



IIGCC

The Institutional Investors
Group on Climate Change

**Understanding
physical climate risks
and opportunities**



ACCLIMATISE
building climate resilience

About IIGCC

The Institutional Investors Group on Climate Change (IIGCC) is the European membership body for investor collaboration on climate change and the voice of investors taking action for a prosperous, low carbon future. IIGCC has more than 230 members, mainly pension funds and asset managers, across 16 countries, with over €30 trillion in assets under management.

Our mission is to mobilise capital for the low carbon transition and to ensure resilience to the impacts of a changing climate by collaborating with business, policy makers and fellow investors. IIGCC works to support and help define the public policies, investment practices and corporate behaviours that address the long-term risks and opportunities associated with climate change. Members consider it a fiduciary duty to ensure stranded asset risk or other losses from climate change are minimised and that opportunities presented by the transition to a low carbon economy – such as renewable energy, new technologies and energy efficiency – are maximised.

For more information visit www.iigcc.org and [@iigccnews](https://twitter.com/iigccnews).



About Acclimatise

Acclimatise is a specialist advisory and analytics company providing world-class expertise in climate change adaptation and risk management. Founded in 2004, our mission is to make the world more resilient to climate change. We do this by making climate change information useful for our clients, helping them to take the very best decisions in the face of uncertainty.

With offices in the UK, US, India and mainland Europe, Acclimatise has worked in over 80 countries. Our experience spans a wide range of sectors including government, finance, insurance, water, energy, transport, mining, agriculture, defence, food and beverages, and development. Working with corporates, financial institutions and governments around the world, Acclimatise is committed to achieving the greatest impact in driving action on climate change adaptation.

For more information, please visit www.acclimatise.uk.com.



About Chronos Sustainability

Chronos Sustainability was established in 2017 with the objective of delivering transformative, systemic change in the social and environmental performance of key industry sectors through expert analysis of complex systems and effective multi-stakeholder partnerships.

Chronos works extensively with global investors and global investor networks to build their understanding of the investment implications of sustainability-related issues, developing tools and strategies to enable them to build sustainability into their investment research and engagement.

For more information visit www.chronossustainability.com & [@ChronosSustain](https://twitter.com/ChronosSustain).

Acknowledgements

The IIGCC would like to thank the lead author of this publication, Robin Hamaker-Taylor, (Acclimatise) for her work on this report. Acknowledgement also goes to IIGCC members and external organisations who contributed to the the report, namely: John Firth (Acclimatise), Caroline Fouvet (Acclimatise), Dr Rory Sullivan (Chronos Sustainability) with support from Universities Superannuation Scheme and input from IIGCC members.

Contents

Executive summary	1
What this guidance includes	6
01. Introduction	7
02. Understanding physical climate risks and how are they measured	9
2.1. What does the latest science suggest about current and future change to the climate?	9
2.2. Which hazards and impacts are associated with a changing climate?	11
2.3. How are climate scenarios used to model and assess physical climate impacts?	15
03. Getting started on physical climate risk assessment	17
3.1. How this guidance helps investors get started	19
3.2. Examples of getting started and working up to a establishing a process	21
04. Understanding the context	25
4.1. Building knowledge and awareness	27
4.2. Determining available information on investees	32
4.3. Integrating physical climate risks into existing risk management processes	32
4.4. Determining available resources, capacities and responsibilities	32
05. Setting the objectives and scope	33
5.1. Determining purpose, desired outcomes and outputs	35
5.2. Identifying priority portfolio segments	35
5.3. Other variables to consider in setting objectives and scope	37
5.4. Identifying available tools and data	39
06. Physical climate risk assessment	43
6.1. Identifying relevant climate-related hazards	45
6.2. Identifying relevant climate scenarios	45
6.3. Assessing impacts on investments	46
6.4. Examples of physical climate risk assessment methods and outputs	48
07. Physical climate risk-related opportunities assessment	53
7.1. Investing in resilience and resilient investments	55
7.2. Frameworks for investors to help identify opportunities	56
08. Management, monitoring and reporting	59
8.1. Management	61
8.2. Monitoring and review	66
8.3. Reporting	67
09. Annex A: Key definitions	69
10. Annex B: Figures, boxes and tables & acronyms lists	71
11. References	74

EXECUTIVE SUMMARY



The need to assess the impacts from, and adapt to, a changing climate is an emerging challenge for the investment community.

The Earth's climate has already warmed by approximately 1.0°C above preindustrial levels¹. Profound changes are locked into the climate system even if man-made greenhouse gas (GHG) emissions stopped tomorrow. More frequent and more extreme weather and climate events, as well as gradual shifts in rainfall patterns, temperature, sea levels, sea ice and glacial retreat, are some of the changes already underway.

The warming of the Earth's climate has brought the issues of adaptation and resilience to the forefront of investor attention, and a changing climate is increasingly understood as having significant financial risks^{2,3,4}. Despite the growing awareness of the issue, and the pressure for investors to report on how climate change impacts them driven by the Task Force on Climate-related Financial Disclosures (TCFD), the reality is that physical climate risk analysis still constitutes a major challenge for financial institutions and investors. Analysing physical climate risks requires a combination of tools, services and processes to translate scientific climate evidence in a way that speaks to the language of investor risk management. Integration of physical climate risks in mainstream risk management processes is yet to be achieved in many organisations.

This guidance provides a comprehensive entrance point for investors who want to make a start on assessing, managing and reporting on physical climate risks in their portfolios. It targets both asset owners and asset managers, and its aims are twofold:

1. To help investors understand physical climate risks and how they are measured. This guidance provides an overview of the physical climate science and clearly illustrates how physical risks are manifesting and causing financial consequences. This helps to further raise the awareness of asset owners and managers, including both investment decision makers and Environmental, Social and Governance (ESG) staff, and establishes motivation to conduct physical risk and opportunity analysis.

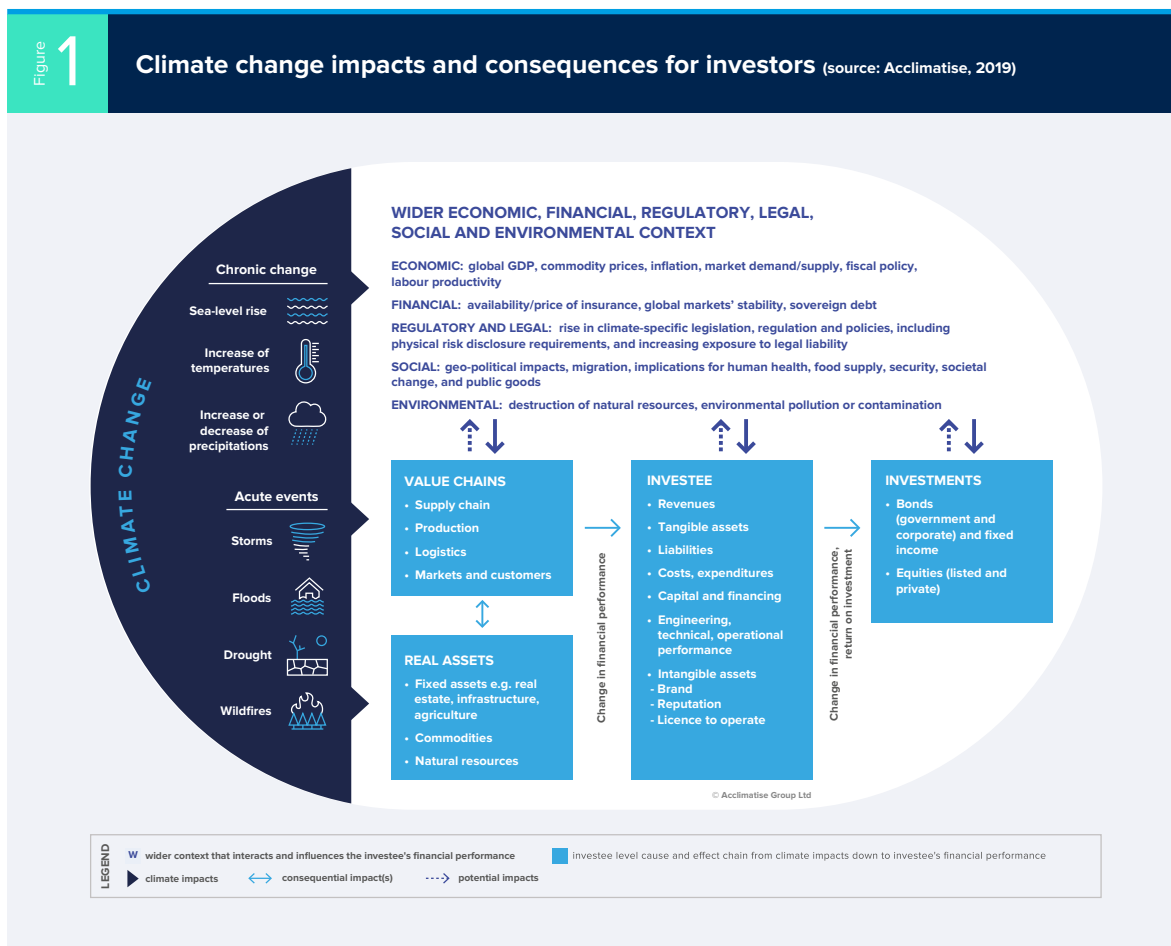
2. To provide investors with practical guidance on how they can begin to analyse, assess and manage the risks and opportunities presented by physical climate hazards (i.e. acute and chronic). This allows investors to understand the wide range of considerations they will need to make, where they can source information, tools and data, and how to tailor the assessment to their needs.

This comprehensive guidance document is complemented by an **additional summary document** for asset owners and asset managers outlining five practical steps to start identifying, assessing, monitoring and managing physical climate risks. The summary document offers an entrance point for investors who want to begin assessing, managing and reporting on physical climate risks in their portfolios.

Understanding physical climate risks and how they are measured

Understanding physical climate risks and associated financial impacts should be grounded in an understanding of the most up to date climate science. Chapter 2 provides a primer for investors on physical hazards, reviewing recent developments in the climate science and illustrating how physical climate hazards can be tracked through to financial impacts on investees.

Acute hazards can be seen in the wildfires in Australia and the USA, drought, flooding and the increasing severity and frequency of tropical storms, with severe impacts on specific locations. Chronic climate change represents the slow, ‘creeping’ manifestations of longer-term climate change over several decades, such as rising temperatures, changes in precipitation patterns, ocean temperatures and sea-level rise. Climate impacts that materialise through both chronic changes and acute climate events have both direct and indirect impacts on investees. Real assets can be damaged and value chains disrupted, affecting their financial performance, e.g. revenues, costs and expenditures. Climate change may also impact the economic, financial, regulatory, legal, social or environmental contexts that investees operate in, further influencing financial performance, with impacts on intangible assets, as shown in the figure below.



Assessments of the economic and financial impacts of climate change require a wide range of information to be gathered. Climate data (observational data and climate projections) needs to be overlaid and combined with other data sets and information, e.g. with financial, business and market data, on investees, and wider socio-economic data. This guidance helps investors visualise the types of information they need to gather to do this work by providing a stylised overview of how the Intergovernmental Panel on Climate Change's (IPCC's) alternative GHG concentration trajectories (known as Representative Concentration Pathways (RCPs)), feeds into climate modelling and downstream impact modelling, including financial modelling (see Figure 6).

Practical guidance on physical risk assessment

This guidance recognises that investors are at different points on their ‘climate change journey’ and outlines a generalised process which can be followed as investors begin to take forward work to identify, assess and manage physical climate risks, wherever they are currently positioned. Investors are presented with key considerations to make and questions to ask themselves along the stages of the process, shown in Table 2 of Chapter 3. The process includes planning stages, assessment stages, and management, monitoring and reporting stages:

Planning

Investors are encouraged to start with the building blocks of a physical risk analysis: understanding the context and setting the scope and objectives.

Early on in their assessments, for examples, investors are encouraged to:

- Determine the available internal resources and capacities;
- Assess the firm’s commitment to setting up and iterating a process;
- Conduct background research to determine known climate impacts and identify available data on assets; and
- Consider which sectors, geographies, or hazards are of importance to determine which should be analysed first.

Investors can shape their assessments in the early stages by carefully setting out their desired outcomes and outputs, selecting an appropriate level of assessment, and considering variables such as timescales and the extent to which direct, indirect and macroeconomic impacts will be considered. These elements of the process are covered in more detail in chapters 4 and 5.



Assessment

Investors are encouraged to shape their assessment of risks and opportunities further. Investors should identify relevant climate hazards scenarios and carefully consider how they bring together the various layers of climate and socioeconomic data required for climate scenario-based physical risk analysis. Investors should consider how they will engage with external experts, if at all, and how to extract and use information available from investees and managers. Investors are encouraged not to overlook the investment opportunities that relate to a changing climate; investors have a vital role to play in ensuring societal resilience is adequately invested in. These elements are covered in more detail in chapters 6 and 7.



Management, monitoring and reporting

Investors are encouraged to evaluate a range of options available to manage the risks and opportunities identified. Investors can review and update risk management frameworks and policies, incorporate current and future potential financial impact of climate-related risks and opportunities into investment decision-making, encourage investee companies and assets to provide data and information that enables a better assessment, and conduct engagement on physical climate risks. Good practice in monitoring and reporting is also reviewed. These considerations are covered in chapter 8.



What this guidance includes

This guidance report collates useful examples and resources for investors who are making a start on assessing physical risk. Resource tables throughout the guidance provide examples of useful sources of background information, sources of analytical tools and datasets, opportunity assessment frameworks and engagement questions. Case studies are also included along the way to illustrate emerging good practice in both risk and opportunity analysis. Peer experience and hypothetical examples are provided throughout the guidance, to illustrate how to bring together relevant climate and other data for physical risk analysis.

By working through critical considerations and questions provided at each stage of a generalised climate risk assessment process, investors can shape physical climate risk and opportunity analysis that is relevant to their individual contexts. This guidance does not set out a 'one-size-fits-all' prescriptive process; it recognises that investors will need to develop an approach relevant to their business model and context. While this guidance presents a linear process, in practice, it will be iterative. Furthermore, investors may not implement all of the steps or they may implement them in a different sequence to that suggested.

As a changing climate alters the fabric of economies, societies and environments across the world, the investors that can act now to both manage physical climate risks and grasp the opportunities to invest in resilience stand to be in the most secure position in the long-term. This guidance report acts as a first step to achieving this.



Summary of content

Investors are provided with practical guidance on how they can analyse, assess and manage the risks and opportunities presented by the physical impacts of climate change.



Chapter 2 provides a primer for investors on physical hazards to ensure that assessment of physical climate risks and associated financial impacts is grounded in an understanding of the most up to date climate science. It reviews recent developments in the climate science and illustrates how physical climate hazards can be tracked through to financial impacts on investees.



Chapter 3 presents a generalised climate risk assessment process, providing guidance on how organisations might start to implement climate change risk assessment processes, and how this might evolve over time as assessment becomes more sophisticated.

The following chapters work through each of the stages of the generalised physical climate risk assessment process, identifying actions that could be considered in each of these stages:



Chapter 4 Understanding the context



Chapter 5 Setting objectives and scope



Chapter 6 Physical climate risk assessment



Chapter 7 provides an overview of opportunities assessment frameworks, highlighting ways that investors can invest in resilience and enable resilient investments.



Chapter 8 works through management, monitoring and reporting actions that investors can establish to allow for their assessments to be kept current in light of changes in the science, in their holdings and in regulatory requirements for investors on climate risk reporting.

Peer experience, hypothetical examples, and resource tables with links to relevant data and tools are provided throughout the guidance, to illustrate how to access background information and bring together relevant climate and other data for physical risk analysis.

This comprehensive guidance document is complemented by an additional summary document for asset owners and asset managers outlining five practical steps to start identifying, assessing, monitoring and managing physical climate risks. See '**Addressing physical climate risks: key steps for asset owners and asset managers**' to open a version of the summary guidance.

INTRODUCTION



01

INTRODUCTION

The unavoidable warming of the Earth's climate has brought the issues of adaptation and resilience to the forefront of investor attention.

Global mean temperatures have already risen by approximately 1.0°C above pre-industrial levels⁵, causing more frequent and more extreme weather and climate events as well as gradual shifts in rainfall patterns, sea levels, sea ice, and glacial retreat, among other changes. Stabilising the climate at 1.5°C or 2.0°C, in line with the Paris Agreement, is the least worst case we can now aim for. 1.5°C or 2.0°C should not be mistaken to be a “safe level” as both will have catastrophic impacts across the world in both developing and developed countries.

A changing climate is increasingly understood as having significant financial risks^{6,7,8}. There are no accepted global estimates for either the loss and damage arising from a changing climate or the global adaptation costs; various sources can be found providing qualified global estimates, but none are sufficiently robust to enable their use in investment decisions. What is clear is that as each new study is released, estimates increase significantly, as the understanding of the climate change impacts on society, the economy and the environment improves. The amount of investment needed to meet adaptation demands over the next 10 years cannot be met by public budgets alone – both public and private finance are needed to meet this challenge⁹.

The imperative to understand, manage and disclose physical climate-related risks has also progressed considerably in recent years due to the emergence of voluntary disclosures frameworks. For example, the TCFD recommendations calls for the analysis of physical risks alongside transition risks. While voluntary climate risk analysis and disclosure grows, regulatory and supervisory bodies are considering or developing mandatory frameworks which include physical climate risk considerations¹⁰. Prominent initiatives include the Network of Central Banks and Supervisors for Greening the Financial System

(NGFS)¹¹, and the body of work taking place under the European Commission action plan on sustainable finance¹². Country-level climate risk disclosure frameworks are also now established in some jurisdictions and unfolding in others, e.g. France and the UK.

Despite the growing awareness of the issue, and the pressure for investors to report, the reality is that physical climate risk analysis still constitutes a major challenge for many financial institutions and investors. This is due to a wide range of factors including the slow emergence of analytical tools and services specifically for investors¹³, a lack of internal capacity in investment firms to operationalise the wealth of climate data now available¹⁴, and a lack of decision useful data provided by investees¹⁵. To date, investor effort on climate change has focused primarily on the need to reduce GHG emissions and to encourage companies along the transition to a low carbon future¹⁶. This emphasis has tended to downplay the investment significance of the physical impacts of climate change. Investors who focus their strategic ‘climate change’ responses only on transition will be failing in their fiduciary responsibilities and may be creating legal liabilities.

This guidance aims to enable investors to better understand and act on physical climate-related risks and related opportunities. It makes a unique contribution to current guidance available in the public domain by focusing entirely on physical climate risks and related opportunities. It builds on a set of reports published by four institutional investors (Universities Superannuation Scheme, Railpen, Insight Investment and Henderson Global Investors, with input from Acclimatise) in 2008-2009¹⁷, presenting investors with a comprehensive review of considerations to make in physical risk analysis and management.

A satellite image of a powerful hurricane with a well-defined eye and swirling cloud bands over a dark blue ocean. The text is overlaid on the left side of the image.

UNDERSTANDING PHYSICAL CLIMATE RISKS AND HOW ARE THEY MEASURED

02



UNDERSTANDING PHYSICAL CLIMATE RISKS AND HOW ARE THEY MEASURED

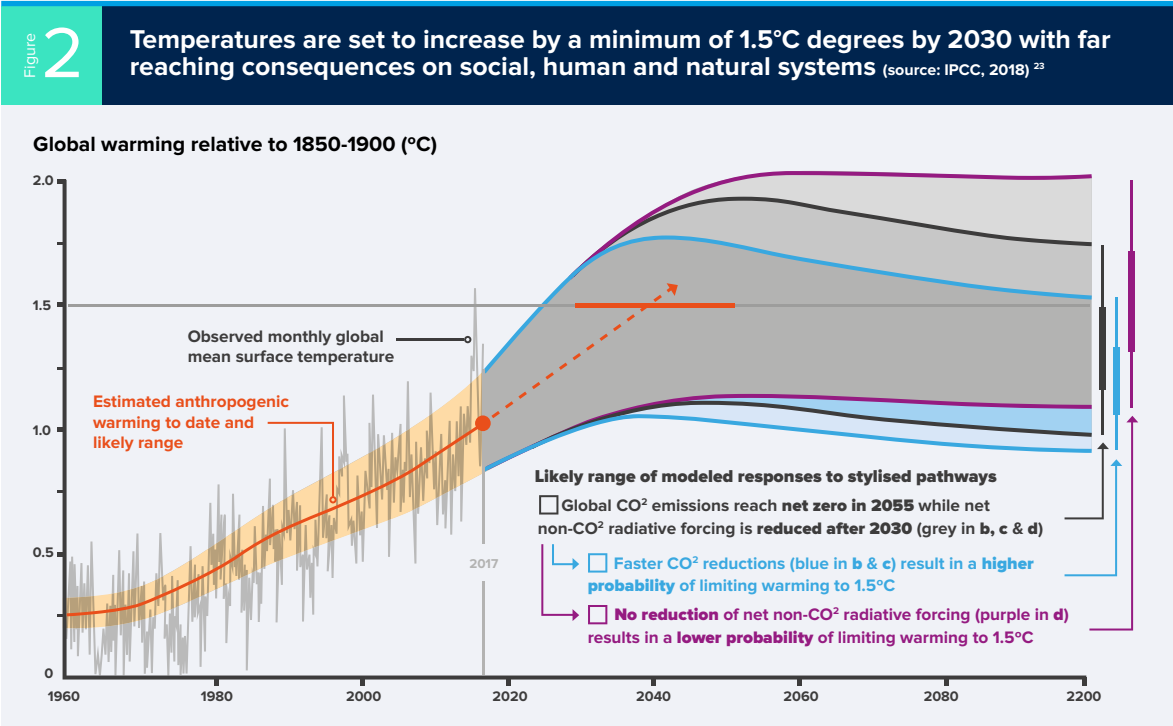
2.1 What does the latest science suggest about current and future change to the climate?

The Earth's climate has warmed significantly over the last century, and human activities such as burning fossil fuels have already caused approximately 1.0°C of global warming above pre-industrial levels¹⁸.

Recent years have been the hottest since direct temperature observations began (in the 1880s), and the six warmest years on record have all occurred since 2010¹⁹. More frequent and more extreme weather and climate events are already being experienced, along with gradual shifts in other climate-related factors (rainfall patterns, sea levels, sea ice, glacial retreat).

Consequent changes in the climate system are therefore locked into the earth's climate system over coming decades and centuries, regardless of the success and rate at which global GHG emissions are controlled. Investors are already feeling the impacts of the changes in climate that have already occurred.

Global mean surface temperatures are set to increase by a minimum of 1.5°C degrees by 2040 (Figure 2). This will mean unavoidable far-reaching consequences on social, human and natural systems²⁰. After 2040, there is less certainty about what will happen, as this depends on how quickly GHG emissions are curbed. The current high-end climate scenario suggests that global warming may reach up to 4°C by the end of the century with associated widespread impacts²¹. Related chronic impacts include a gradual increase in global precipitation over the 21st century, and 0.45 to 0.82m sea level rise by 2081–2100, among others. More hot extremes are also expected, along with more intense individual storms and associated extreme precipitation events. Decreases in soil moisture and increased risk of drought are also increasingly likely in currently dry regions²².



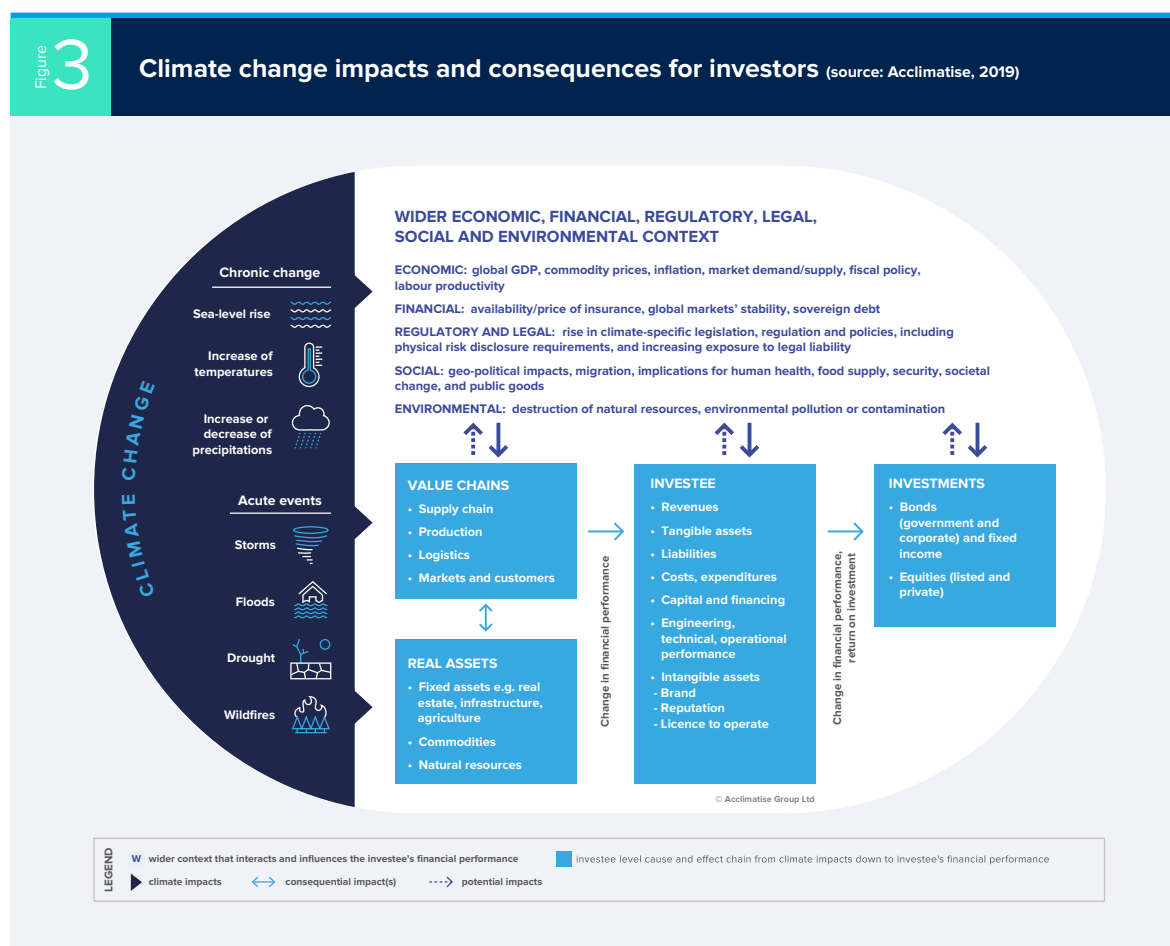
Climate change is a complex issue, with inherent uncertainty about the timing, pace, tipping points and severity of possible impacts. By responding to the risks and opportunities associated with future climate change methodically and comprehensively, investors can ensure they implement prudent and cost-effective actions, which both ensure resilience and deliver strong financial returns even in the face of uncertainty.

2.2 Which hazards and impacts are associated with a changing climate?

A changing climate can lead to changes in the frequency and severity of extreme or incremental hazards. The TCFD recommendations refer to these hazards as acute and chronic, respectively (Table 1). Acute hazards represent severe and extreme events and are location specific (e.g. droughts, heatwaves, storms, wildfire, etc). Chronic climate change represents the background incremental changes in, for example: temperature, precipitation and sea-level rise over several decades.

Acute	Chronic
<div><ul style="list-style-type: none">- Storms (cyclones, hurricanes and typhoons)- Extreme rainfall- Extreme heat- Heatwave- Flood- Drought- Wildfires- Heatwaves</div> <div>Example impact: loss of crops in the agricultural sector following extreme heat/precipitation.</div>	<div><ul style="list-style-type: none">- Variability in precipitation- Variability in temperature- Water stress- Sea-level rise- Land degradation</div> <div>Example impact: reduced river flow negatively affects the operability of hydropower facilities.</div>

Climate impacts that materialise through both chronic changes and acute climate events have both direct and indirect impacts on investees. Real assets can be damaged and value chains disrupted, affecting their financial performance, e.g. revenues, costs and expenditures. Climate change may also affect the economic, financial, regulatory, legal, social or environmental contexts that investees operate in, further influencing financial performance (Figure 3).



Due to the highly contextual nature of physical climate risks, it is challenging to provide a definitive assessment of the extent to which a sector, geography, company, or asset... etc, is riskier than others. The physical risks of one business may not be the same for another business in the same sector due to their ability to adapt, their governance and strategic planning. Similarly, physical hazards in a given region may affect various locations in that region differently. Whether and when physical risks are recognised or priced will differ depending on the asset class.

Sectors involving primary economic activities, however, are typically particularly sensitive to the consequences of climate change due to their immediate dependence on the natural environment. Chapter 5 provides examples and discussion of how certain asset classes and sectors may be vulnerable and exposed to climate change. Countries with lower levels of resilience, or those that are in parts of the world where the climatic changes and consequences will be more pronounced and face increased vulnerability.

Case Study 1 and Case Study 2 present two examples of how climate change-related events affected the physical assets of companies in recent years, and how the associated ripple effects at the national and/or global level combined to eventually affect their financial performance.

CASE STUDY ONE

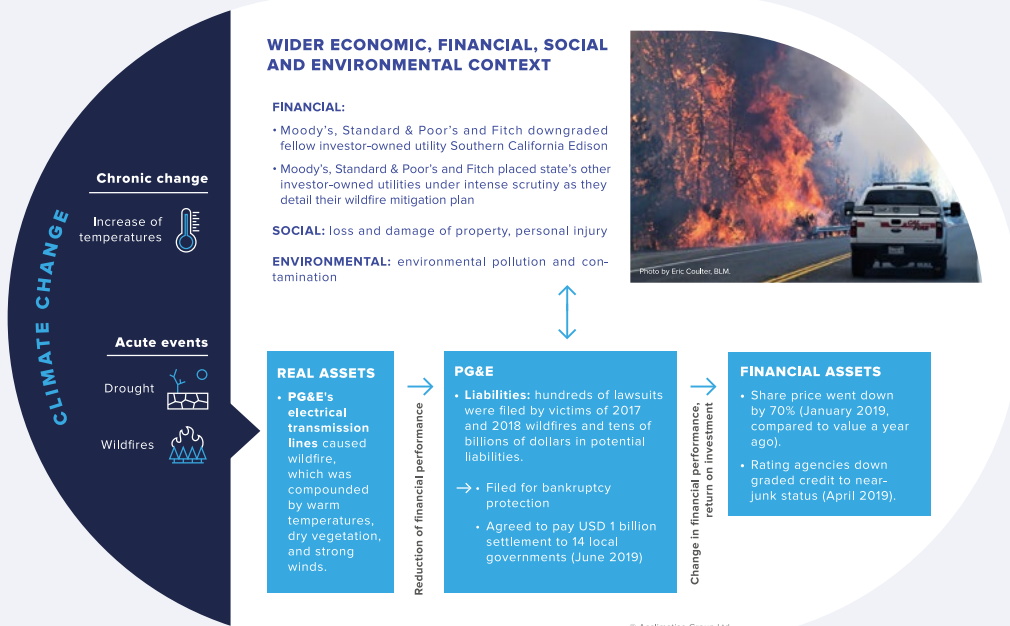
Mapping climate cause and effect chains in the electricity transmission and distribution sector: the case of wildfire and Pacific Gas and Electric Company (PG&E)



Figure 4

Increased temperatures with drought and wildfires contributed to the bankruptcy of US utilities firm PG&E (source: Acclimatise, 2019²⁶)

ELECTRICITY TRANSMISSION & DISTRIBUTION: WILDFIRE IN CALIFORNIA



LEGEND

W wider context that interacts and influences the investee's financial performance

investee level cause and effect chain from climate impacts down to investee's financial performance

▶ climate impacts

↔ consequential impact(s)

---> potential impacts

The 2018 Camp Fire was the deadliest and most destructive wildfire in California state history²⁶, causing estimated losses of USD 16.5 billion²⁷ and killing 86 people. Drought and strong winds helped to fuel the fire, along with the local terrain²⁸. Investigations determined that this fire and several other 2017 wildfires were caused by PG&E's electrical transmission lines, conductors and the failure of power poles^{29,30}. For example, investigations determined that fires were started when vegetation fell onto electrical distribution lines owned and operated by PG&E, who were found to be in violation of California state regulations requiring strict vegetation management practices by utilities³¹. California state regulations allow utilities to face significant liability in wildfire disasters, known as 'inverse condemnation liability'. These regulations meant PG&E could be liable for property damages as well as attorneys' fees. In January 2019, PG&E filed for bankruptcy protection after facing hundreds of lawsuits from victims of 2017 and 2018 wildfires and tens of billions of dollars in potential liabilities. Liabilities arising from the company's responsibility for contributing to a climate change exacerbated natural hazard led to Forbes declaring the "first of many climate change bankruptcies"³².

Beyond PG&E, these events had consequences for other Californian utilities and may continue to do so, as illustrated in Figure 4. Rating agencies including Moody's, Standard & Poor's, and Fitch downgraded fellow investor-owned utility Southern California Edison and placed the state's other investor-owned utilities under scrutiny as they detailed their wildfire mitigation plan³³. Utilities similar to PG&E may not be able to insure their way out of these types of risks in the future - PG&E's previous annual reports have suggested they felt their insurance may not be sufficient to cover losses caused by an operating failure or catastrophic event, and that a concern was the potential lack of affordability and availability of coverage going forward³⁴.

CASE STUDY TWO



Mapping climate cause and effect chains in the manufacturing sector: the case of floods and Western Digital

Figure 5

Storms and floods contributed to substantial disruptions to Western Digital's value chains and real assets (source: Acclimatise, 2019³⁹)

MANUFACTURING AND IMPACTS OF THAILAND FLOODS: GLOBAL HARD DISK PRODUCER WESTERN DIGITAL



LEGEND

W wider context that interacts and influences the investee's financial performance

investee level cause and effect chain from climate impacts down to investee's financial performance

▶ climate impacts

↔ consequential impact(s)

---> potential impacts

Extreme precipitation led to extensive flooding in Thailand in 2011³⁶, which resulted in substantial disruptions of supply chains in manufacturing and other sectors. The manufacturing sector comprised 39% of Thai Gross Domestic Product (GDP) in 2011, and the floods took a heavy toll on the national economy, with Thailand's 2011 annual GDP growth declining from midyear estimates of 4.0% to 2.9%³⁷. One of the world's largest hard disk drive producers, Western Digital, had its factories flooded, leading to 46 days of production stoppage and loss of 45% of its shipments³⁸. In December 2011, Western Digital announced a 60% drop in the company's revenue for that quarter, compared with the preceding year, given the company's high concentration of supply chain factories in flooded areas³⁹.

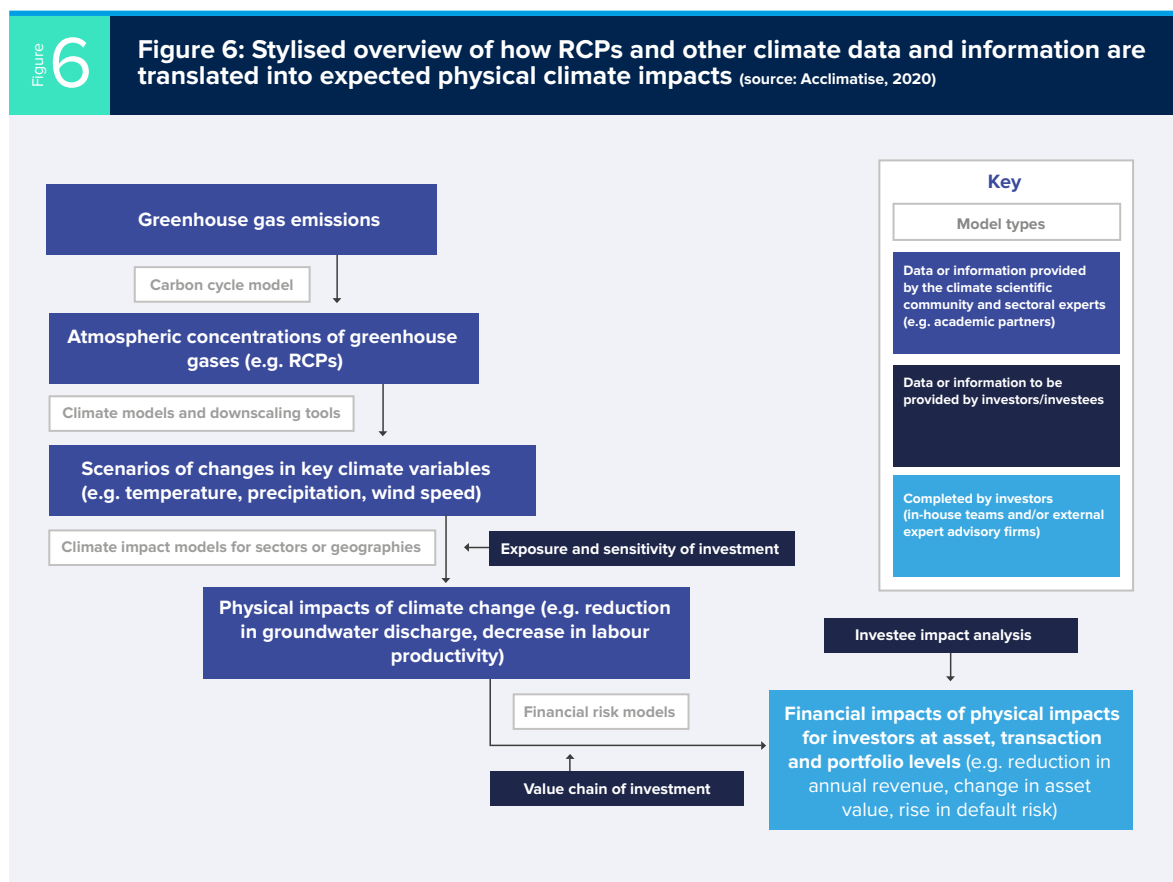
Western Digital's production decline had a large influence on both the Thai economy and global industrial production. As the firm produces one-third of the world's hard disks, and its production decline contributed to a global production drop that translated into a 27.7% reduction in hard disk drive (HDD) shipments and a 10% rise in HDD prices during Q4 of 2011. This further affected computer technology companies, as illustrated in Figure 5.

2.3 How are climate scenarios used to model and assess physical climate impacts?

Physical climate impact assessments integrate climate change projections and responses of natural and human systems to such projected changes. Outputs from climate models are the main data source for deriving climate change projections, or climate change scenarios^I. Climate models use, as key inputs, estimates of atmospheric concentration of GHG as provided in RCPs. RCPs prescribe alternative GHG concentration (not emissions) trajectories and have been adopted by the IPCC^{II} for its most recent Assessment Report (AR5). Four particular RCPs, describing contrasting but plausible climate futures, have been selected for climate modelling and research: RCP2.6, RCP4.5, RCP6, and RCP8.5^{III}. Driven by RCPs and other datasets, climate models simulate, in an internally consistent manner, changes in a wide range of climatic variables (e.g. temperature, precipitation, wind speed) throughout the 21st century and beyond.

To assess impacts of projected changes in climate variables, the ways that economic sectors and activities respond to changes in climatic conditions are studied, in either a statistical (e.g. econometrics) or process-based (e.g. crop modelling) manner.

Figure 6 provides a stylised overview of this modelling chain, showing how RCPs are interpreted into expected physical climate impacts. As shown in the figure, much of the modelling and analysis will be completed by the climate scientific community, which will then need to be translated into impacts by investors, investees, and/or their external advisors.



I Climate change scenarios can also be developed from other sources/methods, for example, by synthetically adjusting baseline climatology (e.g. +0.5, 1.0, 1.5°C to annual average temperature; + or – 5%, 10%, 15% of annual rainfall amount for a particular location), or stochastically generated from observed climate.

II The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change, providing regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. For more information, please see: <https://www.ipcc.ch/about/>

III RCPs are labelled after a possible range of radiative forcing values in the year 2100: 2.6, 4.5, 6.0, and 8.5 W/m², respectively. In turn, these four RCPs are associated with a range of average global annual temperature rise (scenarios) in the year 2100 with respect to 1986-2005: ~1.0, ~1.8, ~2.2, and ~3.7°C, respectively. See Chapter 6 for more information on selection of scenarios and RCPs for use in physical risk assessment.

To assess the economic and financial impacts of climate change, climate data (e.g. observational and climate projections) needs to be combined with other data sets and information (e.g. financial, business and market data, investee, and wider socio-economic data). Climate model outputs based on RCPs are used to analyse how different climate scenarios may affect various sectors of the economy or regions of the world. Climate model outputs, for example, are combined with asset-level data, e.g. exposure and sensitivity data, including location, quality, or critical thresholds data. Together, this information can develop climate impact assessments (also called climate risk assessments or impact modelling). Financial modelling then allows for impact assessments to capture how physical climate change can impacts may have financial impacts, e.g. how an economy is impacted through changes in yield and price of agricultural commodities, or how property values in locations exposed to extreme weather events will be impacted.

Additional impact analysis can be provided by investees who have conducted their own analysis. Investors may be able to utilise this analysis in their own climate impact assessments, as discussed further in Chapters 4 and 6.



GETTING STARTED ON PHYSICAL CLIMATE RISK ASSESSMENT



03



GETTING STARTED ON PHYSICAL CLIMATE RISK ASSESSMENT

Many investors are only beginning to consider physical climate risks and the potential impact on their portfolios.

Table 2 outlines a process which can be followed as investors begin to take forward work to identify, assess and manage these risks. Given that investors are at different starting points, some will see the assessment of physical climate risks as a relatively narrow, one-off exercise, whereas others will see it as a more extensive, portfolio-wide process which is repeated regularly. Investors getting started may wish to use the **key steps** guide accompanying this document as the basis for initial actions.

Some investors may start with smaller pieces of analysis and before deciding on whether they should

establish a more comprehensive process. Investors may choose to start with the available expertise from teams already in place (e.g. responsible investing teams) and data from existing research providers. These early analyses could allow for internal capacity-building and are useful as an initial entry point building on the information already to hand. Having a well-established review and monitoring element to the analysis can allow for the learning developed in these smaller initiatives to evolve into a wider climate risk assessment process down the line.



3.1 How this guidance helps investors get started

Investors should start physical risk analysis by understanding the context and setting the scope and objectives. Starting with these two elements will bring together the building blocks of a physical risk analysis, for example:

- Determining the available internal resources and capacities;
- Assessing the firm's commitment to setting up and iterating a process;
- Conducting background research to determine known climate impacts and identify available data on assets; and
- Considering which sectors, geographies, or hazards are of importance to determine which should be analysed first.

These elements (understanding the context; setting the objectives and scope) are covered in more detail in chapters 4 and 5.

Investors should then move into the risk assessment process itself, assessing risks and opportunities, identifying risk management options, taking action and monitoring and reviewing the effects of these actions. These elements are covered in more detail in chapters 5 through 8.

Investors will ultimately need to conduct analysis and establish processes tailored to their own unique business models and goals. While Table 2 presents the process as a linear one, in practice, it is an iterative process. Furthermore, investors may not implement all of the steps or they may implement them in a different sequence to that suggested by Table 2.

Table
2**Common elements to consider in a physical climate assessment process & corresponding questions for investors**

Element	Investors should be able to answer these questions:
Understanding the context	<ol style="list-style-type: none"> 1. Has relevant background information been gathered? (e.g. information on investees, regulatory contexts, known impacts, and how peers are assessing and developing relevant climate risk assessment initiatives). 2. How can climate change considerations be integrated into existing risk assessment and decision-making processes? 3. What resources are available for the assessment (e.g. time and budget), who needs to be involved and who within the organisation will be responsible?
Setting the objectives and scope	<ol style="list-style-type: none"> 4. Have the purpose, desired outcomes, and desired outputs of the analysis been clearly defined? 5. At which level will the analysis be conducted? (i.e. asset/transaction level, asset class, or portfolio level). 6. Will climate risks and opportunities be covered? How will sector and geographies be covered? 7. What timescales will be used for the analysis? (i.e. what future time periods will be considered?) 8. Which portfolio segments should be prioritised? 9. Will physical climate risks across the whole value chains of investees be considered? 10. Will climate impacts on macroeconomic performance be considered? (including macroeconomic impacts to assets through to whole portfolios). 11. What tools and data are available that will best support your assessment?
Physical climate risk assessment	<ol style="list-style-type: none"> 12. Which range of chronic and acute climate-related hazards will be analysed? 13. Which climate scenarios will be used, and has longer term analysis used a 4°C scenario? 14. How will various layers of climate and socioeconomic data needed for climate scenario based physical risk analysis be brought together? (e.g. climate impact data, critical thresholds, investee-level data, etc.).
Analysis of physical climate risk-related opportunities	<ol style="list-style-type: none"> 15. Which type of opportunities will be screened for? Which emerging frameworks could be used to identify these opportunities?
Monitoring, management and reporting	<ol style="list-style-type: none"> 16. Have a range of risk management responses, including engagement been considered? 17. How will physical climate risk and opportunity assessments be integrated into your existing monitoring processes, what will be monitored, and how often? 18. Are emerging regulations and supervisory expectations around reporting and disclosure being followed and reflected on? 19. Who will the information resulting from the analyses be provided to? How, and when? 20. Have disclosure frameworks been meaningfully engaged with to ensure accurate reporting and reduce liability?

3.2 Examples of getting started and working up to establishing a process

CASE STUDY THREE

Analysing physical climate risks and opportunities: experience from European Bank for Reconstruction and Development (EBRD)



EBRD initiated pilot work on climate resilience investment (or adaptation investment) as early as 2010. For historical reasons, EBRD focused initially on identifying and developing climate resilience opportunities, but more recently – and in the light of TCFD recommendations – the bank is now complementing this with an emerging approach on physical climate risks.

In this way, EBRD intends to develop an approach in which the risks and rewards associated with physical climate change are routinely assessed as part of investment development and reflected in investment design and financing terms where appropriate.

- **Climate resilience opportunities:** Initially, EBRD focused on developing a small portfolio of demonstration investments in sectors that are highly exposed to physical climate risks, for example hydropower and ports, in order to pilot approaches and develop expertise on the integration of climate resilience measures into its investment process. Building on this experience, from 2012 onwards the EBRD adopted a systematic approach to screening project pipelines for climate resilience opportunities, at an early stage in investment development (i.e. at the exploratory or concept stage). This has resulted in a portfolio of more than 170 climate resilience investments by mid-2019, with a total business volume exceeding EUR 7 billion. In addition, the EBRD has developed and adopted a practical approach to estimating the climate resilience outcomes of these investment in both physical and valorised terms, as set out in EBRD's Green Economy Transition Handbook⁴⁰.
- **Physical climate risks:** EBRD has paid close attention to the recommendations of the TCFD and has considered carefully the implications for its assessment, management and disclosure of physical climate risks. This led to EBRD becoming the first Multilateral Development Bank to become a TCFD supporter in April 2018, and to launching together with the Global Center on Adaptation (GCA) a major report on TCFD physical climate recommendations in 2018⁴¹. Building on this, the EBRD is now in the process of developing a systematic approach to integrating climate considerations – including physical climate risk – into its risk management function. This work will result in all EBRD projects being screened, and where appropriate, assessed in terms of its exposure to physical climate risk. In due course, these physical climate risks may begin to be sized and priced into financing decisions in line with evolving best practices.

CASE STUDY FOUR

Getting started – hypothetical analysis for infrastructure investments

Background

An investment firm focusing on direct investment infrastructure in the energy sector sees the recent impact of the 2017 and 2018 wildfires on California utility company PG&E (see Figure 4). The firm's investment committee seeks to understand what potential physical climate risks they might be exposed to in future investments in power transmission and distribution.

Understanding the context – resources

The committee tasks an analyst at the firm with understanding how other energy infrastructure, apart from that operated by PG&E might be impacted. In the early stages, the firm has encouraged the analyst to use internal experts before turning to external support as this is an initial piece of work and the current year's budget did not include it.

CASE STUDY FOUR

Getting started – hypothetical analysis for infrastructure investments continued

Understanding the context – background information

The analyst conducts a desk-based review and identified the 2017 Lender's Guide for Considering Climate Risk in Infrastructure Investments⁴². This guide provides snapshots of infrastructure sub-sectors, including energy transmission and distribution, highlighting further evidence of physical climate impacts, including those relating to revenues; costs; and tangible and intangible assets.

Setting the scope

The analyst determines that the desired outcome for this piece of work is an investment appraisal screening protocol or criteria as the investment committee suggested they want to understand risks in future investments. This protocol is developed to pilot with several new investments in power transmission and distribution, as the deals come through due diligence.

The analyst understands that the Eastern United States is the area where most of the firm's investment activity in this type of energy infrastructure is located, based on deals they see in the pipeline. This leads them to look at the US National Climate Assessment, which reveals that much of the infrastructure in the Northeast, including power supply, among others, is nearing the end of its planned life expectancy⁴³, which the analyst understands to mean that most of the infrastructure there, including that which might eventually be in their upcoming deals, may require substantial investment to continue operation. The National Climate Assessment also sets out key impacts, which include intense extreme precipitation events that are projected to increase the risk of floods for coastal and inland energy infrastructure.

Physical risk assessment

Though the firm makes direct infrastructure investments, they are not involved in the upstream development of projects (i.e. the projects have been built before the firm gets involved). The firm, therefore, cannot influence the project development and consideration of physical climate risks during the construction phase. As such, the analyst determines that instead they will seek to understand which longer-term projections on precipitation and flooding were factored in during the development and construction phase, and to understand any plans the utility company in question has with regards to adapting its current infrastructure, as well as how they will fund that planned adaptation. The analyst conducts further research into what makes energy infrastructure resilient, by consulting the 2019 Resilience Shift primers for electric utilities⁴⁴. The examples in that resource help the analyst understand potential impacts to that type of infrastructure, and allows for criteria relating to the incorporation of adaptation solutions to be developed. The investment firm implements the screening criteria based on evidence of impacts to flag potential high-risk companies or assets.

Monitoring and management

For identified high-risk companies, the firm engages, using a structured questionnaire, to understand how risks have been assessed, to understand how these risks have been incorporated into valuations, and to agree with the company the actions that should be taken to mitigate these risks and/or build resilience. Following experience in the development and application of screening criteria for several projects, the firm is looking to extend the scope of its assessments to all infrastructure holdings, and it is currently developing a broader set of screening criteria that would support this work.

CASE STUDY FIVE

Getting started - hypothetical analysis for commercial real estate investments

Background

An investment firm is looking to carry out a first analysis on part of its portfolio. As the firm has a large commercial real estate portfolio, budget is allocated for analysis in this portfolio segment. The firm has long included climate change as part of its due diligence process for transaction screening but has traditionally not revisited these parts of the due diligence, e.g. to amalgamate them at portfolio level.

Understanding the context – gathering background information and assessing available resources

Analysts have read Institutional Investors Group Climate Change's 2018 report, 'Addressing Climate Risks and Opportunities in the Investment Process'⁴⁵ and recognised that real estate investments are subject to hazards including increased and persistent incidence of flood risk, cyclones (hurricanes and typhoons), storm damage and fires, depending on geography and adaptive capacity. After seeing analysis from other prominent investors around physical climate risks associated with commercial mortgage backed securities (CMBS)⁴⁶, analysts hold internal discussions around the possibility of conducting this analysis on their portfolio. Further internal discussions lead to the understanding that these hazards could have direct impacts to their holdings such as asset damage, and that this could lead to higher insurance costs and decline in value of property assets. These discussions highlight that it also is apparent that these hazards could have further indirect impacts, for example, interrupting their investees' business continuity. Although flood risk assessments have been done as part of due diligence on individual transactions, further analysis across the portfolio is considered valuable. These will assess longer term risks based on forward looking climate impact models, rather than relying on historic data and to consider indirect risks and portfolio-wide aggregation of risk.

After reviewing the 2019 ClimateWise report which presents a physical climate risk framework for real estate⁴⁷, the analysts start to understand which types of information they need to gather for their analysis. For example, analysts see that asset-level data is an important part of the analysis and begin to collect available data on their commercial real estate holdings. The report indicated that that useful asset-level data for this analysis includes construction type and year, roof type, number of floors, occupancy and square footage, in addition to the geographic location. This initial step reveals potential barrier to analysis, as it becomes clear that the firm does not appear to hold all elements of detailed asset-level information that may be relevant.

After their initial literature review, analysts agree to conduct a review of their commercial real estate portfolio for physical climate risks. Further desk-based research is carried out, which indicates that for the commercial real estate portfolio in Europe, inland flooding is likely a key risk and that for their coastal real estate in the US, a primary risk will be sea level rise⁴⁸.

While analysts understand that flood maps are readily available from meteorological offices in many European countries and in the US and that these are frequently used to assess concentrations of risk in portfolios, the firm is unclear on how to operationalise these type of maps and to ensure they take into account longer term forecasts based on climate modelling as they do not yet have staff with relevant capabilities in-house (e.g. Geographic Information Systems specialists). Analysts determine they need external expertise to bring together flood mapping and climate impact models and information on their holdings to run the analysis. External analysts are selected.

Setting the scope

External analysts recommended a portfolio-wide screen be conducted to determine which areas warrant further quantitative analysis, bearing in mind that the purpose of the analysis has been set by the investor to quantify potential losses. To narrow down the scope and keep within budget for this project, the focus will be on the commercial real estate portfolio in Europe, leaving the analysis of coastal real estate for the following year.





CASE STUDY FIVE

Getting started - hypothetical analysis for commercial real estate investments continued

Physical risk assessment

To address the issue of not having comprehensive asset-level data, external analysts suggest several approaches that they can take to assist the investment analysts, ranging from using a representative sample of assets, to collection of data through a survey of companies, to procuring asset-level proxy data. External analysts also look at the adaptive capacity of their investees, including continuity insurance. The adaptation plans and programmes for jurisdictions of interest to determine the extent and quality of support provided to businesses in the case of a flooding event. The analysis provides present day losses of the portfolio from inland flooding events and expected losses in the 2050s.

Monitoring, management, and reporting

The investment analysts consider these results internally to understand how they analysis will influence future investing within the organisation. Specifically, they aim to consider how the results will impact portfolio management, investment strategy, and the extent to which these risks will feed into their risk appetite statement. More comprehensive data collection on assets to allow improved screening of flood risks at the real estate investment level during existing investment appraisal due diligence stages is agreed as an initial measure. To manage the risks identified in the analysis, the firm also plans to conduct further engagement with real estate investees to better understand their consideration of climate adaptation needs and to obtain more detailed asset-level data, with a view to setting threshold criteria for future investment decisions based on level of flood risk. As the firm are planning to disclose the findings in their upcoming financial reporting, internal analysts work with reporting teams to convey the approach taken, results and metrics used. The firm agrees to consider another similar review in three to five years' time.

UNDERSTANDING THE CONTEXT



04



UNDERSTANDING THE CONTEXT

The first step in the process for taking forward risk assessment and management will be to understand the context that the process will take place in.

There are several dimensions to understanding the context. This includes understanding the available science and information that will inform an assessment and, alongside this, the baseline conditions within your organisation that shape how and why an assessment will take place. This chapter covers both dimensions. Chapter 2 can also be used to understand high level contextual information relating to the physical climate science. As mentioned in Chapter 3, this step and the following (setting the objectives) can be carried out in an iterative manner.

Questions for investors:

- Has relevant background information been gathered? (e.g. information on investees, regulatory contexts, known impacts, and how peers are assessing and developing relevant climate risk assessment initiatives)
- How can climate change considerations be integrated into existing risk assessment and decision-making processes?
- What resources are available for the assessment (e.g. time and budget), who needs to be involved and who within the organisation will be responsible?



4.1 Building knowledge and awareness

Building knowledge around climate science and physical climate impacts relevant to the investment portfolio is an important first step in understanding the context. Investors should, where relevant, consider available information on the following areas including:

- Climate change science, including both climate models and impact models;
- Sectoral climate change impacts (e.g. climate change risk/impact assessments, macroeconomic modelling studies);
- Geography-specific impacts (e.g. national climate change risk assessments); and
- Investment regulatory and policy contexts in which the organisation operates.

Investors need not become completely conversant in climate science or climate impact studies. Rather, they should aim to build up background knowledge and improve their knowledge of physical climate risks by tapping into the wide and constantly evolving body of literature relating to climate change impacts, adaptation, and resilience.

The tables below (in sub-sections a-c) contain further resources relating to gathering contextual information related to a physical risk assessment. These tables are not exhaustive but indicate the wide body of available literature in this space. Section 5.4 of this guidance provides examples of analytical tools and climate data in more detail.

a. Information on climate science and known impacts

The IPCC Climate Change 2014 Synthesis Report is a good place to start when becoming familiar with climate science, as the report brings together the findings of the three IPCC working groups^{iv}.

The Synthesis Report includes a summary for policymakers which provides an accessible overview of the main scientific information. There is also a wide body of literature on sectoral and geographic specific impacts, as indicated in Table 3 which provides some examples of resources.

^{iv} IPCC working group I (WG I) aims at assessing the physical scientific basis of the climate system and climate change; WG II: assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change and options for adapting to it; and WG III: WG III focuses on climate change mitigation, assessing methods for reducing greenhouse gas emissions, and removing greenhouse gases from the atmosphere.

Table
3

Examples of sources of information on climate impacts

Topic	Resource examples (non-exhaustive)	Description and link
Climate change science and general introduction	National Oceanic and Atmospheric Administration (NOAA) climate platform	NOAA climate platform provides authoritative scientific data and information about climate. It includes information on climate variables including temperature, sea level, snow, ocean heat, as well as background information, case studies, and event tracking, among others. https://www.climate.gov/
	IPCC 5th Assessment Report (AR5), Working Group II: Impacts, Adaptation, and Vulnerability	The report provides a summary of available authoritative scientific studies globally on climate impacts and adaptation potential for sectors, and regions. It includes data from available climate impact studies in regions or sectors of interest. https://www.ipcc.ch/report/ar5/wg2/
	Nature Climate Change academic journal	This is a prominent peer-reviewed journal covering all aspects of research on global warming, the current climate change, especially its effects. It includes data from available climate impact studies in regions or sectors of interest. https://www.nature.com/nclimate/
	Proceedings of the National Academy of Sciences	The official journal of the National Academy of Sciences is a peer-reviewed authoritative source of high-impact, original research that broadly spans the biological, physical, and social sciences. It includes data from available climate impact studies in regions or sectors of interest. https://www.pnas.org/
	Institute and Faculty of Actuaries (IFoA)	The IFoA Resource & Environment (R&E) Board has commissioned a series of working parties to prepare a number of practical guides to support actuaries who are considering how to appropriately include resource and environment matters, including climate change, into their work. See the practical guide: 'Climate Change for Actuaries: An Introduction' for a useful overview and introduction of the main effects of climate change and impact on natural and human systems, based on IPCC AR5. https://www.actuaries.org.uk/practice-areas/resource-and-environment/resource-and-environment-practice-area-practical-guides
Sectoral impacts	Transport – rail	UIC (International Union of railways) is a sectoral association that provides data on known climate impacts to rail infrastructure and case studies. https://uic.org/sustainable-development/environment/adapting-to-climate-changes
	Transport – ports and waterways	PIANC (Permanent International Association of Navigation Congresses - The World Association for Waterborne Transport Infrastructure) is a sectoral association that provides data on known climate impacts to port infrastructure and case studies. https://navclimate.pianc.org/

Topic	Resource examples (non-exhaustive)	Description and link
Sectoral impacts	Real Estate and Infrastructure	The Global Real Estate Sustainability Benchmark (GRESB) report provides information on how leading real estate and infrastructure companies and funds are taking action to address climate resilience. http://gresb-public.s3.amazonaws.com/2018/Documents/Resilience_Report.pdf
	Mining	The International Council on Mining and Metals is a sectoral association that provides data on known climate impacts to mining and metals firms and case studies. https://www.icmm.com/en-gb/environment/climate-change/climate-change-adaptation
	Individual companies	Carbon Disclosure Project (CDP) provides information and data on disclosed climate impacts on individual companies of interest and actions to manage them. https://www.cdp.net/en/data
	Proceedings of the National Academy of Sciences	The official journal of the National Academy of Sciences is a peer-reviewed authoritative source of high-impact, original research that broadly spans the biological, physical, and social sciences. It includes data from available climate impact studies in regions or sectors of interest. https://www.pnas.org/
Geography specific impacts	Cities	A CDP database on adaptation actions for cities, states, regions provides information on disclosed climate impacts on municipalities of interest and actions to manage them. https://data.cdp.net/browse?category=Adaptation%20Actions
	National Climate Assessment – USA	National Climate Assessment provides information on the different known climate impacts across the USA. https://nca2018.globalchange.gov/
	National climate change vulnerability and risk assessments in Europe, 2018	National climate change vulnerability and risk assessments in Europe provides information on the national climate change impact, vulnerability and risk assessments in Europe. https://www.eea.europa.eu/publications/national-climate-change-vulnerability-2018

See section 5.4 for further information on tools and portals relating to climate data and information.

b. Information on regulatory and policy contexts

Publicly available documents relating to climate change policies and national impact studies, such as those emanating from the United Nations Framework Convention on Climate Change (UNFCCC)^v process (e.g. National Adaptation Plans (NAPs) or Nationally Determined Contributions (NDCs)) are a good place to start when seeking to understand the adaptation needs in a given country. Investors should also take into account the growing interest of regulators and supervisors in climate risks. Table 4 provides examples of resources.

Table 4	Examples of sources of information on regulatory and policy contexts	
Topic	Resource examples (non-exhaustive)	Description and link
Regulatory and policy contexts	NGFS reports	NGFS has published reports for central banks on how to integrate climate considerations in financial regulation, indicating imminent regulatory action for financial institutions in 40+ jurisdictions. https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system
	European Commission's Technical expert group (TEG) on sustainable finance	The TEG has developed the European Union (EU) Sustainable Finance Taxonomy, which provides criteria to determine whether an economic activity contributes to adaptation or mitigation. It is also working on other initiatives such as an EU Green Bond Standard and methodologies for EU climate benchmarks and disclosures for benchmarks and guidance to improve corporate disclosure of climate-related information. https://ec.europa.eu/info/publications/sustainable-finance-technical-expert-group_en
	UK Financial Conduct Authority (FCA) publications	The FCA publishes consultations and feedback statements on the oversight of climate risks in regulated financial institutions in the UK. https://www.fca.org.uk/publications/feedback-statements/fs19-6-climate-change-and-green-finance
	Bank of England (BoE)/ Prudential Regulatory Authority's (PRA's) publications	The BoE publishes guidance documents, supervisory and policy statements for financial institutions the BoE supervises. https://www.bankofengland.co.uk/climate-change
National climate change policy frameworks	NAPs	Official NAP documents identifying medium- and long-term adaptation needs and strategies to address these needs in countries of interest. https://unfccc.int/topics/adaptation-and-resilience/workstreams/national-adaptation-plans-naps/publications-naps
	Nationally Determined Contributions (NDCs)	Official documents for NDCs relating to emissions reductions plans and adaptation measures in countries of interest. https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx and https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs

^v For more information please see: <https://unfccc.int/>.

c. Information on emerging climate risk analysis practices of peers and the private sector

Investors can review what other financial institutions are undertaking around physical climate risk and opportunity assessment and disclosure to build their understanding of what can be reasonably expected of them. Sources of information could be other investors' TCFD or other disclosures, publicly available climate strategies, and publicly available literature which collates investor best practice.

Disclosures by companies in investment target sectors may also be helpful. These disclosures and publications may highlight physical climate impacts to key sectors of interest and give ideas on Key Performance Indicators and identify relevant stakeholders. Climate disclosures should be regarded with a critical eye, however, as good practice around these is still emerging⁴⁹. Table 5 provides examples of resources to consider.

Table 5

Examples of resources and initiatives relating to peer action on climate risk analysis

Resource examples (non-exhaustive)	Description and link
Asset Owners Disclosure Project (AODP) best practice case studies	AODP assesses 75 of the world's largest asset managers on their approach to responsible investment. The publicly available assessment has a focus on climate change, human rights and biodiversity. Physical risk is covered under the report 'Winning climate strategies'. https://aodproject.net/wp-content/uploads/2018/06/AODP-WinningStrategiesReport.pdf
FCA / PRA Climate Financial Risk Forum (CFRF)	The CFRF was set up by the UK FCA and PRA, with four technical working groups on disclosure, scenario analysis, risk management and innovation. Working groups will develop practical guidance / best practice material in 2020. https://www.fca.org.uk/transparency/climate-financial-risk-forum
Coalition for Climate Resilient Investment (CCRI)	CCRI is a private sector-led coalition aiming to create the frameworks and tools to price climate risks and facilitate resilience investments. By the UNFCCC COP26 in 2020, analytical tools including a physical risk pricing framework and methodology to prioritise national resilient investment needs, will be developed, alongside a range of instruments to prevent capital flight from the most vulnerable regions, such as a technology transfer programmes, technical assistance and/or blended finance. Going forward, innovative capital market instruments such as Resilience Bonds will be structured, and the pricing framework will be implemented across resilient infrastructure investment funds. https://www.adaptation-undp.org/sites/default/files/uploaded-images/coalition_for_climate_resilient_investment_cas_launch_.pdf
Investors Group on Climate Change (IGCC) report, From Risk to Return: Investing in Climate Change Adaptation	This report from IGCC looks specifically at how to increase investment in adaptation, providing experience from investors. https://igcc.org.au/wp-content/uploads/2017/03/Adaptation_FINAL.pdf
Mainstreaming Climate in Financial Institutions	Platform designed to help organisations implement the TCFD recommendations by providing hundreds of relevant insights, tools and resources including TCFD disclosures and reports by peers and corporates. https://www.tcfdhub.org/
TCFD Knowledge Hub	Platform designed to help organisations implement the TCFD recommendations by providing hundreds of relevant insights, tools and resources including TCFD disclosures and reports by peers and corporates. https://www.tcfdhub.org/

4.2 Determining available information on investees

Investors should determine early on what data they currently hold and can easily access on the companies and entities they invest in. Investee-level data is typically a fundamental data gap that investors will need to overcome. External data providers or analysts can provide solutions to missing asset-level data. Third-party data on investees can relate to data on the business itself, e.g. value chains, tangible assets (including location data), intangible assets, countries of operation and financial data. Caution should be exercised in using third party data, as they can often be incomplete.

In addition, valuable information is likely to be contained in the disclosures made to or under frameworks such as TCFD, PRI, GRESB, SASB, and the EU Non-Financial Reporting Directive, CDP, and PRI frameworks, or in other public reporting may be useful. For example, as CDP has aligned their climate change questionnaire with TCFD's recommendations⁵⁰ it would be a good place to look, as would CDP's water questionnaire. These disclosures can provide information on the climate-related exposures of investees and measures they are taking to address them, which could help shape investors' physical risk analysis. See Chapter 6, section 6.3 for further discussion.

4.3 Integrating physical climate risks into existing risk management processes

Investors should aim to integrate physical climate risk analysis into their existing systems and processes, rather than creating new standalone processes. Investors will already have risk and investment decision-making tools, systems and processes (e.g. risk assessment tools, screening tools, risk acceptability criteria). They should adapt these to include physical climate risk, rather than developing new tools, systems and processes.

Investors should familiarise themselves with the risk metrics already in use in their organisation. To ensure the analysis is useful, the outputs of the analysis should align with these metrics to the extent possible.

4.4 Determining available resources, capacities and responsibilities

Organisations should agree the available time and budget for conducting the analysis. This will help determine the scope and depth of analysis that is to be conducted. Early on, investors need to evaluate the internal capacity to take on physical risk and opportunity analysis, and the extent to which it is useful, necessary and possible to procure external support.

Investors need to evaluate who is best placed to lead and contribute to the analysis. Investment teams and committees, risk and compliance teams, sustainability or environmental and social risk teams, and senior management should all be involved. Regardless of if internal or external support is preferred, investors should aim to involve a cross-cutting team in the analysis. A well-rounded team from various backgrounds and disciplines will ensure that relevant perspectives and needs from different functions are taken into account, and there is buy-in from across the organisation. A cross-cutting team may unlock further resources (time and budget) from other areas of the business. The coordination role amongst various teams should not be underestimated as active facilitation of the collaboration will be required⁵¹.

Adequate board oversight and senior management ownership of the assessment or wider process should be established, as recommended by the TCFD⁵². Staff with the ability to embed the outputs of the framework in the firm's operations and with sufficient authority to ensure that the outputs inform decisions should lead the assessment and wider development of the risk assessment process⁵³. Ideally, this would help guarantee the assessment is adequately funded and monitored.

SETTING THE OBJECTIVES AND SCOPE



05



SETTING THE OBJECTIVES AND SCOPE

Once the context has been considered, the next step is to set the objectives and scope. As mentioned in Chapter 3, this and the previous step (understanding the context) can often be carried out in an iterative manner.

Questions for investors:

- Have the purpose, desired outcomes and desired outputs of the analysis been clearly defined?
- At which level will the analysis be conducted? (i.e. asset/transaction level, asset class, or portfolio level).
- Will climate risks and opportunities be covered? How will sector and geographies be covered?
- What timescales will be used for the analysis? (i.e. what future time periods will be considered?).
- Which portfolio segments should be prioritised?
- Will physical climate risks across the whole value chains of investees be considered?
- Will climate impacts on macroeconomic performance be considered? (including macroeconomic impacts to assets through to whole portfolios).
- What tools and data are available that will best support your assessment?

5.1 Determining purpose, desired outcomes and outputs

Investors should seek to define a clear purpose for each physical risk analysis, which considers what the assessment or wider process hopes to achieve (i.e. desired outcomes) and who will use it. Defining a clear purpose may be iterative as available resources become clear, and consideration of how the analyses fit in with their firm's wider strategic objectives has been made.

Determining the extent to which qualitative or quantitative outputs of the assessment are preferred will help shape the analyses. For quantitative outputs, investors need to identify core metrics currently used to assess risk and tailor the assessment or wider process to gather data and information which shows how these metrics will change. For qualitative outputs, it is important to consider the intended audience to ensure the narratives produced will be relevant.

Table 6 provides simplified examples of varying purposes, associated end users and associated desired outputs.

Table 6	Examples of various purposes for physical risk analysis and associated outputs (source: Acclimatise 2019)		
Sample purpose	Sample desired outcomes	Example outputs (non-exhaustive)	Sample primary end users of outputs
Investee engagement	Investee company has increased awareness of certain physical risks and improved imperative to manage them.	Investor produces high level summary of risks it has identified during risk assessment (qualitative).	Analysts (internal) and investees.
Disclosure	Regulatory expectations are fulfilled.	Mixture of qualitative and quantitative information.	External stakeholders including regulators and beneficiaries.
Investment decision making	Investment recommendations are better informed and new opportunities identified.	Quantitative analysis with metrics used by internal risk analysts; analysis for both risks and opportunities.	Quantitative analysis with metrics used by internal risk analysts; analysis for both risks and opportunities.

5.2 Identifying priority portfolio segments

Investors may wish to consider ways to prioritise portfolio segments for more detailed analysis. Investors, for example, can start with the asset classes, sectors, or geographies where they are most exposed (of the largest size or value), and check if these sectors or geographies are typically sensitive to climate impacts.

Investors can also prioritise an asset class or sector known to be climatically sensitive, as evidenced by the literature. Table 7 presents information on potential physical impacts to certain asset classes and is intended to indicate entry points for investors considering which portfolio segments to start analysing. It is important to regard this indicative information with caution. Physical climate hazards will impact asset classes, sectors, and geographies in various ways as suggested in Chapter 2, section 2.3. A phased approach, where an initial high-level screen points to the need for more in-depth review of segments which are shown to be riskier, is also a good practice option to identify priority segments of a portfolio.

Table 7 Examples of expected physical risks across asset classes^{54, 55}

Asset Class	Examples of financial risks stemming from physical hazards
Government/ Sovereign bonds	Countries with high exposure to climate-related weather events may require greater public sector funds to finance adaptation. These capital demands may limit the country's ability to borrow for other purposes.
Municipal bonds	Coastal cities are exposed to sea level rise. Direct financial losses and/or a reduced tax base following extreme events could increase the probability of local governments defaulting on their debts.
Corporate bonds	Companies and assets which experience repeated and persistent damage from climate-related weather events may see the value of their bonds fall or be required to pay a higher coupon when issuing new bonds.
Listed equities	Cashflows and profitability may be reduced as a result of climate-related supply chain disruptions.
Real Estate/Property	Insurance costs may be higher, and prices lower for property assets that are at high risk from climate-related weather events.
Private Equity	Some assets may realise lower prices because they are located in climate vulnerable locations.
Infrastructure	Water and transportation infrastructure have a useful life of 30-200 years, while power plants have lifespans of 20-60 years. This long-term nature exposes these assets to changing climate conditions over future decades, such as sea-level rise, shifts in temperature, and alterations in precipitation patterns.

Primary economic activities are often particularly sensitive to the consequences of climate change due to their immediate dependence on the natural environment; examples include agriculture, forestry, fishing and extractive industries. Other particularly climatically sensitive sectors include water, electric power and transport⁵⁶. On the basis that they have the highest potential cost of insuring their physical assets, Schrodgers found that that oil and gas, utilities and basic resources are the sectors most exposed to the physical impact of climate change⁵⁷. That analysis also identified the sectors least at risk are technology, personal & household goods and healthcare. However, these sector assessments can be misleading: other recent analysis found that parts of the technology sector (e.g. Information and Communications Technology) are extremely vulnerable to high temperatures due to the increased need for cooling⁵⁸. Similarly, healthcare including hospitals and care homes are extremely vulnerable to the health impacts of extreme events, e.g. the 2003 heatwave in Europe⁵⁹.

5.3 Other variables to consider in setting objectives and scope

a. Levels of assessment

Several levels investors may consider include asset/transaction level, asset class, mandate/portfolio, or fund level depending on the objectives for the assessment.

The level of assessment should ultimately be selected in line with the purpose and desired outcomes. If investors are looking to inform and guide strategic management decisions, a portfolio-wide screen and portfolio-level stress test can be useful⁶⁰. If the aim is to inform investment decisions, a transactional level screen during due diligence may be appropriate. The frequency of the assessment should be considered as well – for example, if it is a one-off assessment, or if it will be part of an ongoing screening of individual transactions.

Physical climate risk assessment will differ at each of these levels, and complexity will increase as more assets are analysed. Investors may wish to start out with a transactional screen, though analysis of systemic (portfolio-wide) risks should be the eventual aim as these may be missed by conducting analysis at the portfolio level. Asset owners in particular may be best placed to analyse systemic risks in their holdings, as asset managers may not have access to all of the necessary information across the investment chain.

b. Timescales

Understanding how physical risks impact investments requires investors to understand and navigate varying time horizons. These include the timeframe of an asset life, of the financial exposure, and those associated with investor mandates and investor objectives⁶¹, some of which may be shorter than the timeframes used in climate models and impact studies. Generally, climate models indicate longer term impacts from 2040 onwards. However, investors may want to assess impact over shorter timescales. Alternative methods can therefore be used in instances where investors are not comfortable with longer term climate analysis, e.g. that based on climate model projections out to 2050 or 2100. The impacts seen currently and over the previous 30 years will likely continue to be seen until at least 2040, as some amount of climate change is locked in. Investors can therefore opt to work with experts who analyse the impacts of climate change over the last 30 years. This historical analysis, known as near-term trends analysis, uses correlations of historical events and losses, which can provide indicators of near-term impacts. Work is continuing in the academic and research communities to improve the scenarios and provide decadal forecasting.

Investors are encouraged to reconsider having only a short-term outlook, as recommended by the TCFD⁶². Evidence from other areas of the finance sector suggests limiting risk analysis to a shorter timeframe may underestimate the exposure. In particular for institutional investors who are often matching longer term liabilities with long-term assets it will be important to consider short-, medium- and long-term impacts of physical climate change.

c. Direct, indirect, and macroeconomic impacts

Investors should consider if the assessment will cover both direct and indirect impacts. Assessing climate impacts on fixed (physical) assets is the first straightforward link to assess physical climate risk. The effects of concern may not be confined to direct impacts and may include how climate change affects investee companies' value chains, and how this translates in terms of their financial performance, including impact on intangible assets such as brand and reputation.

Macroeconomic impacts should be considered where possible. This means understanding the potential financial, economic, legal, social and environmental dimensions that can affect the entity's financial performance, and how these dimensions interact with one another. For example, increasing temperatures and shifting precipitation patterns may affect the agriculture sector in a given country, which may affect GDP. This can in turn affect the country's ability to access debt markets.

d. Inclusion of both risks and opportunities

Investors should consider if assessments for both physical climate risks and opportunities will be produced. Chapters 6 and 7 discuss risk and opportunity analysis in more detail, respectively. This needs to be determined when setting out the purpose. The TCFD recommendations suggest both are assessed and disclosed. Investors need to determine if and when analysis for opportunities is to be included when setting the assessment process scope. If information on specific opportunities is considered commercially confidential, it may be possible to disclose future areas of interest in general terms rather than specific investment opportunities.



5.4 Identifying available tools and data

Investors need to identify the climate data and tools that are available to analyse physical climate risks in their holdings. Not all sectors and geographies have been studied in the literature equally. Becoming familiar with the wide range of tools and services available will assist in determining what support is available. Investors can consult their current research data providers, conduct an in-house review of tools and services or consult recent publicly available reviews of tools and services. Table 8 suggests a non-exhaustive list of types of climate services currently available that investors could screen.

Table 8 Examples of climate data, tools and services currently available ^{63, 64, 65}		
Types of climate services and description	What these services are for and who provides them	Examples (non-exhaustive) and links
Climate data portals and platforms		
<ul style="list-style-type: none">• Data portals for upstream satellite data• Data portals and datasets for information on climate variables (e.g. atmosphere, ocean, climate indices, reanalyses and satellite data, etc.)• Data portals for information on climate projections• Data portals and datasets for information on extreme events• Climate change studies (e.g. agriculture, energy sector... etc.)• Mapping tools and overview portals provided by financial institutions	<p>The service provides access to ‘upstream’ data on essential climate variables (ECVs) (temperature, precipitation, etc.). The service is typically produced by governmental or research bodies.</p>	<p>Aqueduct Global Flood Analyzer: Assess river flood risks by country, river basin, or state; by population, GDP, or urban damage; current or future (2030). https://floods.wri.org/#/</p> <p>Climate Central: An independent organisation of leading scientists and journalists researching and reporting the facts about the changing climate and its impact on the public. E.g. the Sea Level Rise program assesses and maps coastal threats globally, researches the intersection of social and physical vulnerability on U.S. coasts, and is pioneering a new generation of online tools and visualisations. https://sealevel.climatecentral.org/about/</p> <p>Climate Explorer from The Royal Netherlands Meteorological Institute: Web application to analyse climate data. Includes range of climate model outputs, observational data and climate indices. https://climexp.knmi.nl/</p> <p>National meteorological office datasets e.g. UK Met Office; Finnish Meteorological Institute. https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index</p> <p>Open Access Hub from Copernicus, European Space Agency, and European Commission: Provides access to Copernicus satellites (Sentinel-1, Sentinel-2 and Sentinel-3) user products. https://scihub.copernicus.eu/</p> <p>Oasis Hub: Aggregates catastrophe, extreme weather and environmental risk data, tools and services, as well the provision of data set enhancement, development and data aggregation services. https://oasishub.co/</p> <p>ThinkHazard!: Provides a general view of hazards, for a given location, that should be considered in project design and implementation to promote disaster and climate resilience. http://thinkhazard.org/en/</p>

Table 8

Continued

Types of climate services and description	What these services are for and who provides them	Examples (non-exhaustive) and links
Open access shared information		
<ul style="list-style-type: none">• Publicly available climate data and case studies• Publicly available guidelines and metrics• Publicly available courses	The service provides access to publicly available case studies or training, and is produced and shared by members of a sector. Can include good practice, metrics, experiences that others can learn from.	<p>‘Advancing TCFD guidance on physical climate risks and opportunities’ report, EBRD and GCA with advisory firms Acclimatise and Four Twenty Seven: Presents a set of recommendations for corporates to follow to inform and support early efforts to adopt the TCFD recommendations. Areas covered include metrics for physical climate risk management and disclosures, metrics for climate resilience opportunities, and metrics for climate intelligence for business strategy and financial planning.</p> <p>UNEP-FI Climate Change: Risks and Opportunities for the Finance Sector Online Course.</p> <p>https://www.unepfi.org/training/training/climate-change-training/</p> <p>https://www.unepfi.org/training/training/climate-change-training/</p>
Analytical tools, platforms, and methods		
<ul style="list-style-type: none">• Tools, methods, and services for the finance sector, including:<ul style="list-style-type: none">- portfolio hotspot screening;- investment appraisal;- financial modelling.• Methods/platforms/tools provided by climate risk specialists (beyond finance sector)• Macroeconomic modelling (e.g. Integrated Assessment models (IAMs), Computable General Equilibrium (CGE) model, etc.)	The service provides access to methodologies which overlay data on assets and data on ECVs to determine financial impacts of climate change. It is provided by climate risk advisory firms and is typically referred to as ‘downstream’ climate services because they involve the processing and organisation of information in order for it to be applied successfully to financial holdings.	<p>Acclimatise Aware for Projects platform: Provides an easy three-step process to screen a company or project for exposure to physical climate risks using climate model projections and observed climate data.</p> <p>http://www.acclimatise.uk.com/analytics/applications/</p> <p>Four Twenty Seven climate risk scores in equity portfolios: A method for analysing climate risk exposure of companies and activities and sectors they are involved in.</p> <p>http://427mt.com/our-solutions/</p> <p>JBA Risk Management: Provides flood maps, catastrophe models, analytics and consultancy services.</p> <p>https://www.jbarisk.com/</p> <p>XDI dashboard - provides governments and business with risk analytics to optimise investments and assure climate resilience.</p> <p>http://xdi.systems/</p> <p>See the United Nations Environment Programme Finance Initiative (UNEP-FI) TCFD pilot with investors⁶⁶, Hamaker-Taylor et al. 2018⁶⁷, EBRD and GCA, 2018⁶⁸, or PRI 2018⁶⁹ for detailed lists of examples of additional analytical tools.</p>

Types of climate services and description	What these services are for and who provides them	Examples (non-exhaustive) and links
Additional publicly available literature		
<ul style="list-style-type: none"> • Emerging literature targeted at investors • Literature which reviews tools for investors or summarises good practice. 	<p>Additional publicly available information on impacts or sensitivities in sectors, geographies, or asset classes of interest, which can be used to raise awareness and build capacity internally. The examples provided have been written by experts or specialist organisations.</p>	<p>UNEP-FI literature for investors: https://www.unepfi.org/investment/investment/</p> <p>Cambridge Institute for Sustainability Leadership literature on sustainable finance: https://www.cisl.cam.ac.uk/resources/sustainable-finance-publications/sustainable-finance</p> <p>IGCC report: Investing in Resilience: Tools and frameworks for managing physical climate risk: https://igcc.org.au/wp-content/uploads/2016/04/IGCC-investing-in-resilience_AUG_Final.pdf</p> <p>McKinsey Global Institute 'Climate risk and response' report: Provides data on climate impacts covering 105 countries, with nine case studies. https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts</p>



PHYSICAL CLIMATE RISK ASSESSMENT

06



PHYSICAL CLIMATE RISK ASSESSMENT

With the objectives, scope, and context clarified, investors can then proceed to undertake assessment of physical climate-related risks.

Questions for investors:

- Which range of chronic and acute climate-related hazards will be analysed?
- Which climate scenarios will be used (e.g. 2°C; 4°C) and has longer term analysis used a 4 °C scenario to capture a full range of impacts?
- How will various layers of climate and socioeconomic data needed for climate scenario based physical risk analysis be brought together? (e.g. climate impact data, critical thresholds, investee-level data... etc.)



6.1 Identifying relevant climate-related hazards

Physical climate risk assessments need to consider the impact of both acute and chronic hazards. Chronic hazards may be as important as, if not more, than acute hazards⁷¹. See Section 2.2 and Table 1 for more information.

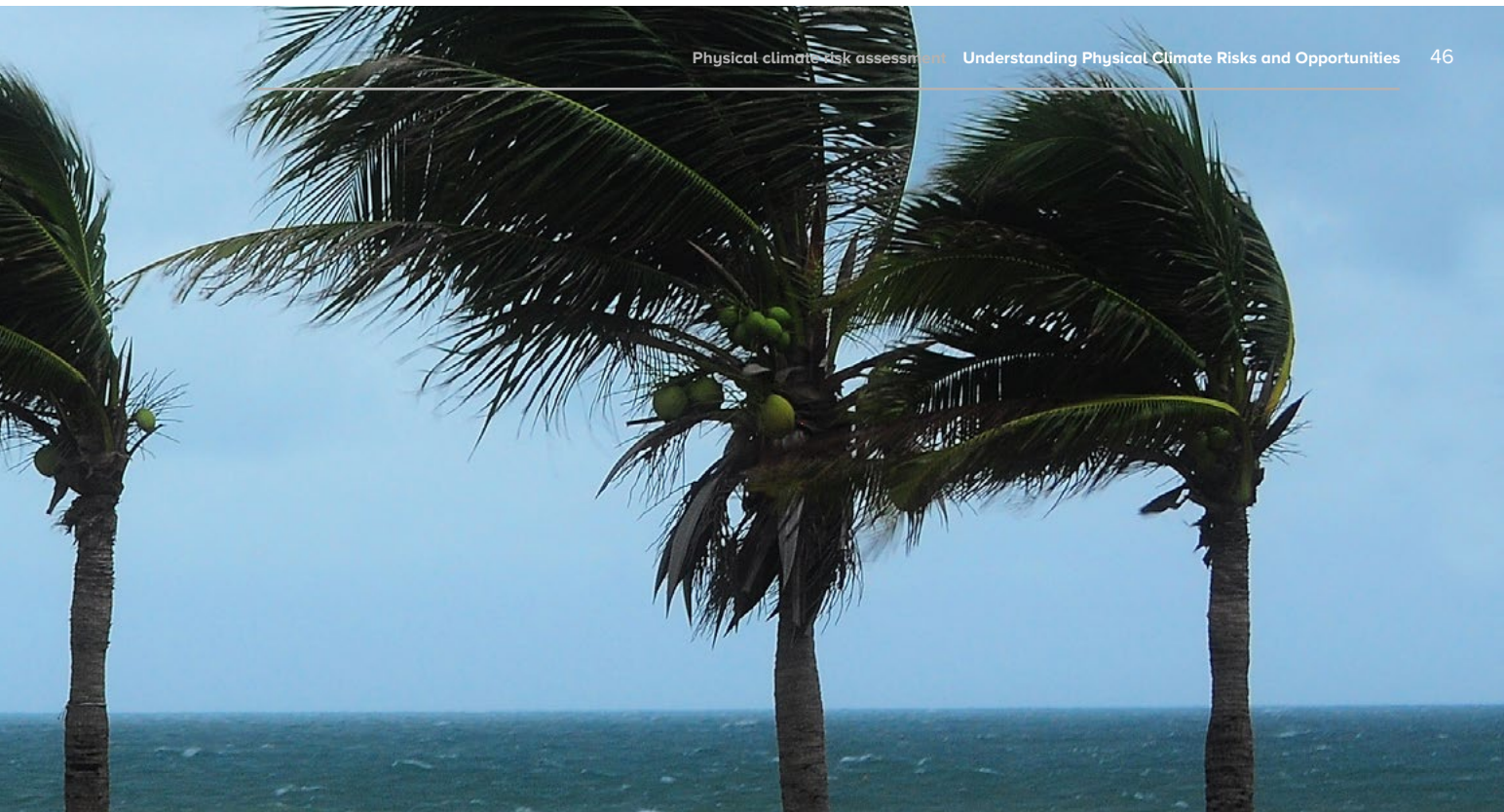
Not all hazards will be relevant for all investors. Investors should seek to understand which hazards are particularly relevant for the geographies where their holdings are located. Investors can identify relevant hazards by looking at the sectors they have prioritised (by size or value), or looking at sectors listed out in Chapter 5, section 5.2 and determining which hazards are particularly relevant for the geographies where they may hold these assets. Some hazards will be more obvious than others, due to extensive media coverage, e.g. acute hazards such as wildfires in Australia, Canada or the Western United States, drought in Southern Africa, and tropical storms in south Asia, China and Japan. However, investors should be careful to ensure that chronic hazards are not overlooked.

6.2 Identifying relevant climate scenarios

For near- and mid-term analysis, investors can consider the range of impacts under a single scenario. In the near-term to mid-term (2020s-2040s), changes in the climate system due to past and present-day GHG emissions are already locked in, and the physical risks are already being felt (see Chapter 2, section 2.1). There is no significant difference in physical risk in the 2020s under different scenarios based on RCPs, and only a small divergence by the 2040s. That is, a 1.5°C or 3°C scenario will not show a difference in the near-term to mid-term (2020s-2040s). Therefore, choosing the correct climate scenario becomes more important the further out the analysis looks.

For longer-term analysis, at least two climate scenarios should be used to ensure risks have been considered in a range of potential climate futures. Over the longer-term, the degree of physical risk is largely determined by which GHG emissions trajectory is followed from now (2020s) onwards; if high emissions continue to go un-mitigated, the extent of climate change is expected to be significant by 2100, and if emissions are curbed, climate change will be less extreme. Investors should explore both potential climate futures, using a higher and lower scenario. A 2°C scenario (based on RCP 2.6)⁷¹ represents a likely best-case situation. A 4°C scenario (based on RCP 8.5) represents the very high end of what might be expected, so represents a reasonable worst-case situation. However, as part of defining the assessment to be undertaken, an investor should consider the probabilities of different scenarios and agree an appropriate range of scenarios to be considered. The IPCC periodically adopts updated GHG concentration trajectories/pathways (such as RCPs), so investors should keep informed to ensure their assessments are based on the most up to date information.

⁷¹ See Chapter 2, section 2.3 for more information on RCPs.



6.3 Assessing impacts on investments

Investors need to bring together the various layers of climate and socioeconomic data required for climate scenario-based physical risk analysis (see Figure 6). This may necessitate external support as climate model data and data from impact models is not always easily accessible; the data will likely require expertise in its interpretation. Furthermore, not all sectors and geographies have been studied in the literature equally, nor do impact studies have outputs which link to investors' internal risk models easily. There are an increasing number of third-party suppliers who can provide assistance in bringing together the layers of data.

Care will need to be exercised in ensuring that external suppliers have the required expertise, established track-record, and are not providing 'black-box' tools. Investors should seek to understand the risks and limitations associated with any modelling approach used. Key features that may vary include, for example:

- Whether or not climate adaptation measures are included;
- The reliance placed on insurance coverage (which may not be available in subsequent years);
- The focus on physical location of assets, rather than the vulnerability of the business, and implications for value chains;
- The inclusion of estimates of the impacts on the intangible elements of a business; and
- Level and accuracy of downscaling and associated assumptions based on variations in coverage as downscaling^{vii} climate models may be problematic⁷².

Investors will need to become familiar with these and other potential limitations, and any implications for results generated.

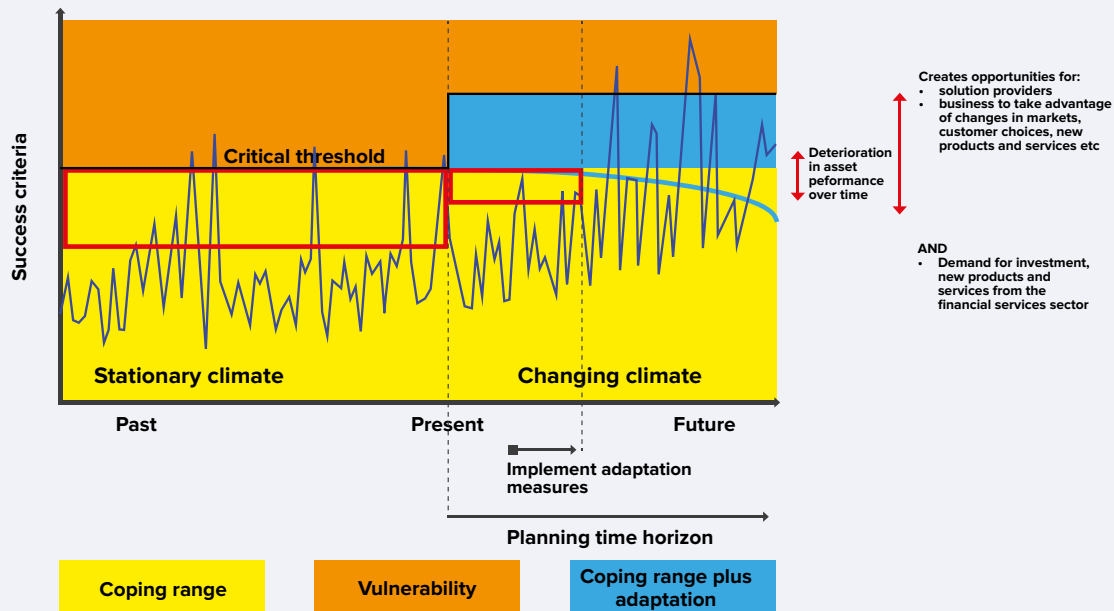
A key element of physical climate risk analysis is the identification of critical thresholds for the performance on an asset and understanding when they may be exceeded, leading to unacceptable levels of risk, as illustrated in Figure 7. All social, economic and environmental systems and their components have thresholds which, when exceeded, may result in failures and changes in performance. A critical threshold can be environmental, social, economic, financial, regulatory or legal, e.g. specific flood risk standards, water requirements for cooling, or temperature ranges for efficient operation. In designing physical assets, critical thresholds are routinely identified, which represent the boundaries between what is a "tolerable" and "intolerable" level of risk. Under a changing climate, these thresholds may be crossed more frequently and with greater intensity, leading to intolerable levels of risk that had not been accounted for when the asset was designed or priced. These thresholds need to be identified during climate impact assessments and brought to bear during the analysis of impacts for investors.

^{vii} Downscaling is a process of generating higher spatial and temporal-resolution data from lower-resolution data and is used to derive local-scale data able to inform short-term decision-making.

Figure 7

Critical thresholds' evolution under the effect of climate change⁷³

(source: Adapted by Acclimatise from Willows and Connell, 2003 ©Acclimatise, 2012)



© Accimatise 2019. Adapted from Willows, R.I. and Connell, R.K. (Eds.). Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical Report. UKCIP, Oxford.

It may not be feasible for investors to collect impact and threshold data for all of their assets. Published sector analyses of thresholds, providing generic information (see Table 3), may provide investors with information to assist with their own appraisals.

Until the breadth and depth of physical climate risk disclosure improves, investors will likely need to conduct their own analyses. The coverage of most climate risk disclosures under the TCFD framework, for example, is still sporadic and most of the current TCFD-style disclosures do not yet present investors with decision useful information⁷⁴. Investors should also consider their capacity to meaningfully collate and assess the disclosures from investee entities, as comparability may be a concern. Direct engagement, discussed further in Chapter 8, may be an alternative to relying on disclosures until the quality improves.

Investee climate risk disclosure practices will likely become more comprehensive and sophisticated as time passes. Investors will have a role to play in ensuring decision useful information is increasingly disclosed. To enable better analysis, for example, investors should consider working amongst themselves to determine what types of physical risk-related disclosures are most useful. They can then work with investees to make their preferences clear.

6.4 Examples of physical climate risk assessment methods and outputs

Box 6 and Box 7 illustrate how large investment firms Blackrock and Aviva have conducted physical climate risk analysis at different levels, in different geographies. BlackRock analysed asset classes linked to fixed long-term physical assets in the USA while Aviva analysed corporate bonds and equity shares, real estate assets, real estate loans and infrastructure assets and sovereign bonds at the global level^{VIII}.

CASE STUDY SIX

BlackRock

Blackrock's scenario analysis for assessing climate-related risk⁷⁵

BlackRock conducted a physical climate change analysis on a selection of portfolio segments in the United States focussing on acute (extreme) events.

Setting the scope

Determining level of assessment and priority portfolio segments -

Blackrock selected asset classes that are backed by long-duration physical assets of known location.

Three following segments of their portfolio were selected for analysis:

- U.S. municipal bonds;
- CMBS; and
- Electric utilities.

Determining timescales - The firm chose to focus on risks facing these asset classes as the firm found that physical climate risk assessments often start by looking decades into the future, which they felt could overlook risks that are already present.

Physical climate risk assessment

The following steps were undertaken for BlackRock's assessments:

- Determine which assets have a readily identifiable physical location (e.g. properties of CMBS loans);
- Overlay the asset locations with climate data to assess exposures to relevant direct physical risks such as hurricanes — today and in the future;
- Link climate data to relevant second-order financial and socioeconomic implications; and
- Analyse if these risks are priced in and/or insured, and determine if the company/issuer has the resolve and financial capacity to adapt.

Blackrock found that, for municipal bonds, a rising share of U.S. metropolitan statistical areas (MSAs) will likely face escalating climate-related risks in the coming decades. The analysis breaks down the potential net economic impact — relative to where GDP would have been absent the effects of climate change — on each of the 383 U.S. MSAs under a “no climate action” scenario. It includes estimates of direct impacts, such as the expected losses from hurricane damage, as well as second-order effects such as changes in labour productivity. Within a decade, more than 15% of the current S&P National Municipal Bond Index (by market value) would be issued by MSAs suffering likely average annualised economic losses of up to 0.5% to 1% of GDP. This would have large implications for the creditworthiness of MSAs and their ability to fund adaptation projects.

^{VIII} Note that both approaches could be improved with the consideration of intangible assets. At present, these analyses focus on impacts on tangible assets. Impacts on intangible assets such as intellectual property, goodwill, and brand recognition, are not yet considered, though they can account for 80% of the overall market value of a company (see Key Definitions).

CASE STUDY SIX

**Blackrock's scenario analysis for assessing climate-related risk** continued**Physical climate risk assessment**

Regarding **CMBS**, Blackrock focused on hurricane and flood risks. The CMBS market is facing a 275%-rise in the risk of being hit by a Category 5 hurricane, within three decades, under a “no climate action” scenario. The analysis of recent hurricanes hitting Houston and Miami finds that roughly 80% of commercial properties tied to affected CMBS loans lay outside official flood zones — meaning they may lack insurance coverage. The analysis shows how the economic impacts of a warming climate could lead to rising CMBS loan loss rates over time.

Finally, for **electric utilities**, Blackrock's analysis reflects that aging infrastructure leaves the U.S. electric utility sector vulnerable to climate shocks such as hurricanes and wildfires. It assesses the exposure to climate risk of 269 publicly listed U.S. utilities based on the physical location of their plants, property and equipment. The analysis shows that risks are under-priced. Electric utilities with exposure to extreme weather events typically suffer temporary price and volatility shocks in the wake of natural disasters. Blackrock also found evidence that the most climate-resilient utilities trade at a premium.

CASE STUDY SEVEN

**Aviva's physical risk modelling approach⁷⁶**

As part of the UNEP-FI investor pilot project on implementing TCFD recommendations, global investor Aviva conducted physical climate risk analysis at the global scale.

Understanding the context

Aviva chose to take a climate Value-at-Risk modelling approach in line with the UNEP-FI investor pilot project on implementing TCFD recommendations which indicates the firm have considered emerging climate risk analysis practices of peers and the private sector as recommended in chapter 4 of this guidance: Understanding the context.

Setting the scope**Determining level of assessment and priority portfolio segments -**

Investments that Aviva looked at part of the physical aspects of their climate risk assessment included:

- Corporate bonds and equity shares;
- Real estate assets, real estate loans and infrastructure assets;
- and Sovereign bonds.

Determining timescale – The firm chose to look at risks over a 15-year time horizon, in line with the UNEP-FI TCFD pilot group of investors.

CASE STUDY SEVEN



Aviva's physical risk modelling approach continued

Physical climate risk assessment

Identifying relevant climate-related hazards and scenarios -

When analysing physical risks and opportunities, Aviva based its approach on an assessment of both the expected costs in the scenario based on RCP 8.5, which they took as indicating current Business As Usual and the costs at a higher 95th percentile arising from hazards such as extreme heat and cold, heavy precipitation and snow, coastal flooding, wind gusts and tropical cyclones.

The methodology sets out that physical risks to investments are generally going to be driven by the exposure of the facilities (buildings, plant, infrastructure) owned or used by the company who has issued the financial instrument, their "facilities", and the supply chain they rely on for producing their end product. It calculates an expected cost that is built up by mapping the facilities onto a world map, with measures that define the facility's exposure to different extreme weather hazards, and then combining this with a vulnerability function that converts the exposure and an assessment of the physical hazard impact in each scenario into an estimated monetary cost, per facility. Different asset classes had tailored methods for assessment:

- **Corporate bonds and equity shares:** the difference between the market value and the adjusted value after factoring in aggregated facility costs and/or revenues is measured. The costs and/or revenues to a business are measured relative to an assessment of physical risks under current conditions as these are assumed to be already factored into the market value. This business impact is then translated into a change in the value of its corporate bonds and equity shares using the Merton model. Aviva acknowledges that the current approach does not capture the impact on companies' supply chains nor necessarily demand for its products and services or potential mitigating impact of insurance.
- **Real estate assets, real estate loans and infrastructure assets:** the same approach is used. For directly held real estate, the impact is carried directly against the property valuation. For real estate loans, Aviva assesses the physical climate change risk impact by running the stressed property value through its debt valuation models.
- **Sovereign bonds:** the impact on the market value of a security is measured by assessing how a sovereign's rating could change as a result of the occurrence of different extreme weather hazards in each scenario. The following climate-related factors may impact sovereign debt: exposure and vulnerability to climate change; readiness and adaptation; ability to raise money for mitigation and post-disaster repair; ability to raise money via taxation and debt; reliance on foreign aid and support of the International Monetary Fund and other supra-national bodies. To assess a sovereign's vulnerability to climate change and readiness, the Notre-Dame University's Notre Dame-Global Adaptation Index (ND-GAIN) measure for country climate change risk has been used.



The ClimateWise physical risk framework (Case Study 8) shows both investors and lenders how they can make use of well-established insurance models, tools and metrics to improve their management of some of the physical risks of climate change.

CASE STUDY EIGHT



Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios⁷⁷

The ClimateWise framework details how outputs from climate models can be used in combination with natural catastrophe models to assess risk under future climate scenarios. The framework sets out a four-step process, highlighted below, that investors and lenders can follow to use these tools (climate models and catastrophe models).

Assessment steps:

Understanding the context

Determining available information on investees - Investors and lenders collect data on the physical assets' they are concerned about. This should include, as a minimum, their geographic locations and some information on asset class, such as whether they are residential or non-residential property. The more detailed that property-level information can be (e.g. construction type and year, roof type, number of floors, occupancy and square footage), the more robust the associated results will be.

Setting the scope

Identifying available tools and data - Which natural catastrophe model(s) to use for their analysis is determined. A number of factors will play into this choice, including whether the modelling will be undertaken in house or sub-contracted to a commercial model vendor. Both entail pros and cons. The former would require use of an open source model, which may allow for more bespoke analysis to be undertaken and provide greater understanding of what drives any results, but these models may not have received as much investment and will also require reasonable technical skills to be confident that the work is being undertaken accurately. For models supplied by vendors, the extent and transparency of model documentation is another important factor, since this will enable investors and lenders to understand and review the assumptions that have been made in the modelling.



CASE STUDY EIGHT



Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios continued

Physical climate risk assessment

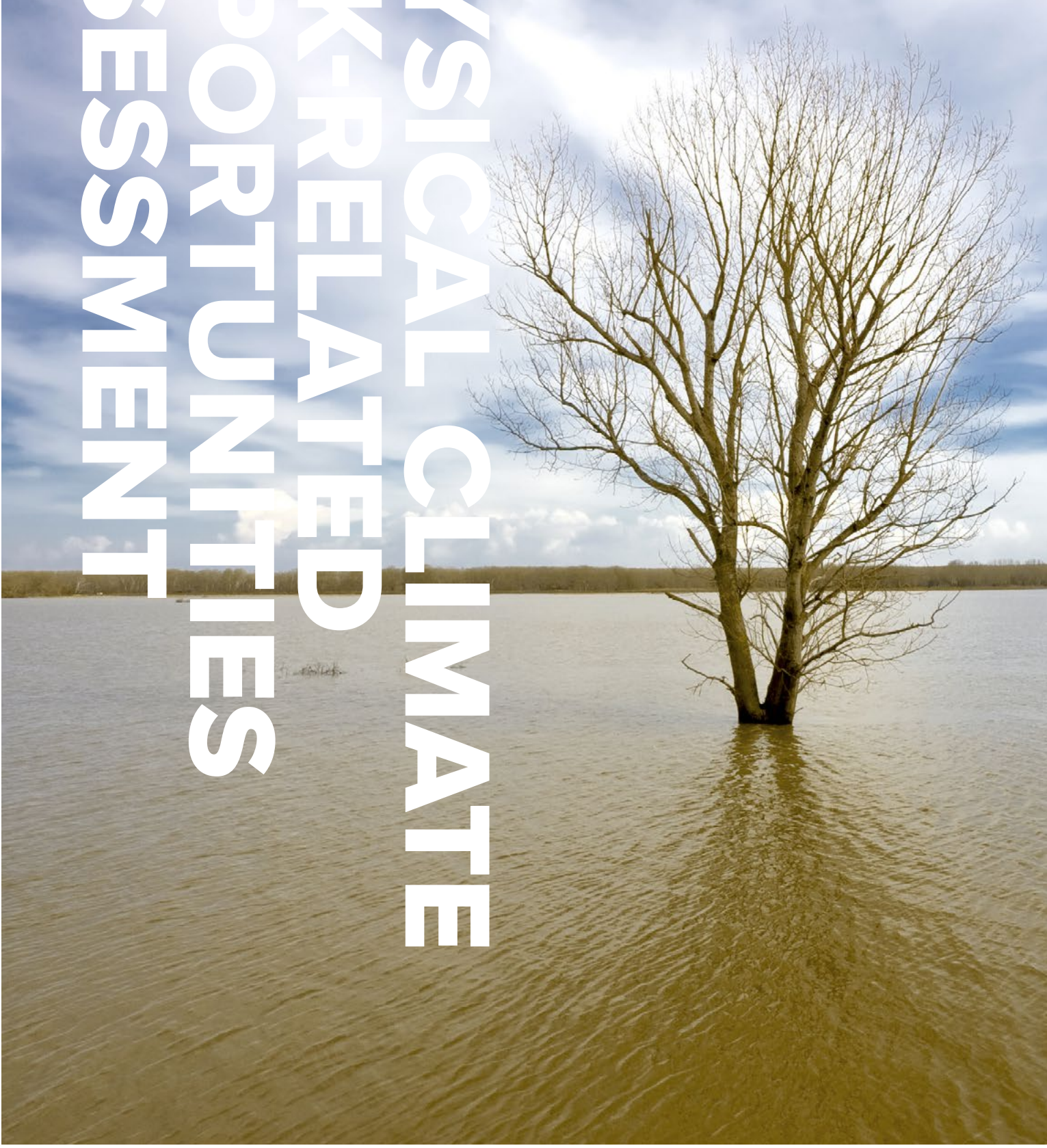
Identifying relevant climate scenarios - Climate scenarios are chosen to model and define probabilities and severity of extreme weather events. The scope of potential ranges in temperature increases, might range from 1.5°C to 4°C or more, which broadly reflects the temperature increases that would be expected given the current possible trajectories of emissions. The relationship between these temperature changes and the severity and frequency of disaster events within a region should incorporate the latest peer-reviewed developments in climate science and account for the uncertainty around these relationships. As climate models continue to develop, for example in their geographic fidelity, these developments can be incorporated into this stage of the analysis.

The model is executed and the associated results interpreted. Catastrophe models can provide a wide range of different results of interest. Two of the most common outputs are Average Annual Loss – the average losses from property damage experienced by a portfolio per year – and annual probability of occurrence – the probability that, over the period of one year, a given asset experiences an event of a given magnitude. Any results should be compared against a 'present day' climate scenario baseline and, where possible, these baseline results should be compared with and scrutinised against historical loss data. Forward-looking results should also be benchmarked against those from comparable studies, where available. When there is confidence that these results are robust, investors and lenders then have the option to convert the changes in expected losses into potential changes in asset values. They can also use the natural catastrophe model(s) to analyse how adaptation measures might reduce losses and asset value impacts.

Outputs

The methodology was applied to a sample of 12 real estate portfolios – with a total market value in excess of £2 trillion, spread across Europe, North and South America and Asia. ClimateWise's analysis shows present day losses of the portfolios from extreme weather events to their expected losses in the 2050s. It finds that financial institutions with long-term investments, including banks and building societies providing new 35-year mortgages today, will have exposure to risks in this time period.

PHYSICAL CLIMATE RISK-RELATED OPPORTUNITIES ASSESSMENT



07



PHYSICAL CLIMATE RISK-RELATED OPPORTUNITIES ASSESSMENT

Alongside assessing risks, investors may wish to identify opportunities associated with a changing climate.

Questions for investors:

- Which type of opportunities will be screened for? Which emerging frameworks could be used to identify these opportunities?

A changing climate will bring an evolving set of investment needs, including infrastructure and products and services that build resilience to climate change and address its consequences⁷⁸. Investors can contribute to building resilience by providing capital needed to finance innovations and technologies as people and communities adapt to new conditions.

To understand the contribution they can make to building resilience, investors need to understand where adaptation and resilience needs of investees and the market more generally lie and explore a range of investment opportunities.

Opportunities assessments will require adequate resources and expertise and should be resourced accordingly. However, assessment of opportunities related to physical climate change is not yet frequently undertaken and therefore the universe of opportunities is not well understood.

7.1 Investing in resilience and resilient investments

Physical climate risk-related opportunities can be categorised as either those ‘investing in resilience’ or ‘resilient investments’⁷⁹. Investing in resilience refers to investments which bring new resilience or adaptation solutions to market. Resilient investments are ordinary or mainstream investments made to be more resilient, which ensures the investment is protected from physical climate risks. Examples of each are provided in Table 9.

Table 9	Examples of investing in resilience and resilient investments (adapted from GARI working group ⁸⁰)
<p>Investing in resilience examples (non-exhaustive)</p> <p>Investments which bring new resilience or adaptation solutions to market.</p> <p>Public equity or fixed income funds:</p> <ul style="list-style-type: none"> • A fund manager undertaking significant engagement with companies and advocacy with governments to develop new solutions that improve activities in the real economy. <p>Company (i.e. private equity or debt) investments:</p> <ul style="list-style-type: none"> • Horizontal investments include investments in companies who provide services (engineering, consulting, forecasting, modelling, monitoring and risk management), and data and technology development (climate and weather modelling, sector specific data aggregation and analysis). • Vertical investments include investments in companies that provide products and solutions in sectors such as water, agriculture, healthcare, energy, coastal area and finance. <p>Infrastructure and real asset investments:</p> <ul style="list-style-type: none"> • Water, agriculture, or nature-based solutions that help protect other assets. <p>Fixed income:</p> <ul style="list-style-type: none"> • Resilience bonds. • Catastrophe bonds. 	<p>Resilient investments examples (non-exhaustive)</p> <p>Mainstream investments made to be more resilient, which ensures the investment is protected from physical climate risks.</p> <p>Public equity and fixed income funds:</p> <ul style="list-style-type: none"> • Tilting an equity or fixed income fund away from investees with high physical risks. • Engaging with investees with high physical risks to understand if there are opportunities directly associated with their high risks and how value can be protected or increased. <p>Real asset investments:</p> <ul style="list-style-type: none"> • Making higher capex investments to reduce costs of physical risk-related operational expenditure (OPEX), i.e.: <ul style="list-style-type: none"> - Smart grids that protect against extreme weather - Buildings that are protected from flooding and extreme heat/cold, as well as resource efficient - Porous pavement parking lot expansion, reducing flood risk; - Protection for resilient manufacturing companies protected from flooding and with workers able to cope with extreme heat; - Road infrastructure projects that focus on increased protection from river erosion. • Micro-finance funds that help micro-finance institutions and their beneficiaries (entrepreneurs) to assess and manage physical risks.

7.2 Frameworks for investors to help identify opportunities

The following publicly available frameworks may assist investors in defining and identifying the two types of opportunities outlined above.

a. EU Sustainable Finance Taxonomy (the Taxonomy)

The Taxonomy⁸¹ helps translate the EU's commitments to the Paris Agreement and the Sustainable Development Goals (SDGs) for investors⁸². The Taxonomy bridges the gap between international goals and investment practice, clearly signalling typical activities that are consistent with the low carbon transition, adaptation and other environmental objectives.

The EU Taxonomy can be operationalised to help screen for sectors of the economy which provide adaptation-related solutions, to identify potential investments. It provides a common language on what constitutes sustainable activities⁸³. It is a list of economic activities with performance criteria for their contribution to six environmental objectives, including climate change adaptation and mitigation. Investors can review the methodology set out in the final technical report, which includes worked examples for evaluating substantial contribution to climate change adaptation⁸⁴.

The Taxonomy sets out two types of adaptation activities that will make a substantial contribution to climate change adaptation. This includes (1) activities that are made more climate resilient by integrating measures to perform well under a changing climate; and (2) activities that enable adaptation in other economic activities⁸⁵. Under the Taxonomy, investors are directed to assess investments according to three principles to understand whether an activity makes a substantial contribution to climate change adaptation. These include:

Principle 1: The economic activity reduces all material physical climate risks to the extent possible and on a best effort basis. The activity must integrate measures aimed at reducing all material physical climate risks posed by current weather variability and future climate change, or it must reduce material risks to other economic activities and/or address systemic barriers to adaptation.

Principle 2: The economic activity does not adversely affect adaptation efforts by others. Activities should be consistent with adaptation needs in the applicable sector or region. Adaptation activities should not hinder adaptation by others.

Principle 3: The economic activity has adaptation-related outcomes that can be defined and measured using adequate indicators. When possible, the outcomes of adaptation activities should be monitored and measured against defined indicators for adaptation results⁸⁶.

⁸¹ The six Taxonomy environmental objectives are: 1. climate change mitigation; 2. climate change adaptation; 3. sustainable use and protection of water and marine resources; 4. transition to a circular economy, waste prevention and recycling; 5. pollution prevention and control; 6. protection of healthy ecosystems.

b. CBI Climate Resilience Principles

Investors are encouraged to review the 2019 Climate Bonds Initiative (CBI) Climate Resilience Principles framework to understand how climate resilience investments can be classified as such. The framework provides high-level guidance for investors, banks and governments to determine if projects and assets contribute to a climate-resilient economy⁸⁷. CBI created the Climate Bonds Standard & Certification Scheme, the only certification scheme for green bonds, which originally focussed on mitigation-related criteria. The scheme now incorporates screening criteria for climate resilience and aims to provide the green bond market with the trust and assurance that it needs to achieve scale. This framework guide is an example of useful guidance and provides helpful background information on physical risk and opportunity analysis in general.

CBI Climate Resilience Principles⁸⁸

Principle	Description
1	Assets and activities being invested in must have clearly defined boundaries and identify interdependencies for assessing climate risks and resilience impacts.
2	Assessment of physical climate risks for assets and activities being invested in.
3	Risk reduction measures for the identified climate resilience risks.
4	Expected climate resilience benefits assessment undertaken for system focused assets and activities being invested in.
5	Mitigation trade-offs assessed.
6	Ongoing monitoring and evaluation.

c. A framework for systematic assessment of resilience opportunities

UNEP-FI in its 'Navigating a New Climate' report set out a framework which can help investors review opportunities in a systematic manner⁸⁹. This framework encourages investors to review the potential finance needs of their clients by considering their needs associated with managing existing risks, responding to existing risks, and how clients are preparing for market shifts associated with a changing climate.

Taxonomy of climate-related opportunities (Adapted from Connell et al. 2018⁹⁰)

Category	Description	Timescales in which opportunities may occur
Managing existing risks	OPEX and capital expenditure (CAPEX) used to help manage existing risks that are affecting revenues and costs: For example, extreme event preparations, contingency planning, event recovery and changes in operating performance.	1 – 5 years
Responding to emerging risks	The changing risk landscape and the adverse or beneficial impacts on value chains may create new corporate or counterparty investment needs.	2 – 10 years
Preparing for market shifts	The fundamental shifts in climate over the longer period may have impacts on value chains and potential changes in revenues, costs and expenditure. For example, in the retail mortgage sector there may be increased demand for loans for home improvements to cool houses in new regions; in agriculture chronic changes in precipitation and temperature may result in farmers changing their business models and moving into alternative crops.	8 years +

d. Opportunity-related analysis

Case study 9 illustrates how the UK Environment Agency Pension Fund (EAPF) has partnered with one of their key asset managers to conduct physical climate risk investment need analysis as part of their ongoing commitments to managing physical climate risks.

CASE STUDY NINE

Environment Agency
Pension Fund

Assessing current investments in resilience as part of EAPF's ongoing commitments to managing physical climate risks

In 2019, the EAPF has focussed on raising the importance of managing the physical risks from climate change. Considering climate-related risks is not new to EAPF, who have been looking at this as far back as 2005. Nearly 40% of their £4bn investments are invested in sustainable assets - in water and waste treatment, renewable energy, energy efficiency and public transport, for example.

Assessing current investments in resilience

As this guidance notes, investors should analyse the investment needs alongside the risks associated with physical climate hazards. To understand whether their fund is helping build climate resilience, EAPF staff engaged one of their long-term asset managers: Impax Asset Management. Impax Asset Management make investments in resource efficiency and environmental markets internationally on behalf of EAPF. In their assessment of EAPF's investments, Impax Asset Management identified that 26% of the EAPF's £115m investments managed by Impax Asset Management are in companies where the majority focus of the business contributes to building climate change resilience. This 26% included firms that provide goods to strengthen the power network and support water infrastructure in coping with climate-related events, for example. As well as supporting the environment and society, these investments have also proved to be a good financial investment for EAPF.

Supporting private sector resilience initiatives

EAPF is also a proud supporter of the private sector led Coalition for Climate Resilient Investment (CCRI)⁹¹. Established in 2019, this international initiative will support investments which help build resilience (see Chapter 4, Table 5, of this guidance).

MANAGEMENT, MONITORING AND REPORTING



08



MANAGEMENT, MONITORING AND REPORTING

Once a risk assessment has been carried out, appropriate management, monitoring and reporting actions should be implemented.

Questions for investors:

- Have a range of risk management responses, including engagement been considered?
- How will physical climate risk and opportunity assessments be integrated into your existing monitoring processes, what will be monitored, and how often?
- Are emerging regulations and supervisory expectations around reporting and disclosure being followed and reflected on?
- Who will the information resulting from the analyses be provided to? How and when?
- Have disclosure frameworks been meaningfully engaged with to ensure accurate reporting and reduce liability?

8.1 Management

As physical climate risks are identified and prioritised, investors should evaluate a range of options available to manage them. Investors should consider, for example, how risks can be transferred, controlled, mitigated, or even accepted as a loss. Table 10 provides an overview of risk management actions that investors can take.

Table 10	Risk management actions for investors
Action	Examples of actions that might be considered
Strengthen risk assessment and management processes	<ul style="list-style-type: none"> • Explicitly consider physical climate risks across a number of different scenarios in due diligence decision-making processes. • Introduce explicit sector-based screening criteria relating to physical climate risks in due diligence. • Update policies, management information and board risk reports to include consideration of physical climate risk.
Reduce or avoid the exposure to risk	<ul style="list-style-type: none"> • Selling or reducing investments in companies or assets that have high exposure to the physical impacts of climate change but poor climate risk management systems. • Increasing holdings in companies or assets that have high-quality climate governance and risk management systems and processes. • Switch to investment managers that are known to better manage physical climate risks.
Strengthen expectations of investment managers	<ul style="list-style-type: none"> • Require investment managers to conduct climate scenario analysis on their investment portfolios to assess physical risks, and to report on the findings and the actions taken as a result.
Engage with investment managers	<ul style="list-style-type: none"> • Encourage investment managers to strengthen their governance and management of climate change-related risks and to take action to manage the identified risks. Table 1 provides examples of the questions that could be asked.
Strengthen expectations of assets and companies	<ul style="list-style-type: none"> • For highly exposed assets or companies, require the asset or company to formally review and update their risk assessments every 3 years to reflect changes in climate science, in public policy, in market conditions and in the asset or company's management of physical climate risks. • Require companies and assets to provide data and information on their exposures to physical climate risk and opportunity, their estimates of the costs and benefits of these exposures, and the actions being taken to manage these risks.
Engage with companies and assets	<ul style="list-style-type: none"> • Encourage companies and assets to strengthen their governance and management of physical climate risks and to take action to manage the identified risks. Table 1 provides examples of the questions that could be asked. • In broad terms, six main risk mitigation options are available to companies: <ul style="list-style-type: none"> - Avoid the risk by, for example, closing or moving operations. - Reduce the risk by, for example, climate-proofing buildings and infrastructure. - Transfer the risk through, for example, purchasing insurance or outsourcing certain activities to third parties. - Accommodate the risk through, for example, better heatwave and emergency planning. - Accept the risk, where the costs of addressing the risk may be too great relative to the benefits received. - Identify opportunities associated with a changing climate.

Table
10

Continued

Action	Examples of actions that might be considered
Support effective public policy	<ul style="list-style-type: none"> • Engage with regulators and policy makers, to encourage policy and regulatory changes that might be required to encourage reductions in GHG emissions, adaptation and resilience (e.g. measures that foster a climate-resilient transition). • Encourage policy makers to: <ul style="list-style-type: none"> - Develop clear, long-term policies that enable companies to plan and invest appropriately. - Ensure that unsuitable/risky developments (for example, on flood plains) are either prohibited or are designed with appropriate adaptations measures. - Ensure that different regulators for the same sector work together more coherently. - Require companies to explicitly discuss the financial and other implications of the physical impacts of climate change for their businesses.
Report	<ul style="list-style-type: none"> • Integrate physical climate risks and opportunities into financial and other reporting (e.g. to clients, to stakeholders), in line with TCFD recommendations. In the short-term, this reporting may simply detail the risks and opportunities that have been identified but over time should extend to cover the financial significance of these investment risks and opportunities, and of the actions being taken to manage them.
Insure	<ul style="list-style-type: none"> • Obtain or enhance insurance for specific physical climate risks (e.g. for flood risk, for extreme weather events, for supply chain disruption). • Review potential and risks for ongoing/future insurance of highly exposed assets.

Engagement is one of the first actions investors can take in the management of physical climate risks.

Engagement can serve two primary objectives:

1. Improve the information available to investors about the assets in which they are invested in relation to climate risks and opportunities; and
2. Ensure relevant actions are taken by investees to address these risks and build resilience.

Investors can operationalise frameworks and guidance set out in recent literature to engage with investees and asset managers on physical climate risks. Investors can develop a set of questions to take to their investees or asset managers. Table 11 provides an overview of the types of information that investors should seek from investee entities and/or their investment managers. Investors can also review emerging frameworks for engagement, as detailed in Table 12.

CASE STUDY TEN

Environment Agency
Pension Fund

EAPF engagement with investees on their approaches to adaptation and resilience

Engagement as a key element in managing physical climate-related risks

As this guidance document notes, considering climate transition risks is often the primary focus of investor attention. To help raise the profile of climate change adaptation and understand whether the companies EAPF is investing in are managing physical climate risks well, EAPF staff attended a number of company Annual General Meetings (AGMs) and asked the Board directly about this issue. Questions put to the Board included:

- a. What scenario planning the company has done to manage the risks long-term;
- b. Who at board and senior management levels has responsibility for climate adaptation and resilience, and;
- c. For financial companies, how physical risks are considered in companies they lend to.

The availability of company data on managing physical risks in annual reports and the types of responses from boards differed among investees but almost without exception, there was interest from the company to have follow up discussions with EAPF. There were often a number of questions from shareholders on climate change mitigation at the AGMs EAPF attended, though interestingly, only one question (theirs) on climate change adaptation.

EAPF's ongoing commitments to managing physical climate risks

The Fund has made managing physical climate risks a priority in a newly established Responsible Investment Strategy. Attending AGMs to raise the profile of climate adaptation and resilience is a key element of the work EAPF is taking to manage physical climate risks as part of that strategy. More generally EAPF is keen to continue developing the active management of physical risks and intends to utilise this guidance as part of that effort.

Table 11

Examples of questions for investees and asset managers
(Adapted from Sullivan et al. 2009⁹² with input from EAPF)

Element	Primary question	Detailed questions
Governance/ Management	Can you describe how you manage the physical impacts of climate change?	<ul style="list-style-type: none"> Who is responsible for assessing and managing the physical risks associated with a changing climate? How does your Board oversee the management of physical climate risks? Have you engaged with key stakeholders to understand their views on climate change-related risks? What have the outcomes of these discussions been?
Risk analysis process	Can you describe your process for assessing the risks and opportunities associated with the physical impacts of climate change?	<ul style="list-style-type: none"> How do you identify climate change-related risks and opportunities? What datasets do you use to understand these risks? Do you use climate change-related scenarios to inform your business scenarios (strategy or risk assessment processes)? If yes, what climate scenarios do you use? What is the scope of your risk assessment? For example, does it consider: <ul style="list-style-type: none"> Direct impacts on assets? Wider value chain and knock-on effects? Impacts on tangible and intangible assets/value? Impacts on competitors, market sectors and economies? Impacts on future market conditions? Opportunities for new products, services or markets? What are the key climate change-related risks and opportunities you have identified? How do you define / assess the significance of these risks and opportunities? Are there areas where further information is required? Do the results of your risk assessment indicate that physical climate risk will have significant financial or other (e.g. brand, market access, regulatory) implications for you?
Risk management and engagement	Can you describe the major actions you are taking to respond to the physical impacts of climate change and improve asset resilience? Are you engaged in any discussions with your suppliers and customers on the impacts of climate change on their businesses?	<ul style="list-style-type: none"> What is the cost of these actions? What is the residual risk? What steps have you taken with your suppliers to ensure they are aware of and responsive to the need to adapt to climate change? What discussions has the asset manager had with the client?
Monitoring and review	Can you describe how you are monitoring the implications of climate physical risks for your investments?	<ul style="list-style-type: none"> What indicators or measures are you using to monitor the investment implications of the physical impacts of climate change? Have you established a structured process to monitor and review climate physical risks over time? Will you be taking any steps in the next 12 months to review your business strategies and your major projects in the light of the risks and opportunities posed by the physical impacts of climate change?
Reporting	Can you describe the information you provide to your investors, to your clients/beneficiaries and to other stakeholders?	<ul style="list-style-type: none"> What information do you report on the implications of the physical impacts of climate change? Do you report on (a) the investment implications of these impacts, (b) the actions you have taken to mitigate these impacts, (c) the effectiveness of the actions you have taken? How often do you report this information? If you do not currently report, do you have plans to start reporting?

Table 12

Frameworks for engagement on physical risks

Topic	Resource examples (non-exhaustive)	Description and link
Engagement with corporates	EBRD and GCA: Advancing TCFD Guidance on Physical Climate Risks and Opportunities ⁹³	Developed by a group of financial institutions and corporate firms, the guidance provides a set of metrics for corporates to use on physical climate risk management and disclosures, metrics for climate resilience opportunities, and metrics for climate intelligence for business strategy and financial planning. Investors can use this guidance as a framework to engage with investees regarding what would be decision useful information. https://www.physicalclimaterisk.com
	Climate Disclosure Standards Board (CDSB), SASB, TCFD Implementation Guide ⁹⁴ and TCFD Good Practice Handbook ⁹⁵	Developed by a group of financial institutions, the guidance provides a set of metrics for corporates to use on physical climate risk management and disclosures, metrics for climate resilience opportunities, and metrics for climate intelligence for business strategy and financial planning. Investors can use this guidance as a framework to engage with investees regarding what would be decision-useful information. https://www.physicalclimaterisk.com
	Managing the Unavoidable: investment implications of a changing climate ⁹⁶	This report provides guidance on investee engagement in the oil and gas, mining, utilities, and real estate sectors. http://www.acclimatise.uk.com/wp-content/uploads/2018/01/Managing_the_Unavoidable_FINAL_Nov2009.pdf
Engagement with asset managers	PRI: Implementing the Task force on Climate-related Financial Disclosures (TCFD) Recommendations: A guide for asset owners ⁹⁷	This report, under “Highlight 2”, on page 23, provides specific questions asset owners can use to engage with fund managers on climate-related risks and opportunities and encourage them to support the TCFD recommendations. https://www.unpri.org/download?ac=4652%20

Investors should consider when is the best time to carry out engagement in line with the purpose and desired outcomes. This may include during risk assessment, to obtain information which can contribute to the analysis. Engagement may also be useful following a risk and opportunity assessment, as a management tactic. It can also be useful to engage with asset managers on lessons learned after physical climate events occur.



8.2 Monitoring and review

Investors should monitor the risks identified in their risk assessments, using existing risk management practices where possible. Placing identified physical climate risks on a risk register should help identify the priority, frequency of, and responsibility for monitoring. Investors should prioritise monitoring of high risks first. Investors could trial monitoring before fully integrating into their conventional risk register, by setting out internal responsibility for the monitoring process and setting out how and when this information will be provided in decision making processes. This should be set out during the design of the analysis or process and be agreed on before it starts.

To monitor how identified risks are changing, investors can follow how the component parts of the risks may be changing (increasing or decreasing) since the assessment was conducted. This includes checking if or how the physical hazards (see examples in Table 1 above), exposure, or vulnerability elements have changed. This will require monitoring of the emerging science, peer disclosures, and impacts following extreme events.

For example, to understand if an identified hazard (e.g. sea level rise) has changed, updates in the science (e.g. impact models) could be checked. To understand if exposure has changed, investors can check if the amount of investment in the sector or geography in question has changed significantly, e.g. if it has increased or decreased. To understand if vulnerability has changed, investors can assess how the ability of assets to handle impacts has changed, e.g. if insurance coverage has been lost or increased. If external experts conduct the original risk analysis, it is worth agreeing if, how, and when they can assist in monitoring, e.g. when and how datasets are updated. External managers should also be reviewed to determine the efficacy of the risk assessment processes they utilised⁹⁸.

Investors should also seek to monitor change in level of identified risks as result of the management tactics they employ. For example, investors could seek to understand how investee governance of physical climate risk has improved after a period of engagement⁹⁹.

Ongoing monitoring of emerging climate risks is also part of good practice risk management¹⁰⁰. As both physical climate risks and the science used to detect and assess them are constantly evolving, investors should ensure periodic monitoring of these is carried out. This may involve asking external experts about how they review and incorporate new data and information as it emerges.

Investors should consider the frequency of monitoring. Thresholds or time scales which would trigger a full reassessment can be established. Annual assessments may be too frequent. A sensible range may be several years, though this will need to be evaluated by each investor for a given context.

8.3 Reporting

Investors should consider the purpose, end users and reporting locations to help determine content of disclosures. Reporting of physical climate risks and opportunities may look and feel different depending on who the intended user is and where disclosures are made. For example, disclosures made by asset owners to beneficiaries or the public may be more qualitative and narrative than those made to regulators or financial supervisors. Furthermore, investors should consider how content will change with internal teams versus external stakeholders (see Table 13). The TCFD recommends disclosures be made in financial filings or annual reports, though many firms are currently including TCFD-related disclosures in standalone reports. The 2019 TCFD Good Practice Handbook¹⁰¹ provides examples of ideal disclosures, both qualitative and quantitative. Examples are drawn from across the G20 to cover multiple jurisdictions and a diversity of practices.

Table 13

Example climate risk disclosure styles based on end user

Discloser	Who to disclose to	Example disclosure style (not exhaustive)
Asset owners	Beneficiaries/public.	Qualitative and quantitative information in annual or standalone reports.
Asset managers	Asset owners.	Quantitative information, key metrics in standalone reports.
Asset managers	Public.	Quantitative information.
Asset owners and asset managers	Regulators/financial supervisors.	Qualitative and quantitative information in annual or standalone reports.
Asset owners and asset managers	Internal teams.	Quantitative information, key metrics in standalone reports.

Investors need to stay informed of evolving stakeholder interest around climate risk reporting and disclosures, which are growing due to the emergence of voluntary frameworks such as TCFD. The 2017 TCFD recommendations are now widely recognised as the authoritative guidance on voluntary reporting of financially material climate-related information¹⁰².

The TCFD suggests that investors should report on their:

- **Governance:** The organisation's governance around climate-related risks and opportunities.
- **Strategy:** The actual and potential impacts of climate-related risks and opportunities on the organisation's businesses, strategy, and financial planning.
- **Risk Management:** The processes used by the organisation to identify, assess, and manage climate-related risks.
- **Metrics and Targets:** The metrics and targets used to assess and manage relevant climate-related risks and opportunities.



Other reporting frameworks such as the Principles for Responsible Investment (PRI) have aligned with TCFD recommendations. Starting in 2020, for example, the PRI's strategy and governance (SG) indicators will be mandatory to report, though it will remain voluntary to disclose responses publicly. These indicators include^x:

- SG 01 CC: outline overall approach to climate-related risks;
- SG 07 CC: provide overview of those in the organisation that have oversight, accountability and/or management responsibilities for climate-related issues; and
- SG 13 CC: outline how strategic risks and opportunities are analysed.

Investors need to follow the emerging regulations and supervisory expectations around reporting and disclosure. Financial supervisors and other regulatory bodies across Europe are actively coordinating on climate disclosure frameworks, as evidenced by establishment of the NGFS and the Coalition of Finance Ministers for Climate Action¹⁰³. Investors should follow NGFS Workstream 1 (micro-prudential and supervisory workstream), which is reviewing practices for integrating climate risks into micro-prudential supervision, including climate information disclosure by banks and asset managers¹⁰⁴. Investors should also follow the EU implementation of the 2018 Action Plan for a Sustainable Finance System as the Commission is currently evaluating proposals to amend EU directives to facilitate better climate risk disclosures. For example, regulation (EU) 2019/2088 was established in November 2019, on sustainability-related disclosures in the financial services, requiring investment firms to consider and disclose risks associated with occupational pensions^{xi}. Liabilities around reporting and disclosure of climate risks should also be considered. Investors need to ensure disclosures are based on rigorous assessment and are accurately communicated to minimise the risk of litigation¹⁰⁵ as emerging legal opinion suggests directors who do not properly manage or disclose climate risks could be held liable for breaching their legal duty of due care and diligence^{106, 107}. Investors should consult with their legal advisors before reporting.

Investors need to meaningfully engage with disclosure frameworks to ensure accurate communication of resulting analysis. Under the TCFD framework, for example, investors need to disclose how the physical risk analysis outputs may impact their business strategy, and how the risks will be managed, not just what the impacts are. Despite the mounting pressure on investors to analyse and disclose climate risks and opportunities, disclosures should not be the sole purpose of investors' physical climate risk analysis. While reporting of physical risks should be considered for reasons mentioned above, conducting cursory assessments just to be able to report or disclose lead to inaccurate disclosures and increased liability.

Good practice on climate risk reporting and disclosure is emerging quickly and should be reviewed, including a review of peer disclosures. The resources suggested in Table 12 also have good practice guidance on disclosures and recent IIGCC reports^{xii} on TCFD implementation should be used.

^x PRI has a number of strategy and governance (SG) indicators in their reporting framework. Those labelled as 'SG 01 CC' etc., as show in the text here, are the PRI indicators relating to climate change.

^{xi} See <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019R2088> for more information.

^{xii} See https://www.iigcc.org/resources/?programme=&sub_programme_policy=&sub_programme_corporate=&sub_programme_investor=&resource_topic=tcfd&document_type=Investor+guide&published_year=na#scroll-form for more information.

09

ANNEX A: KEY DEFINITIONS

ANNEX A:
KEY DEFINITIONS

KEY DEFINITIONS

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects¹⁰⁸.

Climate-related opportunity (associated with physical risk): The potential increase in demand for finance, investment, insurance and advisory services driven by the physical impacts of a changing climate on clients and their adaptation responses¹⁰⁹. **Investing in resilience** refers to investments which bring new resilience or adaptation solutions to market. **Resilient investments** have a resilient feature attached to ensure that the project is protected from climate risks. See Chapter 7 for further details.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected¹¹⁰.

Hazards: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources¹¹¹. In this document, the term hazard refers to climate-related physical events or trends or their physical impacts.

The TCFD suggests hazards can include extreme (acute) events or incremental (chronic) changes. Acute hazards are event-driven, including increased severity of extreme weather events, such as cyclones, hurricanes, or floods. Chronic changes are longer-term shifts in climate patterns (e.g. sustained higher temperatures, sea level rise etc.)¹¹² (see Table 1).

Impacts: The effects on natural and human systems of extreme weather, climate events, and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts¹¹³.

Physical risks: The potential for consequences from impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, (a subset of impacts known as physical impacts)¹¹⁴. The TCFD delineates physical climate risks as those associated with either acute or chronic hazards.

Resilience: The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation¹¹⁵.

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard¹¹⁶.

Scenario analysis: A process of assessing how an investment portfolio might perform in different future states, in order to understand key drivers and possible outcomes. In the case of climate change, scenario analysis focuses on two distinct but interlinked sets of risks and opportunities, (a) transition risk scenarios which consider different pathways for the evolution of GHG intensive economic activities, such as energy generation, industrial production and transportation, (b) physical risk scenarios which focus on changes to the climate, including variables such as temperature rise, sea level rise, and changes to the frequency and severity of extreme weather events, including droughts and storms. The two sets of risks are interdependent, as the greater the degree of transition that takes place, the lower the physical risks and vice versa.

Tangible and intangible assets: Tangible assets capture all physical assets such as property, financial instruments and cash. Intangible assets cover non-physical assets such as intellectual property, goodwill, and brand recognition¹¹⁷.

Transition risks: Risks associated with changes in policies, laws, technologies and markets, as a response to the transition to a lower-carbon economy¹¹⁸.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt¹¹⁹.



10

ANNEX B: FIGURES, CASE STUDIES, TABLES AND ACRONYMS LISTS

ANNEX B: FIGURES, CASE STUDIES, TABLES AND ACRONYMS LISTS



Figures

Figure 1:	Climate change impacts and consequences for investors (source: Acclimatise, 2019)	3
Figure 2:	Temperatures are set to increase by a minimum of 1.5°C degrees by 2030 with far reaching consequences on social, human and natural systems (source: IPCC, 2018)	11
Figure 3:	Climate change impacts and consequences for investors (source: Acclimatise, 2019)	12
Figure 4:	Increased temperatures with drought and wildfires contributed to the bankruptcy of US utilities firm PG&E (source: Acclimatise, 2019)	13
Figure 5:	Storms and floods contributed to substantial disruptions to Western Digital's value chains and real assets (source: Acclimatise, 2019)	14
Figure 6:	Stylised overview of how RCPs and other climate data and information are translated into expected physical climate impacts (source: Acclimatise, 2020)	15
Figure 7:	Critical thresholds' evolution under the effect of climate change (source: Adapted by Acclimatise from Willows and Connell, 2003 ©Acclimatise, 2012)	47

Case studies

Case study 1:	Mapping climate cause and effect chains in the electricity transmission and distribution sector: the case of wildfire and Pacific Gas and Electric Company (PG&E)	11
Case study 2:	Mapping climate cause and effect chains in the manufacturing sector: the case of floods and Western Digital	12
Case study 3:	Analysing physical climate risks and opportunities: experience from EBRD	21
Case study 4:	Getting started – hypothetical analysis for infrastructure investments	21
Case study 5:	Getting started - hypothetical analysis for commercial real estate investments	23
Case study 6:	Blackrock's scenario analysis for assessing climate-related risk	48
Case study 7:	Aviva's physical risk modelling approach	49
Case study 8:	Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios	51
Case study 9:	Assessing current investments in resilience as part of EAPF's ongoing commitments to managing physical climate risks	58
Case study 10:	EAPF engagement with investees on their approaches to adaptation and resilience	63

Tables

Table 1:	Examples of acute and chronic climate-related hazards	11
Table 2:	Common elements to consider in a physical climate assessment process & corresponding questions for investors	20
Table 3:	Examples of sources of information on climate impacts	28
Table 4:	Examples of sources of information on regulatory and policy contexts	30
Table 5:	Examples of resources and initiatives relating to peer action on climate risk analysis	31
Table 6:	Examples of various purposes for physical risk analysis and associated outputs (source: Acclimatise 2019)	35
Table 7:	Examples of expected physical risks across asset classes	36
Table 8:	Examples of climate data, tools and services currently available	39
Table 9:	Examples of investing in resilience and resilient investments (adapted from GARI)	55
Table 10:	Risk management actions for investors	61
Table 11:	Examples of questions for investees and asset managers (Adapted from Sullivan et al. 2009 with input from EAPF)	64
Table 12:	Frameworks for engagement on physical risks	65
Table 13:	Example climate risk disclosure styles based on end user	67

Acronyms

AGM	Annual General Meeting
AODP	Asset Owners Disclosure Project
CBI	Climate Bonds Initiative
CCRI	Coalition for Climate Resilient Investment
CDP	Carbon Disclosure Project
CDSB	Climate Disclosure Standards Board
CFRF	Climate Financial Risk Forum [UK]
CGE	Computable General Equilibrium models
CMBS	Commercial Mortgage Backed Securities
CISL	Cambridge Institute for Sustainability Leadership
EAC	Environmental Audit Committee [UK]
EAPF	Environment Agency Pension Fund [UK]
EBRD	European Bank for Reconstruction and Development
ECV	Essential Climate Variable
EU	European Union
EU-MACS	European Market for Climate Services
FCA	Financial Conduct Authority [UK]
GARI	Global Adaptation and Resilience Investors working group
GCA	Global Center on Adaptation
GHG	Greenhouse gas emissions
GRESB	Global Real Estate Sustainability Benchmark
IAM	Integrated Assessment Models
IFoA	Institute and Faculty of Actuaries
IGCC	Investors Group on Climate Change [Australia and New Zealand]
IIGCC	Institutional Investors Group on Climate Change [Europe]
IORP	Institutions for Occupational Retirement Provision
IPCC	Intergovernmental Panel on Climate Change
MSA	Metropolitan Statistical Areas
NAP	National Adaptation Plans
NDC	Nationally Determined Contributions
NGFS	Network of Central Banks and Supervisors for Greening the Financial System
PG&E	Pacific Gas & Electric
PRA	Prudential Regulation Authority [UK]
PRI	Principles for Responsible Investment
OPEX	Operational Expenditure
RCP	Representative Concentration Pathway
RFI	Request for Information
SASB	Sustainability Accounting Standards Board
TEG	Technical Expert Group [EU]
TCFD	Task force on Climate-related Financial Disclosures
UIC	International Union of Railways [French: Union Internationale des Chemins de fer]
UNEP	United Nations Environment Programme [Also known as UNE as of 2017]
UNEP-FI	United Nations Environment Programme Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change

11

REFERENCES

- 1 Intergovernmental Panel on Climate Change (IPCC). (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.
https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf [Accessed October 2019]
- 2 UNEP. (2018). Greening the rules of the game: How Sustainability Factors Are Being Incorporated Into Financial Policy and Regulation. http://unepinquiry.org/wp-content/uploads/2018/04/Greening_the_Rules_of_the_Game.pdf [Accessed October 2019]
- 3 Barker, S., & Girgis, M. (2017). Bank of England eyeballs the financial sector on climate risk, (June), 1–4.
<https://www.minterellison.com/articles/bank-of-england-eyeballs-the-financial-sector-on-climate-risk> [Accessed October 2019]
- 4 EAC. (2018). Greening Finance: embedding sustainability in financial decision making. London.
<https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/1063/1063.pdf> [Accessed October 2019]
- 5 Intergovernmental Panel on Climate Change (IPCC). (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.
https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf [Accessed October 2019]
- 6 UN Environment. (2018). Greening the rules of the game: How Sustainability Factors Are Being Incorporated Into Financial Policy and Regulation.
http://unepinquiry.org/wp-content/uploads/2018/04/Greening_the_Rules_of_the_Game.pdf [Accessed October 2019]
- 7 Barker S., Girgis, M. (2017). Bank of England eyeballs the financial sector on climate risk, (June), 1–4.
<https://www.minterellison.com/articles/bank-of-england-eyeballs-the-financial-sector-on-climate-risk> [Accessed October 2019]
- 8 UK Environmental Audit Committee (EAC). (2018). Greening Finance: embedding sustainability in financial decision making. London. <https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/1063/1063.pdf> [Accessed October 2019]
- 9 Miller A., Swann S. (2019). Driving Finance Today for the Climate Resilient Society of Tomorrow. United Nations Environment Programme Finance Initiative (UNEP-FI) and the Global Commission on Adaptation (GCA)
<https://www.unepfi.org/wordpress/wp-content/uploads/2019/07/GCA-Adaptation-Finance.pdf> [Accessed October 2019]
- 10 Intergovernmental Panel on Climate Change (IPCC). (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.
https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf [Accessed October 2019]
- 11 Network for Greening the Financial System (NGFS). (2019). Origin and purpose.
<https://www.ngfs.net/en> [Accessed October 2019]
- 12 European Commission. (2019). Green Finance.
https://ec.europa.eu/info/business-economy-euro/banking-and-finance/green-finance_en#action-plan [Accessed October 2019]
- 13 Miller A., Swann S. (2019). Driving Finance Today for the Climate Resilient Society of Tomorrow. United Nations Environment Programme Finance Initiative (UNEP-FI) and the Global Commission on Adaptation (GCA)
<https://www.unepfi.org/wordpress/wp-content/uploads/2019/07/GCA-Adaptation-Finance.pdf> [Accessed October 2019]
- 14 Hamaker-Taylor R., et al. (2018). EU-MACS Deliverable 2.1: Results of Explorations of the Climate Services Market for the Financial Sector
http://eu-macs.eu/wp-content/uploads/2019/02/EUMACS_D21_FINAL.pdf [Accessed October 2019]
- 15 Task Force on Climate-related Financial Disclosures (TCFD). (2019) Task Force on Climate-related Financial Disclosures: Status report.
<https://www.fsb-tcfd.org/publications/tcfd-2019-status-report/> [Accessed October 2019]

- 16 Howard A., Hassler M. (2018). Climate change: the forgotten physical risks. Schrodgers, https://www.schrodgers.com/en/sysglobalassets/_global-shared-blocks/climate-change/physical-risks.pdf [Accessed October 2019]
- 17 Sullivan R. et al. (2009), Managing the Unavoidable: Investment Implications of a Changing Climate (Acclimatise, Henderson Global Investors, Insight Investment, Railpen and USS). http://www.acclimatise.uk.com/wp-content/uploads/2018/01/Managing_the_Unavoidable_FINAL_Nov2009.pdf [Accessed October 2019]
- 18 Intergovernmental Panel on Climate Change (IPCC). (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp. https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf [Accessed October 2019]
- 19 National Oceanic and Atmospheric Administration (NOAA). (2017). Global Climate Report - Annual 2017 <https://www.ncdc.noaa.gov/sotc/global/201713>. [Accessed October 2019]
- 20 Intergovernmental Panel on Climate Change (IPCC). (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp. https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf [Accessed October 2019]
- 21 Intergovernmental Panel on Climate Change (IPCC). (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, et al., (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- 22 Intergovernmental Panel on Climate Change (IPCC). (2013). Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, et al., (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- 23 Intergovernmental Panel on Climate Change (IPCC). (2018). Summary for Policymakers. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp. https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf [Accessed October 2019]
- 24 Global Adaptation & Resilience Investment (GARI). (2017). An Investor Guide to Physical Climate Risk & Resilience An Introduction. http://427mt.com/wp-content/uploads/2017/12/GARI-2017_Investor-Guide_FINAL.pdf [Accessed October 2019]
- 25 **Sources, Figure 3: Increased temperatures with drought and wildfires contributed to the bankruptcy of US utilities firm PG&E** [All accessed August 2019]:

Clements-Hunt P. (2013). Background Paper prepared for the Global Assessment Report on Disaster Risk Reduction 2013: Investment, Finance, and Capital Market Perspectives. <https://www.preventionweb.net/english/hyogo/gar/2013/en/bgdocs/Clements-Hunt,%202012.pdf>

Dignan L. (2011). Thailand floods to lead to hard drive shortages for months. ZD Net. <https://www.zdnet.com/article/thailand-floods-to-lead-to-hard-drive-shortages-for-months/>

Haraguchi M., Lall U. (2014). Flood risks and impacts: A case study of Thailand's floods in 2011 and research questions for supply chain decision making. http://water.columbia.edu/files/2014/10/supply_chain_Thailand.pdf

IHS Markit. (2012). Thailand Flooding Helps Seagate Move into First Place in Hard Drive Market in Fourth Quarter. <https://technology.ihs.com/389489/thailand-flooding-helps-seagate-move-into-first-place-in-hard-drive-market-in-fourth-quarter>

Insurance Journal. (2012). Lloyd's Analyzes Repercussions of Thai Flood Losses a Year Later. <https://www.insurancejournal.com/news/international/2012/10/03/265190.htm>

Insurance Journal. (2012). Best Analyzes Impact of Flood Losses on Thai Insurance Industry. <https://www.insurancejournal.com/news/international/2012/02/10/235055.htm>

Kelly T. (2011). UPDATE 2-Honda's Thai factory shut as floods hit Japan firms. Reuters. <https://www.reuters.com/article/honda-flood/update-2-hondas-thai-factory-shut-as-floods-hit-japan-firms-idUSL3E7LCOVO20111012>

Nikon. (2012). Extraordinary Losses Due to the Flooding in Thailand. https://www.nikon.com/news/2012/0203_01.htm

Polycarpou L. (2014). Floods, Companies and Supply Chain Risk. State of the Planet. <https://blogs.ei.columbia.edu/2014/11/17/floods-companies-and-supply-chain-risk/>

Western Digital. (2012). 2012 Annual Report Western Digital Corporation and Form 10-K. https://materials.proxyvote.com/Approved/958102/20120917/AR_142253/document.pdf
- 26 CNBC. (2019). PG&E, owner of biggest US power utility, files for bankruptcy. <https://www.cnbc.com/2019/01/29/pge-owner-of-biggest-us-power-utility-files-for-bankruptcy.html> [Accessed October 2019]

- 27 Munich Re (2019). Media Information: Extreme storms, wildfires and droughts cause heavy nat cat losses in 2018.
<https://www.munichre.com/en/media-relations/publications/press-releases/2019/2019-01-08-press-release/index.html>
[Accessed October 2019]
- 28 Munich Re (2019). Media Information: Extreme storms, wildfires and droughts cause heavy nat cat losses in 2018.
<https://www.munichre.com/en/media-relations/publications/press-releases/2019/2019-01-08-press-release/index.html>
[Accessed October 2019]
- 29 CNBC. (2019). Officials: Camp Fire, deadliest in California history, was caused by PG&E electrical transmission lines.
<https://www.cnbc.com/2019/05/15/officials-camp-fire-deadliest-in-california-history-was-caused-by-pge-electrical-transmission-lines.html>
[Accessed October 2019]
- 30 CNBC. (2018). PG&E shares sink 4 percent after Cal Fire faults utility for a dozen wildfires.
<https://www.cnbc.com/2018/06/11/pge-stock-falls-after-cal-fire-faults-utility-for-costly-wildfires.html> [Accessed October 2019]
- 31 CNBC. (2019). Officials: Camp Fire, deadliest in California history, was caused by PG&E electrical transmission lines.
<https://www.cnbc.com/2019/05/15/officials-camp-fire-deadliest-in-california-history-was-caused-by-pge-electrical-transmission-lines.html>
[Accessed October 2019]
- 32 Mui C. (2019). PG&E Is Just The First Of Many Climate Change Bankruptcies. Forbes.
<https://www.forbes.com/sites/chunkamui/2019/01/24/pge-is-just-the-first-of-many-climate-change-bankruptcies/#7a64583a7e5f>
[Accessed October 2019]
- 33 John J. (2019). PG&E Bankruptcy Drives Plans for Catastrophe Fund to Cover Wildfire Costs. Green Tech Media.
<https://www.greentechmedia.com/articles/read/pge-bankruptcy-drives-plans-for-catastrophe-fund-to-cover-wildfire-costs#gs.rimjmh>
[Accessed October 2019]
- 34 PG&E. (2016). Joint Annual Report to Shareholders.
http://pgecorp.com/investors/financial_reports/annual_report_proxy_statement/ar_pdf/2016/2016_Annual_Report.pdf
[Accessed October 2019]
- 35 **Sources: Mapping climate cause and effect chains in the manufacturing sector: Floods and Western Digital**
[All accessed August 2019 unless otherwise stated]

Associated Press in San Francisco. (2019). PG&E: California utility firm files for bankruptcy after deadly 2018 wildfires. The Guardian.
<https://www.theguardian.com/us-news/2019/jan/29/pge-bankruptcy-california-wildfires-utilities>

CNBC. (2019). PG&E, owner of biggest US power utility, files for bankruptcy.
<https://www.cnbc.com/2019/01/29/pge-owner-of-biggest-us-power-utility-files-for-bankruptcy.html>

Daniels J. (2018). PG&E shares sink 4 percent after Cal Fire faults utility for a dozen wildfires. CNBC.
<https://www.cnbc.com/2018/06/11/pge-stock-falls-after-cal-fire-faults-utility-for-costly-wildfires.html>

Daniels J. (2019). Officials: Camp Fire, deadliest in California history, was caused by PG&E electrical transmission lines. CNBC.
<https://www.cnbc.com/2019/05/15/officials-camp-fire-deadliest-in-california-history-was-caused-by-pge-electrical-transmission-lines.html>

John J. (2019). PG&E Bankruptcy Drives Plans for Catastrophe Fund to Cover Wildfire Costs. Green Tech Media.
<https://www.greentechmedia.com/articles/read/pge-bankruptcy-drives-plans-for-catastrophe-fund-to-cover-wildfire-costs#gs.boewis>

Mui C. (2019). PG&E Is Just The First Of Many Climate Change Bankruptcies. Forbes.
<https://www.forbes.com/sites/chunkamui/2019/01/24/pge-is-just-the-first-of-many-climate-change-bankruptcies/#3aec8c9b7e5f>

PG&E Corporation. (2016). 2016 Joint Annual Report to shareholders.
http://pgecorp.com/investors/financial_reports/annual_report_proxy_statement/ar_pdf/2016/2016_Annual_Report.pdf
- 36 DWS. (2017). Measuring Physical Climate Risk in Equity Portfolios – Case study: Extreme precipitation and the 2011 Thailand floods.
<https://www.dws.com/en-sg/insights/global-research-institute/physical-climate-risk/> [Accessed October 2019]
- 37 Nabangchang O. et al. (2014). Economic costs incurred by households in the 2011 Greater Bangkok flood. In Water Resources Research, Volume 51, Issue 1, January 2015, pp. 58-77.
<https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014WR015982> [Accessed January 2019]
- 38 Haraguchi M., Lall U., (2014). Flood risks and impacts: A case study of Thailand's floods in 2011 and research questions for supply chain decision making.
https://www.wcdrr.org/wcdrr-data/uploads/469/Haraguchi_Lall_IJDRR.pdf [Accessed October 2019]
- 39 Dignan L. (2011). Thailand floods to lead to hard drive shortages for months. ZDNet.
<https://www.zdnet.com/article/thailand-floods-to-lead-to-hard-drive-shortages-for-months/> [Accessed October 2019]
- 40 European Bank for Reconstruction and Development (EBRD). (2019). What is the EBRD's GET approach?
<https://www.ebrd.com/what-we-do/get.html> [Accessed October 2019]
- 41 European Bank for Reconstruction and Development (EBRD) and Global Commission on Adaptation (GCA). (2018). Advancing TCFD Guidance on Physical Climate Risks and Opportunities.
<https://www.physicalclimaterisk.com> [Accessed October 2019]
- 42 Acclimatise, Climate Finance Advisors and Four Twenty Seven. (2017). Lenders' Guide for Considering Climate Risk in Infrastructure Investments.
https://www.preventionweb.net/files/61128_investmentguide1.8singlehiq17012018.pdf [Accessed October 2019].
- 43 U.S. Global Climate Change Research Program. (2018) Fourth National Climate Assessment, Chapter 18: Northeast.
<https://nca2018.globalchange.gov/chapter/18/#key-message-1> [Accessed October 2019]
- 44 The Resilience Shift (2019). Resilience Primers.
<https://www.resilienceshift.org/campaign/resilience-primers/> [Accessed October 2019]

- 45 Institutional Investors Group on Climate Change (IIGCC). (2018). Addressing Climate Risks and Opportunities in the Investment Process: A Practical Guide for Trustees and Boards of Asset Owner Organisations.
<https://www.iigcc.org/resource/addressing-climate-risks-and-opportunities-in-the-investment-process/> [Accessed October 2019]
- 46 Schulten, A. et al. (2019). Getting Physical: Scenario Analysis for Assessing Climate-Related Risks, BlackRock Investment Institute Global Insights.
<https://www.blackrock.com/ch/individual/en/literature/whitepaper/bii-physical-climate-risks-april-2019.pdf> [Accessed October 2019]
- 47 ClimateWise. (2019). Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios. University of Cambridge Institute for Sustainability Leadership (CISL).
<https://www.cisl.cam.ac.uk/resources/publication-pdfs/cisl-climatewise-physical-risk-framework-report.pdf> [Accessed October 2019]
- 48 Chatain L. (2019) Real estate climate risks: How will Europe be impacted?
<https://www.preventionweb.net/news/view/67550> [Accessed October 2019]
- 49 TCFD (2019). TCFD Status Report.
<https://www.fsb-tcfd.org/publications/tcfd-2019-status-report/> [Accessed October 2019]
- 50 CDP. (2017). CDP Technical Note on the TCFD.
https://b8f65cb373b1b7b15feb-c70d8ead6ced550b4d9d7c03fcd1d.ssl.cf3.rackcdn.com/cms/guidance_docs/pdfs/000/001/429/original/CDP-TCFD-technical-note.pdf?1512736184 [Accessed October 2019].
- 51 Connell et al. (2018). Navigating a New Climate. Assessing Credit Risk and Opportunity in a Changing Climate: Outputs of a Working Group of 16 Banks Piloting the TCFD Recommendations. United Nations Environment Programme Finance Initiative (UNEPFI).
http://www.acclimatise.uk.com/wp-content/uploads/2018/07/NAVIGATING-A-NEW-CLIMATE_24072018.pdf [Accessed October 2019]
- 52 Task Force on Climate-related Financial Disclosures (TCFD). (2017). Recommendations of the Task Force on Climate-related Financial Disclosures
<https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf> [Accessed October 2019]
- 53 Bank of England Prudential Regulation Authority (PRA). (2019). A Framework for Assessing Financial Impacts of Physical Climate Change.
<https://www.bankofengland.co.uk/prudential-regulation/publication/2019/a-framework-for-assessing-financial-impacts-of-physical-climate-change> [Accessed October 2019]
- 54 IIGCC (2018). Addressing Climate Risks and Opportunities in the Investment Process: A Practical Guide for Trustees and Boards of Asset Owner Organisations.
<https://www.iigcc.org/resource/addressing-climate-risks-and-opportunities-in-the-investment-process/> [Accessed October 2019]
- 55 Acclimatise, Climate Finance Advisors and Four Twenty Seven (2017) Lenders' Guide for Considering Climate Risk in Infrastructure Investments.
https://www.preventionweb.net/files/61128_investmentguide1.8singlehiq17012018.pdf [Accessed October 2019].
- 56 Stenek V. et al. (2010). Climate Risk and Financial Institutions: Challenges and Opportunities
- 57 Hassler M. and Howard A. (2019). How will the physical risks of climate change affect companies? Schroders.
<https://www.schroders.com/en/lu/professional-investor/featured/climate-change-dashboard/physical-risks/> [Accessed October 2019]
- 58 Adams P. et al. (2014). Climate Risks Study for Telecommunications and Data Center Services. Report prepared for the General Services Administration (GSA).
- 59 D'Ippoliti D. et al. (2010). The impact of heat waves on mortality in 9 European cities: results from the EuroHEAT project. Environmental Health.
<https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-9-37> [Accessed October 2019]
- 60 Miller, A., Swann, S. for UNEP-FI and the Global Commission on Adaptation (2019). Driving Finance Today for the Climate Resilient Society of Tomorrow.
<https://www.unepfi.org/wordpress/wp-content/uploads/2019/07/GCA-Adaptation-Finance.pdf> [Accessed October 2019]
- 61 Miller, A., Swann, S. for UNEP-FI and the Global Commission on Adaptation (2019). Driving Finance Today for the Climate Resilient Society of Tomorrow.
<https://www.unepfi.org/wordpress/wp-content/uploads/2019/07/GCA-Adaptation-Finance.pdf> [Accessed October 2019]
- 62 IIGCC (2018). Addressing Climate Risks and Opportunities in the Investment Process: A Practical Guide for Trustees and Boards of Asset Owner Organisations.
<https://www.iigcc.org/resource/addressing-climate-risks-and-opportunities-in-the-investment-process/> [Accessed October 2019]
- 63 Hamaker, R., et al., (2018). EU-MACS Deliverable 2.1: Results of Explorations of the Climate Services Market for the Financial Sector.
http://eu-macs.eu/wp-content/uploads/2019/02/EUMACS_D21_FINAL.pdf [Accessed October 2019]
- 64 Stegmaier, P. and Visscher, K. (2017). EU-MACS Deliverable 1.4: A multi-layer exploration on innovations for climate services markets.
http://eu-macs.eu/wp-content/uploads/2016/12/EU-MACS_D14_submitted_31102017-corrected-171113-JAK.pdf [Accessed November 2019]
- 65 Visscher, K et al. (in press, 2020) Matching supply and demand: A typology of climate services. Climate Services.
<http://www.sciencedirect.com/science/article/pii/S2405880719300779> [Accessed January 2020]
- 66 United Nations Environment Programme Finance Initiative (UNEPFI). (2019). Changing Course
<https://www.unepfi.org/investment/tcfd/> [Accessed October 2019].
- 67 Hamaker, R., et al. (2018). EU-MACS Deliverable 2.1: Results of Explorations of the Climate Services Market for the Financial Sector.
http://eu-macs.eu/wp-content/uploads/2019/02/EUMACS_D21_FINAL.pdf [Accessed October 2019].
- 68 EBRD and GCA, (2018). Advancing TCFD Guidance on Physical Climate Risks and Opportunities.
<https://www.physicalclimaterisk.com> [Accessed October 2019].

- 69 Principles for Responsible Investment (PRI). (2018). Implementing the Task force on Climate-related Financial Disclosures (TCFD) Recommendations: A guide for asset owners
<https://www.unpri.org/download?ac=4652> [Accessed October 2019]
- 71 Connell et al. (2018). Navigating a New Climate. Assessing Credit Risk and Opportunity in a Changing Climate: Outputs of a Working Group of 16 Banks Piloting the TCFD Recommendations.
http://www.acclimatise.uk.com/wp-content/uploads/2018/07/NAVIGATING-A-NEW-CLIMATE_24072018.pdf [Accessed October 2019]
- 72 Owain, E. and R. Bater. (2019). Downscaling is a process of generating higher spatial and temporal-resolution data from lower-resolution data and is used to derive local-scale data able to inform short-term decision-making. Acclimatise.
<https://www.acclimatise.uk.com/2019/10/15/beyond-climate-models-climate-adaptation-in-the-face-of-uncertainty/>
- 73 Willows, R.I., and Connell R. (2003). eds. Climate Adaptation: Risk, Uncertainty and Decision-Making. UKCIP Tech.
TCFD (2019) TCFD Status Report.
<https://www.fsb-tcfd.org/publications/tcfd-2019-status-report/> [Accessed October 2019]
- 75 Schulten, A. et al., Getting Physical: Scenario Analysis for Assessing Climate-Related Risks, BlackRock Investment Institute Global Insights.
<https://www.blackrock.com/ch/individual/en/literature/whitepaper/bii-physical-climate-risks-april-2019.pdf> 2019 [Accessed October 2019]
- 76 Aviva (2019). Aviva's Climate-Related Financial Disclosure 2018
<https://www.aviva.com/social-purpose/climate-related-financial-disclosure/> [Accessed October 2019]
- 77 ClimateWise. (2019). Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios. University of Cambridge Institute for Sustainability Leadership (CISL).
<https://www.cisl.cam.ac.uk/resources/publication-pdfs/cisl-climatewise-physical-risk-framework-report.pdf> [Accessed October 2019]
- 78 EBRD and GCA, (2018). Advancing TCFD Guidance on Physical Climate Risks and Opportunities.
<https://www.physicalclimaterisk.com> [Accessed October 2019]
- 79 Global Adaptation & Resilience Investment (GARI). (2016). Bridging the Adaptation Gap: Approaches to Measurement of Physical Climate Risk and Examples of Investment in Climate Adaptation and Resilience, pp. 34–35.
<http://427mt.com/wp-content/uploads/2016/11/GARI-2016-Bridging-the-Adaptation-Gap.pdf> [Accessed October 2019]
- 80 Global Adaptation & Resilience Investment (GARI). (2016). Bridging the Adaptation Gap: Approaches to Measurement of Physical Climate Risk and Examples of Investment in Climate Adaptation and Resilience, pp. 34–35.
<http://427mt.com/wp-content/uploads/2016/11/GARI-2016-Bridging-the-Adaptation-Gap.pdf> [Accessed October 2019]
- 81 European Commission Technical expert group (TEG) on Sustainable Finance. (2019) Taxonomy Technical Report.
https://ec.europa.eu/info/files/190618-sustainable-finance-teg-report-taxonomy_en [Accessed October 2019]
- 82 European Commission Technical expert group (TEG) on Sustainable Finance. (2019) Taxonomy Technical Report.
https://ec.europa.eu/info/files/190618-sustainable-finance-teg-report-taxonomy_en [Accessed October 2019]
- 83 European Commission Technical expert group (TEG) on Sustainable Finance. (2019). Using the taxonomy: Supplementary Report
https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-using-the-taxonomy_en.pdf [Accessed October 2019]
- 84 European Commission Technical expert group (TEG) on Sustainable Finance. (2019) Taxonomy Technical Report.
https://ec.europa.eu/info/files/190618-sustainable-finance-teg-report-taxonomy_en [Accessed October 2019]
- 85 European Commission TEG on Sustainable Finance, 2019.
https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-using-the-taxonomy_en.pdf [Accessed October 2019]
- 86 European Commission TEG on Sustainable Finance, 2019.
https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-using-the-taxonomy_en.pdf [Accessed October 2019]
- 87 Climate Bonds Initiative (CBI). (2019). Climate resilience principles
<https://www.climatebonds.net/files/files/climate-resilience-principles-climate-bonds-initiative-20190917.pdf> [Accessed October 2019]
- 88 Climate Bonds Initiative (CBI). (2019). Climate resilience principles
<https://www.climatebonds.net/files/files/climate-resilience-principles-climate-bonds-initiative-20190917.pdf> [Accessed October 2019]
- 89 Connell et al. (2018). Navigating a New Climate. Assessing Credit Risk and Opportunity in a Changing Climate: Outputs of a Working Group of 16 Banks Piloting the TCFD Recommendations.
http://www.acclimatise.uk.com/wp-content/uploads/2018/07/NAVIGATING-A-NEW-CLIMATE_24072018.pdf [Accessed October 2019]
- 90 Connell et al. (2018). Navigating a New Climate. Assessing Credit Risk and Opportunity in a Changing Climate: Outputs of a Working Group of 16 Banks Piloting the TCFD Recommendations.
http://www.acclimatise.uk.com/wp-content/uploads/2018/07/NAVIGATING-A-NEW-CLIMATE_24072018.pdf [Accessed October 2019]
- 91 Institutional Investors Group on Climate Change (IIGCC). (2019). Launch of the Coalition for Climate Resilient Investment (CCRI)
<https://www.iigcc.org/news/launch-of-coalition-for-climate-resilient-investment-ccri/> [Accessed October 2019]
- 92 Sullivan, R., Russell, D., Beloe, S., Curtiss, F. & Firth, J. (2009), Managing the Unavoidable: Investment Implications of a Changing Climate (Acclimatise, Henderson Global Investors, Insight Investment, Railpen and USS).
http://www.acclimatise.uk.com/wp-content/uploads/2018/01/Managing_the_Unavoidable_FINAL_Nov2009.pdf [Accessed October 2019]
- 93 EBRD and GCA, (2018). Advancing TCFD Guidance on Physical Climate Risks and Opportunities
<https://www.physicalclimaterisk.com> [Accessed October 2019]

- 94 Climate Disclosure Standards Board (CDSB) and Sustainability Accounting Standards Board (SASB) (2019). TCFD Implementation Guide: Using SASB Standards and the CDSB Framework to Enhance Climate-Related Financial Disclosures in Mainstream Reporting <https://www.cdsb.net/tcfid-implementation-guide> [Accessed October 2019]
- 95 Climate Disclosure Standards Board (CDSB) and Sustainability Accounting Standards Board (SASB) (2019). TCFD Good Practice Handbook. <https://www.cdsb.net/tcfid-good-practice-handbook> [Accessed October 2019]
- 96 Sullivan, R., Russell, D., Beloe, S., Curtiss, F. & Firth, J. (2009), Managing the Unavoidable: Investment Implications of a Changing Climate (Acclimatise, Henderson Global Investors, Insight Investment, Railpen and USS). http://www.acclimatise.uk.com/wp-content/uploads/2018/01/Managing_the_Unavoidable_FINAL_Nov2009.pdf [Accessed October 2019]
- 97 PRI (2018). Implementing the Task force on Climate-related Financial Disclosures (TCFD) Recommendations: A guide for asset owners. <https://www.unpri.org/download?ac=4652> [Accessed October 2019].
- 98 PRI (2018). Implementing the Task force on Climate-related Financial Disclosures (TCFD) Recommendations: A guide for asset owners. <https://www.unpri.org/download?ac=4652> [Accessed October 2019].
- 99 IIGCC (2018) Addressing Climate Risks and Opportunities in the Investment Process: A Practical Guide for Trustees and Boards of Asset Owner Organisations. <https://www.iigcc.org/resource/addressing-climate-risks-and-opportunities-in-the-investment-process/> [Accessed October 2019]
- 100 Miller, A., Swann, S. for UNEP-FI and the Global Commission on Adaptation (2019). Driving Finance Today for the Climate Resilient Society of Tomorrow. <https://www.unepfi.org/wordpress/wp-content/uploads/2019/07/GCA-Adaptation-Finance.pdf> [Accessed October 2019]
- 101 CDSB and SASB (2019). TCFD Good Practice Handbook. <https://www.cdsb.net/tcfid-good-practice-handbook> [Accessed October 2019]
- 102 Task Force on Climate-related Financial Disclosures (TCFD). (2017). Recommendations of the Task Force on Climate-related Financial Disclosures <https://www.fsb-tcfid.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf> [Accessed October 2019]
- 103 Coalition of Finance Ministers for Climate Action. (2019). Helsinki Principles <http://pubdocs.worldbank.org/en/600041555089009395/FM-Coalition-Principles-final-v3.pdf> and <https://www.cape4financeministry.org/sites/cape/files/inline-files/Explanatory%20Note%20final.pdf> [Accessed October 2019]
- 104 Network for Greening the Financial System (NGFS). (2019). A call for action: Climate change as a source of financial risk. https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf [Accessed October 2019]
- 105 Hamaker-Taylor, R. et al. (2019). Voluntary climate disclosures can reduce litigation risk. <http://www.acclimatise.uk.com/2019/06/13/voluntary-climate-disclosures-can-reduce-litigation-risk/> [Accessed October 2019]
- 106 Centre for Policy Development and the Future Business Council. (2016). Climate Change and Directors' Duties [The Hutley Opinion] <https://cpd.org.au/wp-content/uploads/2016/10/Legal-Opinion-on-Climate-Change-and-Directors-Duties.pdf> [Accessed October 2019]
- 107 Centre for Policy and Development. (2019). Climate Change and Directors' Duties- Supplementary Memorandum of Opinion [update to 2016 Hutley Opinion]. <https://cpd.org.au/2019/03/directors-duties-2019/> [Accessed October 2019]
- 108 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]
- 109 Connell et al. (2018). Navigating a New Climate. Assessing Credit Risk and Opportunity in a Changing Climate: Outputs of a Working Group of 16 Banks Piloting the TCFD Recommendations. http://www.acclimatise.uk.com/wp-content/uploads/2018/07/NAVIGATING-A-NEW-CLIMATE_24072018.pdf [Accessed October 2019]
- 110 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]
- 111 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5. https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]

- 112 TCFD. (2017). Recommendations of the Task Force on Climate-related Financial Disclosures.
<https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf> [Accessed October 2019]
- 113 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5.
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]
- 114 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5.
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]
- 115 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5.
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]
- 116 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5.
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]
- 117 European Commission (2016). Switching of tangible and intangible assets between different insurance products.
https://ec.europa.eu/competition/sectors/financial_services/KD0216917ENN.pdf [Accessed October 2019]
- 118 TCFD. (2017). Recommendations of the Task Force on Climate-related Financial Disclosures.
<https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf> [Accessed October 2019]
- 119 Intergovernmental Panel on Climate Change (IPCC). (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp. Pg. 5.
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf [Accessed October 2019]



Acclimatise
Hexgreave Hall
Farnsfield, Newark
Nottinghamshire, NG22 8LS

T: +44 (0) 1623 884347
F: +44 (0) 5603 105079
E: r.bater@acclimatise.uk.com
www.acclimatise.uk.com

IIGCC
The Institutional Investors
Group on Climate Change

Adam House
7-10 Adam Street
The Strand
London, WC2N 6AA

+44 (0) 207 520 9305
info@iigcc.org
twitter @iigccnews
www.iigcc.org