flood events and more common, less dramatic occurrences to calculate the "expected annual affected population." Higher values for this indicator signify that a larger portion of the population is expected to experience the effects of coastal floods on an annual basis.

For the three indicators the risk classes have been created according to the following approach: "Low" risk category in the database has been associated to "Low" risk for ERM's methodology, "Low-medium" to "Medium", "Medium-high" to "Medium-high", "High" and "Extremely high" to "High".

- WESR Database [4]: The metric adopted to assess the landslide risk is the "Global Estimated Risk Index For Landslide Hazard Triggered By Precipitations". Its spatial resolution is 0.083 degrees which corresponds to approximately 10 km $\times$ 10km grid size, while the temporal resolution is the annual one. The hazard index was formulated through a comprehensive modeling approach, incorporating both the triggering factor, represented by rainfall intensity data, and susceptibility factors, which encompassed four critical indicators: topography, lithography, vegetation cover, and soil moisture. Subsequently, the risk indicator was derived by the multiplication of the hazard index by the calculated exposure and vulnerability of the population (using Landscan population and World Bank GDP distribution models [14]).

For the indicator the risk classes have been created according to the following approach: "Low" risk category in the database has been associated to "Low" risk for ERM's methodology, "Moderate" to "Medium", "Medium" to "Medium-high", "High" and "Extremely high" to "High".

- Think Hazard (landslides) [36]: The Global Landslide Hazard Map provides a qualitative assessment of global landslide hazard on a broad scale. It combines data on rainfall-triggered and earthquake-triggered landslides, simplifying it into four categories, ranging from Very Low to High hazard levels. The map defines landslide hazard as the average annual frequency of significant landslides in a specified area. This assessment is conducted globally at a 1 km$^2$ grid level and aggregated at the administrative level.

  For the indicator the risk classes have been created according to the following approach: "Very low" risk category in the database has been associated to "Low" risk for ERM's methodology, "Low" to "Medium", "Medium" to "Medium-high", "High" to "High".

- Copernicus [1]: The metrics adopted to assess the wildfire risk are three percentages for each cell, respectively for "Low risk", "Medium risk" and "High risk". Its spatial resolution is 0.11 degrees which corresponds to approximately 12.5 km $\times$ 12.5 km grid size, while the temporal resolution is the annual one. The wildfire risk assessment relies on both quantitative and semi-quantitative data sources, encompassing fire danger and vulnerability components. Multiple dimensions and proxy indicators, such as weather conditions and vegetation type, are considered to comprehensively evaluate wildfire risk. A Pareto ranking method prioritizes and integrates these data to provide a structured assessment of risk components. Inherent uncertainty in risk components is addressed through multiple simulations and model instances, allowing for the identification of high and low-risk areas with greater confidence.

  Based on the abundance of the three risk percentages, four risk classes have been created in order to adapt to ERM's methodology.

- Think Hazard (wildfire) [37]: The classification of wildfire hazard levels in this approach relies solely on the climatology of fire weather indices. These indices are commonly employed worldwide to evaluate when conditions are suitable for the occurrence and propagation of wildfires. In this method, a statistical modeling technique known as extreme value analysis is applied to a 30-year data-set of fire weather conditions. This analysis allows to gauge the expected intensity of fire weather for specific return periods. These intensities are then categorized using predefined thresholds and conventions to establish hazard classes. These classes represent conditions that could potentially support the rapid spread of fires across the landscape if ignition sources and ample fuel were to be present. For the indicator the risk classes have been created according to the following approach: "Very low" risk category in the database has been associated to "Low" risk for ERM's methodology, "Low" to "Medium", "Medium" to "Medium-high", "High" to "High".

- Hurricane tracks: the metric employed for the evaluation of cyclones and storms risk pertains to their frequency of occurrence (of any magnitude) that have manifested within a circle whose radius is 50 km and centered at the asset location. The time span of the historical dataset depends on the geography, however at least 100 years of recordings is granted. The risk classes for this indicator have been assigned according to the following thresholds: from 0 to 5 cyclones and storms at the asset location has been associated the risk class "Low", from 6 to 15 "Medium", from 16 to 25 "Medium-high", for more than 25 "High".

Once the risk classes for each asset of the portfolio have been identified, the following step is to convert the risk category into a risk value, as shown in Table 3.5. The non-linearity in risk grading underscores the importance of considering the inherent severity associated with single high. Indeed, when aggregating the risk scores of different climate hazards into a single value, if using linear risk grading system, the assumption made is that the addition of multiple lower-risk values equates to the same level of risk as a single, higher-risk value. However, in the context of physical risk, this assumption does not hold true, as the presence of a high physical risk element is inherently more perilous, regardless of the presence of other lower-risk factors. Consequently, the grading scale takes into account this non-linear relationship by assigning a higher level of risk to singular high physical risk values, reflecting their disproportionate potential for adverse consequences. In conclusion, the attempt is to avoid the "dilution effect" of a high risk among several low risks hazards. Once the risk value is assigned for each type of risk,

Table 3.5: Conversion between risk classes and risk values

| Risk class | Risk value |
|---|---|
| Low risk | 1 |
| Medium risk | 2 |
| Medium-high risk | 3 |
| High risk | 5 |

the aggregation is computed by summing them up. The overall aggregated risk score at asset level is defined as shown in Table 3.6. If more than an asset is owned by the same company, by averaging the overall aggregated risk scores at asset level, the overall company risk score is obtained.

Table 3.6: Evaluation of the aggregated risk score at asset level

| Aggregated risk score | Risk class | |
|---|---|---|
| $\leq 11$ | Low risk | |
| $> 11$ and $\leq 14$ | Medium risk | |
| $> 14$ and $\leq 17$ | Medium-high risk | |
| $> 17$ | High risk | |

**Transition risks exposure assessment**

The initial assessment of transition risks and opportunities at a high level relies on the company's NACE code. This assessment is carried out using a materiality map, which classifies each NACE code based on the potential exposure of the sector, both directly and indirectly, to transition-related risks and opportunities. The methodology adopted to produce the materiality map is shown in Figure 3.2. The variables that have been reviewed to perform the activity[3] are the following:

- Energy intensity of the sector: it refers to industries that require a significant amount of energy for their operations. These sectors are typically more vulnerable to transition risks and opportunities related to energy efficiency, carbon emissions, and regulatory changes.
- Carbon Border Adjustment Mechanism (CBAM): It is a regulatory tool that aims to level the playing field between domestic industries subject to carbon pricing and foreign competitors. It may impact businesses by imposing tariffs or adjustments based on the carbon emissions associated with imported goods.
- Potential eligibility under the EU taxonomy: It implies that a business may be subject to an evaluation process to determine whether it conforms to the criteria for environmentally sustainable practices. Such categorization may either enhance or diminish its competitive standing in the market, contingent upon the outcome of this evaluation.
- Large emissivity of the sector as a whole, including the supply chain: It encompasses sectors that are significant contributors to greenhouse gas emissions, not only through their direct operations but also through their entire supply chain. Such sectors may face risks and opportunities related to emissions reduction, supply chain sustainability, and regulatory changes aimed at reducing emissions across the entire value chain.

Once the potential exposure to transition risks and opportunities based on the business sector is done, further evaluations are conducted to check whether the companies are:

- Included within the National list of energy intensive companies (if the company operates plant in Italy).
- Included within the National/European databases listing companies subjected to the EU Emission Trading System (ETS) scheme: The EU ETS is a cap-and-trade program established by the EU to combat climate change by setting a limit on the total amount of emissions that can be released by industries. Each entity is allocated a certain number of emission allowances that they can either use or trade with other market participants.

[3] The sources examinated for the review are illustrated in Appendix A

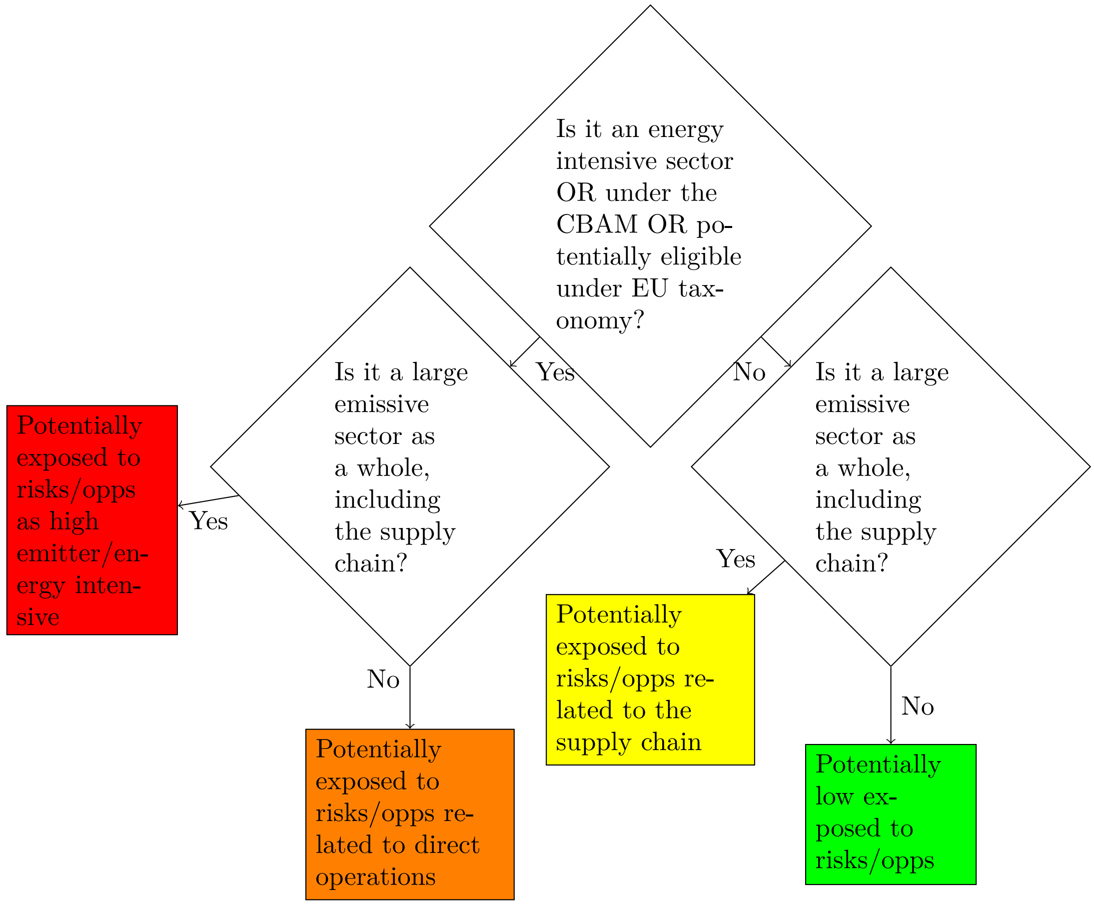



Figure 3.2: Flowchart of the methodology employed to design the materiality map. Regarding the outputs, from right (green box) to left (red box) the level of potential exposure increases.

Next, the qualitative risk-value assigned based on the transition materiality mapping is converted to a 1 (low risk/opportunities) to 5 (high risks/opportunities) scale, to calculate the overall transition risk/opportunities exposure. The calculations integrate in a quantitative metric the information described above by considering as "base risk score" the outcome from the materiality assessment of the company's NACE code (Table 3.7).

Table 3.7: Conversion of the Risk Class into the Base Transition Risks/Opportunities Score

| Risk Class | Base Transition Risks/Opportunities Score |
|---|---|
| Potentially low exposed to risks/opportunities | 0 |
| Potentially exposed to risks/opportunities related to the supply chain | 1 |
| Potentially exposed to risks/opportunities related to direct operations | 2 |
| Potentially exposed to risks/opportunities as high emitter/energy intensive | 3 |

Then, the base risk score is incremented by a unit whether the company is classified as energy intensive and by another unit if the company is included within the EU ETS scheme, obtaining the "overall transition risks/opportunities score". The thresholds adopted to define the risk classes are shown in Table 3.8.

Table 3.8: Selected thresholds for the Risk Classes of the overall transition risks/opps score.

| Overall transition risks/opps score | Risk class |
|---|---|
| $\leq 1$ | Low risk |
| $> 1$ and $\leq 3$ | Medium risk |
| $> 3$ and $< 5$ | Medium-high risk |
| $\geq 5$ | High risk |

### Results of the Portfolio climate risks exposure screening

The assessment yields quantitative information in the form of the count of PC sites and the corresponding percentage of AUM allocated to each company's site exposed to climate-related risks and opportunities in terms of four discrete categories, namely: low, medium, medium-high, and high. These categorizations are conducted at both the Asset Manager and Fund levels, and for both transition and physical risks and opportunities.

Furthermore, the assessment identifies PCs that exhibit a propensity for significant exposure to climate-related risks and opportunities. Those categorized as high or medium-high are duly flagged for further considerations in the context of climate risk management and strategic decision-making.

### 3.2.2 Company engagement

Based on the previous analysis, those PCs highly exposed to climate risks are encouraged by the SGR to conduct further evaluations. At this point, there is a shift in the accountability for completing the assessment, passing from the SGR to the PC. ERM's methodology to engage with companies in the context of climate-related risk assessment involves the utilization of a structured questionnaire designed to systematically evaluate a company's exposure to both transition and physical climate factors. This questionnaire is divided into two distinct sections, each tailored to scrutinize the specific dimensions of climate risk. The first section is dedicated to physical risks and aims to analyse the potential exposure of the company's assets to physical climate topics. If eligible under the EU Taxonomy, a further assessment on the potential materiality of physical risks is performed to be compliant with the normative.

The second section addresses transition climate aspects and aims to analyse the potential exposure of the company and its sector to climate transition topics.

In contrast to the high level portfolio's exposure screening, not all the information required to fill out the questionnaire is publicly available. Indeed, as the level of detail of the analysis increases some of the data necessarily become company or asset specific.

The outcomes of this assessment serves as a foundation for identifying specific aspects that merit further examination during the scenario analysis.

#### Physical screening

The results of this screening offer a better understanding of the effective potential exposure of the business to the risks identified, by checking information on the industrial processes carried out within the asset are checked out, to estimate its exposure: whether the company carries out industrial processes which generate heat and/or need to maintain high/low temperature, if the company employs process water in its industrial operations. In case of negative answers, the potential exposure to the risks "extreme heat/cold" and "water stress" is straightforwardly considered not applicable to the business run by the company. The last section is related to the indirect impacts that physical risks may generate, which focuses on evaluating how the company's asset operations are indirectly exposed to climate-related physical events through its supply chain[4]: if suppliers are located in areas highly exposed to climate change, if the company's supply chain relies on agricultural products which may be subject to scarcity, and if the company is engaged in the insurance sector.

For the companies assessed as potentially eligible under the EU Taxonomy in the screening described in Subsection 3.2.1, a further assessment concerning physical risks is conducted. This is necessary because demonstrating to do not consistently harness to the environmental objective "climate change adaptation" is required to be Taxonomy-aligned [32]. To do so, a screening must be performed on 28 climate hazards, reported

[4]The reference used to support the analysis of the supply chain physical risks' exposure is reported in Appendix A.2.

in Table 3.9, and, if any risk is detected, adaptation solutions to reduce it need to be assessed [32].

Table 3.9: Climate Hazards to evaluate to be EU Taxonomy-aligned.

| | **Temperature-related** | **Wind-related** | **Water-related** | **Solid mass-related** |
|---|---|---|---|---|
| Chronic | Changing temperature (air, freshwater, marine water) | Changing wind patterns | Changing precipitation patterns and types (rain, hail, snow/ice) | Coastal erosion |
| | Heat stress | | Precipitation or hydrogeological variability | Soil degradation |
| | Temperature variability | | Ocean acidification | Soil erosion |
| | Permafrost thawing | | Saline intrusion | Solifluction |
| | | | Sea level rise | |
| | | | Water stress | |
| Acute | Heat wave | Cyclone, hurricane, typhoon | Drought | Avalanche |
| | Cold wave/Frost | Storm (including blizzards, dust and sandstorms) | Heavy precipitation (rain, hail, snow/ice) | Landslide |
| | Wildfire | Tornado | Flood (coastal, fluvial, pluvial, ground water) | Subsidence |
| | | | Glacial lake outburst | |

The relevance of each of the 28 climate hazards to the economic activity needs to be assessed, filtering out hazards not relevant to the activity and its operating context. Relevance in this case is defined as the ability to "affect the performance of the economic activity during its expected lifetime". Relevance can therefore be determined through a qualitative and/or quantitative filtering process, based on the occurrence of a climate-related hazard at the site location and the negative impacts that it generates for any system element if it occurs (i.e. elements at risk). If these two conditions are respected, then the climate hazard is relevant. If not, it should be excluded from the assessment. For transparency, the reasoning underpinning the screening must be provided. At this stage, the assessment is performed on a qualitative basis, and the materiality level mainly focus on the potential impact on the asset type as a whole and its geographic location. Next, the vulnerability of the elements at risk is examinated. This is done by engaging with site personnel about whether specific investigation objects have been adversely impacted by climate hazards in the past, and the degree to which impacts were felt.

The result of the process is the materiality analysis, whose results are provided with a matrix where on the axis are reported respectively the elements at risk of the asset and the relevant climate hazards. Thus, the materiality level of each climate hazard is assessed with respect to each element at risk. The most significant risks are selected, and considerations on the need to perform a scenario analysis for each significant risk are made. Factors affecting the decision are the availability and/or reliability of climate scenario data for the risk, if the risk is included within the scope of the current permitting practice (e.g. the Hydrogeologic Master Plan), and the expected lifetime of the asset. For economic activities with an expected lifetime of $< 10$ years, the assessment is performed at the smallest appropriate scale. At a minimum, to be Taxonomy-aligned, baseline data (present day) derived from historical climate trends are used. In addition, if a specific climate hazard has been identified to have impacted the performance of the economic activity in the past, then this information must be considered. For all other activities, the assessment is performed using climate projections across the existing range of future scenarios consistent with the expected lifetime of the activity, including, at least, 10-to-30-year climate projections scenarios for major investments. For assets that constitute major investments (i.e. investments higher than a certain threshold based on the company size) with an expected lifetime of $\geq$10 years, to be Taxonomy-aligned, the assessment must cover, at least, 10-to-30-year climate projections.

For businesses that do not constitute major investments but have an expected lifetime of $\geq$10 years, the Taxonomy does not define a specific scope. It can be assumed that it would not be reasonable to mandate a scope equal or smaller than the one for economic activities with an expected lifetime of $<$10 years as well as equal or larger than the one for major investments with an expected lifetime of $\geq$10 years as minimum requirement. Thus, a reasonable interpretation is to cover at least 10-year climate projections is to be considered sufficient for non-major investments with an expected lifetime of $\geq$ 10 years.

### Transition screening

The results of this assessment[5] encompass a comprehensive breakdown of various transition aspect categories, shaped by the company's sector trends, size, and managed operations, both directly and indirectly along its supply chain. The questionnaire structure comprises four distinct sections: (A) Screening Questions, strategically designed to establish the relevance of transition aspect inquiries based on company size and sector: indeed, based on these answers, some transition aspects may not be applicable for the company; (B) Policy & Legal Assessment, focused on evaluating the company's exposure to compliance requirements at international, national, and state levels, which may increase input and operating costs and threaten licenses for high carbon activities; (C) Market & Technology Evaluation, dedicated to appraising the company's exposure to market and technological shifts toward a low-carbon economy, potentially necessitating bespoke policies and investments and affecting market demand and revenues for high

[5] The references used to support the assessment are illustrated in Appendix A.2.

carbon products; and (D) Brand & Reputation Analysis, which examines the company's susceptibility to escalating expectations for responsible conduct from stakeholders, including investors, lenders, customers, and host governments, potentially entailing risks and opportunities for reputation, brand value, and trust in management. Scope of this activity is the identification of relevant transition aspects that warrant in-depth analysis during the next phases of climate risk assessment, ensuring a comprehensive understanding of potential materiality associated to risks and opportunities within the evolving transition landscape.

In this screening, each transition question is assigned a binary response, either "Yes" or "No," with corresponding numerical values of 1 and 0, respectively (all the questions have the same weight). These values are utilized to compute an average score for each of the three sections, ranging from a minimum score of 0 to a maximum score of 1. Finally, an overarching score is calculated, as average of the scores of the three sections, to quantify the company's exposure to transition aspects. These indicators serve as a reflection of the company's susceptibility to transition aspects. It's important to note that a high score on these indicators does not inherently imply a threat to the business. Instead, it depends on the strategic stance adopted by the firm, as a high score could potentially signify an opportunity for the company to benefit from these transitional changes. The results of the analysis are presented in three exposure categories, based on the thresholds reported in Table 3.10. For the areas evaluated as "Moderate" or "High"

Table 3.10: Selected thresholds for the Exposure Classes of the transition score and comments on its meaning

| Score threshold | Exposure Class | Comment |
|---|---|---|
| $\leq 0.51$ | Low risk | Company low exposed to the climate transition aspect |
| $\geq 0.51$ and $\leq 0.76$ | Moderate risk | Company moderately exposed to the climate transition aspect |
| $\geq 0.76$ | High risk | Company highly exposed to the climate transition aspect |

it is suggested to focus the effort on the next stages.

### 3.2.3 Scenario analysis

The previous evaluations may highlight the need of performing a scenario analysis. Scenario analysis is a powerful tool in the realm of climate change preparedness and strategic planning. It involves using plausible narratives of the future, known as scenarios, to illuminate critical aspects of potential outcomes and the driving forces behind them. These scenarios are not crystal ball predictions; rather, they serve to challenge conventional assumptions and broaden strategic perspectives in an uncertain world. Two primary types of scenarios exist: holistic and event-based. Holistic scenarios paint comprehensive, overarching pictures of the future, encompassing a wide array of potential developments. They aim to provide a deep understanding of long-term trends and structural shifts that may shape the landscape. In contrast, event-based scenarios focus on specific incidents or triggers that could occur, delving into the details of how such events might unfold and their consequences.

At its core, scenario analysis aims to enhance strategic thinking by encouraging organizations to contemplate various paths of development. Indeed, it is a valuable tool for comprehending how the risks and opportunities associated with climate change, both in terms of transition and physical impacts, might influence the company's operations over time. In other words, it helps understanding the resiliency of the business, how it might perform under different future states. By engaging in this process, organizations can better prepare themselves for an ever-changing world, as they can identify the key areas to focus on during more detailed analyses.

### Physical risks scenario analysis

In this context, ERM's approach is to use holistic scenarios, to comprehensively understand which may be the financial categories potentially most impacted by physical risks. Indeed, the scenarios at the basis of ERM's analyses are the Share Socio-economic Pathways (SSPs) published by the IPCC in the Assessment Report 6 released in 2021 [10]. These scenarios have been computed by utilizing data coming from the Coupled Model Intercomparison Project (CMIP) 6. They provide possible future climate pathways, disclosed in terms of temperature increase with respect to pre-industrial levels (Table 3.11 ), based on different assumptions of the following anthropogenic parameters: radiative forcing, GHG emissions pathways, short-lived gases (e.g. methane) and aerosols (e.g. dust, smoke, Particulate Matters (PMs)), land cover and use, population and GDP growth. To be aligned with TCFD recommendations, ERM's scenario analysis can be

Table 3.11: IPCC Shared Socio-economic Pathways.

| | Near term, 2021-2040 | | Mid-term, 2041-2060 | | Long term, 2081-2100 | |
|---|---|---|---|---|---|---|
| Scenario | Best estimate (°C) | Very likely range (°C) | Best estimate (°C) | Very likely range (°C) | Best estimate (°C) | Very likely range (°C) |
| SSP1-1.9 | 1.5 | 1.2 to 1.7 | 1.6 | 1.2 to 2.0 | 1.4 | 1.0 to 1.8 |
| SSP1-2.6 | 1.5 | 1.2 to 1.8 | 1.7 | 1.3 to 2.2 | 1.8 | 1.3 to 2.4 |
| SSP2-4.5 | 1.5 | 1.2 to 1.8 | 2.0 | 1.6 to 2.5 | 2.7 | 2.1 to 3.5 |
| SSP3-7.0 | 1.5 | 1.2 to 1.8 | 2.1 | 1.7 to 2.6 | 3.6 | 2.8 to 4.6 |
| SSP5-8.5 | 1.6 | 1.3 to 1.9 | 2.4 | 1.9 to 3.0 | 4.4 | 3.3 to 5.7 |

conducted under different scenarios. TCFD encourages the use of at least two scenarios to provide a scientifically robust, strategically relevant, and forward-looking framework for assessing climate-related risks and opportunities, taking into account both current trends and potential future developments. Usually the "sustainable scenario" (i.e., the SSP1-2.6) and the "Business as Usual scenario" (i.e., the SSP5-8.5) are picked because they provide the largest range of uncertainty related to future economic and social development. Furthermore, the analysis can be performed according to different time horizons, based on client's needs.

The scenario analysis is carried out by using an ERM's proprietary platform, namely "Climate Impact Platform" (CIP).

#### Climate Impact Platform (CIP)

The CIP offers an overview of potential physical risks, both acute (e.g., flooding and cyclones) and chronic (e.g., extreme heat, water stress, and drought). The methodology consists of four key steps:

1. **Asset Data Collection (Input Data):** Asset data are gathered through interviews with site contact persons. This includes operational details.

2. **Climate Hazard Data (Input Data):** Asset-specific climate variables are extracted based on location information. Climate variables are used to compute Climate Hazard indicators. Climate Hazard indicators undergo a normalisation process.

3. **Exposure Ratings (Input Data):** Exposure ratings to assets for each climate hazard are assigned, drawing on ERM's knowledge base and qualitative information. They reflect the significance of each climate hazard on an asset types operations, supply chain and market (i.e, the level of exposure).

4. **Risk Scores (Output Data):** The combination between exposure ratings and climate hazard data generates risk scores for individual hazards. These can be averaged to give the overall asset risk scores. Risk scores facilitate comparisons to determine the relative risk level associated with each hazard.

The data providers from which the climate variables are extracted are the CMIP6, the World Resources Insitute (WRI), Fathom-Global 2.0, the International Best Track Archive for Climate Stewardship (IBTrACS), the NASA, the American Meteorological Society, and the European Space Agency (ESA). The climate indicators upon which the analysis is based are the ones indicated by the Expert Team on Climate Change Detection and Indices (ETCCDI) [2], an international team of experts who developed a set of 27 core extreme climate indicators specifically for physical climate risk assessments. Among them, the appropriate ones are selected to represent the respective climate hazard type (e.g., flooding and cyclones, extreme heat, water stress etc.), by considering the context of the analysis. Next, a normalisation process is performed, to traduce the climate hazard indicator (e.g. flood depth in metres, wind speed in knots, days of fire weather etc.) into a dimensionless parameter, according to the relevant literature on the matter at hand.

Obtaining a dimensionless parameter is crucial to allow a fair comparison across a range of hazards and it facilitates the calculations of risk scores.

The second variable, the exposure rating, serves the purpose of integrating an asset type's inherent susceptibility to each physical risk. Indeed, exposure ratings take into account how various climate hazards can impact in terms of financial, reputational, environmental and operational performance an asset, related supply chain and market significance. Thus, exposure ratings are assigned to each asset based on its facility type (e.g. onshore wind, manufacturing and chemicals, real estate, offices etc.). To each of them and for each climate hazard, default exposure ratings are tuned in the platform, based on a review of past projects undertaken by ERM and a range of literature including:

- Sector/asset-type specific climate risk assessments;
- Company risk assessments;
- Carbon Disclosure Project (CDP) reports;
- Government guidance and reports;
- Industry body reports;
- Financial institution guidance;
- Scientific papers and news articles on specific events.

Based on discussions with clients on the mitigation measures installed, the default exposure ratings can be overridden and re-tuned properly.

Once the two variables are defined, the risk scores can be computed. They are quantitative numbers used to assess the current and future impacts from climate hazards. CIP computes the risk scores at each asset for individual hazards, or these can be aggregated to obtain a risk score for the overall asset. Risk scores for individual hazard types are generated by combining climate hazard indicators and exposure ratings.

Asset risk scores are the average of all hazard risk scores for an asset. Selected thresholds are used to define the risk score, from "Minimal" to "Very High".

Furthermore, CIP uses thresholds to identify the magnitude of change between time periods, which is the difference between the future risk score and the baseline value. This information is of paramount importance for better planning of adaptation actions in a dynamic and evolving physical risk landscape.

This assessment, encompassing two different scenarios and timeframes while considering the activities carried out by the companies, allows to infer assets' exposure to physical risks more accurately.

#### Transition risks scenario analysis

As described in Subsection 2.2.1, the TCFD already posed the basis of a risk and opportunity "taxonomy", by categorizing them. The previous steps of ERM's methodology aim to highlight with increasing level of detail the transition aspects that potentially could be material for PCs. At this stage, the potentially material aspects are reviewed by performing a benchmark and high level literature analysis based on the answers to the CDP Climate Questionnaire of selected players which operate similar business as compared to the PC target. The goal is to draw a list of sector-specific climate related risks and opportunities for which conducting a scenario analysis to evaluate the scale of potential business impacts, in agreement with the TCFD guidelines. In this context, scenarios are built based on a coherent and internally consistent set of assumptions regarding transition drivers, such as rate of technology change, policy developments, and commodity prices. Several public referenced scenarios are available. Among them, the International Energy Agency (IEA) [3] is one of the main sources for scenarios at the global level concerning the energy sector. It provides for four scenarios, reported from the most optimistic to the most pessimistic:

- Net Zero Emissions 2050 (NZE): It shows a narrow but achievable pathway for the global energy sector to achieve net zero $CO_2$ emissions by 2050.
- Sustainable Development Scenario (SDS): All current net zero pledges are achieved in full and there are extensive efforts to realise near-term emissions reductions.
- Announced Pledges Scenario (APS): The global trends in this scenario represent the cumulative extent of the world's ambition to tackle climate change as of mid-2021.
- Stated Policies Scenario (STEPS): It takes a sector-by-sector look at what has been put in place to reach energy related objectives, taking account not just of the existing policies and measures but also those that are under development.

Besides the IEA, a source that provide for a set of scenario at the global level, but which encompasses all the economic sectors, is the Network for Greening the Financial System (NGFS) [28]. It provides six different scenarios, reported from the most optimistic to the most pessimistic:

- Orderly-Net Zero 2050: An ambitious scenario that limits global warming to 1.5°C through stringent climate policies and innovation, reaching net zero $CO_2$ emissions around 2050.
- Orderly-Below 2°C: Gradually increases the stringency of climate policies, giving a 67% chance of limiting global warming to below 2°C.
- Disorderly-Divergent Net Zero: Reaches net-zero by 2050 but with higher costs due to divergent policies introduced across sectors and a quicker phase out of fossil fuels.
- Hot house world: Nationally Determined Contributions (NDCs): Includes all pledged policies even if not yet implemented.
- Hot house world-Current Policies: Assumes that only currently implemented policies are preserved, leading to high physical risks.

The TCFD recommends to include different scenarios in the analysis, including a 2°C or lower scenario.

Once scenarios are selected, relevant scenario indicators (e.g., $CO_2$ price, Total Energy Demand, Regulatory-driven efficiency gains, Renewable Power uptake, Total transport Demand) for each climate-related risk and opportunity are identified. The indicators represent climate-related risks and opportunities in terms of driving risk and opportunity trends. These trends data are extracted from the scenario source, and may be directly relevant to the risk/opportunity identified or they could be used as proxies.

The following step is to explore how scenario indicators may change between two scenarios (e.g., a "Business as Usual" (BAU) and a "$<$ 2 Degrees"($<$2°C) Scenario) and at different timeframes (e.g., 2030 and 2050). This process facilitates further prioritization of climate risks and opportunities. The relative change of the same scenario indicator, under different scenarios and at same time intervals is used as metric to capture the magnitude of exposure to climate-related risks and opportunities associated with the transition to a low carbon economy. This metric is also known as "scenario delta indicator". The higher the scenario delta indicator the greater the inferred potential impact of the related climate risk or opportunity.

All indicator deltas are normalised in terms of percentage with respect to the largest and smallest delta obtained, in order to be able to apply absolute risk classes for the categorization of the risk score.

Next, for each scenario indicator a Relevance Weighting is assigned, which can be linked with the materiality of the risk/opportunity that was already determined through the questionnaire, the benchmark and literature review analysis.

Finally, the qualitative assessment of materiality is given by the combination of the relevance weightings and the normalized scenario delta indicator, which provides an indication on the magnitude of each risk/opportunity across different timeframes. Selected thresholds are used to define the risk/opportunity classes, from "Higher Risk" to "Higher Opportunity".

### 3.2.4 Quantification of the financial impact of climate-related risks and opportunities

Scenario analyses help performing assessments of the financial drivers related to climate risks and opportunities. Financial drivers are the commercial consequences that material risks and opportunities may potentially generate on company's OPEX, CAPEX, revenues streams and business continuity. However, scenario analyses provide a qualitative description. The process of identification of the key financial drivers and their linkage to relevant quantitative parameters and thus to the performance of the business is addressed in the last stage of the assessment, which is the financial quantification. In this context, an overall approach rather than a comprehensive methodology is presented, because the analysis to be conducted depends on several factors. The process of quantification of the financial impact of climate risks and opportunities involves designing economic models based on scenario indicators and company's (or asset) specific data. They are the inputs of an economic model built to estimate the potential financial impact of the key financial driver previously identified. To achieve this task, given the detail of the analysis, there is not a single approach because it highly depends on company's data availability and assumptions made. For this reason, there is no difference in the overall approach adopted to quantify financial drivers of the different nature (i.e. legal, reputational, market, physical); rather, it occurs on an case-by-case basis.

For sake of clarity, an example related to the financial impact of running future needs for air conditioning is reported. The input variables coming from the scenario indicators would be:

- The baseline monthly mean temperature.
- The projected monthly mean temperature.

The input variables coming from the company are:

- Site indoor Temperature Limit (i.e. IT room temperature limits).
- Approximately the cost of running air conditioning daily.

The temperature data allow to to compute the Average Daily Cooling Degree Days (CDD) for the baseline and future projections. CDD is a measure used to quantify how much the air temperature exceeds a certain base temperature. It is calculated by subtracting the monthly mean temperature to the Site Indoor Temperature Limit (if the result is less than zero, it is considered as zero). This calculation is performed for each month. CDD is often used as a proxy for the energy demand (and therefore cost) required to cool an environment to below a defined temperature. Considering that climate change is expected to increase the number of CDD, it can result in an escalation of Operational Expenditure (OPEX). The financial impact of this physical risk aspect is quantified by dividing the daily cost of cooling by the average daily Baseline CDD, in order to obtain the cost of one CDD. This metric can be multiplied by the projected change in CDD to estimate future average daily additional OPEX. By multiplying this value by the number of days in a month the monthly additional OPEX cost is obtained. By summing up the monthly OPEX cost the annual additional OPEX cost is retrieved, due to the increased need for air conditioning due to climate change.

## 3.3 Application of ERM methodology to case studies

The ensuing section applies the framework previously elucidated to real-world case studies. The goal is to empirically evaluate the strengths and weaknesses of the methodology. The case studies come from ERM's clients that have been requested by Bank's of Italy to achieve the alignment with its "Supervisory Expectations on climate and environmental risks" [20], for which ERM provided support. In the case studies examined will not be disclosed any PC name as well as sites location, because of confidentiality. Nonetheless, companies will be distinguished by disclosing their respective economic sectors. Finally, no case studies pertaining to the final phase of the methodology, which involves quantifying the financial impact, will be presented, as none of ERM's clients have requested this service.

### 3.3.1 High-level portfolio's exposure screening

#### Data collection

The high-level screening is applied to two portfolios belonging respectively to two funds under the SGR client. For the case study addressed, the PCs information is reported in Table 3.12.

Table 3.12: Information gathered at company level. PC 1 to 5 belong to the first fund, PC 6 to 14 belong to the second fund.

| Company Name | Percentage of AUM (%) | % of AUM Compared to total AUM currently invested by the fund | % of Ownership (%) | Revenue (Million Euro) | NACE Code | Economic Sector |
|---|---|---|---|---|---|---|
| PC 1 | 7.00 | 15.22 | 52 | 145 | 25.6 | Treatment and Coating of Metals, Machining |
| PC 2 | 8.00 | 17.39 | 57 | 137 | 24.5 | Casting of Metals |
| PC 3 | 16.00 | 34.78 | 25 | 144 | 13.9 | Manufacture of Other Textiles |
| PC 4 | 9.00 | 19.57 | 51 | 136 | 30.3 | Manufacture of Air and Spacecraft and Related Machinery |
| PC 5 | 6.00 | 13.04 | 71 | 50 | 27.9 | Manufacture of Other Electrical Equipment |
| PC 6 | 6.51 | 9.81 | 15 | 5 | 63.9 | Other Information Service Activities |
| PC 7 | 7.41 | 11.17 | 5 | 200 | 26.1 | Manufacture of Electronic Components and Boards |
| PC 8 | 15.33 | 23.10 | 20 | 22 | 47.9 | Retail Trade Not in Stores, Stalls, or Markets |
| PC 9 | 4.49 | 6.77 | 33 | 15 | 62 | Computer Programming, Consultancy, or Markets |
| PC 10 | 8.99 | 13.55 | 46 | 35 | 71.1 | Architectural and Engineering Activities |
| PC 11 | 7.48 | 11.27 | 19 | 5 | 27.9 | Manufacture of Other Electrical Equipment |
| PC 12 | 6.73 | 10.14 | 41 | 6 | 62 | Computer Programming, Consultancy, or Markets |
| PC 13 | 5.61 | 8.45 | 19 | 32 | 27.9 | Manufacture of Other Electrical Equipment |
| PC 14 | 3.81 | 5.74 | 20 | 5 | 62 | Computer Programming, Consultancy, or Markets |

It is pertinent to underscore that the majority of the companies in the second fund are focused on delivering services rather than manufacturing products, thus they operate in offices only. Assuming the potential non-materiality for this asset type to physical risks, for the second fund only data related to the operational sites of PC 7 and PC 13 are collected. Details of each operational site are reported in Table 3.13.

Table 3.13: Information at site level. The "site code" is provided to be able to distinguish the assets. The first number, before the dot, refers to the PC, while the second, after the dot, refers to the site. The "Percentage of AUM - Not considering the dry powder" is obtained by computing the percentage of AUM out of the total AUM currently invested by the fund.

| **Site Overview** | | | | | |
|---|---|---|---|---|---|
| Fund | Site Code | Percentage of AUM (%) | Percentage of AUM - Not considering dry powder | Property | Type of activity |
| FUND 1 | 1.1 | 1.40% | 3.13% | Leased | Industrial |
| | 1.2 | 1.40% | 3.13% | Leased | Industrial |
| | 1.3 | 1.40% | 3.13% | Leased | Industrial |
| | 1.4 | 1.40% | 3.13% | Leased | Industrial |
| | 1.5 | 1.40% | 3.13% | Leased | Industrial |
| | 2.1 | 0.89% | 1.99% | Owned | Industrial |
| | 2.2 | 0.89% | 1.99% | Owned | Industrial |
| | 2.3 | 0.89% | 1.99% | Leased | Industrial |
| | 2.4 | 0.89% | 1.99% | Owned | Industrial |
| | 2.5 | 0.89% | 1.99% | Leased | Industrial |
| | 2.6 | 0.89% | 1.99% | Owned | Industrial |
| | 2.7 | 0.89% | 1.99% | Leased | Industrial |
| | 2.8 | 0.89% | 1.99% | Leased | Industrial |
| | 2.9 | 0.89% | 1.99% | Leased | Industrial |
| | 3.1 | 0.33% | 0.75% | Leased | Industrial |
| | 3.2 | 0.33% | 0.75% | Owned | Industrial |
| | 3.3 | 0.33% | 0.75% | Leased | Industrial |
| | 3.4 | 0.33% | 0.75% | Leased | Industrial |
| | 3.5 | 0.33% | 0.75% | Leased | Industrial |
| | 3.6 | 0.33% | 0.75% | Leased | Industrial |
| | 3.7 | 0.33% | 0.75% | Leased | Industrial |
| | 3.8 | 0.33% | 0.75% | Leased | Industrial |
| | 3.9 | 0.33% | 0.75% | Leased | Industrial |
| | 3.10 | 0.33% | 0.75% | Leased | Industrial |
| | 3.11 | 0.33% | 0.75% | Leased | Industrial |
| | 3.12 | 0.33% | 0.75% | Leased | Industrial |
| | 3.13 | 0.33% | 0.75% | Leased | Industrial |
| | 3.14 | 0.33% | 0.75% | Leased | Industrial |
| | 3.15 | 0.33% | 0.75% | Leased | Industrial |
| | 3.16 | 0.33% | 0.75% | Leased | Industrial |
| | 3.17 | 0.33% | 0.75% | Owned | Industrial |

| Fund | Site Code | Percentage of AUM (%) | Percentage of AUM - Not considering dry powder | Property | Type of activity |
|---|---|---|---|---|---|
| | 3.18 | 0.33% | 0.75% | Leased | Industrial |
| | 3.19 | 0.33% | 0.75% | Leased | Industrial |
| | 3.20 | 0.33% | 0.75% | Leased | Industrial |
| | 3.21 | 0.33% | 0.75% | Leased | Industrial |
| | 3.22 | 0.33% | 0.75% | Leased | Industrial |
| | 3.23 | 0.33% | 0.75% | Owned | Industrial |
| | 3.24 | 0.33% | 0.75% | Leased | Industrial |
| | 3.25 | 0.33% | 0.75% | Owned | Industrial |
| | 3.26 | 0.33% | 0.75% | Leased | Industrial |
| | 3.27 | 0.33% | 0.75% | Leased | Industrial |
| | 3.28 | 0.33% | 0.75% | Leased | Industrial |
| | 3.29 | 0.33% | 0.75% | Leased | Industrial |
| | 3.30 | 0.33% | 0.75% | Leased | Industrial |
| | 3.31 | 0.33% | 0.75% | Leased | Industrial |
| | 3.32 | 0.33% | 0.75% | Leased | Industrial |
| | 3.33 | 0.33% | 0.75% | Leased | Industrial |
| | 3.34 | 0.33% | 0.75% | Leased | Industrial |
| | 3.35 | 0.33% | 0.75% | Leased | Industrial |
| | 3.36 | 0.33% | 0.75% | Leased | Industrial |
| | 3.37 | 0.33% | 0.75% | Leased | Industrial |
| | 3.38 | 0.33% | 0.75% | Leased | Industrial |
| | 3.39 | 0.33% | 0.75% | Leased | Industrial |
| | 3.40 | 0.33% | 0.75% | Leased | Industrial |
| | 3.41 | 0.33% | 0.75% | Leased | Industrial |
| | 3.42 | 0.33% | 0.75% | Leased | Industrial |
| | 3.43 | 0.33% | 0.75% | Leased | Industrial |
| | 3.44 | 0.33% | 0.75% | Leased | Industrial |
| | 3.45 | 0.33% | 0.75% | Leased | Industrial |
| | 3.46 | 0.33% | 0.75% | Leased | Industrial |
| | 3.47 | 0.33% | 0.75% | Owned | Industrial |
| | 3.48 | 0.33% | 0.75% | Leased | Industrial |
| | 4.1 | 1.29% | 2.88% | Owned | Industrial |
| | 4.2 | 1.29% | 2.88% | Owned | Industrial |
| | 4.3 | 1.29% | 2.88% | Leased | Industrial |
| | 4.4 | 1.29% | 2.88% | Leased | Industrial |
| | 4.5 | 1.29% | 2.88% | Leased | Industrial |
| | 4.6 | 1.29% | 2.88% | Owned | Industrial |
| | 5.1 | 6.00% | 13.42% | Owned | Industrial |

| Fund | Site Code | Percentage of AUM (%) | Percentage of AUM - Not considering dry powder | Property | Type of activity |
|---|---|---|---|---|---|
| FUND 2 | 7.1 | 7.41% | 11.17% | Owned | Industrial |
| | 13.1 | 5.61% | 8.45% | Owned | Industrial |

**Potential Physical Risk exposure screening results**

Based on the methodology illustrated in the previous chapter, the results of the potential physical risk exposure screening are reported in Table 3.14. For sake of clarity, the risk class in which the PC falls based on the risk score is given by the cell color.

Table 3.14: According to the methodology a risk value is assigned to each risk class. By summing up the risk values of each risk category the overall risk exposure score of the site is obtained. By averaging out the risk exposure scores of the sites belonging to the same company, the overall company exposure score is obtained.

| | Chronic | | Acute | | | | | Overall physical risk exposure score | |
|---|---|---|---|---|---|---|---|---|---|
| 1.1 | Medium | Medium-high | Low | Low | Low | High | Low | 14 | 13.4 |
| 1.2 | Medium | Medium-high | Low | Low | Low | High | Low | 14 | |
| 1.3 | Medium-high | Low | Low | Low | Low | High | Medium-high | 15 | |
| 1.4 | Medium-high | Low | Low | Low | Low | High | Medium-high | 15 | |
| 1.5 | Low | Medium | Low | Low | Low | Medium | Low | 9 | |
| 2.1 | Medium | Medium | Medium-high | Medium-high | Medium | Medium | Low | 15 | 14.9 |
| 2.2 | Medium-high | Low | Medium-high | Medium-high | Low | Medium | Low | 14 | |
| 2.3 | Medium | Low | Medium-high | Medium-high | Low | Medium | Low | 13 | |
| 2.4 | Medium | Low | Low | Low | Medium-high | High | Low | 14 | |
| 2.5 | Low | High | Medium | Low | Low | High | Low | 16 | |
| 2.6 | Medium-high | Low | Medium-high | Medium-high | Low | Medium | Low | 14 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2.7 | Medium-high | Low | Medium | Medium-high | Medium | Medium | Low | 14 | |
| 2.8 | Medium-high | High | Medium-high | Medium | Medium | Medium | Low | 18 | |
| 2.9 | Medium | Low | Medium-high | Medium-high | Low | High | Low | 16 | |
| 3.1 | Medium | Medium-high | Low | Low | High | High | Low | 18 | 17.8 |
| 3.2 | Medium | Low | Medium-high | Medium-high | Low | Medium-high | Low | 14 | |
| 3.3 | Medium | Low | Low | Low | Medium | High | Low | 13 | |
| 3.4 | Medium-high | Low | Medium-high | Medium-high | Medium | Medium-high | Low | 16 | |
| 3.5 | Medium-high | Low | Medium-high | Medium-high | Medium | Medium-high | Low | 16 | |
| 3.6 | Medium-high | Low | Medium-high | Medium-high | Low | Medium | Low | 14 | |
| 3.7 | Medium-high | Low | Medium | Low | Medium | Medium | Low | 12 | |
| 3.8 | Medium | Medium-high | High | Medium-high | Low | High | Low | 20 | |
| 3.9 | Medium | Medium-high | High | Medium-high | Low | High | Low | 20 | |
| 3.10 | Medium | Medium-high | High | Medium-high | Low | High | Low | 20 | |
| 3.11 | Medium-high | High | High | Medium-high | Low | High | Low | 23 | |
| 3.12 | Medium-high | High | High | Medium-high | Low | High | Low | 23 | |
| 3.13 | Medium-high | Low | Medium-high | Low | Medium | High | Low | 16 | |
| 3.14 | Medium-high | High | Low | Low | Low | High | Low | 17 | |
| 3.15 | High | High | Medium-high | High | Low | Low | Low | 21 | |
| 3.16 | High | High | Medium-high | High | Medium | High | Low | 26 | |
| 3.17 | Medium-high | High | Medium-high | Low | Medium | High | Low | 20 | |
| 3.18 | Medium-high | Medium | Low | Low | Low | Low | Low | 10 | |
| 3.19 | Medium-high | Medium | Low | Low | Low | Low | Low | 10 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.20 | Medium-high | High | Low | Low | Low | High | Low | 17 |
| 3.21 | Medium-high | High | Low | Low | Low | High | Low | 17 |
| 3.22 | Medium-high | High | Low | Low | Low | High | Low | 17 |
| 3.23 | Medium-high | High | Low | Low | Low | High | Low | 17 |
| 3.24 | Medium-high | High | Medium-high | Low | Low | Medium-high | Low | 17 |
| 3.25 | Medium-high | High | Medium-high | Low | Low | Medium-high | Low | 17 |
| 3.26 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.27 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.28 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.29 | Medium-high | Medium-high | Medium-high | Low | Medium | Medium-high | Low | 16 |
| 3.30 | Medium-high | Medium-high | Medium-high | Low | Medium | Medium-high | Low | 16 |
| 3.31 | Medium-high | Low | Medium-high | Low | Low | High | Low | 15 |
| 3.32 | Medium-high | High | Medium-high | Low | Medium | High | Low | 20 |
| 3.33 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.34 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.35 | Low | High | Medium | Medium | Low | Medium | Low | 14 |
| 3.36 | Low | High | Medium | Medium | Low | Medium | Low | 14 |
| 3.37 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.38 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.39 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.40 | Medium-high | High | Medium-high | Low | Low | High | Low | 19 |
| 3.41 | Medium-high | High | High | Medium-high | High | Medium | Low | 24 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3.42 | Medium-high | High | High | Medium-high | Low | Medium-high | Low | 21 | |
| 3.43 | High | High | Medium | Medium-high | Low | High | Low | 22 | |
| 3.44 | High | High | High | Medium-high | Low | Medium-high | Low | 23 | |
| 3.45 | High | High | High | Medium-high | Low | Medium-high | Low | 23 | |
| 3.46 | Medium-high | High | Medium-high | Low | Medium | High | Low | 20 | |
| 3.47 | Low | Medium-high | Low | Low | Low | Medium | Low | 10 | |
| 3.48 | Medium-high | High | Medium-high | Low | Low | Medium | Low | 16 | |
| 4.1 | High | High | High | Medium-high | Low | Medium-high | Low | 23 | 15.7 |
| 4.2 | Medium | Low | Medium | Medium | Medium | High | Low | 15 | |
| 4.3 | Low | Low | Medium-high | Low | Low | High | Medium | 14 | |
| 4.4 | Low | Low | Medium-high | Low | Medium | High | Medium | 15 | |
| 4.5 | Low | Medium-high | Low | Low | Low | High | Medium-high | 15 | |
| 4.6 | Medium-high | Low | Medium | Low | Medium | Medium | Low | 12 | |
| 5.1 | Medium-high | High | High | Medium-high | Low | Low | Low | 19 | 19 |
| 7.1 | Medium-high | High | Medium-high | Low | Medium | High | Low | 20 | 20 |
| 13.1 | Medium | Low | Low | Low | Low | Medium | Low | 9 | 9 |

The obtained risk score, provided in Table 3.14, based on the thresholds explained in the methodology, is then reassociated with a risk class.

### Potential Transition Risk and Opportunities exposure screening results

The results of the screening of the potential risks and opportunities to which the examined PCs are exposed are reported in Table 3.15. For sake of clarity, the risk class in which the PC falls based on the risk score is given by the cell color.

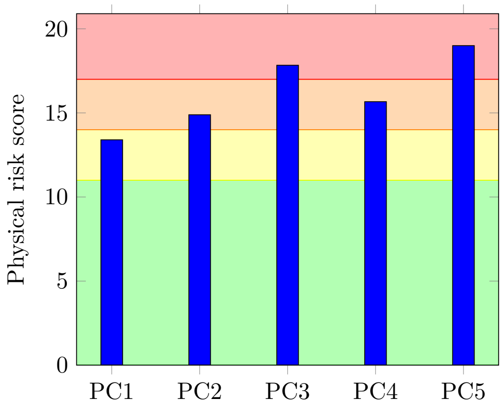
Table 3.15: Transition Risk/Opportunity Exposure

| **Company Name** | **Transition risks/opps potential exposure** | **Energy intensive** | **EU ETS** | **EU Taxonomy eligibility** | **Overall Transition Risk/Opportunity Exposure Score** |
|---|---|---|---|---|---|
| PC 1 | Potentially exposed to risks/opps as high emitter/energy-intensive | No | No | Yes | 3 |
| PC 2 | Potentially exposed to risks/opps as high emitter/energy-intensive | Yes | No | Yes | 4 |
| PC 3 | Potentially exposed to risks/opps related to the supply chain | No | No | No | 1 |
| PC 4 | Potentially exposed to risks/opps as high emitter/energy-intensive | No | No | No | 3 |
| PC 5 | Potentially exposed to risks/opps related to direct operations | No | No | Yes | 2 |
| PC 6 | Potentially low exposure to risks/opps | No | No | No | 0 |
| PC 7 | Potentially exposed to risks/opps related to direct operations | No | No | Yes | 2 |
| PC 8 | Potentially low exposure to risks/opps | No | No | No | 0 |
| PC 9 | Potentially low exposure to risks/opps | No | No | No | 0 |
| PC 10 | Potentially low exposure to risks/opps | No | No | No | 0 |
| PC 11 | Potentially exposed to risks/opps related to direct operations | No | No | Yes | 2 |
| PC 12 | Potentially low exposure to risks/opps | No | No | No | 0 |
| PC 13 | Potentially exposed to risks/opps related to direct operations | No | No | Yes | 2 |
| PC 14 | Potentially low exposure to risks/opps | No | No | No | 0 |

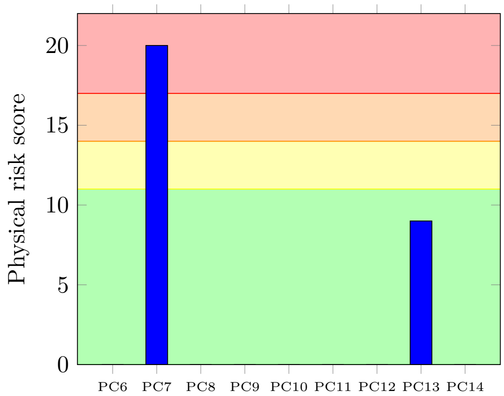
According to the methodology, the obtained risk score is classified under the four risk classes in agreement with selected thresholds.

### Presentation of the results

The results of the high-level screening are provided in terms of exposure of each PC to physical and transition risks, as shown in Figure 3.3 and Figure 3.4. The colors in the background refer to the risk category in which the PC bar can fall: green is associated to low risk, yellow to medium, orange to medium-high and red to high.

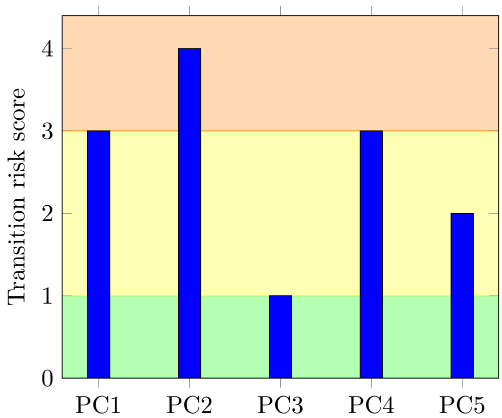



(a) Physical risk score for PCs belonging to the first fund.

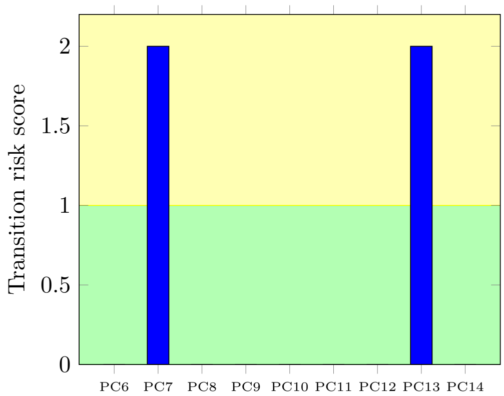



(b) Physical risk score for PCs belonging to the second fund.

Figure 3.3: Exposure to physical risks for each PC according to the high level screening.




(a) Transition risk score for PCs belonging to the first fund.




(b) Transition risk score for PCs belonging to the second fund.

Figure 3.4: Exposure to transition risks for each PC according to the high level screening.

However, asset managers invest different amount of equities in each PC, while Figure 3.3 and Figure 3.4 do not contain this information. For this reason, the results are also provided in terms of % of AUM at risk. This aggregation is performed by associating the risk to which a PC (or site) is exposed to the % of AUM invested in that company (or site). The % of AUM falling under the same risk category is summed up and the % of AUM exposed to low, medium, medium-high and high risk is obtained. In first place, the analysis is carried out at fund level. The results are reported in Table 3.16 for physical risks and Table 3.17 for transition risks.

Table 3.16: % of AUM under each risk class for Funds 1 and 2, regarding physical risks.

| | FUND 1 | | | FUND 2 | | |
|---|---|---|---|---|---|---|
| **Risk Level** | **Number of Sites** | **Percentage of AUM (%)** | **Percentage of AUM compared to the total AUM currently invested by the fund (%)** | **Number of Sites** | **Percentage of AUM (%)** | **Percentage of AUM compared to the total AUM currently invested by the fund (%)** |
| Low risk | 4 | 2.4% | 5% | 1 | 5.6% | 8% |
| Medium risk | 15 | 11.8% | 26% | 0 | 0% | 0% |
| Medium-high risk | 22 | 14% | 31% | 0 | 0% | 0% |
| High risk | 28 | 16.5% | 37% | 1 | 7.4% | 11% |

Table 3.17: % of AUM under each risk class for Funds 1 and 2, regarding transition risks.

| | FUND 1 | | | FUND 2 | | |
|---|---|---|---|---|---|---|
| **Risk Level** | **Number of Companies** | **Percentage of AUM (%)** | **Percentage of AUM compared to the total AUM currently invested by the fund (%)** | **Number of Companies** | **Percentage of AUM (%)** | **Percentage of AUM compared to the total AUM currently invested by the fund (%)** |
| Low risk | 1 | 16% | 35% | 6 | 46% | 69% |
| Medium risk | 3 | 22% | 48% | 3 | 21% | 31% |
| Medium-high risk | 1 | 8% | 17% | 0 | 0% | 0% |
| High risk | 0 | 0% | 0% | 0 | 0% | 0% |

In second place, the results are provided at SGR level, by computing a weighted average of the results obtained at fund level, based on the absolute capital allocated in each fund. Data are provided in Table 3.18.

Table 3.18: Assets under Management (AUM) and Commitment Information.

| Fund | AUM (Million Euro) | Committed (Million Euro) | % on total committed | % tot - not considering dry powder |
|---|---|---|---|---|
| Fund 1 | 226.55 | 492.5 | 78.65% | 71.86% |
| Fund 2 | 88.72 | 133.7 | 21.35% | 28.14% |

The results of the screening at SGR level are provided in Table 3.19 for physical risks and in Table 3.20 for transition risks.

Table 3.19: % of AUM under each risk class at SGR level, regarding physical risks.

| | SGR | | |
|---|---|---|---|
| **Risk Level** | **Number of Sites** | **Percentage of AUM (%)** | **Percentage of AUM compared to the total AUM currently invested by the fund (%)** |
| Low risk | 5 | 3.1% | 6.2% |
| Medium risk | 15 | 9.3% | 19% |
| Medium-high risk | 22 | 11% | 22.5% |
| High risk | 29 | 14.6% | 29.7% |

Regarding physical risks, to avoid the oversimplification of the assessment, the weighted average is also computed with respect to the % of AUM of the two funds exposed to each of the physical risks considered in the analysis. The results are provided in Table 3.21, where the % of AUM at medium-high and high risk for each physical hazard is indicated.

In light of this assessment, The SGR is advised to engage with PCs potentially exposed to climate risks identified in the analysis, encouraging them to conduct further evaluations on this topic. In the next phases there will be a shift in the ownership of the climate risks assessment, passing from the SGR to the PC potentially exposed.

### 3.3.2 Company engagement

The process of engagement generally starts by submitting the questionnaire described in the methodology section to the PC, to begin a discussion on climate related risks and opportunities aspects. In this context, the case study refers to a windows and doors manufacturing company resulted potentially exposed to transition and physical risks.

#### Physical aspects

The high level screening assigned an aggregated score of "High" to the potential exposure to physical risks to the company under examination. In particular, "Extreme heat" was classified as "High", "Water Stress" as "High", "River flood" as "High", "Coastal flood" as "Medium-high", "Landslide" as "Medium", "Wildfire" as "Medium-high" and

Table 3.20: % of AUM under each risk class at SGR level, regarding transition risks.

| | SGR | | |
|---|---|---|---|
| **Risk Level** | **Number of Sites** | **Percentage of AUM (%)** | **Percentage of AUM compared to the total AUM currently invested by the fund (%)** |
| Low risk | 7 | 22.4% | 44.4% |
| Medium risk | 6 | 21.7% | 43% |
| Medium-high risk | 1 | 6.3% | 12.5% |
| High risk | 0 | 0% | 0% |

Table 3.21: Percentage of AUM at Medium-High risk and High risk per risk type at SGR level.

| SGR | | |
|---|---|---|
| **Risk type** | **AUM at Medium-High risk (%)** | **AUM at High risk (%)** |
| Wildfire | 3.3% | 18.4% |
| Water Stress | 4.6% | 16.0% |
| River flood | 13.8% | 7.4% |
| Extreme heat | 20.0% | 2.1% |
| Coastal flood | 12.4% | 0.5% |
| Landslides | 0.6% | 0.5% |
| Cyclones & Storms | 2.9% | 0.0% |

"Cyclone/Storms" as "Low", obtaining an overall aggregated score of 24 (i.e. "High"). For this reason, further evaluations have been conducted, by performing an activity of engagement with the company.

The most peculiar criteria investigated to evaluate the potential materiality of physical risks exposure are illustrated. The company under evaluation does not use water for industrial processes as well as it does not require specific temperatures for its activities. Indeed, PVC and aluminum window profiles are provided by suppliers, thus in-house operations begin with the cutting of the profiles.

Regarding the supply chain, the suppliers of the company are mainly located in Italy and Germany, and according to the Global Climate Risk Index magnitude of the German Watch Atlas they are not regions very highly or highly exposed to climate risks. Furthermore, the company's sector is not associated to agricultural products nor to the insurance sector. These elements show a relatively low exposure to physical risks considering the business operations of the firm and its supply chain.

However, as illustrated in paragraph 3.3.2, the company is potential eligible under the EU Taxonomy. The Regulation requires the assessment of physical climate risks by performing a materiality analysis, considering the materiality of climate hazards with respect to each element at risk of the company. Considering previous assessments on the magnitude of climate hazards at the asset location, the asset type and business operations, the results of the materiality analysis are shown in Table 3.22, in which only the relevant hazards among all the ones considered by the EU Taxonomy are reported.

Table 3.22: Assessment of physical risks materiality

| **Element at risk** | **Subsidence** | **Extreme Heat** | **Landslide** | **Flood (coastal, fluvial, pluvial, ground water)** | **Wildfire** |
|---|---|---|---|---|---|
| O&M Workers | Low Materiality | High Materiality | Low Materiality | High Materiality | High Materiality |
| Site Accessibility | Medium Materiality | Medium Materiality | Medium Materiality | High Materiality | High Materiality |
| Manufactured products | Medium Materiality | Low Materiality | Medium Materiality | High Materiality | High Materiality |
| Structure - Plant Integrity | Medium Materiality | Low Materiality | High Materiality | High Materiality | High Materiality |

Considering the most relevant risks, the current permitting procedures, the availability and reliability of climate data indicators, the expected lifetime of the asset (i.e. greater than 10 years) and the entity of the investment, a physical scenario analysis covering 10-to-30-year climate projections while addressing at least "Extreme Heat", "Landslides", "Flood" and "Wildfires" should be performed.

### Transition aspects

The high level screening assigned a "Medium" potential exposure to transition risks to the company under examination. Based on its NACE code, C22.2 (i.e. manufacturing of plastic products), the company is embedded in a large emissive sector as a whole, and is potentially eligible under the EU Taxonomy, considering that highly energy efficient windows and doors can improve buildings performance, thus substantially reducing GHG emissions. For these reasons, further evaluations have been carried out.

The salient information reviewed to assess the potential materiality of transition risks and opportunitites is reported. Regarding the "Policy & Legal" aspect, the size of the company is expected to become large enough (i.e., more than 250 employees and revenues greater than 40 millions euro) to be subject to the forthcoming EU Corporate Sustainability Reporting Directive (CSRD). The company's production site is in Italy, country that scheduled to implement carbon pricing schemes, according to the World Bank Carbon Pricing Compass. Even though the company will be impacted by the CSRD, it is not already disclosing voluntarily a sustainability report. The company does not have any production plant performing energy intensive activities. By acknowledging these facts, together with the ones gathered during the previous step (i.e. eligibility under the EU taxonomy) the exposure to the Policy & Legal aspect is assessed as "Moderate" (0.75 score). Regarding the "Market & Technology" aspect, the company does not engage directly in highly energy intensive sectors (i.e., Oil&Gas, Energy&Renewables, etc), but indirectly, through the supply chain, it does. Moreover, one of the company's key customers is a large client: having key large clients may translate in external pressures for the company which may need to implement carbon reduction strategies as a result of Scope 3 emission (i.e., indirect GHG emissions) reduction activities implemented by the client. In light of these data, the company's exposure to the Market & Technology aspect is "Moderate". Regarding the "Brand & Reputation" aspect, the company is not directly or indirectly engaged in a sector likely to be exposed to public scrutiny. However, the company does not publicly disclose a Carbon Footprint analysis nor perform climate reporting initiatives (e.g. disclosing through the CDP Climate Change Module, the TCFD Framework etc) nor has defined decarbonization targets (aligned to international frameworks such as the Science Based Target initiative (SBTi). Considering the information gathered, the exposure of the company to the Brand & Reputation target is assessed as "Moderate" (0.67 score).

Overall the exposure of the company risks and opportunities related to transition aspects is evaluated as "Moderate" (0.67 score), thus further assessments are carried out through a scenario analysis.

### 3.3.3 Scenario analysis

#### Physical risks scenario analysis

In this section the results of the scenario analysis related to physical risks performed with ERM's proprietary platform are reported. The risk score is provided for the baseline and 2030 and 2050 time horizons across the SSP 5-8.5 (business and usual scenario) and SSP 1-2.6 (sustainable scenario). For future projections, the relative increase of magnitude of the risk for each timeframe and scenario is also provided. Proper climate hazard indicators were selected to represent the climate hazard categories.

The asset exposure ratings selected for each climate hazard are illustrated in Table 3.23. Asset exposure ratings are combined with the normalized climate hazard

Table 3.23: Asset exposure ratings associated to each climate hazard assessed. The default exposure ratings based on the "manufacturing plant" asset type are properly tuned after a discussion with the client.

| Climate Hazard | Asset Exposure Rating |
|---|---|
| Extreme Heat | Moderate |
| Extreme Cold | Moderate |
| River Flooding | High |
| Extreme Rainfall Flooding | High |
| Coastal & Offshore | High |
| Extreme Winds & Storms | High |
| Rainfall-Induced Landslides | Moderate |
| Water Stress & Drought | Low |
| Wildfires | Moderate |

indicators extracted from the ERM's proprietary Global Climate Data (GCD) platform to compute the risk scores. Risk scores are calculated at asset level for individual hazards and then these are aggregated to obtain the average risk score for the overall asset. The calculated risk scores at asset level related to individual hazards for the baseline, 2030 and 2050 time horizons under the SSP 1-2.6 scenario yielded the following findings: under this scenario the company presents an overall risk score of "Low" by 2030 and by 2050. This is mainly driven by the following climate hazards: "Water Stress & Drought" ("very high" scores by 2030 and by 2050) and "Extreme heat" ("Moderate" score by 2030 and by 2050). However, considering company's operations, "Water Stress and Drought" represents a potential physical hazard for the target location but can be considered as not material risk for the business since water consumption is limited to meet employees needs. Potential financial drivers that would impact the company in terms of costs are related to increased energy bills, (e.g., due to the use of heating/cooling systems) and health and safety issues for employees (e.g., due to temperature changes).

Regarding the risk score in terms of magnitude of increase in the future, "Water Stress & Drought" (not material) has the highest baseline score, resulting as "Very High". However, the asset is not expected to experience either an increase or decrease in risk score across different timeframes. "Wildfire" has a baseline risk score of "minimal". This hazard is projected to exhibit a minimal increase remaining stable within the minimal risk score threshold by 2030 and a moderate increase to "moderate" by 2050. "Extreme heat" has a baseline risk score of "low". This hazard is projected to exhibit a minimal increase to "moderate" by 2030 and a moderate increase to "moderate" by 2050. Finally, "Extreme cold" presents a "high" baseline risk score. This hazard is projected to exhibit a moderate decrease to "moderate" by 2030 and a moderate decrease to "low" by 2050.

Analogously, the findings related to the risk scores under the SSP5-8.5 are reported. Together with the hazards mentioned for SSP1-2.6, in this scenario also the "Wildfire" hazard emerges as potentially material ("moderate" score by 2050). In terms of costs, the business may be impacted in terms of business disruptions because of wildfires, due to potential direct damages to the physical structure, materials stored and machineries.

While the baseline hazards risk score are the same of those discussed under the SSP1-2.6, some differences related to the risk score in terms of magnitude of increase are registered. In particular, "Wildfire" is projected to exhibit a minimal increase to "moderate" by 2030 and a significant increase to "high" by 2050. Moreover, "Extreme heat" is projected to exhibit a moderate increase to "moderate" by 2030 and a significant increase to "high" by 2050, and "Extreme cold" presents is projected to exhibit a minimal decrease to "moderate" by 2030 and a moderate decrease to "low" by 2050.

In addition, some hazards are further investigated. Indeed, due to the proximity of the company to a river, the "River flooding" hazard is double-checked by reviewing the regional hydrogeologic risk map related to the baseline, which confirms CIP's assessment as the Asset does not fall within any flooding risk area. However, a "medium risk" area is close to the asset. The same operation is carried for the "Extreme Winds & Storms" hazard type, for which an indicator that relies on tropical cyclones is used. This choice has been driven by the fact that global data is not available for (non-tropical) "Storms". As a result, further evaluations are typically required to comprehensively understand the regional projected trends for (non-tropical) "Storms". In particular, the double-check is done by reviewing the IPCC Interactive Atlas. According to a projected scenario where global temperatures increase and stabilize by 2050 at 2°C, there is a high confidence of decrease of the mean wind speed, while there is a medium confidence of increase of severe windstorm. This implies that potentially in the long term acute events may become more frequent than today in the region where the asset is located.

By aggregating the results, the company shows an overall climate risk with respect to baseline of "1.20" ("low"). Across the scenarios, the overall risk undergoes a "minimal increase", remaining stable within the low risk score threshold. Although the aggregated risk score is "low", some physical hazards, such as "Extreme heat" (under SSP1-2.6 and SSP5-8.5) and "Wildfire" (under SSP5-8.5), are flagged as potentially material. The subsequent step in the analysis would be the quantification of the financial impact of the key financial drivers identified during the scenario analysis. For example, the increase in the cost of the energy bills due to an higher use of cooling systems could be computed as explained in Subsection 3.2.4, if data related to the daily cost of air conditioning and on the site indoor temperature limit were to be available.

**Transition aspects scenario analysis**

Since the activity of engagement performed with the company (i.e. the questionnaire) highlighted a potential exposure to the three transition aspects, a benchmark analysis and a high-level literature review is conducted on all of them: the outcomes are shown in Table 3.24. The transition aspects, customized to the company's operations, are expressed in relation to risks. However, this represents only one side of the coin. In fact, based on company strategic stance on sustainability, the exposure to these risks can potentially evolve into opportunities. The choice of focusing on risks is driven by the indicators publicly available by referenced sources (e.g. IEA) to perform the scenario analysis. Indeed, the risk/opportunities identified are associated to a scenario indicator that is used as proxy for the scenario analysis. The selected indicators are reported in the last column of Table 3.24. For the scenario indicators, data are extracted across two time horizons, 2030 and 2045, and for two scenario pathways: the IEA STEPS and the IEA NZE (described in Paragraph 3.2.3). The extracted data are reported in Table 3.25. The choice of selecting 2045 as time horizon rather than 2050 is driven by the projections of $CO_2$ intensity of GDP by 2050, which very ambitiously expect to have an almost negligible amount of $CO_2$ emissions per unit of GDP. This assumption makes the calculations less informative by abating variability in the results. Next, delta indicators are computed (Table 3.26). The deltas in Table 3.26 are then normalized, and the results of this process are indicated in Table 3.27. On the other hand, the Relevance Weightings are assigned to each scenario indicator based on the materiality of the transition aspects for the business run by the company, by taking into account the assessments performed previously on this matter.

By combining the Normalized Deltas with the respective Relevance Weightings the score which conveys information about the future potential exposure to transition aspects is obtained, which allows to populate the "heatmap" reported in Table 3.28.

The heatmap highlights that the Policy & Legal is the transition aspect most critical for the company by 2045, followed by Reputation & Brand. The quantification of the financial impact for the financial driver of the Policy & Legal aspect would be computed

Table 3.24: Risks/opportunities for each transition aspect identified for the company target, together with the respective indicator deployed for the scenario analysis.

| **Category** | **Risk** | **Scenario indicator** |
|---|---|---|
| Policy & Legal | New stricter environmental climate policies & regulations at company (i.e. CSRD) and product (i.e. increase in the energy efficiency requirements driven by the EU taxonomy) | *$CO_2$ intensity of GDP* [Mt $CO_2$ per GDP PPP] |
| Market & Technology | Damages to the revenue stream in case of inefficient alignment of the products to the transition to a low carbon economy and/or failure on meeting consumer demand on more energy efficient windows and doors | *Buildings Energy Demand* [EJ] |
| Reputation & Brand | Reputational damages in case of inefficient responses to external stakeholder pressure (e.g. investors, consumers, etc.) on company's climate change performances | *$CO_2$ intensity per capita* [t$CO_2$ per capita] |

Table 3.25: Scenario indicators data for different timeframes.

| $CO_2$ intensity of GDP [Mt $CO_2$ per GDP PPP] | | |
|---|---|---|
| | 2030 | 2045 |
| **STEPS** | 24818 | 15945 |
| **NZE** | 14471 | 1147 |

| Buildings Energy Demand [EJ] | | |
|---|---|---|
| | 2030 | 2045 |
| **STEPS** | 136 | 153 |
| **NZE** | 99 | 87 |

| $CO_2$ intensity per capita [t$CO_2$ per capita] | | |
|---|---|---|
| | 2030 | 2045 |
| **STEPS** | 1.4 | 1.2 |
| **NZE** | 0.9 | 0.2 |

by combining future projections of carbon pricing with current $CO_2$ intensity data of the business.

Table 3.26: Deltas for each scenario indicator.

| $CO_2$ intensity of GDP | | |
|---|---|---|
| | 2030 | 2045 |
| **Delta** [%] | 72% | 1291% |

| Buildings Energy Demand | | |
|---|---|---|
| | 2030 | 2045 |
| **Delta** [%] | 37% | 76% |

| $CO_2$ intensity per capita | | |
|---|---|---|
| | 2030 | 2045 |
| **Delta** [%] | 54% | 545% |

Table 3.27: Normalized Deltas for each scenario indicator.

| $CO_2$ intensity of GDP | | |
|---|---|---|
| | 2030 | 2045 |
| **Delta Normalized** [%] | 3% | 100% |

| Buildings Energy Demand | | |
|---|---|---|
| | 2030 | 2045 |
| **Delta Normalized**[%] | 0% | 3% |

| $CO_2$ intensity per capita | | |
|---|---|---|
| | 2030 | 2045 |
| **Delta Normalized**[%] | 1% | 40% |

## 3.4 Critical review of ERM methodology

In light of a literature analysis of climate risk management and of the application to case studies, some aspects of the methodology employed by ERM to evaluate climate risks of Private Equity portfolios emerged to be limiting factors on the accuracy of the outcomes, even though, overall, it can be considered a robust analysis. Concerning the high-level screening, several limitations are detected. In particular, the case study highlighted a potential overestimation of the physical risks. The resolution of the maps sometimes seems to be not able to provide the level of detail necessary for spatial analysis of single building size. This lower resolution can lead to the oversimplification of risk patterns and the potential oversight of the actual risk exposure. This claim is supported by the observation satellites' acquisitions of the assets under evaluation and by the application of the methodology to case studies. For some climate hazards (i.e. landslides and wildfires) the grid size is problably too large to be representative of the effective risk to which assets are exposed. Indeed, it occurs that the hazardous trigger elements (i.e. bushes and woodlands for wildfires, slope for landslides) are located far away to the asset to the extent to possibly not represent any risk for the facility.

Regarding the evidences from the case studies, the detailed analysis carried out on

Table 3.28: Heatmap of the scenario analysis for transition risks and opportunities.

| **Category** | **Risk** | **Scenario Indicator** | 2030 Transition Aspects' Exposure | 2045 Transition Aspects' Exposure |
|---|---|---|---|---|
| Policy & Legal | New stricter environmental climate policies | *$CO_2$ intensity of GDP* | Limited Risk/Opportunity | Higher Risk |
| Market & Technology | Damages to the revenue stream in case of inefficient alignment of the products to the transition to a low carbon economy | *Buildings Energy Demand* | Limited Risk/Opportunity | Limited Risk/Opportunity |
| Reputation & Brand | Reputational damages in case of inefficient responses to external stakeholder pressure | *$CO_2$ intensity per capita* | Limited Risk/Opportunity | Moderate Risk |

the windows and doors manufacturing asset decreases the risk calculated through the high-level screening, passing from "High" to "Low": while during the high-level screening "Extreme Heat", "Water Stress", "River Flooding", "Coastal Flooding" and "Wildfire" were flagged as highly or medium-highly potentially material, the findings of the scenario analysis confirmed the potential materiality of "Extreme Heat" and "Wildfire" only. Because of the large number of assets and the expected outcomes of the analysis, at this stage no cross comparisons to better estimate the risk are generally performed.

In other cases, the issue depends on how the exposure of the assets is integrated in the analysis. The exposure models employed in some datasets adopt a top-down approach, wherein information pertaining to socio-economic parameters, building typologies, and capital assets at a national or sub-national scale, primarily derived from statistical data, are transposed onto a regular grid. While this approach provides a degree of uniformity and comparability, it tends to introduce limitations by closely correlating risk assessments with demographic factors, neglecting which kind of operations are carried out in the asset. This is particularly relevant for "Water Stress and Drought": the asset is exposed to the materiality of this risk only whether industrial water is used for the operations run by the business. Additionally, the datasets often fall short in considering the broader spectrum of indirect impacts that may result from adverse events related to the supply chain.

Furthermore, for some types of risks (e.g. Hurricane Tracks for Cyclones and Storms and IPCC Interactive WGI Atlas Extreme Heat), a poorly rigorous approach to define the metrics representing the risk is adopted, which is not quantified as the magnitude of the hazard multiplied by the exposure of the element at risk to that hazard, rather proxies are identified to estimate it (e.g. number of days with temperature higher than 35° for Extreme Heat).

In general, different physical risks are addressed with different methodologies, based on data availability: a standardized framework to allow a fair comparison among different risk types is not in place.

Regarding the aggregation of the physical risk scores into a single indicator, even though the non-linearity of the scoring methodology, a dilution of high physical risks among low ones still occurs.

However, as the focus of this stage is to highlight the most critical aspects, the case study shows a quite well distributed percentage of AUM under the different risk classes, making possible a prioritization with a focus for the most exposed assets. Moreover, the overestimation can be seen as the application of a conservative approach to the analysis.

The same objective is effectively achieved at a high level, without differentiation among transition aspects, through transition risk screening. However, it is worth noting that the categorization of portfolio companies based on their economic sector does not always comprehensively capture the actual scope of their operations. This is particularly true for SMEs, as their business activities often have a more limited and focused scope. This claim is supported from the case studies, since the company on which the in-depth analysis was conducted was considered belonging to the "Manufacturing of plastic products" economic sector. However, the company does not manufacture the products "from cradle", instead the most energy and water intensive operations are transferred to the suppliers, while company's business operations begin with the cutting of the PVC profiles.

The questionnaire has the scope of overcoming the inaccuracies present in the high level screening. This is done by gathering more data on the businesses most exposed according to the high level screening in order to customize the analysis. Regarding physical risks, the materiality of potential risks is further investigated as well as the exposure of the supply chain, while for transition risks and opportunities the analysis of the exposure is subdivided into the three transition aspects, and the questions become more company-specific.

The scenario analysis regarding physical risks, performed with CIP, applies a standardized and robust methodology to allow the comparison in terms of magnitude among different physical risks and it comprehends an asset-specific exposure rating. An illustrative example of the concept is to compare how the "Extreme Heat" risk is assessed in the high-level screening through the IPCC Interactive WGI Atlas and how it is evaluated by CIP. While in the first risk thresholds are based directly on the raw data, the second computes a relevant climate hazard indicator starting from the raw data, it applies a normalisation process to the indicator, and combines the indicator with the level of exposure of the asset to the "Extreme Heat" risk.

Nevertheless, it presents some limitations. Its versatility to be used worldwide has the drawback of relying on data less accurate than the historical and/or local data, which often provide more precise and granular information. At this stage of the analysis, there is room for validating CIP's output by cross comparing it with historical data and local maps. Concerning the general approach, another limitation is that the methodology holds the assumption of independence among the physical risks, since they are averaged to determine the overall risk score at the asset location. Within the intricate framework of nature, it is quite common for processes to be interrelated and to interact with one another. There exist various types of interactions between these hazards, and these interactions often result in considerably more severe negative consequences compared to when these hazards operate in isolation [8].

Regarding the transition scenario analysis, the most critical aspect lies in the subjectivity of the assessment. On one hand, the choice of the scenario indicator to be used as proxy of the transition risk/opportunity affects the outcome of the analysis, as well as the Relevance Weightings assigned. On the other hand, a set of assumptions to conduct assessments with this level of detail is essential. For these reasons, their selection should be the result of an open discussion (e.g., workshops) with a client's team composed by different areas of expertise, to be able to factor the majority of the significant aspects in the analysis. Within the perimeter of the limitations, the assessment carried out is rigorous and robust. Scenario delta indicators are used to describe the landscape of risk within which organisations can be expected to operate over a set time horizon. The higher the indicator, the higher the landscape of risk within which the organization will potentially navigate in the future.

# Chapter 4

# Conclusions

The scope of the Thesis was to provide a methodology to effectively fulfil the most technical requirements of the emerging regulations and frameworks regarding the disclosure of climate-related risks and opportunities in the Private Equity sector. From a strategic standpoint, the methodology allows to: recognize how climate risks and opportunities can impact portfolio companies, evaluate portfolio companies exposure through materiality analysis and perform in-depth analysis in case the exposure is material. The subsequent steps to define a comprehensive climate strategy would be the implementation of a tailored action plan to enhance climate resilience and to guarantee ongoing sustainability through a vendor due diligence.

The theoretical principles of the methodology were applied to real-world case studies to add depth to the dissertation. In particular, they were used to test it, and, by integrating a review of relevant studies, strengths and weaknesses of the framework were highlighted.

Regarding the high-level screening, the methodology underscores the importance of evaluating climate risks at a higher level. ERM's experience registered a trend in assessing climate risks on a company-by-company basis, without integrating the analysis in traditional risks management practices that aggregate the risk at portfolio level. This approach induced a concentration of climate risks for some investment portfolios.

The scenario analyses, based on quantitative evaluations, provide a forward-looking companies' exposure to climate risks. On this matter, the "black box challenge" emerged as relevant. Due to ownership of the intellectual property of the tools used to conduct the assessment, the details of the analysis carried out cannot be reported, implying a lack of transparency that negatively affect the overall disclosure to stakeholders [13], undermining TCFD's primary objective.

The last stage of the methodology, the quantification of the financial impact, is the most immature one within the Italian Private Equity sector. SGRs passively received the regulations and the effort to reach their alignment was delayed as much as possible. As a result, the procedure could have not be tested yet and eventually improved where weaknesses were detected.

In conclusion, the Thesis contributes to the disclosure of climate related risks by proposing a methodology to quantify the risks and opportunities related to climate change. Further developments would be the testing of the framework to a wider range of case studies, allowing for a comparative analysis and eventually improve the detected weaknesses. Moreover, the high-level screening could be tested in adjacent fields of work, such as by policymakers to assess in which channels direct institutional fundings. In this context, the high-level screening may be the most applicable approach, as policymakers need to evaluate a large number of companies. The proposed screening seems to be the most compatible, considering the time efficiency and level of detail required by policymakers. However, as explained in section 3.4, when applied to SMEs, the results may be misleading.

Finally, to properly interpret the results of the assessment, it is important to acknowledge the inherent uncertainties of the analysis. Regarding physical risks, climate predictions are not precise due to the complex nature of climate systems. In the case of transition risks, the analysis is based on macro-trends and speculations. For these reasons, the methodologies employed for assessing climate risks and opportunities in the financial sector are continuously evolving, and there is no universally applicable approach. Instead, the field is characterized by ongoing experimentation and refinement of various methods by experts. Therefore, stakeholders and businesses should approach climate risk analysis with adaptability and a recognition of the evolving landscape. This flexibility will be paramount for effective risk management and informed decision-making among the uncertainties of the climate change era.

# Appendix A

# Additional references for climate-related risks assessment

## A.1 High-level transition risks screening

The references reviewed when creating the materiality map for assessing the base score for the exposure to transition risks and opportunities are reported in Table A.1. The

Table A.1: References used as support for the assessment of the base score to transition-related risks and opportunities.

| Risk/opportunity mapping rationale | Source |
|---|---|
| Energy intensity of the sector | Our World in Data, Net-zero Investment Framework: Implementation Guide and U.S. Environmental Protection Agency |
| Carbon Border Adjustment Mechanism | Carbon Border Adjustment Mechanism |
| Potential eligibility under the EU taxonomy | Taxonomy Compass |
| Large emissivity of the sector as a whole, including the supply chain | International Energy Agency, List of raw materials subject to scarcity due to climate change |

references used to complete the high-level transition risk assessment are reported in Table A.2.

Table A.2: References used to complete the assessment.

| Risk/opportunity mapping rationale | Source |
|---|---|
| Company included within the list of energy intensive companies | List of energy intensive companies |
| Company included within the EU ETS scheme | In Italy: Ministero dell'Ambiente e della Sicurezza Energetica, in Europe: European Union Transaction Log |

## A.2 References supporting the Company Engagement process

The reference reviewed during the process of Company Engagement to enlarge the perimeter of the physical risks analysis by investigating the exposure of the supply chain is the Global Risk Index 2021 provided by Germanwatch.

Regarding transition risks, the references checked to increase the level of detail of the analysis are reported in Table A.3.

Table A.3: References used for assessing supply chain exposure to physical risks.

| Risk/Opportunity rationale | Source |
|---|---|
| Carbon Pricing initiatives at Country level | The World Bank: Carbon Pricing Dashboard |
| Countries with TCFD-aligned disclosure requirements | TCFD Status Report 2022: Table D1 |
| List of mined material which might be subject to scarcity due to the transition to a low carbon economy | European Commission: Critical Raw Materials Resilience |
| Climate reporting initiatives performed by the PC | Past Carbon Disclosure Project questionnaire responses |

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