CFRF CLIMATE FINANCIAL RISK FORUM

MOBILISING ADAPTATION FINANCE TO BUILD RESILIENCE

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Contents

This chapter represents the output from the Adaptation Working Group, part of the Climate Financial Risk Forum (CFRF).

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Executive Summary

The Paris Agreement set the long-term goal to hold the increase in the global average temperature to well below 2°C and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change[1]. Temperatures fluctuate year-on-year and using a longer-term average, global temperatures are now 1.26°C above pre-industrial levels[2]. However, that we have seen the first 12-month period above 1.5°C (12 months from the end of January 2023) is concerning, and indeed, ocean temperatures and other key indicators, such as the decline in Arctic sea ice extent, are also regularly hitting record levels. Further climate change can be expected and is inevitable, although the magnitude and rate of this over the coming decades will be determined by societies' actions. In fact, it is often overlooked that keeping global temperature increases to no more than 1.5°C and reaching net zero by 2050 is a scenario that itself requires adaptation.

Large-scale proactive mobilisation of private capital will be key to facilitating an orderly transition to a net zero, adapted and resilient economy. While it remains essential that decarbonisation efforts are accelerated–given the Intergovernmental Panel on Climate Change's (IPCC's) advice that global emissions need to roughly halve from 2010 levels by 2030 in order to stay on course for at least a 50% chance of limiting global warming to no more than 1.5°C – it is essential that we scale up action on adaptation. Even with this level of ambition in emission reduction, we are now committed to some further warming and other changes in climate such as sea-level rise. This adds to the climate change we have already experienced. Urgent efforts need to be made alongside emission reduction to strengthen the financial resilience of the sector to a changing climate and catalyse investment to respond to these fundamental changes to life on earth. As the case studies show, this is already happening, but activity is ad hoc and mainstreaming is needed to integrate adaptation within decision making, avoid maladaptation and do no significant harm.

The Climate Financial Risk Forum Adaptation Working Group (CFRF AWG) members identify a number of challenges in terms of increasing efforts to mainstream adaptation and scale-up financing. These are:

- Concerns about the quality and relevance/usefulness of data for supporting physical risk analysis – particularly when moving from global emission scenarios to local hazard and asset level data.
- Lack of clarity on what potential climate futures (scenarios) to consider in developing adaptation strategies and product development.
- Lack of guidance on how to integrate that scenario analysis into investment, lending and underwriting decisions – and how best to disclose it to the market.
- Lack of clarity on national and international adaptation goals and lack of consensus on standards and definitions for adapted assets to support strategic decision-making on adaptation responses by firms.
- Lack of scaled deal opportunities for adaptation activities.

Developing adaptation-inclusive transition plans – as encouraged by the Transition Plan Taskforce (TPT) – can be a useful way to think through both risk and opportunity. This approach is in line

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[1] The Paris Agreement | UNFCCC.

[2] This is based on a 20-year mean period, combining the last decade of the observations with trends from a climate model for the next decade. Betts, R. A., Belcher, S. E., Hermanson, L., Klein Tank, A., Lowe, J. A., Jones, C. D., Morice, C. P., Rayner, N. A., Scaife, A. A., & Stott, P. A. (2023). Approaching 1.5 °C: How will we know we've reached this crucial warming mark? *Nature, 624* (7990), 33–35. https://doi.org/10.1038/d41586-023-03775-z.

with the recommendations of the Taskforce on Climate Related Financial Disclosures (TCFD) and Taskforce on Nature Related Financial Disclosures (TNFD) and will need to take the form of a robust but also iterative process. This guidance provides advice and tools for financial institutions to get started on their journeys.

Key to moving forward is understanding what constitutes decision-useful scenario analysis and physical risk assessment to support adaptation efforts. The Network for Greening the Financial System (NGFS) scenarios provide a very useful starting point but are not fully sufficient for this purpose. A survey of CFRF AWG members identified the following market needs to support enhanced scenario and data analysis:

- Enhanced accessibility and reliability of climate-related information to support informed decision-making processes. This includes addressing challenges related to data availability, quality, interoperability and frequency of updates.
- Growing demand for tailored guidance and educational resources to assist information users in understanding and navigating the complexities of climate adaptation. This includes providing support for interpreting and applying climate-related information effectively within the context of financial decision-making. Overall, addressing these issues can unlock more action.

We have responded in the following ways in this guidance:

Climate scenarios: We have sought advice from the scientific community on which climate scenarios and datasets should ideally be used by the finance sector for scenario analysis over differing timescales to inform physical climate risk management and adaptation planning. For the short-term (up to 5 years) the focus should be on understanding projected weather variability, including where climate change is already happening, and using local hazard data to support analysis with a particular focus on understanding potential tail risks, supported for example by deep dives into vulnerabilities of asset types, sectors or locations – as advised by the Short-Term Scenario Analysis guide. A database of hazard data sources is provided to support financial institutions in this endeavour. Looking out beyond approximately 5 to 10 years, further change must be considered, with the uncertainty in the climate response taken into account. Beyond roughly 10 years, users will need to consider both different possible emissions pathways and also climate response uncertainties.

We suggest an **Aim-Build-Contingency (ABC framework)** be used to support for decision-making under uncertainty. Here we have labelled the scenarios with the global warming up to 2050 relative to pre-industrial times, but firms may perform the risk assessment beyond 2050 if appropriate:

- **Aiming** for 1.5°C (a suitable proxy for this is the IPCC's Shared Socioeconomic Pathway 1-1.9 (SSP1-1.9) scenario and taking the median climate response).
- **Building and budgeting** for 2°C by 2050 (the best proxy for this is the IPCC's SSP2-4.5 scenario and taking the median climate response).
- **Contingency planning** for 2.5°C by 2050 (this is represented by the IPCC's SSP3-7.0 scenario and taking the 95th percentile of the climate response).

It is possible to substitute appropriate NGFS scenarios for the IPCC scenarios in some cases. This is covered in Section 3. Through the report, we provide examples of how this framework can be used in different forms of adaptation decisions.

We provide guidance on accessing and using hazard data in risk assessment and adaptation planning. We have sought to understand how financial organisations currently use physical climate risk data to assess risk, identifying where there are gaps. We provide good practice guidance on how to assess and select physical risk (hazard) data – and provide a database of hazard data sources searchable by timeframe, region and spatial detail (resolution). When assessing risks and adaptation opportunity, we suggest users look at the distribution based on the purpose of the assessment – when looking at critical infrastructure or real estate, for example, the median, 5th and 95th percentiles of the climate response may well be appropriate to consider. This will help those using the guidance to understand adaptation opportunity through understanding the range of severity of hazards that need to be considered at an asset level.

This is a difficult task that most financial services firms are still in the foothills of understanding. To provide support we have developed a database of hazard data sources: a list of credible and legitimate hazard data sources to use. Guidance on how to get started is provided. This is covered in Section 5, including sample case studies on how to select data and apply it to decision-making for (i) a bank looking at flood and heat risk and (ii) an asset manager looking at risks to a fisheries stock.

Integrating the data to strategic planning and financial decision making: We provide some early thoughts on how to apply the results of this analysis to:

1. Support the development of **adaptation-inclusive transition** plans – see Section 4.
2. Support financial **risk management and disclosure** – see Section 5.
3. Identify and create **new adaptation focused opportunities** – see Section 6.

Accelerating Action: The TCFD guidance proposes *'organizations should include scenario analysis in strategic planning and or enterprise risk management processes'*, by *'identifying a range of scenarios that provide a reasonable diversity of potential future climate states'*.[3] The ABC Framework provides the technical guidance the finance sector needs on what 'potential future climate states' the sector should be prepared for in making investment decisions and seeking further resilience investment opportunities, over different timescales. Examples of how financial organisations can start accelerating action using the guidance provided include:

- **For banks:** it can be recommended to clients, especially those operating critical infrastructure assets and with real estate portfolios, as a basis for scenario analysis and transition planning. It can also help with assessment of local hazards and weather-related risks already manifesting in mortgage and agri-foods portfolios to better inform risk assessments (over near to medium term).
- **For asset managers:** recommending the ABC framework (and hazard + asset datasets) to investee companies and clients as a basis for scenario analysis and transition planning.
  - Using the hazard and asset datasets to build-out proprietary physical risk analysis models to improve firmwide risk assessment and for individual funds.
  - Using improved models to identify engagement priorities (regions, sectors, and specific companies/assets within companies).
- **For infrastructure investment managers:** the ABC Framework

[3] TCFD. (2024). *The Use of Scenario Analysis in Disclosure of Climate-related Risks and Opportunities*. TCFD Knowledge Hub. https://www.tcfdhub.org/scenario-analysis/.

can inform what warming levels contingency planning will be needed for assets and differing local hazards.

- **For insurers:** the ABC framework can inform product development, including dialogue with clients and government/ regulators on how to ensure continued and adapted insurance coverage.

While examples are provided for real economy companies and finance sector practitioners seeking to increase investments in adaptation and resilience, fundamentally better regulation is key to levelling the playing field and accelerating action. This guidance document therefore provides proposals on the opportunities for policy makers and regulators to also accelerate action.

Summary recommendations to accelerate action.

Stakeholder group	Recommendation
Financial Sector	• **Recommendation 2:** The ABC framework is recommended as a good practice approach to assessing physical risk, forbearance is needed around the fact there are data challenges to work through to be able to fully apply the approach however. • **Recommendation 4:** Developing and disclosing an adaptation-inclusive transition plan in line with the Transition Plan Taskforce proposals, which are a gold standard template for reporting, is recommended. More detailed guidance on adaptation planning provided in this report (Section 4). • **Recommendation 5:** Facilitate greater sharing of aggregate data sets to protect assets in the UK from climate change and physical hazard risks. This includes seeking annual updates to coverage on insurance for mortgage and commercial loans in the built environment to better price risk exposures, coverage needed and support product innovation.
Real economy companies	• **Recommendation 3:** Businesses need to improve disclosure of physical climate risks and adaptation strategies and opportunities. Similar to the TNFD-recommended asset level disclosures, the CFRF AWG encourages the disclosure of the locations of assets and/or activities in real economy companies' direct operations and, where possible, upstream and downstream value chain(s) that meet the criteria for priority locations, where the effects of physical climate risk are material. • **Recommendation 4:** The CFRF AWG supports corporate reporting in line with the Transition Plan Taskforce proposals, which are a gold standard template for reporting, with an adaptation-inclusive transition plan.
Third party data vendors and suppliers	• **Recommendation 6:** Standards and assurance need to be created for third party climate risk data providers. Alternatively, there should be transparency on evidence sources, methodology and the assumptions made to enable users to select sources and tools appropriate to the task at hand and enable independent and expert academic assessment of quality by experts like the technical advisors to the CFRF AWG (Met Office, University of Leeds and Oxford University).

Stakeholder group	Recommendation
Technical advisors and scientific community	• **Recommendation 6:** Standards and assurance need to be created for third party climate risk data providers. Alternatively, there should be transparency on evidence sources, methodology and the assumptions made to enable users to select sources and tools appropriate to the task at hand and enable independent and expert academic assessment of quality by experts like the technical advisors to the CFRF AWG (Met Office, University of Leeds and Oxford University).

Policy and regulators	• **Recommendation 1:**
	  ◦ UK government to commit to make the country resilient to climate change by 2030. Outline specific and costed goals/ delivery plans for each sector by 2025 – and envisaged public/ private sector roles.
	  ◦ Continue the work started by the Land Use Nature and Adapted Systems (LNAS) Advisory Group to develop a UK adaptation-focused taxonomy.
	• **Recommendation 3:** UK regulators working with other regulators to make the case for these disclosure requirements to be implemented elsewhere, for example via the G20 Sustainable Finance Working Group, International Platform on Sustainable Finance, in relevant International Organization of Securities Commissions (IOSCO) fora and so on.
	• **Recommendation 7:** Fully incorporate climate resilience into the mandates of all existing regulatory bodies – enabling them to set clear resilience standards – in particular for water, energy, telecoms, transport, the natural environment and land. Enable data integration across regulators to manage cascading risks.
	• **Recommendation 8:** Integrate climate resilience into infrastructure and green investment planning across Government departments. A key consideration should be how public capital and regulation can be deployed most efficiently to maximise private co-investment.
	• **Recommendation 9:** The introduction of Flood Performance Certificates (FCPs) should be considered.
	• **Recommendation 10:** Continue to use fiscal policy to support a shift to more resilient and sustainable farming systems.

We provide case studies to illustrate the points made – and further case studies can be found in a separate paper. For further detail on the role of financial organisations, policies and better data in accelerating action see Section 7. Finally, next possible steps for this work are set out in Section 8.

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1. Introduction

In 2023, new climate change records were broken with the average global temperature breaching 1.5°C above pre-industrial averages for the first time. Temperatures fluctuate year-on-year – on average global temperatures are now 1.26°C above pre-industrial levels[4] – yet the fact that we have seen the first 12-month period above 1.5°C is concerning. The world is already facing damaging impacts from this climate change. Further climate change can be expected and is inevitable, although the magnitude and rate of climate change will be determined by societies' actions. In fact, it is often overlooked that keeping global temperature increases to no more than 1.5°C and reaching net zero by 2050 is in itself a scenario that requires adaptation to happen. It is this required adaptation that the guidance in this paper seeks to support. Financial institutions need to build resilience. Yet, large-scale proactive mobilisation of private capital will be key to facilitating an orderly transition to an adapted and resilient economy; a win-win for financial institutions and society. As the case studies show, adaptation is already happening, but activity is ad hoc–and mainstreaming is needed–as well as a focus on doing no significant harm, by which we mean ensuring that as one party adapts, they do not impair others' ability to also adapt. Guidance is also required to avoid maladaptation, i.e. taking incorrect decisions that can expose a firm to greater risks.

It remains imperative that decarbonisation efforts are accelerated given the Intergovernmental Panel on Climate Change's (IPCC's) advice that global emissions need to roughly halve from 2010 levels by 2030 in order to stay on course for at least a 50% chance of limiting global warming to no more than 1.5°C on average.[5] But, at the same time, the impacts of climate change can already be seen every day: from rising risks of wildfires to floods and droughts across Europe, the US and around the world. Society also now needs to adapt. Indeed, based on current policies, global temperatures will be well over 1.5°C, and so while we aim for 1.5°C, it is imperative to be ready for more adverse outcomes.

The question then is how much and to be resilient to what? And what does this mean for the actions that financial institutions need to take now? The components of adaptation include:[6]

- **Ensuring its own resilience to physical climate risks**, including managing any risks associated with the transition to a well-adapted society and seizing opportunities to support this transition. This will include appropriate risk pricing across the portfolio as well as managing risks to own buildings and operations, including insurance.
- **Engaging with clients or investees and offering new products and services to promote and support adaptation and resilience across the client and investee base**. This can include investing in new types of technologies, such as water conservation technologies or new varieties of crops, as well as supporting existing clients to adapt through new financial products – such as green bonds or sustainability-linked loans for adaptation.
- **Ensuring financed activities do not inadvertently harm the resilience of wider society**. For example, financed activities that lead to deforestation, soil erosion or overextraction of water could increase the risks faced by others. Around 45% of companies across the FTSE350 are in industries that could impact on the resilience of wider society.

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[4] This is based on a 20-year mean period, combining the last decade of the observations with trends from a climate model for the next decade. Betts, R. A., Belcher, S. E., Hermanson, L., Klein Tank, A., Lowe, J. A., Jones, C. D., Morice, C. P., Rayner, N. A., Scaife, A. A., & Stott, P. A. (2023). Approaching 1.5 °C: How will we know we've reached this crucial warming mark? *Nature, 624* (7990), 33–35. https://doi.org/10.1038/d41586-023-03775-z.

[5] As a 20-year/long-term average.

[6] Mullan, M. and N. Ranger (2022), "Climate-resilient finance and investment: Framing paper", OECD Environment Working Papers, No. 196, OECD Publishing, Paris, https://doi.org/10.1787/223ad3b9-en.

The Climate Finance Risk Forum Adaptation Working Group (CFRF AWG) members identify a number of challenges in terms of increasing efforts to mainstream adaption financing. These are:

- Concerns about the quality and relevance/usefulness of data for supporting physical risk analysis particularly when moving from global emission scenarios to local hazard and asset level data.
- Lack of clarity on what potential climate futures (scenarios) to consider in developing adaptation strategy and product development.
- Lack of guidance on how to integrate that scenario analysis into investment, lending and underwriting decisions – and how best to disclose it to the market.
- Lack of clarity on national and international adaptation goals as well as lack of consensus on standards and definitions for adapted assets to support strategic decision-making on adaptation responses by firms.
- Lack of scaled deal opportunities coming through.

Limited revenue streams and long investment horizons are often cited as barriers to adaptation. However the barriers identified above by the CFRF AWG and recent reports from Standard Chartered and the Green Finance Institute/Oxford University suggest current underinvestment stems largely from short-term perspectives and market inefficiencies, a lack of data and understanding, the lack of a common language (e.g. taxonomies, metrics) and inaction by policymakers to set resilience standards, provide a clear set of objectives and integrate climate risks within their own policies and financing (Table 1).

Table 1: Real and perceived barriers to private finance for adaptation and resilience (Source: Standard Chartered, United Nations Office for Disaster Risk Reduction (UNDRR) and KPMG 2024).[7]

Perceived barriers	Real barriers
• Limited revenue streams for many adaptation and resilience investments (mainly generating avoided losses). • Long investment horizon and size of adaptation and resilience projects.	• Short-term perspectives and market inefficiencies that affect the accurate pricing and adequate consideration of natural hazard and climate-related risks. • Lack of country-specific data and asset-level data on natural hazard and climate risk and vulnerability which impedes informed investment decisions. • The private sector's challenge in understanding and measuring the environmental and social benefits of investing in adaptation and resilience. • Information disparities and gaps in knowledge, including understanding/ measuring the extent of potential environmental and social benefits, which influence the assessment of public-private investment returns and decision-making processes. • The absence of common market language, standard definitions and classification frameworks for adaptation and resilience-building investments and transactions.

[7] Standard Chartered, UNDRR and KPMG (2024). Guide for adaptation and resilience finance https://www.undrr.org/media/95342/download?startDownload=20240523.

This guidance attempts to provide some solutions to address these barriers. It builds on the work that has gone before in the Climate Financial Risk Forum – notably the work on Risk Management and Scenario Analysis – as well on other largely market-led initiatives.[8] It is premised on the understanding that a certain amount of climate change is already locked in into the 2040s and the impacts of this need to be reduced through significantly increased resilience and adaptation investments facilitated by the finance sector.

As a separate case study document shows, there is a significant amount of adaptation-focused investment and product development that is already happening in the market. However, many adaptation-focused investments are most often facilitated by the public sector or predicated on avoided losses (i.e. avoided asset damages or business interruption risk). Revenue-based models to facilitate investment are scarce – although in the UK there are efforts underway to address this. For example, the Department for Environment, Food and Rural Affairs' (Defra's) efforts to incorporate climate change adaptation into the design of Environmental Land Management schemes (ELMs) to promote resilient and sustainable land management and farming practices and the Department for Transport consulting on a new transport adaptation strategy, which will take a holistic approach to addressing climate risks to transport.

In this report we make a start on providing answers. Throughout, we use case studies to bring these challenges, potential solutions and proposals to life.

We have sought to understand how physical climate risk data is currently being used to measure risk, identifying where there are gaps, and provide good practice guidance on how to assess and select physical risk (hazard) data. We also provide a database of hazard data sources searchable by timeframe, region, and resolution. This is covered in Section 5.

We have sought advice from the scientific community on which climate scenarios and datasets should be used by the finance sector for scenario analysis over differing timescales (present day, a season ahead, the next decade and multiple decades to 2050 and beyond). To support short-term scenario analysis efforts, it is sufficient to rely on forward looking hazard data that includes the climate change that is already locked in due to inertia in the climate system – and a hazard data sources database is provided. Looking out beyond ~5 years, users will need to consider different possible emissions pathways and also climate response uncertainties – we suggest an Aim-Building-Contingency plan or 'ABC' framework for framing this analysis. This is based on the latest science and the pragmatic view of the group on what is most useful for considering risk to assets – importantly tail risks as well as median points should be considered. This is covered in Section 3.

We provide an introduction to some of the adaptation taxonomies that are emerging and their use cases, which range from supporting asset level adaptation decisions to investment universe selection. This is covered in Section 5 and Section 6.

We also start to consider how this information can be integrated to develop an adaptation strategy – or to integrate adaptation within a transition plan – consideration of this topic will be the focus of further work in the next CFRF session. This is covered in Section 4.

We also look at what actions could be taken by governments and regulators to accelerate the mainstreaming of adaptation focused investment, lending, and underwriting – with a focus on improving access to quality of data and increasing deal flow. This is covered in Section 7. These gaps will also need to be filled to enable the development publication and delivery of credible adaption-inclusive climate change Transition Plans.

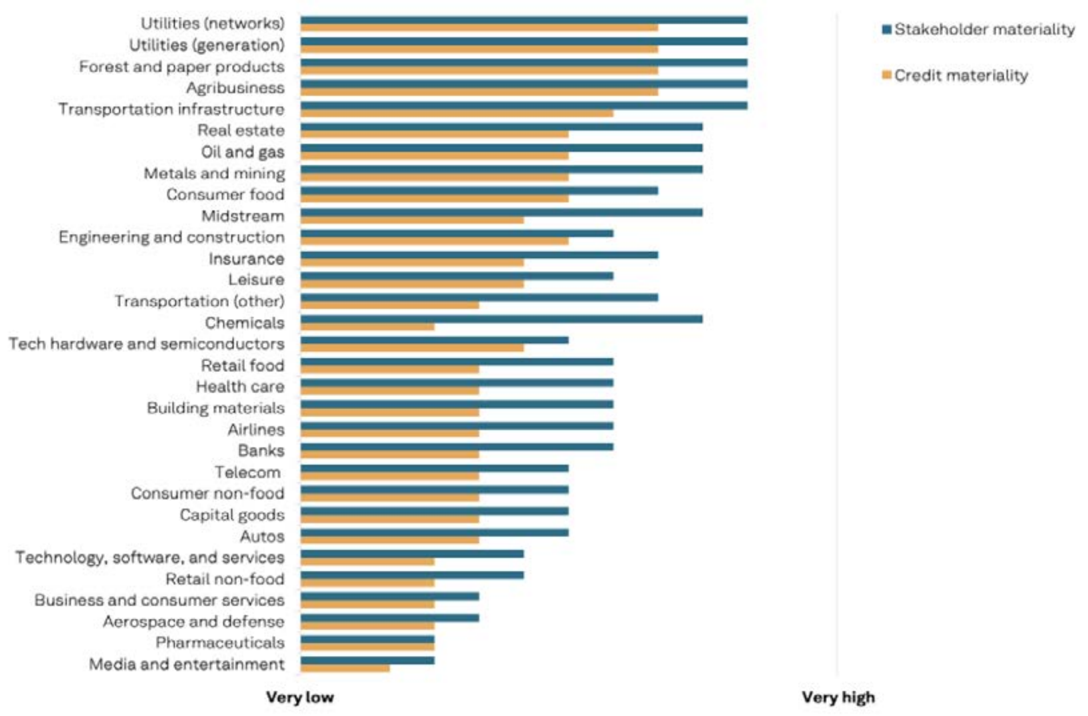
8 These include IIGCC – Physical Climate Risk Assessment Methodology, UNEP FI – Climate Adaptation Target Setting Guidance, CBI – Climate Resilience Principles, CCC's Investment for a Well Adapted UK, GFI-Oxford Mission Climate Ready, OECD-Oxford Framework for Climate Resilient Finance and Investment, CISL's 2022 report and 2019, The Triple Resilience Dividend concept and its application across sectors and geographies, Oxford Guidance on Adaptation Targets and Metrics, TCFD Guidance on Risk Management Integration and Disclosure.

2. Current market context

This guidance has a dual focus on increasing investment into UK adaptation (including infrastructure investment, bank lending, insurance and UK listed equities) – but also on working to ensure the resilience of the financial system itself – including, for example, ensuring products and investments respond to climate risks and adaptation opportunities, including through integrating adaptation into existing investments (real-estate, agri-foods, utilities, infrastructure), risk-adjusted pricing and underwriting, and scaling investment into adaptation goods and services.

Today, many firms are underestimating the costs related to climate change impacts (BIS, 2022)[9] and few companies are disclosing those risks (TCFD, 2023).[10] As a result, the finance sector is under-pricing this risk, which is subsequently constraining action and investment. Recent research by S&P's, for example, found that more than one-third of all sectors are highly exposed to physical climate risks (Figure 1). Yet only around one-fifth of companies sampled disclosed an adaptation plan and less than half said that they were planning to implement their adaptation plan within the next decade, implying that companies' progress on adaptation is not keeping pace with worsening climate impacts. In general, physical climate risks are found to be more material for companies with fixed, long-lived assets and those more reliant on the natural environment, such as utilities, forestry and paper, agri-foods, transportation, real-estate, oil & gas, metals, and mining.

Figure 1: Stakeholder and credit materiality of physical climate risks by sector.[11]



[9] Bank of International Settlements. (2022). https://www.bis.org/publ/bppdf/bispap130.htm.

[10] TCFD 2023 Progress Report. (2023). https://www.fsb.org/2023/10/2023-tcfd-status-report-task-force-on-climate-related-financial-disclosures/.

[11] S&P's. (2024). *Risky Business: Companies' Progress On Adapting To Climate Change*. https://www.spglobal.com/_assets/documents/ratings/research/101595538.pdf.

There is also insufficient focus on adaptation implementation and the investment opportunity that adapting to climate change presents. The World Resources Institute (WRI) estimates that every $1 invested in adaptation generates between $2-$10 return on investment, depending on the intervention.[12] This cost benefit analysis is based on interventions in early warning systems, climate-resilient infrastructure, improved dryland agriculture crop production, global mangrove protection, and investments in making water resources more resilient. It includes avoided loss benefits with some also including economic, social, and environmental benefits.

Yet just in the UK, the market opportunity is significant. The Climate Change Committee estimates around £5–10bn per year or £50–£100bn over the next 10 years will need to be invested in adaptation in the UK across both the public and private sector to address climate and physical risks.[13] A lot of this is associated with integrating adaptation within existing systems and investments. For example, the Infrastructure and Projects Authority estimates that total infrastructure investment alone over the next 10 years, including private investment, will be nearly £650bn. It is vital and also cost-effective to ensure that this investment is climate resilient to prevent maladaptation and the build-up of systemic financial risks caused by inadequate action.[14]

The 2023 reports of the CFRF[15] highlighted the technical challenges in estimating physical climate risks and also identified adaptation plans as a key missing data point that limited efforts to manage the financial risks of climate change in the UK and identify solutions for clients.

A survey of CFRF AWG members – drawn from asset management to corporate banking and insurance – confirmed these data quality and data use challenges – identifying:

- A clear need for enhanced accessibility and reliability of climate-related information to support informed decision-making processes. This includes addressing challenges related to data availability, quality, interoperability, and frequency of updates.
- Growing demand for tailored guidance and educational resources to assist information users in understanding and navigating the complexities of climate adaptation. This includes providing support for interpreting and applying climate-related information effectively within the context of financial decision-making. Overall, addressing these issues can contribute to addressing the challenges and unlocking more action.

A full survey report is shown in Annex C: Summary of data use survey.

Better data and guidance are foundational because they are key to addressing the aforementioned short-term perspectives and market inefficiencies that affect the accurate pricing and adequate consideration of natural hazard and climate-related risks. This is key to enhancing users' understanding of the economic and social imperative and benefits of investing in adaptation and resilience – and closing existing gaps in knowledge, which influence the assessment of public-private investment returns and decision-making processes.

While it is not within the gift of the CFRF AWG to tackle all of these barriers – we have proposed solutions to the informational barriers that exist as well as ideas on how actions taken by financial institutions can be accelerated by policy and regulatory intervention.

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12 Global Commission on Adaptation, & World Resources Institute. (2019). *Adapt Now*. https://www.wri.org/initiatives/global-commission-adaptation/adapt-now-report.

13 Climate Change Committee *Investment for a well-adapted UK*. (2023) https://www.theccc.org.uk/wp-content/uploads/2023/01/Investment-for-a-well-adapted-UK-CCC.pdf.

14 Ranger, N., Bremner, C., Brown, K., Fankhauser, S., Holmes, I., & Boyd, E. H. (2023). *Mission Climate Ready: Unleashing finance and investment for a prosperous Climate Ready economy*. https://www.smithschool.ox.ac.uk/sites/default/files/2023-06/Mission-Climate-Ready-Unleashing-finance-and-investment-REPORT.pdf.

15 Financial Conduct Authority. (2019). *Climate Financial Risk Forum*. https://www.fca.org.uk/cfrf.

We include suggestions for applying climate hazard analysis and tools developed by the scientific and service provider community to assess climate change risk impacts and opportunities for increased investment in adaptation and resilience. We also provide guidance for how financial institutions can use this information to:

- assess their own resilience to physical climate risks – especially important for critical infrastructure and real estate;
- engage their clients or investee companies;
- develop/offer new products and services to promote and support adaptation and resilience across the client and investee base.

We also provide an overview of some of the taxonomies that can be used to identify adaptation opportunities and finance activities that do not harm the resilience of wider society – and finally share insights into how this information could be incorporated into a credible adaptation-inclusive transition plan.

However, it is important to note the financial services sector is very much in the foothills of being able to access and use the tools and methodologies needed, with more work required. While the goal must be to move quickly from understanding risks to addressing them, the sector is dealing with inherent uncertainties and dependencies, which makes modelling and decision-making challenging. Furthermore, practice will continue to evolve with sophistication increasing over time.[16] Thus, the guidance provided here is a start only; the next phase should focus on testing, refining, and expanding it.

[16] Financial Conduct Authority, & Climate Financial Risk Forum. (2020). *CFRF Guide 2020—Risk management chapter*. https://www.fca.org.uk/publication/corporate/climate-financial-risk-forum-guide-2020-risk-management-chapter.pdf.

3. Foundations: A framework for using scenarios to assess risks and identify adaptation needs and opportunities

3.1 Background

One of the challenges with increasing investment into adaptation is knowing what futures plausibly need to be prepared for: this was a key challenge raised by CFRF AWG members. While financial institutions are used to dealing with uncertainty, dealing with future climate change-based uncertainty is new and addressing it requires a novel approach. For a financial institution with a large global portfolio, this can be a particularly complex as, in an ideal world with unconstrained time and resources, scenarios would be developed and used for every region in which capital is invested. In the real-world, time and resources are constrained and so the approach needs to balance being as simple and widely applicable as possible with being as accurate and decision-useful as possible.

In this section, the CFRF AWG proposes a framework to guide decision-making across a plausible range of future climate change scenarios that can be applied to the development of adaptation-inclusive transition plans; engaging clients and investee companies; undertaking physical risk assessment and disclosure; and asset-specific financial decisions. We outline this framework below and give examples to show how it can be applied to different use cases, drawing upon existing and new case studies developed by CFRF AWG.

First, it is important to understand the sources of uncertainties that scenarios and risk assessments need to capture to ensure robust adaptation planning. There are three main sources of uncertainty:

- **Emissions uncertainty**: differences in climate outcomes driven by different possible future socio-economic pathways (e.g. climate policies, population) that lead to different emissions levels.
- **Climate model response uncertainty**: even if future emissions were known, different climate models would give different estimates of the response of the climate globally and locally. This uncertainty can be particularly important for the local scale, where different models can disagree on the scale of changes and in some cases, also the direction of change.
- **Natural weather variability**: on top of emissions and climate model response uncertainties, there is also ‘normal’ day-to-day and year-to-year weather variability – although this natural variation is growing and forecast to continue to grow as climate change deepens.

Often the focus is on emissions uncertainty (e.g. NGFS current policies versus net zero scenarios), yet for adaptation the natural weather variability and climate model response uncertainty can be more important, particularly in the near- to medium-term and at local scales.

We demonstrate this in the projections shown in this report and this is embedded in the approaches recommended. Our recommended approaches draw upon well accepted frameworks for adaptation decision making under uncertainty that have been developed, implemented, and refined over more than two decades.

The scenarios of the NGFS are one example of a set of scenarios that have been produced specifically for use within scenario analysis by financial institutions. To create these, the NGFS partnered with an expert group of climate scientists and economists to design a set of scenarios that provide a common, easy-to-use, and up-to-date reference point for exploring physical climate change risks and transition risks in combination with macro-financial developments under different futures.[17] These scenarios have evolved over four iterations to date, becoming progressively more comprehensive. These are not the only scenarios used by financial institutions (e.g. GARP 2023 survey[18]) but are commonly used.

Importantly, while these scenarios can be a helpful starting point, they were not designed for adaptation planning. Adaptation planning requires more granular data at local scales and robust representation of the range of possible local future climate and weather that accounts for uncertainties. The NGFS recent paper[19] outlines the limitations of the scenarios, particularly in the context of physical climate risks, and provides guidance on their use, for example, it says *"NGFS scenarios present only a limited yet credible set of pathways. These scenarios do not necessarily represent the most likely or most extreme potential outcomes. This is why scenarios will not always map to specific user objectives. Hence, scenario users should seek to tailor their analyses to suit their needs and determine which additional risk assessment tools and scenario calibration may be required"*.

- NGFS scenarios have not been run with complex and high-resolution climate models, meaning that their local scale simulation of extreme weather may be less reliable than scenarios used directly with climate models, for example those of the UK Climate Projections (UKCP).[20]
- They do not cover the full scenario range recommended for considering adaptation options. While the NGFS scenarios deal with uncertainty in emissions, they cannot account for the remaining scientific uncertainty reflected in the multitude of existing climate models (NGFS 2024).
- There are many limitations in the way physical risks and impacts on GDP are represented, as outlined in the NGFS 2024 guidance note, for example: see Table 1 of NGFS (2024). For example, estimates on impacts on GDP are based upon an aggregated global damage function – and so are not sufficiently granular or robust to inform local asset-level financial decision-making in banks, asset managers both on the risk and opportunity (i.e. adaptation) side. To inform the development of effective build back better policies for insurers, users would also likely need to extend the scenarios to provide the level of granularity needed.
- The NGFS scenarios, like all alternative climate scenarios, do not account for every potential implication of climate change, and come with acknowledged limitations such us with regard to capturing extreme tail risks and tipping points, as recognised by the NGFS and Financial Stability Board themselves (FSB-NGFS 2023, NGFS 2024).

These limitations all need to be factored in by users, who should adjust the scenarios as required for their specific purposes (NGFS 2024) – such as for appropriate adaptation-based opportunity responses.

For domestic holdings and activities, we also recommend that financial institutions validate their scenarios against the risks identified in the **UK Climate Change Risk Assessment (CCRA)**[21] and

[17] NGFS Climate Scenarios Portal. https://www.ngfs.net/ngfs-scenarios-portal/.

[18] GARP. (2022). *Fourth Annual Global Survey of Climate Risk Management at Financial Firms.* https://www.garp.org/sustainability-climate/fourth-global-climate-risk-survey.

[19] Network for Greening the Financial System (NGFS). (2024). *NGFS scenarios: Purpose, use cases and guidance on where institutional adaptations are required.* https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guidance_note_on_the_scenarios.pdf.

[20] Met Office. (2024). *UKCP data*. Met Office. https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/data/index.

[21] Climate Change Committee. (2021). *Independent Assessment of UK Climate Risk*. https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/.

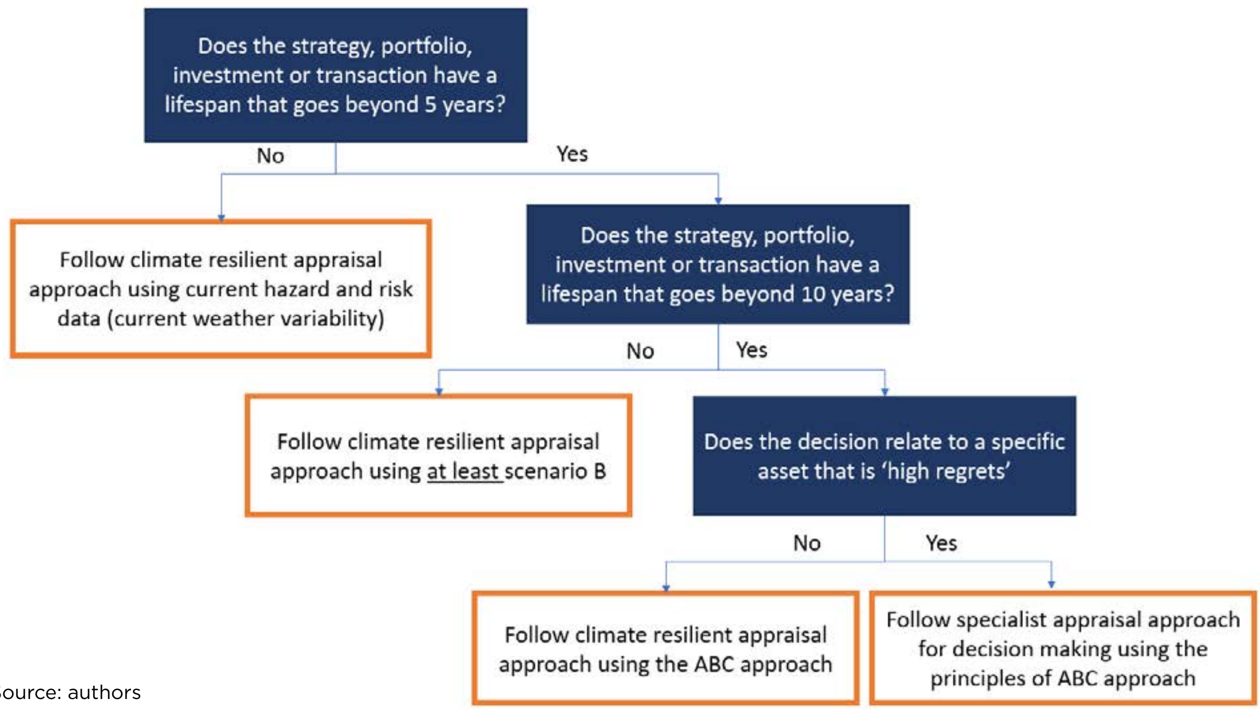
the projections provided by the **UKCP** as well as other key government agencies such as the **Met Office** and the **Environment Agency**. For example, the UK CCRA identifies a range of risks that go well beyond the set considered by the NGFS (e.g. impacts on agriculture, forestry, supply chains).

This represents a more granular approach to scenario analysis across a range of decision-useful timescales and with the appropriate level of precision to increase the accuracy of short (and longer) term climate impact assessments. This will enable those deploying capital to direct it toward investments that will reduce the risk of current and future climate change impacts on economic activity, people, nature and individual assets through increasing their resilience to the changing climate.

3.2 The ABC approach to selecting scenarios

The CFRF AWG proposes a simple framework for selecting future climate change scenarios to support decision making across different timescales. This framework builds upon the substantial guidance and best available data on adaptation-related decision making. We draw on the summary of best practice provided by the *Supplementary Guidance on Accounting for the Effects of Climate Change*,[22] which is consistent with the approach of the UK's CCRA and the Climate Change Committee. From this best practice, Figure 2 provides an approach to guide decisions about which types of hazard data and future scenarios to select based on the type of decision being made and timescale being considered. This is explained in more detail in the following subsections.

Figure 2: Approach to using data and scenarios within decisions.



Source: authors

[22] Department for Environment, Food & Rural Affairs. (2020). *Accounting for the Effects of Climate Change—Supplementary Green Book*. https://assets.publishing.service.gov.uk/media/5fabacf98fa8f56da26ba375/Accounting_for_the_Effects_Of_Climate_Change_-_Supplementary_Green_Book_.._.pdf.

Which timescales are relevant to different decisions?

To support the development of adaptation plans. Timelines longer than the usual 5-yearly strategic planning cycle need to be considered. Timelines that include 2030 and 2050 should be considered to match net zero commitments. For some businesses–for example critical infrastructure–potentially timelines beyond 2050 may be useful.

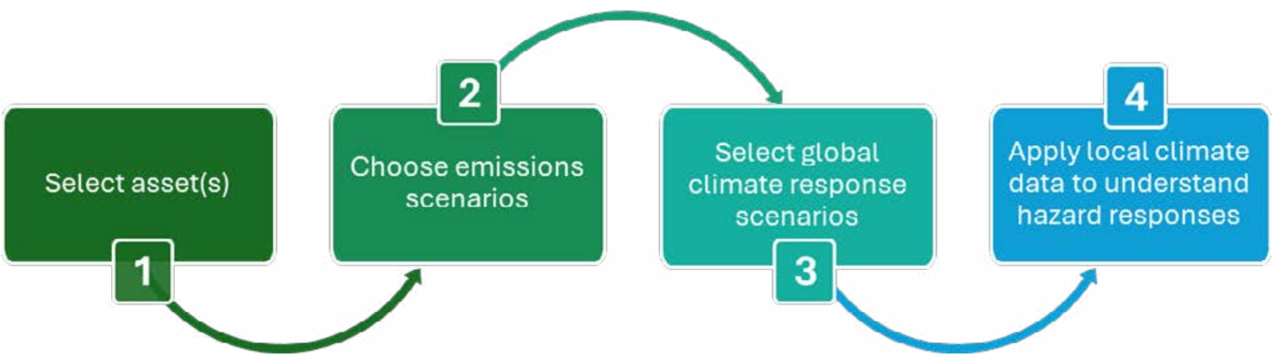
Disclosures. Timescales should follow internal practice and climate-specific regulatory guidance.

Asset-specific financial transactions and decisions (including pricing). Timelines will depend upon the lifespan of the asset. When assessing risks, financial institutions should consider risks over the full lifetime of the asset and, in the case of investors, factor that both into pricing as well as consideration of next steps – including decisions on whether to hold, engage or sell. For banks and insurers, they should consider what this means for resilience requirements when lending to or underwriting assets. The under-pricing of risk due to the short-term perspectives is part of the problem and dis-incentivises action.

The CFRF AWG asked its technical advisers – a consortium of the Met Office, University of Leeds and Oxford University – to advise on which scenarios the finance sector should consider preparing for and disclosing against as part of its TCFD disclosures. Based on the latest scientific evidence from the IPCC, risk assessment principles and based on feedback and user opinions from the CFRF AWG, the CFRF's AWG's technical advisers have proposed the following **ABC framework**.

The **Aim-Build-Contingency (ABC framework)** comprises layering three components – emissions response; climate response; local hazard response – in a 4-step process.

Figure 3: ABC Framework.



Step 1: Select asset and timelines of interest

Once the asset (business line or plan) has been selected for assessment and its location(s) identified, a decision is needed on what timelines over which to undertake risk assessment. Different applications will typically have different time horizons. For example:

- For developing adaptation-inclusive transition plans, 2030 and 2050 might be considered.
- For financial risk management, 2030 might be prioritised.
- Asset-specific financial transactions and decisions (including pricing) will vary with the asset. A mortgage lender might consider up to 35-year time horizons, an equity investor 15 years.

For short term (up to 5 years) it is sufficient to rely on forward-looking hazard data and a database of hazard data sources is provided:

users should jump straight to step 4. Looking out beyond ~5 years, users will need to consider different possible emissions pathways and also climate response uncertainties. **We suggest an 'Aim-Build-Contingency' or 'ABC framework' would be the ideal approach for framing this risk analysis** – while noting important implementation challenges with using this, discussed in the Technical paper in Annex A: Technical explainer for the ABC approach.

Step 2: Applying the emissions uncertainty lens

Future climate states will depend on policy support, market behaviour and the combined impact of consumer preferences. For analysis looking out 5 years or longer, a new 'ABC framework approach' is suggested. It should be emphasised the proxy global warming levels linked to the A, B and C elements of the framework are not presented as some form of 'optimal' target. Rather they create a conceptual framework for regulated firms to develop transitions plans that focus on the continued need to finance the decarbonisation of the economy, but also the need to finance adaptation to the already changing climate and support a more holistic view of the transformation to deliver multiple benefits.

The three scenarios were selected based on review of the scientific literature, comparison between different scenarios sets (including those from the IPCC and the NGFS) and through discussion with the CFRF AWG members.[23]

The starting point is the A scenario **aiming** for a strong mitigation case that could translate to at most around 1.5°C warming globally for a median sensitivity of the climate; B **building and budgeting** to moderate action or around 2.0°C for a median sensitivity of the climate by 2050 (in line with current policies); and C **contingency planning** for a higher scenario to be used with assets with longer lifetimes, such as critical infrastructure. For adaptation planning, these scenarios next need to be mapped against local climate projections, with additional consideration of both natural weather variability and the uncertainty in climate model response.

The scenarios are built on the following inputs/assumptions:

- **Scenario A – Strong Mitigation**. *Aiming* to stay below 2°C and pursuing efforts to achieve 1.5°C through reducing emissions by 45% by 2030 compared to 2010 levels and delivering a net zero economy no later than 2050. Even in this best-case scenario, there will be material financial risks and a need for adaptation and firms should look across the range of model predictions. **The recommended proxy for this is the IPCC's SSP1-1.9 scenario or the NGFS net zero by 2050 scenario**.
- **Scenario B – Moderate Action**. *Building and budgeting* to prepare to be resilient to the warming current policy efforts imply,[24] which gives a median 2050 warming of ~2°C. Significant adaption will likely be required. **The recommended proxy for this is the IPCC's SSP2-4.5 scenario or the NGFS current policies scenario**.
- **Scenario C – Backtracking**. *Contingency plan* for a warming of 2.5°C in 2050. This is a reasonable worst-case scenario, due to policy backtracking combined with acceleration of global warming due to climate sensitivity turning out to be at the upper end of current estimates. Very significant adaption and resilience measures will be needed. **This is represented by the IPCC's SSP3-7.0 scenario and using the 95th percentile climate response to the scenario**.

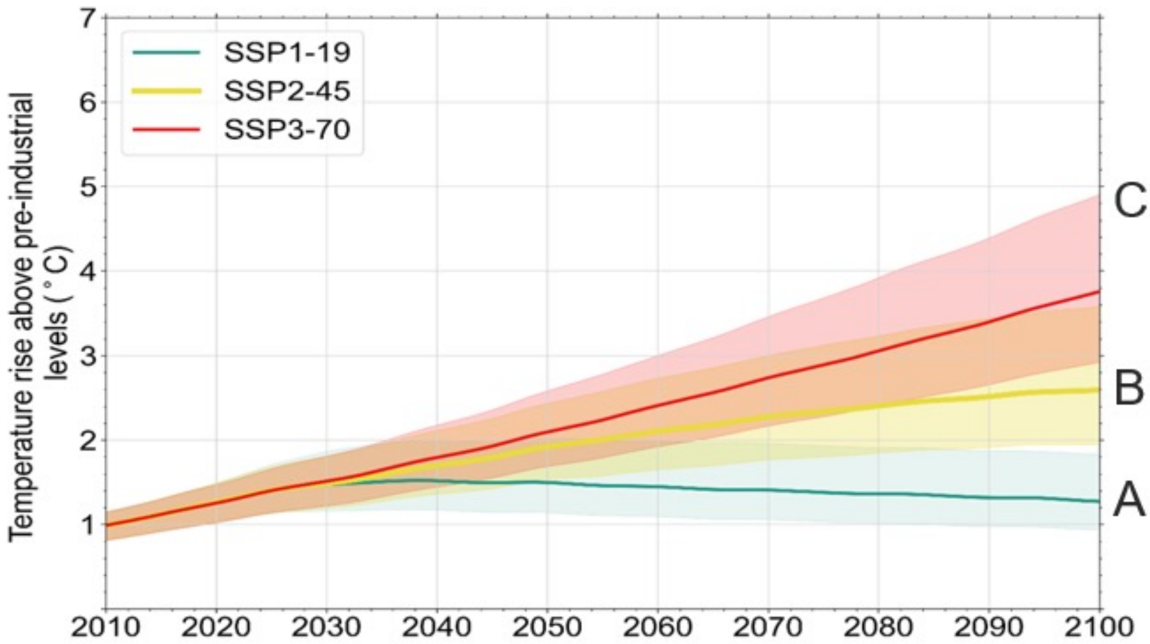
[23] We have chosen not to select NGFS scenarios directly for our study of physical risk because these focus on uncertainty in emissions and have not been used as input to the most comprehensive climate models, which are the best source of hazard information.

[24] Climate Action Tracker (2023). 2100 Warming Projections: Emissions and expected warming based on pledges and current policies. December 2023. https://climateactiontracker.org/global/temperatures/.

Step 3: Applying the climate response uncertainty lens

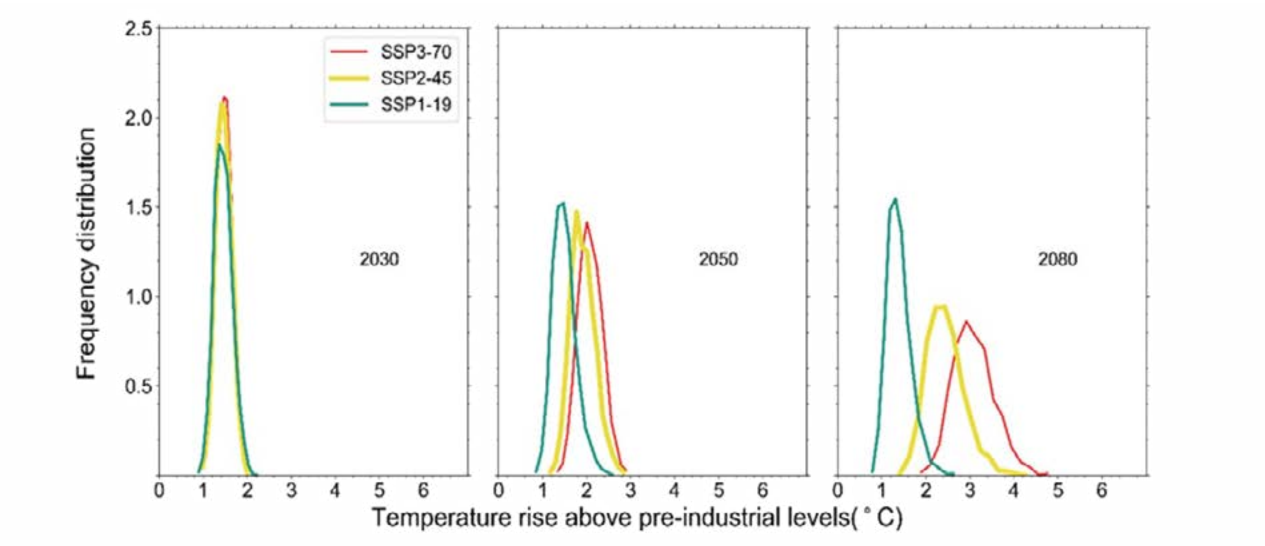
Step 3 requires adding the climate response. During the 2020s to 2030, as a result of the lagged response of the climate to changes in emissions, uncertainty in the climate response dominates over uncertainty in the emissions and therefore the range of hazards that need to be prepared for.

Figure 4: Global mean near surface temperature rise for the chosen emission scenarios (see Annex A for details). The thick lines show the median warming for each case and the shaded area shows the 5th to 95th percentile range. Red corresponds to the backtracking case (C), yellow current policy case (B) and green strong mitigation (A).



Further into the future, the emissions scenario uncertainty starts to become more important and comparable to the degree of uncertainty in the climate response to emissions. The spread in both emissions and global climate response uncertainty increase over time (Figure 5).

Figure 5: Frequency distribution of global mean warming for the three emission scenarios shown in Figure 4 (green is the strong mitigation A scenario; yellow is the moderate action B scenario; red is the backtracking C scenario) shown at 2030, 2050 and 2080. The global mean warming response has been calculated using a reduced complexity climate model with 2237 different model variants, covering different but plausible realisations of aspects such as the sensitivity of the climate system to changes in atmospheric greenhouse gas concentrations and how the earth's carbon cycle changes as a result of climate change.



Applying ABC to different timescales

The TCFD guidance says, that *'organizations should include scenario analysis into strategic planning and or enterprise risk management processes'*, by *'identifying a range of scenarios that provide a reasonable diversity of potential future climate states'*[25]. We propose the ABC Framework provides the technical guidance the finance sector needs on what 'potential future climate states' to be prepared for in making investment decisions and seeking further resilience investment opportunities, over different timescales. Examples include:

- **For banks**, it can help with assessment of local hazards and weather-related risks already manifesting in mortgage portfolios to better inform risk assessments (over near to medium term).
- **For asset managers,** the 'ABC Framework' can help inform engagement with portfolio companies in asking whether their transition and adaptation plans, are resilient to A and B and C scenarios. Integrated transition, resilience plans could be asked for from clients and portfolio companies (from near to medium term decision making).
- **For insurers and infrastructure investment managers**, it can inform to what warming levels contingency planning will be needed to build and maintain assets with long-life times, greater than 10 years (from the near to longer term).

[25] TCFD. (2024). *The Use of Scenario Analysis in Disclosure of Climate-related Risks and Opportunities*. TCFD Knowledge Hub. https://www.tcfdhub.org/scenario-analysis/.

Short-term decision making – up to 5 years

In support of Short-Term Scenario analysis for a range of use cases – including capital allocation planning and risk management – it is appropriate to rely upon forward-looking hazard and risk data. This localised data is important to assess the increased severity and frequency of weather events expected from existing climate change now at 1.26°C above pre-industrial levels[26] or already 'locked-in' due to inertia in the climate system, as illustrated in Figure 5 with the overlap in temperature rise above pre-industrial levels distributions for scenarios A, B and C to 2030. For some use cases this would ideally be combined with newer techniques such as initialised decadal forecasts that can capture natural interannual variability in climate and capture cycles such as the El Nino and Atlantic Meridional Oscillation which can increase the probability of some extremes on short timescales. Such approaches therefore include the normal weather variability, including extreme weather events within risk analysis, allowing the decision maker to capture the chance that a drought, heatwave or heavy rainfall will occur in planning. Many other changes can happen also over the short-term that will need to be accounted for, such as changing global macroeconomic conditions and domestic policy. These issues are considered in the CFRF guidance on short-term scenarios.

When considering present day risks it is vital to recognise that the climate has already changed and one must ensure that datasets are not biased by the inclusion of backward-looking data to periods when the climate state was quite different, as this will likely underestimate many types of risk. However, appropriate use of both observations and climate model data can be important ingredients to physical risk assessment on this timescale. The CFRF AWG has compiled at database of hazard data sources that are appropriate to use over a 1-5 year period. It is also vital to note, that whilst the change in climate over 1-5 years will be dominated by growing natural weather variations, there is the potential for different short-term transition scenarios to emerge that could have an impact and increase physical risks.

Medium-term decision making (5–10 years)

For medium-term decision making, it is sufficient to use one emissions scenario. This is because of the inertia in the climate system, which means that scenarios do not diverge on this timescale. We propose Scenario B. This is because, as noted earlier, the impacts of climate change over the next 10 years are largely locked-in and not dependent on the emissions scenario. However, as illustrated by Figure 5 above it is still important to consider the range of uncertainties in climate response across models for whichever impact metrics are most relevant to the decision. Hence, our proposal is to use:

> **Scenario B – Moderate Action (IPCC SSP2.4.5 or NGFS current policies scenario)**, but it can be useful to sensitivity test decisions to the upper and lower 5^{th} to 95^{th} percentile of warming response and impacts alongside the median case.

Long-term decision making (beyond around 10 years)

Looking out beyond around 10 years, users will need to consider a range of possible emissions pathways and their impacts (Figure 4). From around 2035 (as of today), climate models predict a notable divergence in global warming levels (and therefore climate change impacts) between different emissions scenarios. We also still need to capture normal weather variability (as above) as well as the uncertainties in future climate due to the climate model response.

Step 4: Applying the local climate response – hazard data – lens

The fourth step, the actual risk assessment, will need to be applied at a physical asset level and focuses on understanding selected local hazard responses.

[26] This is based on a 20-year mean period, combining the last decade of the observations with trends from a climate model for the next decade. Betts, R. A., Belcher, S. E., Hermanson, L., Klein Tank, A., Lowe, J. A., Jones, C. D., Morice, C. P., Rayner, N. A., Scaife, A. A., & Stott, P. A. (2023). Approaching 1.5 °C: How will we know we've reached this crucial warming mark? *Nature, 624* (7990), 33–35. https://doi.org/10.1038/d41586-023-03775-z.

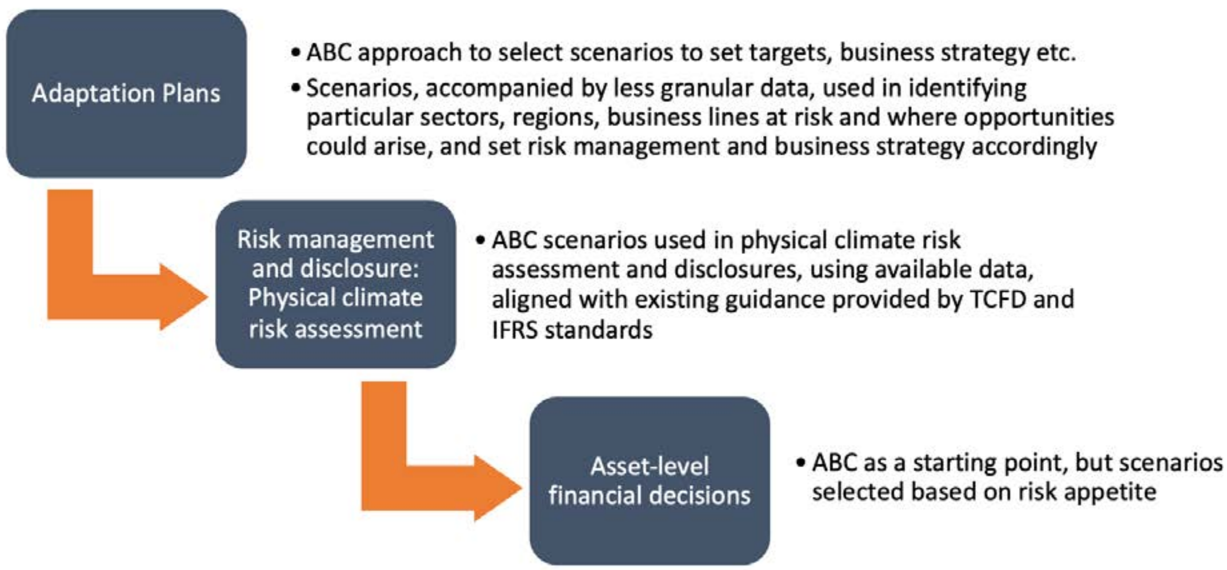
For all time periods of analysis (short-term, medium-term and long-term) the assessment of global climate response can be a useful tool, especially for communication with a range of stakeholders with a financial organisation (e.g. a sustainability officer highlighting physical risk to a chief financial officer) or more broadly (for instance to shareholders or customers). For a detailed assessment of risk, however, it is necessary to go to finer spatial scales and look at local climate response.

When doing so, **our recommendation is that it is important to look across the range of local climate outcomes going from the 5th to the 95th percentile**. This is illustrated in Section 5 for cases of flood risk and extreme heat risk in the UK.

Implementing ABC in practice

Figure 6 illustrates how the ABC approach can be applied to different use cases. For example, in forming corporate adaptation-inclusive transition plans, the ABC approach can be used to ensure the business strategy is robust to different possible future climates. At the strategy level, for example, a large water-dependent firm (e.g. a semi-conductor manufacturer, agri-foods, data centres) should assess the robustness of its business strategy under an A and B scenario and plan adaptations accordingly, as well as ensure that there is a contingency plan in place to cope with a scenario C outcome in the longer-term. This could include, for example, regularly reviewing the plan against the latest science (annually or every 3 – 5 years) and planning to avoid 'locking-in' any investments or business strategies that might be difficult to change in the future and could lead to substantial financial risks to the firm. These three scenarios may also be used for physical risk assessment and disclosures. For asset-level decision making, ABC can be a starting point for risk and opportunity screening, though in some cases, a different approach is needed – see Figure 6 and Figure 7.

Figure 6: Summary of how this approach can be used in different types of applications.



Dealing with uncertainties in decision making

For certain types of adaptation decisions, the ABC approach will need to be augmented by other tools and best practice on decision making under uncertainty. In general, this holds true for cases where a firm would make a different decision given scenario A or B that could have financially material implications for the firm. An example could be a large capital expenditure on a new facility, or a decision to open operations in a new country. Here we summarise some of the basic principles relevant to financial institutions, but we encourage users to explore the existing guidance for more information.

1. **Sensitivity test decisions to a range of possible climate outcomes using the ABC approach**. For example, for risk pricing, calculate the risk price under different climate hazard levels and see how this affects the price. For an adaptation plan, explore how the plan would perform under the ABC scenarios. Ask clients or investee companies to explain how their plans or corporate strategies would perform under a range of ABC scenarios.
2. **Favour robustness, but ultimately make decisions based on the firm risk tolerance**. Once it is understood how a risk price, investment or plan would play out under different scenarios, the question is how to make a decision. In some cases, there may be a trade-off between making a decision that gives the optimal return versus one that gives the best return under a range of scenarios (i.e. is robust). This trade-off might be large or small. If the trade-off is small, then leaning toward robustness may be a good approach. The 'best' approach will also be guided by a firm's risk tolerance: for example, risk tolerances may guide toward being conservative in pricing or plans to cope with a wider range of uncertainty. If the trade-off is large, then different economic decision-making approaches can help a firm take a decision that gives the 'best' outcome given a set of preferences, including the risk appetite.[27] For specific cases, there are also specific regulatory requirements on risk appetite, for example as part of Solvency II and Basel III.
3. **Make flexible plans wherever possible**. A central principle in dealing with uncertainty in high-stakes planning is to make the decision as flexible as possible, i.e. 'minimise regrets'. For example, many insurance pricing decisions can be revisited each year. Business strategies might be revisited every quarter. A robust plan is one that optimises based on the information available at the time but allows sufficient flexibility to adjust and importantly, avoids locking-in risks for the future. An example of lock-in could be making a long-term illiquid investment in a coastal asset that is then difficult to exit if sea levels rise more quickly than expected. Approaches to create flexibility include sequencing specific decisions over time to be made as information becomes available. This is an example of a so-called *'adaptive pathways'* approach.[28]
4. **Monitor and adjust over time**. Changes in climate (and scenarios) and their implications for the business should be monitored over time and processes put in place to revisit, reassess and adapt plans and pricing over time wherever possible.

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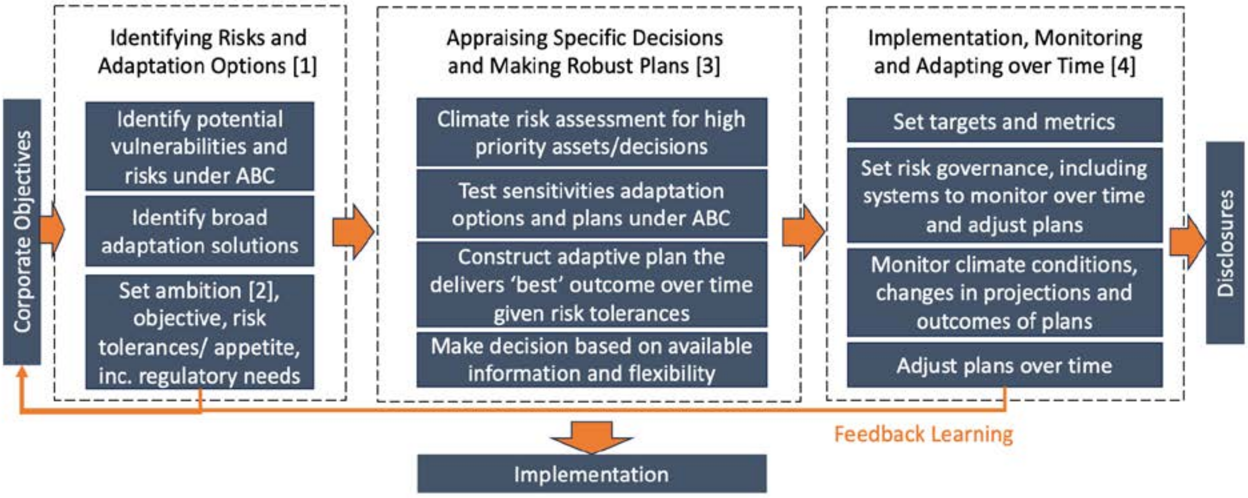
[27] See, for example: Ranger et al. (2014). *Adaptation in the UK: a decision-making process*. https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2014/03/PB-Ranger-adaptation-UK.pdf.

[28] Substantial guidance is available on adaptive pathways approaches. For a real example, see work and guidance around the design of the Thames Estuary 2100 project: Reeder, Tim and Nicola Ranger. "How do you adapt in an uncertain world? Lessons from the Thames Estuary 2100 project." World Resources Report, Washington DC. https://climatelondon.org/wp-content/uploads/2019/10/wrr_reeder_and_ranger_uncertainty.pdf.

Figure 7 visualises how these principles can be implemented by firms as part of adaptation planning. Importantly, while in the descriptions above we have focussed on climate uncertainties, clearly other uncertainties are also important in long-term planning, including wider market trends in market sectors, changes in government policies and changes in the macroeconomic environment.

Figure 7: Applications of ABC approach: Dealing with uncertainty within adaptation planning at corporate or asset level. The numbers shown in square brackets map the actions shown later in Figure 9.



4. Setting the framework for action

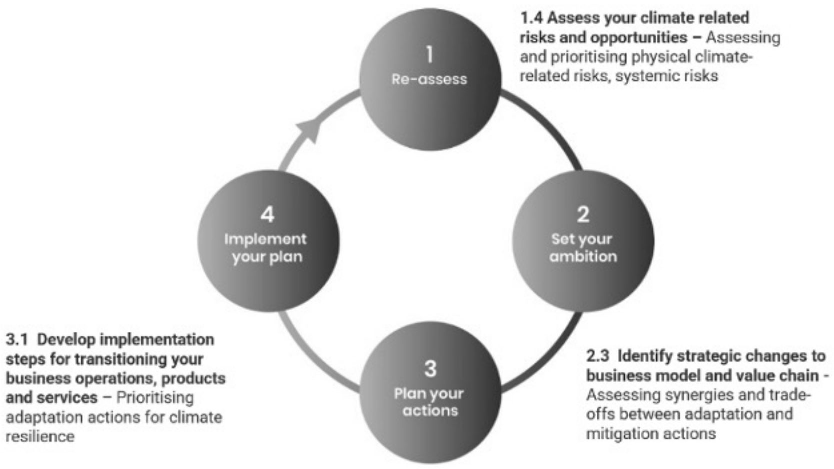
4.1 Toward adaptation-inclusive transition plans for financial institutions

The Transition Plan Taskforce (TPT) recommends that transition plans incorporate both climate mitigation and adaptation options and has integrated adaptation within its own guidance, providing a primer for financial institutions and real economy firms.[29] This process of integrating adaptation into corporate plans is already underway. For example, forthcoming research by the University of Oxford shows that around 34% of key performance indicators (KPIs) within corporate sustainability disclosures and existing sustainability-linked financial instruments sampled across the agri-foods, utilities and real-estate sectors globally are relevant to adaptation and resilience (i.e. specifically targeted to adapt to climate risks).

Adaptation and transition plans need to be integrated to form one clear business strategy for the firm. While it helps to develop the adaptation plan separately, to ensure it receives the right focus, ultimately the two need to be consistent and aligned. So, what constitutes a good adaptation plan – and what are the steps to develop one? This is relevant both for financial institutions setting their own plans and assessing the credibility of clients' and investee companies' adaptation plans as part of physical risk management and identifying opportunities. Financial institutions – such as large multinational banks – should also create their own adaptation transition plan, that includes the property and assets they manage.

The recent TPT Adaptation Primer provided a helpful set of evidence-based principles and background information to help firms begin their adaptation planning journey. In this section, we build upon this, but go a step further. Figure 8 shows the process for developing an adaptation plan developed by the CFRF AWG with the University of Oxford. This can be read alongside Figure 7 and Figure 9.

Figure 8: From TPT Transition Planning Cycle and AWG additions.[30]



[29] In the past two years, there has been increased emphasis on transition plans as a vital instrument for both financial and real economy firms. As introduced in the TPT 2023 Disclosure Framework *"Transition plans form a critical component of a firm's business strategy – helping to explain to their customers, shareholders and investors how they will adapt and grow as the global economy transitions to net zero" and "a robust approach to transition planning provides a blueprint for strategic delivery. Disclosure of transition plans can equip investors with the information they need to finance the transition at the speed and scale required".*

[30] Transition Plan Taskforce and Adaptation Working Group.

Step 1: Identify, assess, and prioritise physical-related risks and adaptation

As outlined in Figure 7, it is important for financial institutions to begin the process with a high-level screening of the corporate business plan and individual business lines to identify overarching risks and opportunities. This is then complemented by deep dives for specific asset types, sectors and locations of material interest (infrastructure and real estate, for example, are likely to be high priority). The 'Aim-Build-Contingency' or 'ABC framework'–which is consistent with the core framework of the TCFD–can be used as a starting point for this process. Alongside future risk assessments, we strongly recommend that firms consider short-term physical climate risks, taking account of the climate changes that are already occurring and learning from previous climate-related shocks. Questions asked in this step could include: *Where might opportunities arise in a changed climate? How might the business focus need to shift to reflect changing patterns of demand? Which parts of the portfolio/business activities might need to be adapted and how?*

Step 2: Set the ambition

High-level objectives and ambitions in relation to adaptation now need to be set (see Figure 7). It is likely that firms will start with high-level qualitative statements, possibly linked to externally disclosed commitments on the intent of the firm. This should include risk tolerance within the context of the ABC framework suggested. Key questions to answer are: *Financial services provided to which sectors of the economy are most strategically important to focus on? Is the focus on entity/portfolio risk management or is the ambition to go further and offer new products and services and also align with (inter)national adaptation goals?*

Step 3: Plan your actions

The detailed process of constructing a plan based upon a set of scenarios and under uncertainty was covered in Section 3 and more detailed discussion on particular elements, such as engaging clients and identifying opportunities is given in subsequent sections. This process will also provide more clarity on external factors and processes that a company depends on and priorities for engagement or intervention to help facilitate progress, including with regulator and national policymakers. Figure 9 captures the key actions. See subsequent sections for further guidance on this.

Step 4: Implement the plan

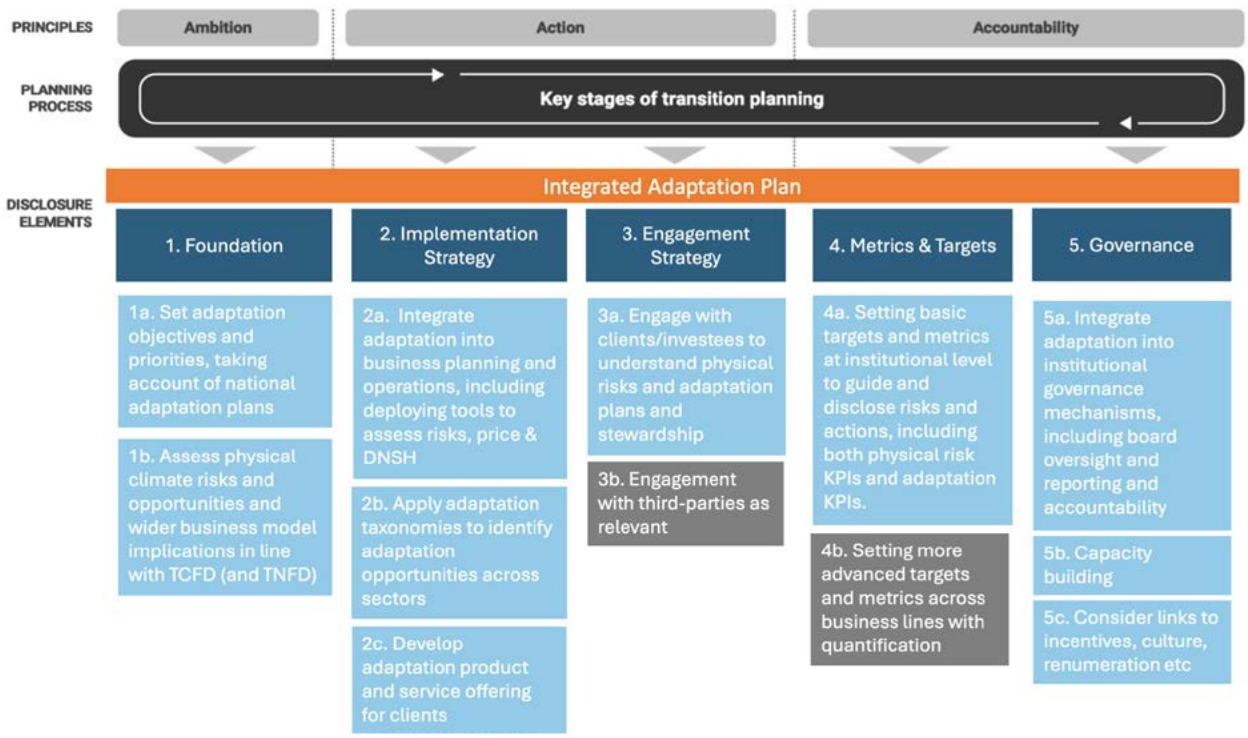
This is where investment/lending/underwriting decisions, governance and accountability mechanisms are put into play and should include integrating adaptation into business planning and operations, supported by the use of appropriately selected tools to assess and price risks and making efforts to ensure that decisions do no significant harm to wider societal adaptation objectives. It could include using adaptation taxonomies to work with clients and investee companies identify adaptation financing opportunities. It will also include developing and deploying new investment strategies (see Case Study 6, in Section 6, from Impax), products (for example adaption-linked sustainability-linked loans and novel risk transfer mechanisms) and services. As outlined in Figure 9, the implementation phase should include a series of steps to track and monitor progress and outcomes and adapt plans over time as well as integrating adaptation within broader risk governance.

Governance is the final critical pillar, including setting institutional processes such as board oversight, reporting and accountability mechanisms. This is supported by institutional capacity building, culture building and incentives. Climate risks will typically be escalated and monitored through existing risk governance. Portfolio/investment/credit risks are monitored by the first line, while the board and the risk committee have oversight of all other climate risks. Given that climate risks are uncertain and change over time, it is important that processes are in place to track not just risks but also changes in projections over time – as well as integrate the learning from implementation and adjust plans.

Metrics and targets need to include risks and adaptation actions, including KPIs for managing risks and adapting to climate change. This can also include joint action plans for mitigation. As noted in previous CFRF reports, targets and metrics for physical risks are more nascent than for mitigation and across the industry, clear, uniform KPIs are still developing. However, it is crucial that financial institutions engage with the debate on useful KPIs, as there is a clear trend towards more transparency on resilience to deliver solutions in the most cost-effective way. As a starting point, we point users of the guidance to the advice provided by the UN Environment Programme Finance Initiative (UNEP FI) and the University of Oxford[31]. Longer-term, firms should begin to assess how metrics can best include the results from scenario analysis and impact assessments, or trend analysis (e.g. weather-related catastrophe losses over the years).

Based upon these recommended steps from the CFRF AWG, we propose a framework for adaptation and present this in alignment with the overall TPT framework (Figure 8). We use the TPT framework as a basis to ensure that firms can integrate these new concepts on adaptation within their ongoing existing work to develop transition plans. This framework also aligns with TCFD and International Sustainability Standards Board (ISSB) guidance. Such a framework can be used both by financial institutions to set their own plans and assess the credibility of plans of clients and investees, including identifying gaps and needs for further enhancement.

Figure 9: Proposed elements of an adaptation framework for firms.[32]



[31] Bernhofen and Ranger (2024). *Adaptation and resilience metrics*. https://www.cgfi.ac.uk/adaptation-and-resilience-metrics/ and UNEP. (2023). *Principles for Responsible Banking: Climate Adaptation Target Setting*. https://www.unepfi.org/wordpress/wp-content/uploads/2023/11/PRB-Adaptation-Target-Setting-Guidance.pdf.

[32] Authors.

5. Implementing the framework: selecting and using data

5.1 Selection of data

A significant amount of guidance is already available to firms on how to implement physical risk assessment and the link to disclosures, including previous reports by the CFRF.

Despite this, financial institutions still note significant challenges in identifying the right scenarios and data to use in their assessments and this was seen as a barrier to adaptation. The ABC approach we have proposed, along with supporting tools and datasets provided, should help for both short term and longer term scenario analysis to support strategic and financial decision-making.

Selecting appropriate local hazard data and understanding its strength and limitations to ensure proper interpretation is key to fully understanding physical climate change risk–and the appropriate response. Typically, the type of information needed will depend on the nature and location of exposed assets and their vulnerability or sensitivity to particular hazards of interest. For instance, an organisation investing in assets in central America that might be sensitive to high temperatures (for instance a Real Estate Investment Trust (REIT) investing in data centres in Mexico) will have different needs and options for hazard information than an organisation seeking a global view of coastal assets at risk (for instance an international insurance portfolio). Past and future climate information contains uncertainties that may have different levels of confidence. Here we provide guidance on assessing and quantifying confidence and uncertainty in future climate projections. We suggest three key considerations: suitability, credibility and legitimacy.[33]

This three-step process can be used to navigate and utilise the hazard data spreadsheet the CFRF AWG has developed that collates existing credible sources of information but also used to assess other data sources users may have identified, including from third party data providers.

This is a complex process, of course. Guidance is provided as a means to encourage users to fully understand and, as appropriate, disclose the limitations of any data sources being used.

- **Assessing suitability**: This involves selecting the hazard data source most suitable for the risk being assessed. For example, assessing the risk to a particular sector in a particular region from a particular hazard will require different data tools to hot-spotting climate risks for all sectors in all regions of the UK to a range of risks. We suggest users address the set of questions listed in Annex B: Assessing the usefulness of hazard data to filter the columns in the spreadsheet tool.
- **Assessing credibility:** The second step concerns assessing the quality of the data and should be used when several potential hazard data sources have been identified. Annex C: Summary of data use survey sets out questions to be asked when assessing credibility. They can be used to assess the quality of data provided in the hazard data spreadsheet the CFRF AWG has developed – but also used to assess other data sources users may have identified, including from third-party data providers.
- **Assessing legitimacy:** This third step involves assessing the source of the climate model data. Ensuring datasets are impartial is critically important. When

[33] This is based on original ideas from Cash et al. (2002) for linking research, assessment and decision making. This framework has been adapted and combined with more recent literature for evaluating climate information.

assessing these factors to consider are quality of any peer review and source of funding for the research.

Within this report, a range of different hazard and risk tools and datasets are applied. It is important to understand that **these are often designed for particular purposes and application beyond these should be performed with care**. For instance, in the Climate Impacts Explorer cited in Case Study 1 is easy to use and is well suited to providing a first impression of climate risks, especially on larger spatial scales. It is much less well suited to looking at the full range of extreme weather events on finer spatial scales. The dataset in Case Study 4 from the UKCP local dataset is well suited to looking at finer scale extreme events – but it is more difficult to apply for a rapid first look assessment. We encourage firms to investigate the caveats and limitations of different tools as part of assessing risks.

To illustrate the importance of selecting appropriate data, we give the example of assessing flood risk to the mortgage book of a UK bank.

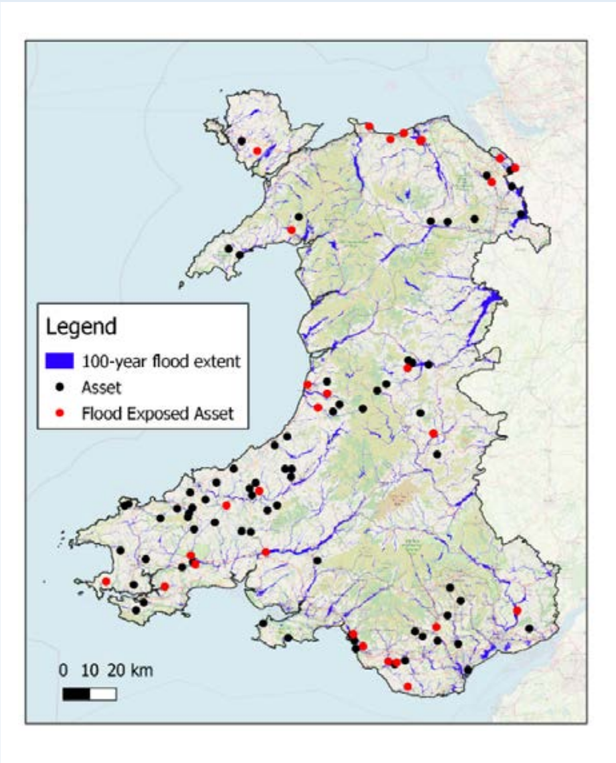
Case Study 1: Applying the ABC framework to assess flood risks to a fictious Welsh bank's mortgage portfolio

In this case study, we explore how a bank might assess flood risk using the ABC framework to a hypothetical portfolio of 100 residential properties in Wales using open data. The bank is assumed to be concerned about risks to the residential property portfolio over the next 2, 5, 10 and 30 years.

Over the 2- and 5-year period the risk is likely to be dominated by natural variations in the weather and climate, thus the choice of emissions scenarios is unimportant and the focus should be on physical risk assessment using present day hazard data and data from the near future from, for example, decadal climate forecast systems.

We use flood maps[34] produced by Natural Resources Wales to understand the exposure of the hypothetical residential mortgage portfolio to river flooding over the next 2-5 years. We use the flood Zone 3 maps which show areas with a probability of flooding greater than 1% (1 in 100) in any given year.[35] Figure 10 shows that 29% of the residential mortgage portfolio is already exposed to flooding.

Figure 10: Hypothetical Welsh residential mortgage portfolio exposure to 1 in 100-year flood.[36]



Looking 10 years into the future, further climate change will have taken place. However, in this period where although the risk is deviating significantly from the baseline, the choice of emission scenario is not so important – and so our recommendation is to use scenario B (in this example we use Representative Concentration Pathway 4.5 (RCP4.5) as an example scenario, SSP2-4.5 or NGFS current policies would also be credible scenario choices). However, it is far enough into the future that the uncertainty between models is becoming important.

Focusing on the spread in weather and climate response on local scales is important. We suggest using the 5th and 95th percentiles of local climate change as our upper and lower bound for risk assessment.

To illustrate how the ABC approach can be combined with the 5th and 95th percentiles of local climate change, Figure 11 shows the change in winter precipitation anomalies for Wales under the ABC framework using forecasts taken from the UK Climate Projections (UKCP) User Interface. We use the 25 km probabilistic projections for the UK as they have data for a number of emission

[34] https://datamap.gov.wales/layergroups/inspire-nrw:FloodMapforPlanningFloodZones2and3. Such maps already include some consideration of climate change, albeit just a central estimate and not capturing uncertainties.

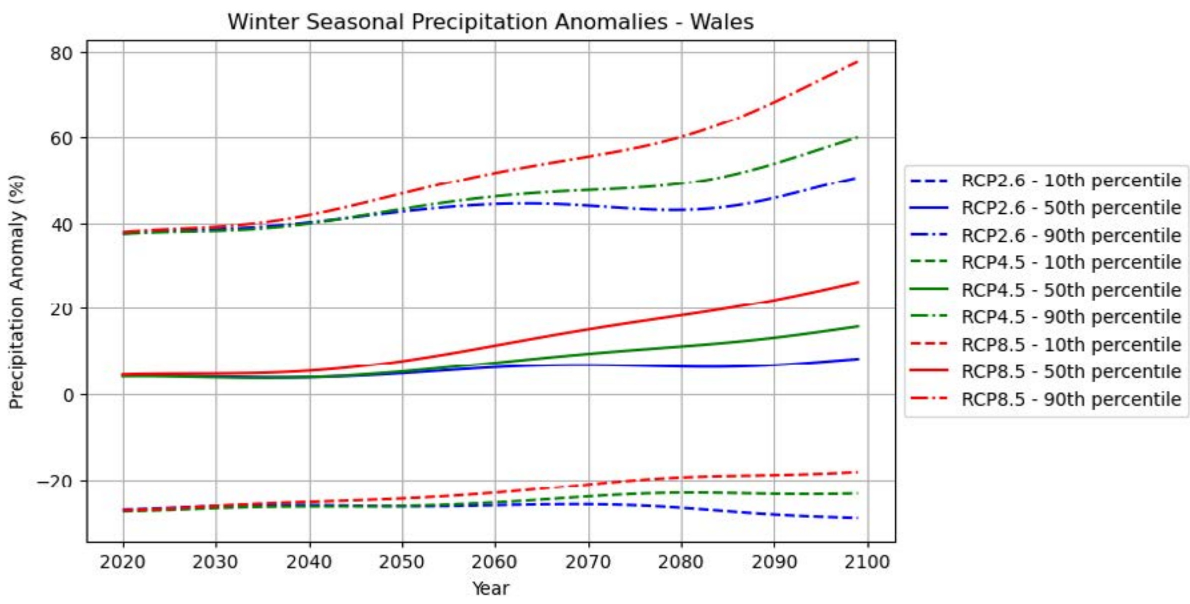
[35] The flood maps produced by Natural Resources Wales already include climate change information, however, these are central estimates and do not consider uncertainty in climate projections.

[36] Authors, based on a synthetic residential portfolio and flood data extracted from Natural Resources Wales. https://datamap.gov.wales/layergroups/inspire-nrw:FloodMapforPlanningFloodZones2and3.

scenarios. More granular regional (12 km) and local (2.2 km) projections are available from the UKCP. However, these projections only consider a high emission (RCP8.5) scenario so we don't use them to illustrate the ABC approach. Incorporating these more granular projections would be useful in your own scenario analyses, as they will provide a more detailed geographical picture of the changes in precipitation in Wales.

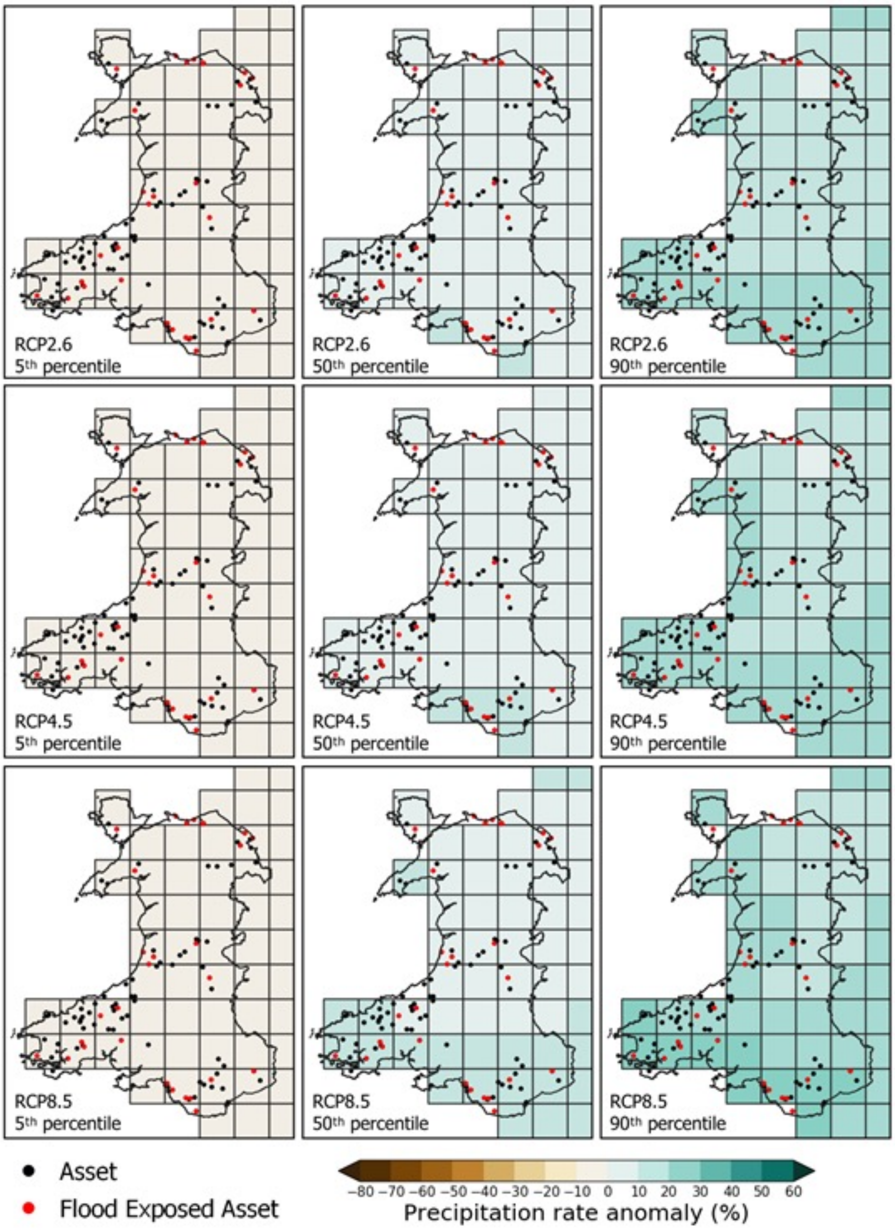
In Figure 11, scenario A is represented by RCP-2.6; B by RCP-4.5 and Scenario C, represented by RCP-8.5 (since RCP-7.0 is not available within the UKCP probabilistic projections). Because the UKCP User Interface doesn't directly output the 5th and 95th percentiles, we instead report the 10th and 90th percentiles. As the graphic shows, the spread in projections across models (from the 10th percentile to the 90th percentile) is wide, ranging from a 24-26% decline in rainfall anomalies to a 42-47% increase in rainfall anomalies in Wales by the 2050s. This uncertainty is driven by disagreements in models and is clearly much wider than the uncertainty attributable to different emissions scenarios, hence the importance of looking at a range of percentiles.

Figure 11: UKCP Wales Winter Precipitation Anomalies under different scenarios and models.[37]



[37] Authors, based on data extracted from the UK Climate Projections User Interface 1st May 2024. Figure shows winter precipitation anomalies relative to a baseline (1980-2000) for Wales.

Figure 12: Flood exposed real estate assets overlain with UKCP rainfall projections for Wales.[38]



[38] Climate Impact Explorer.

Figure 12 shows the outputs from the UKCP probabilistic winter rainfall projections for scenarios A, B and C in 2050, overlaid with the assets assessed with the river flood maps produced by Natural Resources Wales. The figures show that although there is high uncertainty in the magnitude of future rainfall changes in Wales across the scenarios, on average, rainfall is expected to increase. One can also observe geographical variations in the change of rainfall that would be important to account for in the mortgage portfolio assessment. Across scenarios A, B, and C, the median and 90th percentile estimates show greater increases in rainfall in southern and coastal Wales. This could suggest that already exposed assets in these areas (the red points) could see an increase in flood risk to their properties that may warrant further investigation. In addition, some assets not exposed today may become exposed in the future.

When conducting flood risk assessments such as this, it is important to consider the **legitimacy** of the data being used. In this case, we use flood hazard maps produced by the Welsh Government and climate projections provided by the UK Met Office. However, in many places outside the UK, there may not be national data on climate change readily available. In this case, one can use global or regional data (see Table 2 for some examples). When choosing climate data to use it is important to consider whether the data used is peer-reviewed, comes from a legitimate source or whether it can be validated against official data.

The data you use also needs to be **suitable** for the question being asked. For example, flood risk is driven by a number of factors beyond rainfall. This makes it important to assess exposure or risk using flood hazard maps, as done here using the flood maps provided by Natural Resources Wales. The UKCP rainfall projections provide a useful indicator of where flood risk may increase in the future – but cannot be used to provide a detailed view of how flood risk will change at the asset level. To quantify this, it would be necessary to use future flood hazard maps.

Once the assessment is completed, it is also important to verify the **credibility** of risk estimates with legitimate sources, such as the Environment Agency and the UK Climate Change Risk Assessment (CCRA). The estimates shown here of changing flood risk in Wales are in general agreement with the trends described in the UK CCRA Summary for Wales[39].

[39] Dr. Alan Netherwood. Netherwood Sustainable Futures, & UK Climate Risk. (2021). *Evidence for the third UK Climate Change Risk Assessment (CCRA3): Summary for Wales*. https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA-Evidence-Report-Wales-Summary-Final.pdf.

Table 2 below gives examples of open sources of flood risk information from the CFRF AWG hazard database. There are also many proprietary providers of flood risk information, including specialist risk modelling firms. For the UK, the Environment Agency will publish updated flood maps in 2024 that will form an important source of information for firms.

Table 2: Open sources of flood risk information.

Short-term (Global)	Short-term (National)	Long-term
• The Global Flood Awareness System (GloFAS) • The Flood Hub • Global Flood Monitoring System (GFMS) • Deltares (Delft-FEWS Platform) • GDACS Disaster Alerts • HYDRAFloods	• UK: Climate Change Impacts tool • Europe: European Flood Awareness System • USA: FLASH Project • Africa: Fanfar	• Map viewer | GIRI (unepgrid.ch) • Climate impact explorer • Aqueduct • CLIMADA • Fathom | Global Flood Hazard Mapping & Water Risk Intelligence (not open access) • UK: Enhanced Future Flows and Groundwater (eFLaG)

5.2 Applying data

Analysis can be conducted for a number of means, as set out earlier. This includes:

- **Physical risk assessment needs to be considered alongside transition risks**, as recommended by the TPT, to produce adaptation-inclusive transition plans.
- **Ensuring its own resilience to physical climate risks**, this includes managing risks to own buildings and operations, such as purchasing insurance, training staff and ensuring appropriate business continuity planning and extreme heat, as referenced in Case Study 2.
- **Engaging with clients or investees and offering new products and services to promote and support adaptation and resilience** across the client and investee base. It includes seizing opportunities for competitive advantage and returns. This can include investing in new types of technologies to support adaptation, such as water conservation technologies or new varieties of crop. It can also include supporting existing clients to adapt through new financial products, such as resilience-focused green bonds or sustainability-linked loans for adaptation, or engaging and placing resilience standards on investments in climate-sensitive areas like real-estate, infrastructure and agri-foods. See Case study 5 on assessing the vulnerability of a salmon farm business as an example of client engagement.

Case Study 2: Applying physical risk assessments to fashion supply chains impacted by extreme heat and flooding

Schroders mapped the supply chain footprint of six global apparel brands across four focus production centres – Dhaka (Bangladesh), Ho Chi Minh (Vietnam), Karachi (Pakistan) and Phnom Penh (Cambodia) – and then assessed the exposure of each brand's assets to heat stress and flooding in 2030 and 2050. The analysis then goes on to explore the associated Value at Risk (VaR) from these climate impacts, driven by decreases in worker productivity and disruption to the functioning of factories.

For heat stress, Schroders used wet-bulb globe temperature (WBGT) and daily maximum surface air temperature data as proxies, with data sourced from 10+ CMIP6 (Coupled Model Intercomparison Project Phase 6) models from Copernicus and SSP2-4.5 as the chosen scenario. For flooding, WRI's Aqueduct coastal and riverine/rainfall flooding models built around RCP 4.5/SSP 2 were used. The full methodology is set out from p.57 in this linked paper found here.

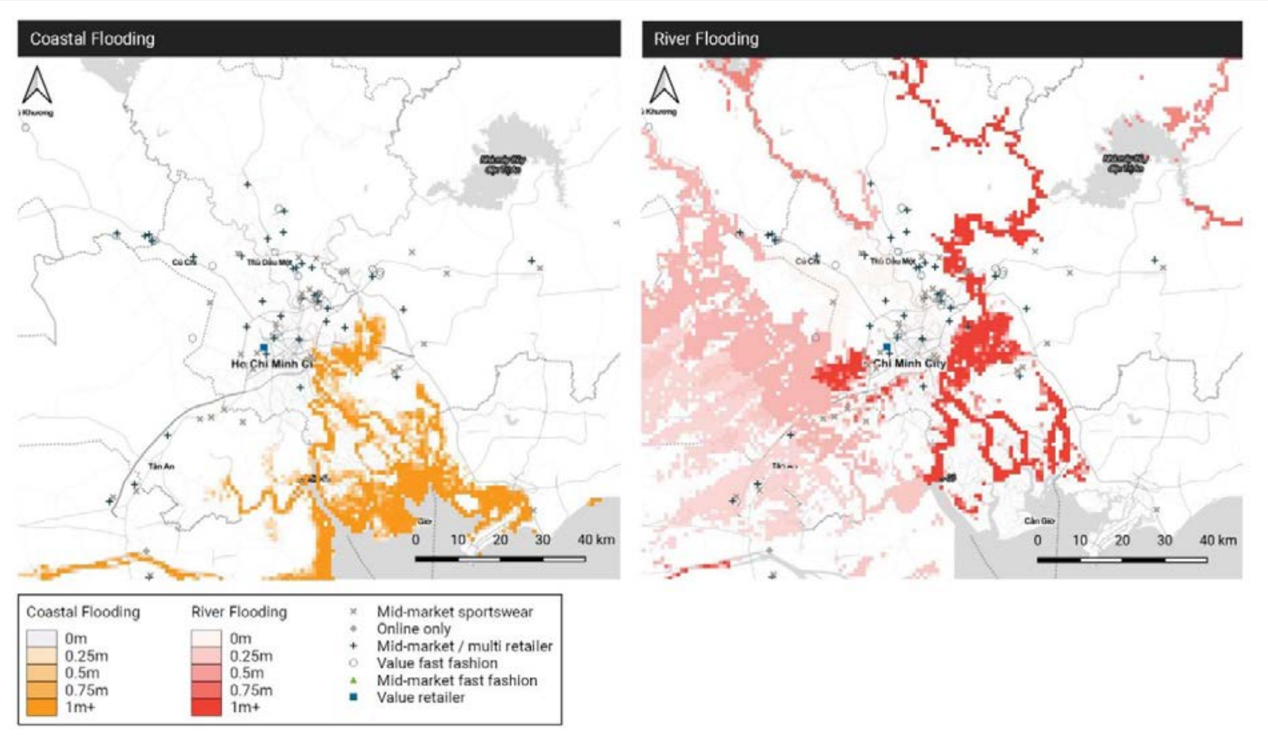
The analysis identifies Vietnam as one of the largest fashion hubs that are most vulnerable to climate physical risks, as per the geospatial analysis of flooding risk in the Figure 13.

However, few manufacturers with operations in Vietnam have explicitly acknowledged and addressed these risks in their sustainability reports, nor have they provided transparency on what measures they are taking to adapt to these heightened risks.

On this basis, site visits and engagements were conducted with apparel original equipment manufacturers (OEMs) with factories in Vietnam to better understand what stage they are at in anticipating and adapting to physical climate-related risks. Schroders found that while some have conducted a qualitative assessment of the risk exposure, the use of scenario analysis, evidence of quantitative physical risk impact assessment, and the implementation of adaptation measures appear lacking within the industry. Notably, it is rare to see OEMs apply physical risk assessment criteria to their suppliers.

These insights were used to develop a set of adaptation-specific engagement questions for investors to help companies in high-risk areas, such as Vietnam, to think about and improve their resilience to physical risks. This continues to be a focus area of engagement for Schroders.

Figure 13: Brand exposure to Ho Chi Minh coastal and riverine flooding in 2030.[40]



In terms of asking investee companies to respond to physical risk assessments, the PCRAM tool is a useful tool. See Case Study 3.

[40] Schroders. (2023). *Higher ground: How fashion supply chains are being impacted by extreme heat and flooding*. https://www.schroders.com/en-gb/uk/institutional/insights/higher-ground-how-fashion-supply-chains-are-being-impacted-by-extreme-heat-and-flooding/.

Case Study 3: The Physical Climate Risk Assessment Methodology (PCRAM)[41]

PCRAM is an industry-developed, dynamic impact assessment framework for physical climate risks (PCRs) that can be incorporated into investment decision making, with a current focus on infrastructure. PCRAM advances traditional approaches to PCR assessments by considering the impact of PCRs on revenue and cost projections and changes in credit quality simulations. PCRAM is expected to contribute to a shift in the perception of resilient investments from being loss-minimisation exercises to contributing to strategic reviews that lead to value optimisation and the enhancement of investment appraisal practices.

In terms of engaging clients or investee companies to act, tools such as PCRAM can be very useful, while noting it applies only to infrastructure investment. The overall approach is to provide a strategic review of assets to optimise and enhance investment appraisal practices to improve investment decision making. It enables a rigorous interpretation of climate risk and climate data to assess the operational, commercial, and financial materiality of an infrastructure asset. PCRAM guidelines have been prepared for infrastructure asset developers, managers, and providers of capital.

The methodology combines three distinct fields to incorporate physical climate risks into the appraisal of infrastructure assets, namely (a) climate science, (b) infrastructure asset management and engineering, and (c) infrastructure finance. PCRAM builds on good practice from each of these fields, including IPCC models with the Synthesis Report of the Sixth Assessment Report (AR6), ISO Standards on Climate Adaptation and the Asset Management Institute ASCE MPE 140. The IIGCC Adaptation Group is now further developing the Physical Climate Risk Assessment Methodology (PCRAM) guidance.

To date, a number of case studies on infrastructure assets, including two in the UK, have helped confirm the process, with a report on four of these cases to be published in Q2 2024. A call for a second round of case studies and subsequent working groups will be forthcoming at the same time. IIGCC will also focus on integrating PCRAM into current financial risk management and due diligence processes to form a basis for an infrastructure component in their Climate Resilience Investment Framework and build out the methodology for other asset classes, such as real estate.

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[41] Coalition for Climate Resilient Investment (CCRI) and International Investor Group for Climate Change. https://storage.googleapis.com/wp-static/wp_ccri/c7dee50a-ccri-pcram-final-1p.pdf.

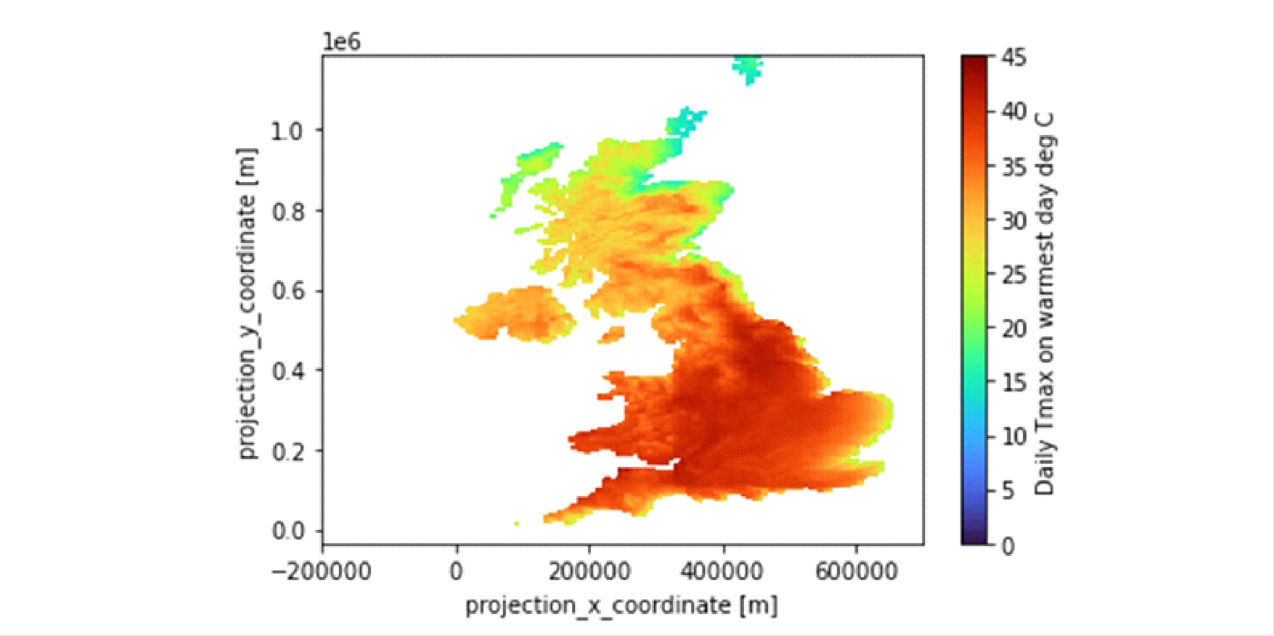
It will also be important to understand whether financed activities inadvertently harm the resilience of wider society. Some activities, for example, financed activities that lead to deforestation, soil erosion or overextraction of water could increase the risks faced by others. Around 45% of companies across the FTSE350 are in industries that could impact on the resilience of a wider society. This is something that taxonomies should address but is a wider point for the finance sector to keep in mind when responding to adaptation opportunity and a just transition.

Case Study 4: Snapshot of an extreme heat tail risk analysis

In the case study, we examine heat risk at a global warming of 2.5°C. This corresponds approximately to the 95th percentile of emissions scenarios B and C, with B a little below 2.5°C and C a little above 2.5°C as the response to emission scenarios starts to diverge. This warming level might also be reached under the 50th percentile of the C scenario but at a later time, in the 2060s. For this analysis, we select data over the UK region with a high spatial detail, suitable for simulating the physics associated with short-lived extreme events.

To study the extreme local change, we use data from the UKCP local simulations, which were produced with a state-of-the-art climate model at 2.2km spatial resolution. The distribution of local temperature at this global warming level has a 95th percentile response **in the annual maximum of daily peak temperature of around 42.6°C. This is in excess of the warmest temperature recorded so far in the UK in 2022 of 40.3°C**. In an example model simulation or storyline, on the warmest day of the year around 11% of the UK experiences a maximum temperature over 40°C, and 74% of the UK reaches above 30°C (Figure 14).

Figure 14: Maximum temperatures on the warmest day of the test case – 10th July.[42]

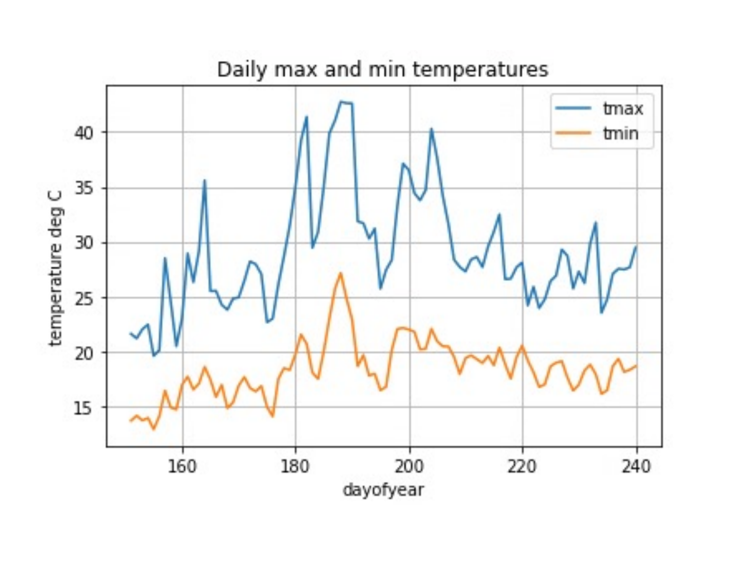


Within the simulation, there are **two especially warm periods, with around 40 days in excess of 30°C in total during the summer and an extended run of 11 consecutive days over 30°C for the warmest location over the UK**.

The precipitation amounts leading up to the summer are normal (for a baseline period based on near present day) or above precipitation in the Northwest England and most of Scotland, but below normal precipitation in many other parts of England and Wales. From a Meteorological perspective, the two warmest periods in early and late July are dominated by a transition between a high-pressure system over the UK, a Scandinavian high and an NAO- (North Atlantic Oscillation minus) state. The cooler periods in early and late summer see more low-pressure systems and NAO+ weather types.

[42] https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp_local_guidance_2023.pdf.

Figure 15: Time series of maximum daytime temperature and minimum nighttime temperatures of the example year. 1st July corresponds to day 180 on this plot.



What is also noteworthy – from an adaptation investment point of view – is the spikes in minimum daily temperature during the snapshot period, indicating the need for cooling measures to enable proper nighttime rest periods.

Implications for the UK financial sector

How might this information be used by a financial firm? For banks and asset managers investing in infrastructure, this case study illustrates the prudence of ensuring key UK-based infrastructure assets such as railroads and data centres can operate at sustained higher temperatures during the summer including peaks above 40°C. For the built environment – including hospitals, schools and homes – investment is needed to adapt these assets for increased cooling for sustained periods above 30°C and above 25°C at night to enable proper night-time rest. This additional cooling, some of which will need to be actively provided (air conditioning, fans etc), will also have a knock-on effect in increasing summer-time peak energy requirements.

As the above examples illustrate, the UK is experiencing warmer wetter winters and the risk of flooding is increasing. Financial institutions should be engaging with critical infrastructure companies (energy, water, transportation etc) to ensure they have adaptation plans in place to be resilient to hotter, more extreme summers and warmer wetter winters in the UK. As investments are being made to retrofit existing infrastructure and buildings to reduce transition risks, they should also incorporate resilience and adaptation measures. Some of the case studies included here indicate this is already starting to happen, but this needs to become systematic.

Financial institutions should be asking clients to develop and implement **integrated transition and adaptation plans**. For banks – this includes updating assumptions on the risk of default and loss given default of critical infrastructure during increased periods of higher temperatures and/or as a result of wetter winters. For asset managers, it is to assess the robustness of adaptation plans of their portfolio companies. For insurers, and reinsurers, it is about pricing the value at risk and impact on coverage and insurance premiums and considering more innovative risk transfer solutions – for example nature and place-based flood management schemes and build back better policies. These investment risks also create investment opportunities for these measures.

Case Study 5: Applying the ABC framework to an investment in a fictious salmon farming business

The aim of this case study is to assist an investor in a salmon farming company to evaluate direct climate-related risks. It also takes into account the risks within global supply chains for salmon feed. It is structured to provide a framework for identifying risks across short- to long-term planning horizons.

Step 1: Identification of Climate Hazards

- **Temperature increases** (sea and air). Both sea and air temperature increases can affect salmon's health and growth rates, change the distribution of wild fish stocks and change the prevalence of pathogens.
- **Ocean acidification** can affect the health of marine ecosystems and impact the food web that supports salmon.
- **Extreme weather events,** especially storms and heavy rainfall, can lead to runoff and pollution, affect water quality and salmon health and damage infrastructure.
- **Sea level rise** could affect coastal aquaculture facilities.
- **Changes in precipitation intensity/ seasonal patterns** impact freshwater availability and quality, affecting salmon farming in freshwater environments.

Prioritise hazards based on their likelihood and potential impact on salmon farming and supply chains. Assessing climate risk can be framed around several key dimensions: magnitude, duration, frequency, timing, and spatial extent. These elements can be integrated into a hazard estimation framework:

- **Magnitude** – The intensity or severity of a climate event. Example: Assess the highest temperatures reached during heatwaves or the lowest oxygen levels recorded in water bodies over several years.
- **Duration** – The length of time a specific condition persists. Example: Evaluate the continuous number of days with temperatures above the optimal range for salmon growth or below critical oxygen thresholds.
- **Frequency** – How often an event occurs within a given time frame. Example: Count the number of heat waves per year or episodes of harmful algal blooms.
- **Timing** – The specific period during which an event occurs. Example: Determine the occurrence of temperature spikes in relation to the event/s being analysed.

Step 2: Assess supply chain risks

Identify the regions where feed ingredients are sourced and assessing their climate risks (e.g. droughts, floods and changing temperature patterns). Examine potential effects on shipping routes and logistics due to extreme weather events or sea level rise.

Step 3: Choose Appropriate Models and Data

For assessing these risks, a combination of global and regional climate models can be used, such as:

- Global Climate Models (GCMs) provide projections of global climate change and can be used to assess general trends in temperature, precipitation and ocean conditions.
- Regional Climate Models (RCMs) offer more detailed regional projections that are crucial for assessing specific risks to aquaculture operations in Norway and in regions where feed ingredients are sourced. Aquaculture-specific models that specifically simulate the impact of environmental changes on aquaculture, including temperature effects on salmon growth rates, disease prevalence and oxygen levels, can provide insights into potential production changes.

Step 4: Risk Assessment Framework

Assess risks for up to 5, 10 and 30 years, considering both immediate and future climate impacts.

Short-Term (up to 5 years)

The selection of emissions scenarios is less critical. Instead, the focus shifts to the current global warming level (GWL). Immediate risk management could use the latest oceanographic data for sea surface temperature (SST) and pH levels. Potential Data Sources include Real-time SST monitoring from the Copernicus Marine Environment Monitoring Service (CMEMS) and National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer (NOAA AVHRR). pH levels and broader ocean chemistry insights are provided by the Global Ocean Data Analysis Project (GLODAP), and The Global Ocean Acidification Observing Network (GOA-ON). The International Argo Program, with its fleet of autonomous floating sensors, offers additional real-time data on temperature, salinity, and other oceanographic parameters. Operational decisions can be informed by real-time and annual data from the Copernicus Marine Environment Monitoring Service (CMEMS) and the Global Ocean Data Analysis Project (GLODAP), The Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS).

Medium-Term (5-10 years)

Due to the ocean's slow response to atmospheric heating, combined with the gradual adjustments in ocean chemistry from absorbed CO_2, it is likely that the variability in ocean conditions over a 10-year period will be relatively subtle compared to the natural variability observed in shorter time frames. Nevertheless, this period is distant enough that uncertainties in the global response to these emissions begin to matter. We recommend using the SSP2-4.5 scenario ("Middle-of-the-road" – trends follow historical patterns and social development is uneven) for medium-term climate projections, as it offers a balanced and moderate path well aligned with both historical trends and future expectations. For specific farm location, we recommend using downscaled data to assess potential changes and trends over the next decade. Projections can be used from the Coordinated Regional Climate Downscaling Experiment (Euro-CORDEX), data from CMEMS and the statistically downscaled CMIP6 ocean variables for European waters. We also recommend interacting with models or scenarios created by marine research institutes or organisations specialising in fisheries and oceanography, such as the Institute of Marine Research (IMR), which regularly publishes climate research (see examples).

Focus on the upper (95th) and lower (5th) percentiles of the projections to capture a wider range of potential outcomes. By better understanding potential worst-case scenarios, investing in innovation and technology, such as breeding programs for stronger salmon strains or advanced monitoring and control systems, becomes a more justified and calculated expense. However, farmers operating in regions less affected by climate extremes may prefer to focus on median projections to avoid unnecessary measures.

Although significant changes are not anticipated within the next decade, it is advisable for the salmon industry to formulate a strategic response now to prepare for expected developments after this period. This proactive approach allows for the adaptation of operations, the exploration of new technologies, and the refinement of strategies before potential impacts intensify. Such planning could particularly benefit from enhanced involvement by asset managers.

Long-Term (30 years)

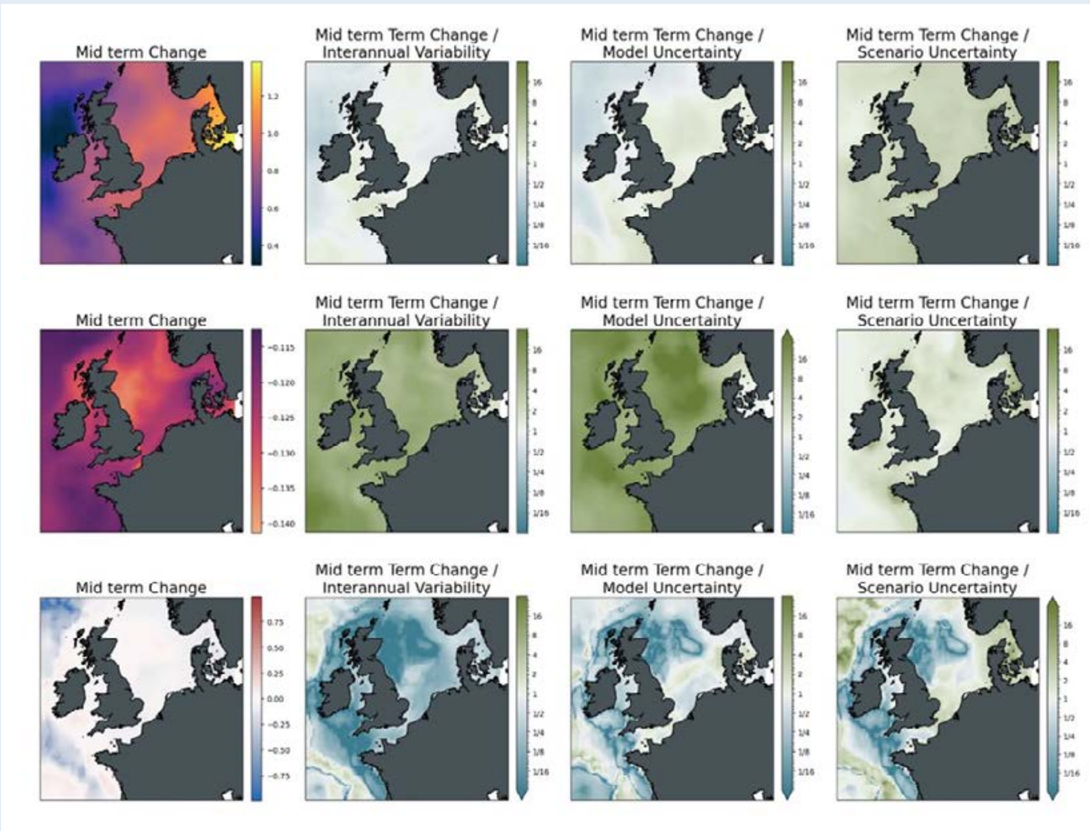
In the next phase we identify GWLs for scenarios A, B, and C as 1.48°C, 1.57°C and 1.96°C, respectively. Given the close similarity between the first two, we proceed with scenarios B and C, representing GWLs of roughly 1.5°C and 2°C, in further analysis. Planning for both SSP2-4.5 and SSP5-8.5 (a 'High-emission') ensures that operations are prepared for significant changes in ocean conditions. If a business is considerably impacted by international supply chains or operates within diverse geopolitical contexts, integrating aspects of SSP3-7.0

('Regional rivalry') into strategic planning may be beneficial in preparing for potential economic and regulatory shifts. Focus primarily on the upper (95th) and lower (5th) bands of the projections. However, if resources allow, the inclusion of the median projection (50th) should be considered, as it provides a valuable benchmark for the most likely future scenario under each assessed climate path. Similar to the medium-term approach (5-10 years), we recommend using downscaled data to assess potential changes. It is also important to validate these climate models against peer-reviewed sources such as the IPCC and marine and fisheries research institutes and services.

It is also essential to consider factors beyond direct climate impacts, such as changes in ocean currents and ecosystem dynamics, which may impact nutrient and oxygen levels in aquaculture areas. Information on these broader ecological conditions can often be obtained through detailed oceanographic studies and reports from specialised marine environmental monitoring agencies.

Based on high end projects, long-term strategies could include advanced breeding programs and infrastructure enhancements to withstand changes in sea conditions.

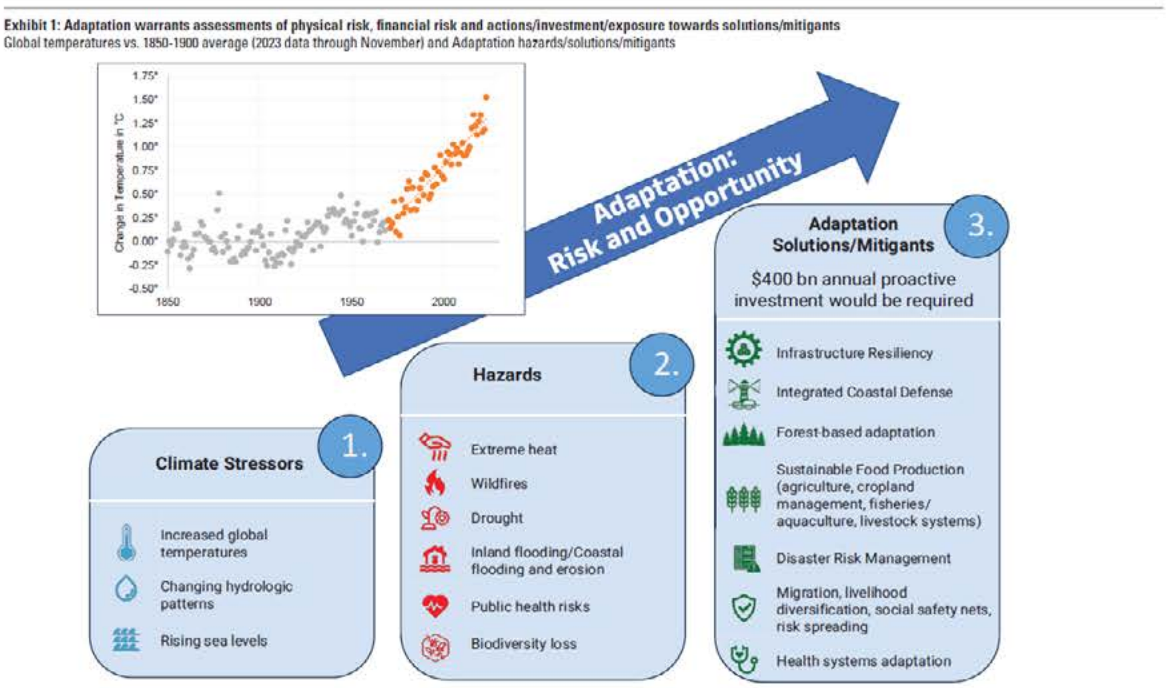
Figure 16: Significance of mid-term changes in the North Sea under SSP2-4.5 scenarios, against three sources of uncertainty for three ecosystem indicators: changes between mid-term conditions (2041-2060) and present-day conditions (1995-2014): changes relative to internal variability; changes relative to model uncertainty; changes relative to scenario uncertainty. Top to bottom: Surface Temperature (K), surface pH; bottom dissolved oxygen (ml/l).[43]



[43] Kristiansen, T., Butenschön, M., & Peck, M. A. (2024). Statistically downscaled CMIP6 ocean variables for European waters. *Scientific Reports, 14*(1), 1209. https://doi.org/10.1038/s41598-024-51160-1.

As physical risk analysis capability increases– as climate scenarios at a global level are better understood at a local risk hazard level – adaptation and resilience opportunities will become more visible, increasing the investment universe, as highlighted in Figure 17.

Figure 17: From physical risk to financial risk and opportunity.[44]



5.3 Acknowledging data gaps

In many cases, financial institutions will not necessarily be able to access all the hazard data needed to complete risk assessments, particularly when also applying the framework of saliency, credibility and legitimacy. Pinpointing the gaps and setting out how data should be improved/guidance on selecting the next best proxies will be a next sort for steps for this work.

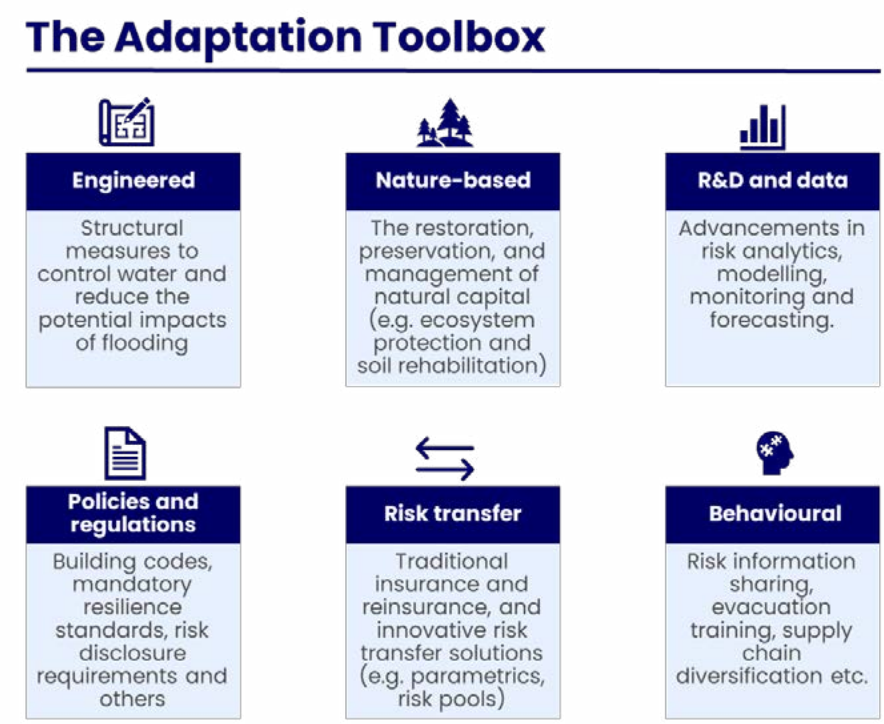
To cope with this issue, best practice guidance is to (a) sensitivity test risk assessments and adaptation decisions with the best available data, as illustrated in the mortgages example above and (b) where possible, design risk management and adaptation approaches that are flexible to be adjusted over time as information improves.

[44] Goldman Sachs. (2024). *GS SUSTAIN Adaptation Physical risk, Financial risk, Opportunity*. https://www.goldmansachs.com/intelligence/pages/gs-research/gs-sustain-adaptation-physical-risk-financial-risk-opportunity/report.pdf.

6. Identifying and creating new adaptation-focused opportunities

When considering investing in adaptation or implementing adaptation actions, a wide range measures and tools should be taken into account as part of the 'adaptation toolbox' (see Figure 18). Many of these tools are currently underutilised, underfunded or inefficiently implemented – thus there is great scope for evolution of the use of this toolbox, both by the market and by governments/regulators.

Figure 18: The Adaptation Toolbox – Example for Flood.[45]



6.1 Identifying opportunities: the role of taxonomies in creating common definitions and standards

One of the challenges faced by financial services firms is understanding what adapted assets need to look like. As with mitigation, taxonomies can be an important tool for firms to make an initial assessment – even stepping into the breach where policies are lacking. Indeed, in CFRF AWG discussions, the observation was made that financial services firms will always prefer a taxonomy approach if it is decision-useful and easy to use.

The CFRF AWG is fully supportive of the work started by the Land Use Nature and Adapted Systems (LNAS) Advisory Group – which was convened by Defra – to do this for the UK. The

[45] Marsh McLennan. (2022). *Staying above water: A systemic response to rising flood risk*.

initiative spun out of the UK Green Technical Advisory Group (GTAG) – who advised the UK government on the design of a green taxonomy in the UK, and who highlighted that the EU green taxonomy did not sufficiently focus on describing how to make UK infrastructure assets resilient to a changing climate. It also missed important sectors crucial for adaptation, such as agriculture.

While this UK taxonomy is being developed, and early publication of the advice is urged, others are available developed by governments but also academia, non-profit organisations and the private sector (examples are shown in Table 3). As the table shows, different taxonomies have different purposes. A separate technical paper published by Oxford University provides a synthesis and comparison of current taxonomies and their uses.

Table 3: Example of publicly available taxonomies and their uses cases.

Use case	Time	Example taxonomy
Assess sovereign bonds	Ex-ante	Standard Chartered Adaptation & Resilience Taxonomy
	Ex-post	ARIC Adaptation & Resilience Impact Measurement Framework
Assess corporate bonds	Ex-ante	Standard Chartered Adaptation & Resilience Taxonomy, Tailwind taxonomy
	Ex-post	ARIC Adaptation & Resilience Impact Measurement Framework
Assess equities	Ex-ante	ASAP taxonomy, Tailwind taxonomy
	Ex-post	CRISP framework
Assess infrastructure	Ex-ante	FAST
	Ex-post	ARIC Adaptation & Resilience Impact Measurement Framework
Public Finance	Ex-post	Oxford CRAFT Taxonomy
Development finance (e.g. loans, grants, working capital, intermediate financing)	n/a	IDFC-MDB Common Principles on Adaptation Finance Tracking

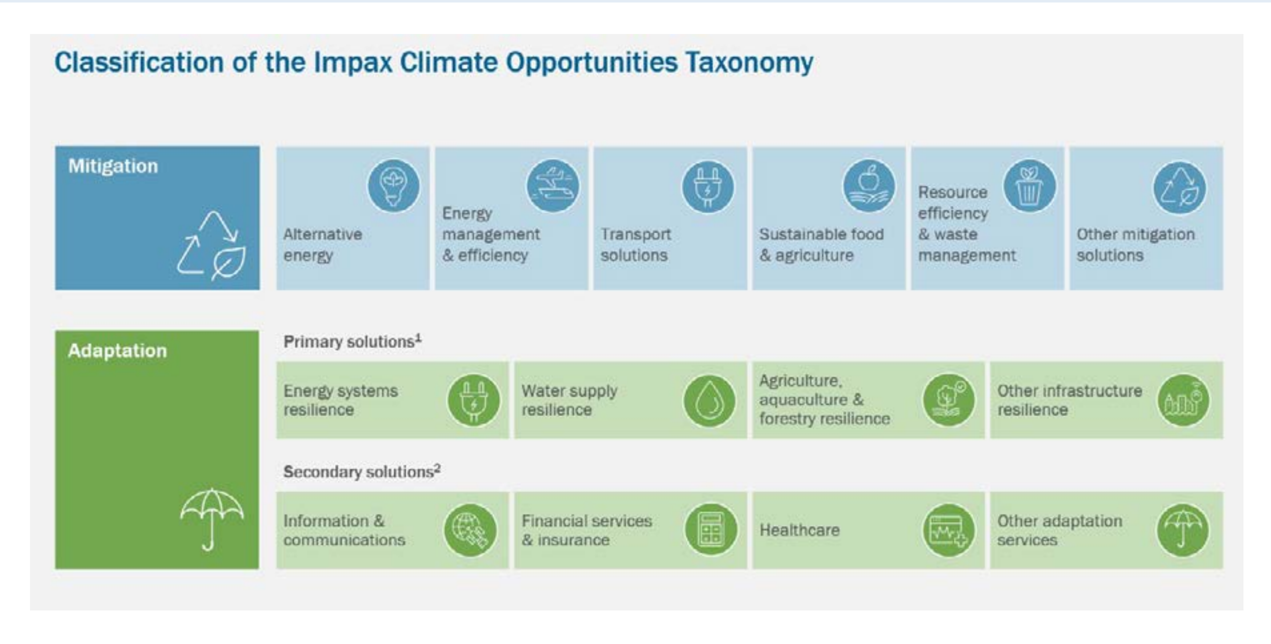
Some taxonomies that are already in existence focus more on private investment. The Impax Asset Management taxonomy (Case Study 6), for example, aims to support users to identify new market opportunities and therefore focuses on adaptation products and services, such as climate data companies.

Case Study 6: Capturing the adaptation opportunity – Impax Asset Management[46]

To respond to client interest in investing in the growth opportunities of companies providing solutions for the mitigation of or adaptation to climate change, in 2018 Impax Asset Management created a Climate Framework, subsequently supported by a new Taxonomy and Investment Universe focusing on these challenges which at 31 December 2023 encompassed approximately 1400 securities.

Adaptation offers investment opportunities in technologies and systems that improve our resilience to acute physical risks like floods, droughts, wildfire, extreme precipitation, cyclones and hurricanes and other climate-driven events – and to chronic risks like extreme heat, sea level rise and expansion in the geographic distribution of diseases and pests.

Figure 19: Impax Taxonomy.



The Climate Universe is split into Mitigation and Adaptation, with a broad selection of sectors and related opportunities which allows for a well-diversified portfolio. Impax Asset Management has classified adaptation into two broad categories: primary adaptation and secondary adaptation. Primary adaptation is focused on addressing the immediate impacts of climate change such as stronger storms, rising sea levels and extreme heat. A few examples of the kinds of ideas that Impax Asset Management sees as primary adaptation include the following:

- **Electric grid resilience**. Extreme weather phenomena put a lot of stress on electricity grids around the world. Impax sees opportunities to invest in solutions that enhance the resilience

[46] Disclaimer: This material is provided for educational purposes only. Nothing presented herein is intended to constitute investment advice and no investment decision should be made solely based on this information. Nothing presented should be construed as a recommendation to purchase or sell a particular type of security or follow any investment technique or strategy. Information presented herein reflects Impax Asset Management's views at a particular time. Such views are subject to change at any point and Impax Asset Management shall not be obligated to provide any notice. Any forward-looking statements or forecasts are based on assumptions and actual results are expected to vary. While Impax Asset Management has used reasonable efforts to obtain information from reliable sources, we make no representations or warranties as to the accuracy, reliability or completeness of third-party information presented herein. No guarantee of investment performance is being provided and no inference to the contrary should be made.

of the energy network while enhancing integration of renewables. Backup power and storage are particularly attractive areas.

- **Water infrastructure resilience**. Similarly, climate change is responsible for water stress in an increasing number of locations and that led us to look for solutions in water infrastructure and treatment. From an investment point of view, this space is a source of defensive exposure for the strategy.
- **Agriculture resilience**. Impax sees opportunities for companies to identify solutions that better protect crops and shield them from the changing weather patterns and chronic risks like sea level rise and extended droughts.

Secondary Adaptation encompasses solutions that help us respond and adapt to the indirect impacts of a changing climate. Some examples of opportunities in secondary adaption include the following.

- **Information and communication resilience.** As weather disasters multiply in number and severity, emergency response and business continuity solutions are growing more crucial. Impax looks at the necessary infrastructure which includes things like videoconferencing, cybersecurity, weather monitoring and climate prediction analysis.
- **Modelling and pricing of climate risks.** Companies providing leadership in modelling (and pricing) of climate Risks through the utilization of advanced modelling techniques reflecting exposure, hazard, vulnerability to climate change risks, and actions taken by policyholders.
- **Human health resilience.** There is growing evidence that climate change affects human health, in part because many disease vectors formerly confined to the tropics are expanding into temperate regions, and in part because heat itself can worsen human health in many ways. Impax sees opportunities in companies that help prevent and treat these climate related infectious diseases and conditions through better diagnostics, therapies and vaccines.

The Standard Chartered, KPMG and UNDRR taxonomy focuses on investments that can be considered commercially viable within the context of adaptation and resilience needs in emerging markets and developing economies (Figure 20).

Figure 20: Indicative Eligible Investments (Use of Proceeds) – Resilient Agrifood systems.[47]

Others still, such as that developed by Mott MacDonald operate at the very detailed level – defining what changes to infrastructure are desirable to be resilient to a range of hazards.

[47] Standard Chartered, KPMG, & UNDR. (2024). *Guide for Adaptation and Resilience Finance*. https://www.sc.com/en/adaptation-resilience-finance-guide/.

Figure 21: Mott Macdonald Taxonomy.[48]

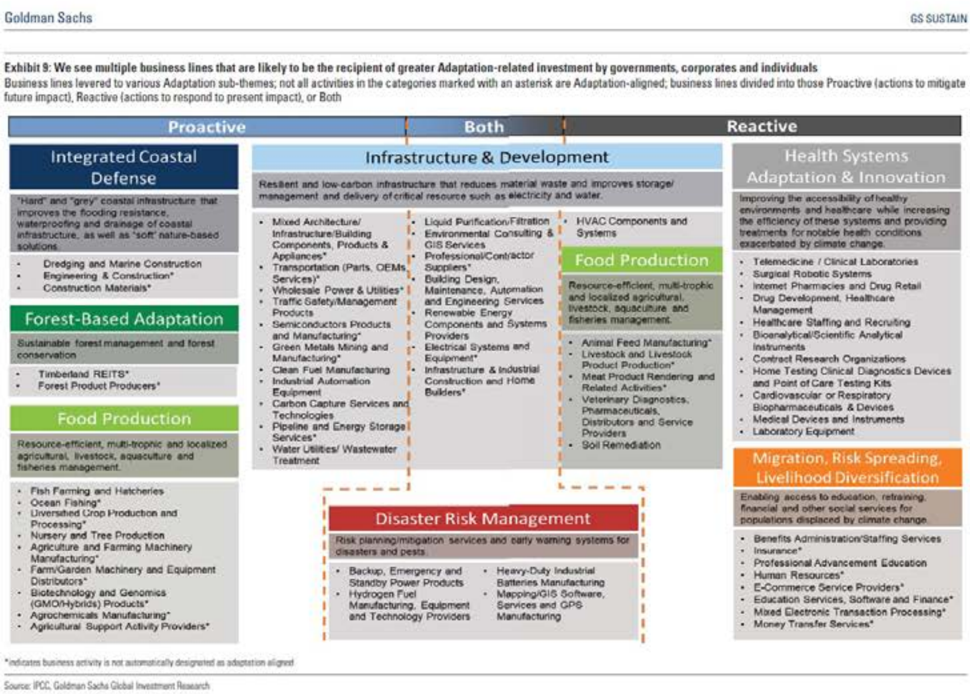
Climate Hazard Database

Vater | Wa:Pipelines and networks | Clean water pipe network | Climate hazard: ☑ Freeze-thaw (extreme shifts in temperature) ☑ Flooding - fluvial ☑ Extreme heat ☑ Drought ☑ Flooding - groundwater ☑ Ground movement (heave, subsidence)

imate Hazard	Climate Risk	Types of impacts	Resilience measures	Recovery Measures	Prompts
eeze-thaw (extreme shifts in mperature)	Fluctuating temperatures around zero to cause pipe bursts	Structural damages Operational disruptions (temp) Interruptions to supply (temp)	Proactive replacement of ageing pipe Use of material resistant to freezing conditions Gravel casing around vulnerable pipes	Emergency replacement of pipes	What soil type is the pipe lined within? What is the pipe material? What is the pipe diameter and its criticality within the network?
treme heat	Increased water demand causing pipe bursts	Structural damages Operational disruptions (temp) Interruption to supply (temp)	Upgrade network capacity Customer campaigns to reduce consumption Proactive replacement of aging pipes	Emergency pipe replacement Network reconfiguration	Is the system able to cope under increased water demand? Which parts of the network experience the highest peak demand?
ooding - groundwater	Pipe floatation and bursts from increased groundwater levels affecting lining	Structural damages Operational disruptions (temp) Interruption to supply (temp)	Proactive replacement of aging pipes in areas at risk of groundwater flooding Regular inspection of networks Establish redundancies in the network	Emergency replacement of pipes Tankering	Is the area prone to groundwater flooding/high levels of water table? What type of soils are present? What is the pipe material?
ooding - fluvial	Collapse/burst of traversing pipes from erosion of riverbanks	Structural damages Operational disruptions (temp) Interruption to supply (temp)	Relining of pipes away from riverbanks Establish redundancies in the network Surveying and monitoring of pipe conditions	Emergency replacement of pipes	Is the area prone to erosion? What type of soils are present? What is the pipe material? What is the pipe diameter and its criticality
rought	Increased water demand causing pipe bursts	Structural damages Operational disruptions (temp) Interruption to supply (temp)	Upgrade network capacity Proactive replacement of aging pipes Customer campaigns to reduce consumption	Emergency pipe replacement Network reconfiguration	Is the system able to cope under increased water demand? Which parts of the network experience the highest peak demand?
rought	**Shrinking and swelling of soils leading to pipe bursts**	**Interruption to supply (temp) Operational disruptions (temp) Structural damages**	**Proactive replacement of pipe with material resistant to expansive soil conditions Gravel casing around vulnerable pipes**	**Emergency replacement of pipes**	**Is the pipe lined in clay soils? What is the pipe material? What is the pipe diameter and its criticality within the network?**
round movement (heave, subsidence)	Ground movement with effect on lining of underground pipes (i.e. burst/collapse)	Structural damages Operational disruptions (temp) Interruptions to supply (temp)	Proactive replacement of pipes in areas prone to ground movement Establish redundancies in the network	Emergency replacement of pipes	Is the area prone to erosion and/or ground movements? What type of soils are present? What is the pipe material?

Goldman Sachs' adaptation report emphases those adaptation investment measures that are proactive versus reactive.

Figure 22: Goldman Sachs adaptation approach.[49]



[48] Mott Macdonald, (2024). Example of in-house taxonomy.

[49] Goldman Sachs. (2024). *GS SUSTAIN Adaptation Physical risk, Financial risk, Opportunity*. https://www.goldmansachs.com/intelligence/pages/gs-research/gs-sustain-adaptation-physical-risk-financial-risk-opportunity/report.pdf.

It is worth noting that existing adaptation taxonomies tend to have less quantified criteria than mitigation taxonomies and this is because what constitutes 'good adaptation' can vary significantly by location. The EU taxonomy, as many others, takes a process-based approach: that is, laying out the process for assessment of the contribution of an activity to adaptation, rather than defining 'good' adaptation measures for a specific risk and threshold (e.g. 1 in 200-year flood protection). For users, we hear that this is challenging and there is a call for clearer resilience standards, at least for some critical areas like infrastructure and buildings.

An outcomes-focused and quantified approach to taxonomy design – as deployed by Mott Macdonald in their taxonomy (see Figure 21) – has been identified by CFRF AWG members as most useful to support client and investee company dialogue on adaptation investment opportunities. This is the approach being taken by the LNAS Advisory Group as it starts work on proposals for a UK adaptation taxonomy and is an approach that the CFRF AWG is supportive of.

6.2 Risk transfer solutions

Facilitating the shift to a resilience-focused insurance system

The insurance sector is emerging as a key player and partner in climate adaptation. They already play a unique role in the financial services sector, with frontline exposure to diverse climate risks via their own clients, as well as in their roles as some of the largest global investor cohorts as they invest insurance premiums in the financial markets.

Some insurers and brokers have started to prioritize adaptation and collaborate with their clients and the public sector to identify innovative ways to enhance current and future resilience. This has clear commercial value for the insurance industry, allowing insurers to expand their role beyond traditional risk transfer and to protect their existing markets. At the heart of this is the understanding that adaptation can be catalysed through a shift to a resilience-focused insurance system.

How (re)insurance can support the shift to a more resilient economy

(Re)insurers and investors could lean on three key capabilities to support the public and private sectors to better understand their climate-related risks and act upon them:

1. Data and analytics;
2. Advisory; and
3. Risk transfer products and efficient use of capital.

Data and analytics

Brokers, insurers and reinsurers have invested in advanced climate modelling capabilities for decades, from computing capabilities to skills. Outside of academia are ahead of other sectors in modelling climate risks and quantifying these risks into financial impacts.

Typically (re)insurers have the capabilities to model a wide range of climate risks – see Table 4.

Table 4: Climate risks modelled by insurance.[50]

	Temperature-related	Wind-related	Water-related	Solid mass-related
Chronic	Changing temperatures (air, freshwater, ocean) Heat stress Temperature variability Permafrost thaw	Changing wind patterns	Changing precipitation Ocean acidification Saline intrusion Sea level rise Water stress	Coastal erosion Soil degradation and erosion
Acute	Heat waves Cold waves Wildfires	Hurricanes, cyclones, typhoons Storm intensity tornadoes	Drought Heavy precipitation Flooding	Avalanches Landslides Subsidence

While (re)insurers do have further to go in developing forward-looking models, and not just relying on past data, there is a lot that the sector can contribute for corporates and policymakers alike to better understand the types and severity of climate risks they may become exposed to.

Risk engineers, who traditionally support underwriters and claims managers by bringing in technical expertise of the assets being evaluated, are also starting to use satellite data and algorithmic image recognition.

Advisory

Based on advanced climate modelling, (re)insurers advise clients on short- and long-term strategic planning. This can include ways to anticipate and prepare for chronic and acute risks; making informed decisions on locating new offices or operations; or how to allocate investments.

Many risk engineering teams are also able to translate climate risks into financial risks and support their clients in understanding the costs and benefits (or avoided costs) of implementing specific resilience measures.

Risk transfer solutions and more efficient use of capital

Increasingly, people and businesses can't assume the full costs of climate risks from their own balance sheets. For hundreds of years, (re)insurers have helped businesses, people and investors to share risks more efficiently. (Re)insurers are already innovating with new mechanisms like parametric insurance and alternative risk transfers – as are highlighted in section 6b. There are also examples where (re) insurers were able to create financial resilience for more vulnerable parts of the world, especially by working with the third sector (e.g. through

[50] Floodlight. (2024).

resilience bonds[51] or reinsuring third sector funds[52]). With integrated strategies that tie risk transfer to risk reduction measures, insurers can provide incentives to promote the deployment of resilience interventions. For example, the purchase of policies can be accompanied by guidance for property-level protection measures or through the adoption of "build back better" principles by Flood Re in the UK that ensures rebuilding projects prioritize climate adaptation investments. Another example is the development of innovative community-based catastrophe insurance schemes that rely on parametric insurance cover and can create financial incentives for resilience interventions through investments.[53]

The three case studies that follow set out how the role of innovative approaches to insurance can facilitate resilience and adaptation.

[51] World Bank. (2021). *World Bank Catastrophe Bond Provides Jamaica $185 Million in Storm Protection World Bank*. https://www.worldbank.org/en/news/press-release/2021/07/19/world-bank-catastrophe-bond-provides-jamaica-185-million-in-storm-protection.

[52] AON. (2022). A*on Provides Innovative Solution for Red Cross Disaster Response Emergency Fund (DREF)*. Aon Plc Global Media Relations. https://aon.mediaroom.com/Aon-Provides-Innovative-Solution-for-Red-Cross-Disaster-Response-Emergency-Fund-DREF.

[53] Marsh McLennan. (2023). *Building a Climate Resilient Future*. https://www.marshmclennan.com/insights/publications/2023/december/building-a-climate-resilient-future.html.

Case Study 7: Milwaukee River risk and resilience initiative (M3RI)[54]

Type of intervention: Public-private partnership (PPP)

Structure: The aim of the PPP was to utilise the insurance mechanism to capture and scale the economic benefits of nature-based risk reduction projects across the Milwaukee River watershed. The Metropolitan Milwaukee Sewerage District (MMSD) is a long-time leader in deploying nature-based solutions to address water quality and flood management challenges. Recently, they entered into a larger-scale program with Ducks Unlimited (DU) to restore 4,000 acres of wetlands and plant six million trees to reforest the Milwaukee River watershed. In an effort to document and monetise the flood reduction benefits of these projects, Guy Carpenter is working with MMSD and DU to reconcile their modelling of the hydrological impacts of the new vegetation with more traditional insurance catastrophe risk modelling by working with leading (re)insurance companies to structure a parametric-based community-level insurance program that would be re-priced each year — up or down — to reflect the new risk factors.

Success criteria: PPP that addresses the gap between environmental benefits and climate data with insurance risk data.

What next: If successful, the program should create a scalable model for capturing the positive externalities of nature-based flood mitigation projects. The M3RI continues to seek funding partners for the effort, as well as other private sector actors — including farmers, shippers, and railroad companies — that can contribute to reducing flood risk even further throughout the watershed.

[54] Marsh McLennan. (2023). *Building a Climate Resilient Future*. https://www.marshmclennan.com/insights/publications/2023/december/building-a-climate-resilient-future.html.

Case Study 8: Quintana Roo Reef Protection – Mexico

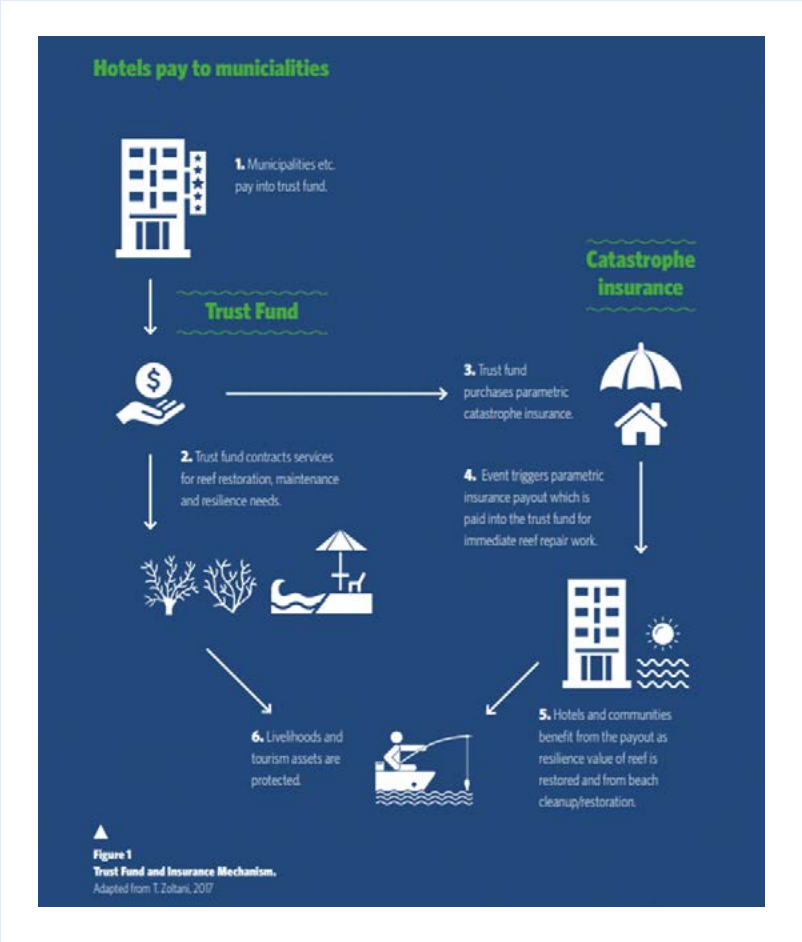
Type of intervention: Insurance

Structure: In 2018, the world's first insurance solution to preserve a natural ecosystem was launched, using a parametric mechanism. Private sector taxes and government funding are combined into a Trust, responsible for maintaining the reef. The insurance premium is then paid by the Trust, with fees generated through public/private sources. The claim payment release is triggered when hurricane wind speeds reach a certain level, allowing the policy holder to repair the area's coral reef quickly. The policy helps to maintain the reef and, by extension, the community that relies on it.

Success criteria: There are several stakeholders involved in this parametric insurance structure, which include coastal property owners, municipal governments, State Government of Quintana Roo and Coastal Management Zone Trust (CMZT) and insurance companies.

What next: Since launching this innovative design, Swiss Re is working to replicate this model elsewhere in the world. This includes coral reefs but also other types of natural ecosystems, such as mangroves[55].

Figure 23.



[55] GFI Hive Case Study on the Quintana Roo Protection Scheme https://www.greenfinanceinstitute.com/gfihive/case-studies/quintana-roo-reef-protection-parametric-insurance/.

Case Study 9: Environment Agency – Port Clarence and Greatham South flood coastal erosion scheme[56]

Costing almost £16million, the Port Clarence and Greatham South project has increased flood protection to Port Clarence residents from the River Tees and Greatham Creek while also creating a new habitat the size of over 90 football pitches for local wildlife. The Environment Agency joined forces with local industry to build the scheme with a multinational company SABIC UK contributing £3.8m and INOVYN ChlorVinyls offering land to allow the creation of the new habitat. Combined with flood defences that were completed at Port Clarence in 2015, the project reduces the risk of flooding to 350 homes and 32 businesses in Port Clarence and the Seal Sands Industrial Complex. Contractors BMMJV (BAM Nuttall and Mott MacDonald Joint Venture) carried out the work on behalf of the Environment Agency. Phase 1 of the scheme saw new flood defences built in Port Clarence, consisting of a mixture of earth embankments, flood walls, and a raised section of the road on the approach to the Transporter Bridge. In addition, the Environment Agency worked together with local business Wilton Engineering to install removable steel flood defences along the River Tees to improve flood protection while still allowing Wilton to operate from the river.

Throughout the project, the Environment Agency has worked closely with the Royal Society for the Protection of Birds (RSPB) and Natural England to create a scheme which maximises benefits for the internationally designated habitat which includes rare birds as well as seals.

In the 2020 budget, the UK government doubled its investment in the flood and coastal erosion risk management (FCERM) scheme. They committed a record £5.2bn between 1 April 2021 and 31 March 2027. The aim is to protect 336,000 homes and non-residential properties. In the previous 6-year investment programme (2015-2021) 60% of FCERM schemes required partnership funding. In the current programme (2021-2027) 58% of FCERM schemes require partnership funding. The partnership funding needed is £1.73bn to deliver the 200,000 properties better protected target. There remains a substantial private finance gap.

[56] Environmental Agency (UK Government). (2018). *£16 million Teesside flood scheme complete*. GOV.UK. https://www.gov.uk/government/news/16-million-teesside-flood-scheme-complete.

7. Accelerating action

In the process of developing this guidance document, a number of ideas for how investments from the finance sector could be accelerated through well-targeted policy interventions and investment in public goods have emerged. These ideas include actions for real economy companies and the finance sector seeking to increase investments in adaptation and resilience. But fundamentally better regulation is key to levelling the playing field and accelerating action. In this section, we outline a set of recommendations and case studies that aim to address several barriers identified by the CFRF AWG:

- Lack of clarity on national and international adaptation goals.
- Lack of consensus on standards and definitions for adapted assets to support strategic decision-making on adaptation responses by firms (resilience standards, taxonomies, etc).
- Concerns about the quality and relevance of data for supporting physical risk analysis including at the Local Authority level.
- Lack of scaled deal opportunities coming through.

7.1 Addressing the lack of clarity on national and international adaptation goals and lack of consensus on standards and definitions for adapted assets

In the survey of CFRF AWG members, respondents highlighted the need for greater clarity on government plans and on what constitutes an adapted asset or company to strengthen physical risk management and increase adaption-focused business development.

The National Adaptation Programme 3 (NAP3) explains the UK government's five-year plan to adapt to climate change until 2028. The headline vision is *"for a country that effectively plans for and is fully adapted to the changing climate, with resilience against each of the identified climate risks."*[57]

The NAP3 included £2.2bn of accelerated investment in water quality and resilient supply; £5.2bn investment in flood and coastal erosion schemes; a new transport adaptation strategy; and incorporating climate change adaptation into the design of Environmental Land Management schemes to promote resilient and sustainable land management and farming practices. However, there are no detailed plans on how this will be delivered and how other sectors not mentioned in the NAP3 will be addressed.

Recommendation 1

The CFRF AWG supports the call made by the Committee on Climate Change[58] and in the Mission Climate Ready Report[59] for the UK government to commit to make the country resilient to climate change by 2030 and outline specific and costed goals and delivery plans for each sector by 2025, and envisaged public/private sector roles. The CFRF AWG also supports the work of the Land, Nature and Adapted Systems (LNAS) Advisory Group in advising on the development of an adaptation-focused taxonomy and recommendations from

[57] Climate Change Committee. (2024). *Independent Assessment of the Third National Adaptation Programme*. https://www.theccc.org.uk/publication/independent-assessment-of-the-third-national-adaptation-programme/.

[58] Ibid.

[59] Ranger, N., Bremner, C., `Brown, K., Fankhauser, S., Holmes, I., & Boyd, E. H. (2023). *Mission Climate Ready: Unleashing finance and investment for a prosperous Climate Ready economy*. https://www.smithschool.ox.ac.uk/sites/default/files/2023-06/Mission-Climate-Ready-Unleashing-finance-and-investment-REPORT.pdf.

the National Infrastructure Commission (NIC), the Committee on Climate Change (CCC) and Mission Climate Ready on the adoption of resilience standards and integration of clear targets and metrics within key areas of regulation (e.g. water, energy).

Recommendation 2

The CFRF AWG has set out guidance on what climate futures to prepare for in its ABC approach. The group recommends that the ABC framework is implemented by financial institutions as a good practice approach to assessing physical risk with forbearance around the fact there are data challenges to work through to be able to fully apply the approach. Guidance on this should be updated as the latest scenarios, climate change models and local hazard data sets improve.

7.2 Addressing concerns about the quality and relevance of data for supporting physical risk analysis

The survey of CFRF AWG members found a diverse array of information and tools is being used for decision-making on adaptation. Most reported employing third-party scenarios and climate impact information to inform their adaptation strategies. These sources include external third-party providers including MSCI and Moody's Risk Management Solutions, academic research institutions, government agencies such as Defra and the Environment Agency, and even local grassroots-level sources such as from community-based environmental groups and also local authorities.

Despite this, respondents highlighted challenges relating to data availability, quality, and interoperability, which were compounded by resource constraints and legal considerations. Metrics, as well as asset location information from third-party data providers are extensively used by respondents. There was a clear appetite for additional information, particularly corporate data, to enrich decision-making processes. Better locational and resilience data is needed to understand and price physical risk. One of the challenges for asset managers investing globally is to understand the location of assets, which is necessary to understand fully the more detailed and accurate physical risk assessments set out in this guidance.

Recommendation 3

Businesses need to improve disclosure of physical climate risks and adaptation strategies and opportunities. Similar to the TNFD recommended asset level disclosures, the CFRF AWG encourages the disclosure of the locations of assets and/or activities in real economy companies' direct operations and, where possible, upstream and downstream value chain(s) that meet the criteria for priority locations, where the effects of physical climate risk are material.

This is an approach that has been widely adopted in the TNFD. Asset level guidance is provided in the TNFD Strategy Recommendation. Understanding the geo-location of assets is critical in assessing both physical climate and nature related climate risk exposures and co-benefits. Businesses should also disclose what they are doing to understand and adapt to these risks – describing how they create resiliency in addressing these risks. Investors have already begun to make clear their expectations of investee companies regarding the governance, assessment, management and disclosure of physical climate risks and opportunities. It is important that corporate leadership takes responsibility for managing physical climate risks and opportunities – i.e. the steps that can be taken to assess physical climate risks, develop a strategy for building climate resilience and identify opportunities to provide adaptation solutions. The CFRF AWG also supports UK regulators working with global regulators to make the case for these disclosure requirements to be implemented elsewhere, for example via the G20 Sustainable Finance Working Group, International Platform on Sustainable Finance, in relevant IOSCO fora and so on, which would level the playing field and accelerate action.

There also needs to be more investment into and awareness of what good flood resilience buildings look like and sharing of this information across the industry. However, the paucity of high resolution and quality data should not be seen as a reason for inaction. A semi-quantitative approach to determining physical risk could still provide guidance on the most significant areas for action and help build adaptation into decision making.

Recommendation 4

The CFRF AWG supports corporate reporting in line with the Transition Plan Taskforce proposals, which are a gold standard template for reporting, with an adaptation-inclusive transition plan.

As firms begin to develop transition plans, we agree with the recommendation of the TPT that these include adaptation. This is important to both financial institutions and real economy firms. The development of adaptation plans should follow appropriate guidance, as we have begun to outline in this document and be stress tested against the ABC framework.

Recommendation 5

The insurance sector, asset managers, and banks identified the need to facilitate greater sharing of aggregate data sets to protect assets in the UK from climate change and physical hazard risks. This includes seeking annual updates to coverage on insurance for mortgage and commercial loans in the built environment to better price risk exposures and coverage needed and support product innovation.

Given the extensive level to which financial institutions are relying on third-party data, there is a clear need for them to be transparent on their methodology and the assumptions used to enable users of that data to better understand the limits of its usefulness and ensure it is applied appropriately in decision-making. This is especially vital for smaller asset managers and owners, so that costs of information and data are not prohibitive.

Recommendation 6

Standards and assurance need to be created for third party climate risk data providers. At the very least there should be transparency on evidence sources, methodology and the assumptions made to enable users to select sources and tools appropriate to the task at hand. Independent experts such as the technical advisors to the CFRF AWG (Met Office, University of Leeds and Oxford University) and the broader scientific community should be assessing the quality of the data being used and updating the recommendations for which climate scenarios the finance community should use in both global and local hazard data sets.

Recommendation 7

Regulation has been successful in driving investment into areas aligned with UK resilience. In 2021/2, the Environment Agency and the National Infrastructure Commission highlighted the need to update current regulation to meet the challenges of climate change and mobilise investment in a climate resilient economy. **Fully incorporating climate resilience across all existing regulatory bodies must be prioritised, in particular for water, energy, telecoms, transport, the natural environment and land. Enabling data integration across regulators is key to managing cascading risks and should be a key collective priority to address.**

7.3 Increasing deal flow

Climate proofing the UK and its investments will demand that the government and the financial sector work hand-in-glove. Government must establish the regulatory and policy conditions that correct market failures and allow financial institutions room to run. The Committee on Climate Change's review of the UK's NAP3 concluded that *"adaptation in the UK is insufficiently funded to manage the scale of the climate impacts we will experience. NAP3 does not tackle effectively the barriers to investment, such as low perceived urgency of adaptation, lack of clear targets and the limited understanding of adaptation actions. There also remains a limited understanding on the role of spending on adaptation from the private and public sector."*[60]

As the Dutch Adaptation WG report says, *"In some cases the financial sector can act independently to stimulate climate adaptation, but first and foremost support or guidance from (central and local) government is required on the basis of a clear vision and unambiguous course of action."*[61]

In working with the financial sector, a range of approaches could be taken by HMG and regulators to increase adaptation focused deal flow. Case study 10 is a case in point.

[60] Climate Change Committee. (2024). *Independent Assessment of the Third National Adaptation Programme*. https://www.theccc.org.uk/publication/independent-assessment-of-the-third-national-adaptation-programme/.

[61] DeNederlandscheBank. (2023). *Working Group on Climate Adaptation*. https://www.dnb.nl/en/green-economy/sustainable-finance-platform/working-group-on-climate-adaptation/ and Samen Klimaat Bestendig. (2023). *Financiële sector samen met overheid aan de slag*. Klimaatadaptatie. https://klimaatadaptatienederland.nl/samen/klimaatbestendig/klimaataanpassingen/klimaatbestendige-financiele-sector/.

Case Study 10: Severn Trent Water – Resilience and longevity of water supply[62]

The UK's future water supply is at risk from the growing impacts of climate change, drought, and population growth. At the same time, Severn Trent is obligated to reduce the risk of water abstraction causing environmental harm. Severn Trent's supply-demand modelling shows that, without action, a deficit in water supply will arise off about 8% of daily production by 2030. Severn Trent has submitted a case for £678m of additional investment to Ofwat (the regulator) in its PR24 plans (2025-2030), as well as maximising benefits from base expenditure. This investment is needed to secure the region's future water needs and support a thriving environment. Severn Trent has identified several actions focused on 3 pillars:

- **Reducing demand**: Leakage reduction through mains renewal; a Smart Meter strategy to replace and install across both household and business customers; customer service system improvement & a water efficiency education programme; and efficiency programmes.
- **Replacing unsustainable supply & creating new supply**: Construction of two new links and transfer mains; raising a dam for increased reservoir capacity; and expansion of four water treatment works.
- **Investigations to reduce future uncertainty**: Ensuring feasibility of solutions against alternative pathway modelling to allow flexibility in planning; and development of Direct Procurement for Customers (DPC) scheme to improve on innovation and whole life cost.

KPIs for the plans include customer feedback and customer service scores; leakage reduction % against 2017-2020 baseline; number of smart meters installed; reduction in per capita consumption ('PCC') of water.

What next: Severn Trent awaits Ofwat approval of its PR24 plans, however, £400m of investment is being accelerated and work has commenced. Future investment will continue to expand on and develop the work in progress now, with flexibility built in to adapt to changing scenarios, as the company invests for the long term in securing water resources for the future.

[62] Lloyds Banking Group.

For infrastructure (including water, energy, telecoms), which in many cases is a regulated asset base, the importance of the price review control process cannot be underestimated. Regulation has played a vital role in driving private investments in hard (and soft) infrastructure that deliver critical services to people and the economy and ensures standards are met, including on safety, service provision, risk, and environmental protection. Major new investment is needed to make the UK's core systems Climate Ready. Resilience standards need to be designed and implemented. The fourth National Adaptation Programme (NAP4) in 2028, alongside the devolved adaptation programmes, provides an opportunity to progress this.

In April 2023, the National Infrastructure Commission and Committee on Climate Change jointly wrote to government urging ministers to take steps to improve the resilience of key infrastructure services to the effects of climate change. As stressed by Sir John Armitt, Chair of the National Infrastructure Commission in 2019, "Good infrastructure needs effective regulation. The services we receive from water, energy and telecoms companies, and the bills we pay, depend on it. Regulators set targets for providers, determine new investments they should make and protect consumers' interests… Updating our system of regulation is overdue and necessary".

Research by the National Infrastructure Commission in 2019 concluded that the UK's model of regulation for energy, water and telecoms has generated significant investment over the past decades, but it is increasingly facing new challenges that it was not designed to address… "the UK's model of regulation for energy, water and telecoms must be updated to meet the coming challenges of achieving net zero, adapting to changing weather patterns, and increasing digitalisation".[63] It recommends that government should introduce legislation ensuring that, where they are currently missing, Ofwat, Ofgem and Ofcom have duties to require them to ensure their decisions promote the resilience of infrastructure systems. To deliver resilient infrastructure, a framework is required that values resilience properly and drives adaptation "before it is too late". There are existing data, tools and approaches that can be leveraged to support this integration but there is also a role for increased government investment in this area, as discussed later.

In terms of private sector efforts, the CFRF AWG supports the ongoing development work of PCRAM and the IIGCC establishment of an adaptation working group to continue to develop guidance for resilience in infrastructure. However, greater clarity on national adaptation needs is a priority and – if provided by the UK government – will lead to better clarity on infrastructure needs and investment horizons. Taking a place-based approach will enable consideration of the role of the public and private sector in working together on engineered and nature-based solutions. This public and private cooperation will open up new opportunities for blended finance solutions to emerge as has been seen in the case of the Environment Agency Port Clarence and Greatham South flood coastal erosion scheme (see Case Study 11).

Recommendation 8

Government departments, including those responsible for critical infrastructure, housing and transport, need to integrate climate resilience into infrastructure and green investment planning. There are existing data, tools and approaches that can be leveraged to support this integration – a key consideration should be how public capital and regulation can be deployed most efficiently to maximise private coinvestment.

[63] National Infrastructure Commission. (2019). Strategic Investment and Public Confidence https://nic.org.uk/app/uploads/NIC-Strategic-Investment-Public-Confidence-October-2019.pdf.

Case Study 11: Environment Agency: Port Clarence and Greatham South flood coastal erosion scheme[64]

The case study underscores how it is important to focus on nature-based solutions: nature protection and recovery more widely are an important part of adaptation. For example, urban green spaces and green buildings can be a key adaptation to heat and flooding risks in cities, as well as enhancing biodiversity and acting as natural carbon stores. Protecting natural capital is also important for water quality. In 2020, the value of the natural capital services that the government currently quantifies was estimated to be worth at least £1.8tr. Natural capital clearly meets the UK definition of critical national infrastructure. As noted by the Dasgupta Review, the loss of natural capital would have a major detrimental impact on critical services in the UK and national security. The UK is already one of the most nature-depleted countries in the world and the government has committed to reverse biodiversity loss – but progress is not being made fast enough. The economic value of nature needs to be recognised in policy in order to power up the necessary regulatory frameworks, and mobilise investment. Doing so will create significant co-benefits for the UK's resilience to climate change – as Case Study 12 shows.

Case Study 12: Natural Flood Management (NFM) – Gissing, Norfolk[65]

Amidst a winter of exceptionally high rainfall in Norfolk, the River Waveney Trust (RWT) and Norfolk Rivers Trust (NRT) joined forces, in collaboration with WWF and Aviva, to proactively protect the village of Gissing, in south Norfolk, from flooding. Through effective collaboration with the local community, landowners and parish council, the two trusts successfully delivered a Natural Flood Management project in October 2023, using low-cost natural solutions to make the landscape more flood resilient. Natural Flood Management uses natural processes, such as restoring wetlands, reconnecting floodplains, planting trees and improving soil health, to slow down, store and filter water.

In Gissing, this included lowering the stream banks in strategic places to allow peaks of high water to escape onto the surrounding meadow land. Other work included the installation of a leaky dam, the reconnection of a dry, historic channel and the creation of new shallow depressions, called scrapes, to slow and store water. The Natural Flood Management measure faced its first significant test during the arrival of Storm Babet.

The deluge of rain, resulting in high volumes of surface water, found refuge in an adjacent meadow, where it could be temporarily stored and released gradually to reduce the flood peak.

What next: This is a relatively simple and low-cost project that will have far-reaching, positive impacts for the local community. The farmers involved could potentially be rewarded through the government's Environmental Land Management Scheme (ELMS) programme, for providing an ecosystem service for public good.

[64] Environmental Agency (UK Government). (2018). *£16 million Teesside flood scheme complete*. GOV.UK. https://www.gov.uk/government/news/16-million-teesside-flood-scheme-complete.

[65] Barkham, P. (2019, September 20). Norfolk slows down coastal erosion with sandscaping scheme. *The Guardian*. https://www.theguardian.com/environment/2019/sep/20/norfolk-slows-down-coastal-erosion-with-sandscaping-scheme.

In the built environment – Adaptation should draw on the mitigation playbook. In the built environment this means introducing building codes to ensure structures are resilient to increasing heat extremes, water efficient and resilient to flood. Around 5,000 new homes have recently been approved in high flood risk areas. With the current wave of housebuilding the issue is more urgent than ever. Reforms are needed to the planning system and building codes to ensure all new buildings are resilient. Insurance and banks can encourage investment that 'builds back better'.

Recommendation 9

The introduction of Flood Performance Certificates (FCPs), similar to the Energy Performance Certificate (EPC) regime in mitigation, should be considered. It could provide an incentive to not only reduce carbon emissions but make them resilient to flood events.

However, FPCs encourage action at an individual consumer level as opposed to system-level intervention – FPCs also have a potential knock-on effect to homeowners, lenders and insurers given potential impacts on property value and risks to integrity of assessments. Support is therefore also needed for catchment-level planning and to encourage collaboration between local authorities, communities, builders, insurers and banks in encouraging more resilience investment into flood-proofing (and heat proofing) the built environment – with the natural flood management example cited above.

There has been progress. For example, the UK government was a signatory of the Chaillot Declaration signed recently at the Buildings and Climate Global Forum, which calls for the establishment and implementation of decarbonisation and resilience pathways for all buildings. However, a lot more needs to be done. A resilience roadmap is needed for UK buildings, similar to net zero roadmaps for housing in the UK. High standards should be introduced for new build and for existing homes minimum requirements introduced, as happened for the private rented sector in the UK. This could include a resilience rating for buildings. Examples of best practice can be sought in countries such as the Netherlands – as set out in the case study below. Capability building is also needed within local `authorities to oversee these changes and ensure resilience measures are effective.

Case Study 13: Netherlands Government – working group on climate adaptation – Climate label for housing[66, 67]

The Working Group on Climate Adaptation investigates how best to contribute through insurance, investment, and finance to adapting the Dutch economy to climate change. A key recommendation from the working group has been for government to ensure clarity on climate-adaptative construction and the introduction of a climate label for buildings and homes.

One example of how residents and businesses (customers of financial institutions) can be informed about climate risks is the Framework for climate adaptive buildings as described by the Dutch Green Building Council (DGBC). This sets out a standard approach for assessing physical climate risks at the building level (risk analysis). Once information on foundation risks is verifiable and leads to more widespread changes in the way we need to view risks, this will in turn be adopted by the market. The speed at which damage to foundations is reflected in house values (step-by-step versus a shock) ultimately touches upon a distribution problem. Major banks ABN AMRO, ING and Rabobank are currently researching the impact of physical risks (including foundation risks) and of climate-mitigating and climate-adaptive measures on the housing market as follows to the study 'An economic perspective for a thorough renovation of the housing market'.

Equipping people with information on risks, opportunities, and solutions. This is a climate analysis that tells a building owner which specific climate risks apply to their building and to what extent.

What next: This type of framework has the potential to be developed further into a label. A climate label could potentially also be used to obtain a discount on, for example, mortgage interest rates for adaptation modifications to homes. The Dutch National Mortgage Guarantee Scheme could perhaps play a role as well, for groups who are unable to implement sustainability measures but want or need to do so (price incentives and financing). A valuable addition might also be that insurers can provide insight into the insurability of the building based on this type of climate label (terms and conditions). This is useful information for making a well-informed decision about a new home. Central or local government can then inform residents and businesses on the climate risks and solutions.

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66 DeNederlandscheBank. (2023). *Working Group on Climate Adaptation*. https://www.dnb.nl/en/green-economy/sustainable-finance-platform/working-group-on-climate-adaptation/ and Samen Klimaat Bestendig. (2023). *Financiële sector samen met overheid aan de slag. Klimaatadaptatie*. https://klimaatadaptatienederland.nl/samen/klimaatbestendig/klimaataanpassingen/klimaatbestendige-financiele-sector/.

67 Sustainable Finance Platform. (2024). *Working Group on Climate Adaptation*. Accelerating climate adaptation: An alliance between the financial sector and government.

Case Study 14: China's 'Sponge Cities'[68]

A Beijing based landscape architecture company, Turenscape, has developed hundreds of urban waters parks in China where runoff from flash floods can be diverted to soak into the ground or be absorbed into constructed wetlands. Conventional drainage infrastructure has not worked in China's cities with monsoon climates subject to extremely heavy bursts of rain. The sponge city program began with pilots in 16 cities in 2015 and since expanded to more than 640 sites in 250 municipalities across China. Where enough land is not available to repurpose into wetlands and ponds, permeable pavement, green roofs and trenches called bioswales are being developed to channel storm water runoff and use vegetation to filter out debris and pollution.

Having enough land to repurpose into wetlands and ponds within the cities and municipalities as well as policy direction to develop sponge cities were crucial to this programme. It is also a way to recharge local aquifers, and is a low-tech adaptation to help overheated city neighbourhoods as the evaporating water has a cooling effect.

What next: Adoption of the sponge city concept in other cities around the world. Bangkok opened the Benjakitti Forest Park in 2022 which occupies more than 100 acres for example. In Copenhagen, Denmark, floodable parks are being used which are temporary ponds during heavy rains.

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[68] Schiffman, R. (2024, March 28). He's Got a Plan for Cities That Flood: Stop Fighting the Water. *The New York Times*. https://www.nytimes.com/2024/03/28/climate/sponge-cities-kongjian-yu.html.

Even with the above measures implemented and encouraging increased investment in future-proofing buildings in the UK, there will still be cases of tail risk where bank and insurance will not be able to cover losses. There is a strong call by the CFRF AWG to keep FloodRe in place – as a mechanism it is working on covering these tail risks. There was a suggestion that FloodRe's remit should be extended and FloodRe has workstreams underway in conjunction with Build Back Better including one on FPCs to provide homeowners with a view of their home's risk, including scoring methodology that underpins that. However, it is important that mechanisms such as FPCs are considered in terms of the potential impacts on property value and therefore the homeowner and local communities as a whole, as well as the lender (for example via risk of stranded assets). It is vital the UK considers alignment of the FloodRe scheme beyond 2039 with market incentives and alternative forms of collateral to support community-led adaptation. Finance should also be increased for 'climate ready homes' – and taking an integrated approach to providing investment for both net zero and resilience at the same time, removing the need to later retrofit a home that may not be suitable for heat waves or extreme weather and subsidence (worsened by water stress). As well as seeking ways to protect properties and indeed communities, the root cause of flooding and public infrastructure required to address that is of utmost importance.

Recommendation 10

For agriculture – the focus should continue to be on using fiscal policy to support a shift to more resilient and sustainable farming systems and integrate adaptation within financing related to nature and mitigation. Combined with taxonomies, this could significantly scale the amount of private finance made available to help farmers in their transition. In the Netherlands, a framework has been created to enable banks to invest in agricultural adaptation[69]. In the UK, proposals being developed for UK agriculture technical screening criteria developed by the LNAS Advisory Group could become a lending framework for adapted farming practices and used to align with subsidy regimes and support the crowding in a private finance to support transition.

[69] accelerating-climate-adaptation-report.pdf (dnb.nl).

8. Next steps

The CFRF AWG in this report has provided a summary of the current guidance and information on:

- Sources of good quality hazard and asset level data – up to 5 years;
- Beyond the next 5 years, provided a framework (ABC) for assessing longer-term climate risks that could form the basis for longer-term adaptation plans in engaging with corporations;
- Reviewed how adaptation is being defined by organisations developing resilience and adaptation taxonomies;
- Provided case studies of adaptation and resilience investments and where positive action is already being taken by the finance sector in responding to climate change investment opportunities; and
- Suggested where policy and government could develop adaptation roadmaps and strengthen the framework for financial institutions to increase investment in the UK.

However, the CFRF AWG has also identified a number of areas for further work, which include:

On improving data availability, quality and applications

- Demonstrating how hazard data is and should be applied in practice across insurance, banking and asset managers;
- Working with the scientific community to identify gaps in local hazard data sets and how these could be addressed through the creation of a hazard data portal and tools that can be used by financial sector organisations to improve local risk assessments;
- Improving the quality of hazard data through the use of improved climate models and experiments that sample a greater range of natural variations. One priority example for UK climate data would be for government to invest in updating the UKCP dataset;
- Ensuring new weather and climate data is more readily converted into more relevant hazard information, such as conversion of rainfall information into flood levels;
- Providing new and updated information on hazards associated with tipping points and system thresholds – and looking at complex hazards in more depth such as correlated and compound hazards;
- Refining the database of hazard data sources to be more usable based on feedback;
- Identifying data gaps and recommend-ations for who addresses them;
- Working with third party data providers on how to develop credible standards for the industry that they can use and trust in assessing physical climate risk;
- Create an 'on-line' hub for enhanced guidance and improved database of KPIs, metrics and sources, building from the Road to Resilience action plan. This could include how the finance sector communicates the opportunities for adaptation and resilience to its clients and stakeholders; and

- Recognise the transdisciplinary nature of the risk assessment and adaptation challenge and ensure ongoing co-development with organisations in physical and social sciences, including national meteorological services and academia.

On improving risk assessments

- Develop and test further guidance on how to undertake physical risk assessment of a portfolio of assets, or loans and calculation of the financial impacts or value at risk;
- Develop further guidance on integrating Risk Assessments into investment decision, engagement and product development, and developing good practice for Risk Appetite Statement (RAS) for enhanced disclosures;
- Look at climate impact cascading risks and how these are being incorporated by the finance sector into infrastructure decision making across supply chains;
- Develop guidance on integrating risk assessments into investment decision, engagement and product development, developing good practice RAS for enhanced disclosures;
- Provide guidance on how to address cascading risks across infrastructure systems and supply chains;
- Providing support in the UK for climate services that produce risk and adaptation information, perhaps following the National Framework for Climate Services approach advocated by the World Meteorological Organisation.

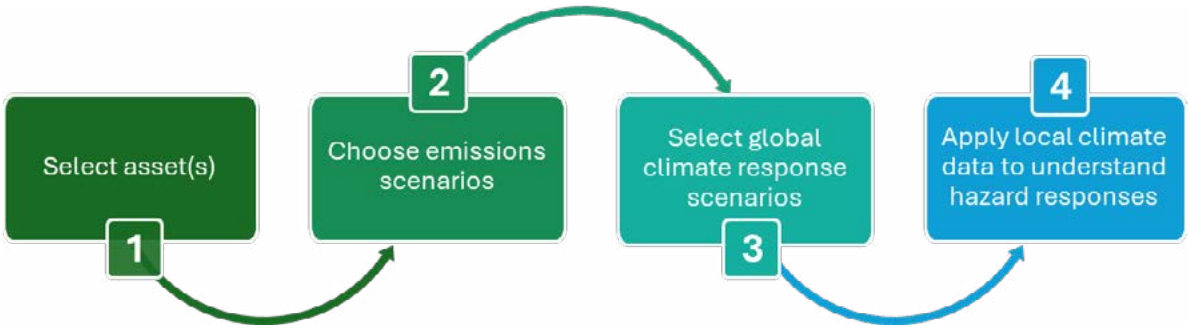
On improving deal-flow

- Use case studies to identify quick wins for embedding adaptation; e.g. examples of mitigation products that can easily incorporate adaptation and benefits they can deliver, financial areas that can embed adaptation quicker, etc;
- Guidance on how this work could help deliver more competitive advantage for financial products (e.g. reduce premiums) and collaborations needed to help with that;
- Developing adaptation and resilience investment roadmaps by sector – identifying where the main adaptation investment opportunities lie for the finance sector in the UK, expanding on the list of case studies;
- Explore how financial institutions could communicate adaptation to their clients/ stakeholders and support clients with conducting their own risk assessment of adaptation and resilience exposure – especially given data gaps;
- Identifying decision useful metrics/KPIs;
- Collaborate with other stakeholders, IIGCC on PCRAM and UN PRI adaptation working groups on how to increase investments in adaptation and resilience.

Annex A: Technical explainer for the ABC approach

We propose here a new approach to selecting scenarios for an **'Aim-Build-Contingency' (ABC framework)** that comprises the layering of three variables – emissions response; climate response; local hazard response – in a 4-step process:

Figure A1: ABC Framework.



Step 1: Select asset and timelines of interest

Once the asset has been selected for assessment and its location identified, a decision is needed on what timelines over which to undertake risk assessment. Different applications will typically have different time horizons. For example:

- For developing adaptation-inclusive transition plans, 2030 and 2050 might be considered.
- Financial risk management 2030 might be prioritised.
- Asset-specific financial transactions and decisions (including pricing) will vary with the asset. A mortgage lender might consider up to 35 year time horizons, an equity investor 15 years.

For short-term it is sufficient to rely on present day hazard data and decadal forecast information –and a database of hazard data sources is provided – in which case users should jump straight to step 4 to look the local hazards (which is covered in detail in the previous section). Looking out beyond ~5 years, users will need to consider future climate change and the uncertainty in the climate response to the emissions. Beyond around 10 years they will also need to consider different possible emissions pathways and the global climate response uncertainties. **We suggest an 'Aim-Build-Contingency' (ABC framework) would be the ideal approach for framing this analysis – while noting important implementation challenges with using this, discussed later**.

- A – Aiming to stay below 2°C and pursuing efforts to achieve 1.5°C.
- B – Building and budgeting to prepare to be resilient to the warming current policy efforts imply.[70]
- C – Contingency plan for a higher level of warming This is a reasonable worst case scenario, due to policy backtracking combined with an acceleration of global warming due to climate sensitivity turning out to be at the upper end of current estimates.

Step 2: Applying the emissions uncertainty lens

Future climate states will depend on policy support, market behaviour and the combined action of consumer preferences. A new 'ABC framework approach' is suggested. The proxy global warming levels linked to the A, B and C elements of the framework are not presented as some form of 'optimal' target. Rather they create a conceptual framework for regulated firms to develop transitions plans that focus on the continued need to finance the decarbonisation of the economy – but also the need to finance adaptation to the already changing climate and support a more holistic view of the transformation to deliver multiple benefits.

The three scenarios were selected based on review of the scientific literature, comparison between different scenarios sets (including those from the IPCC and the NGFS) and through discussion with the CFRF AWG members.[71]

- **Scenario A. Strong mitigation**. This scenario reflects a narrative of strong emissions mitigation, beyond that currently reflected in emission reduction policies. This emissions scenario is aligned with the Paris Agreement goal of limiting peak warming to well below 2ºC and aiming to limit it to below 1.5ºC above pre-industrial levels. The scenario includes approximately halving global greenhouse emissions by 2030 compared to 2010 levels and achieving net zero global carbon dioxide emissions towards the middle of this century. Carbon dioxide removal approaches, comprising both technological and nature-based solutions, are assumed to be available at a large scale for this case. In this best-case scenario, risks from existing climate change will still continue to develop and will translate into material financial risks, therefore well-informed and sufficient adaptation actions will be necessary. **This scenario is closest to IPCC SSP1-1.9 and the NGFS 2050 net zero scenario.**
- **Scenario B. Moderate action**. This scenario reflects a world in which current climate policy sees some moderate upgrades of emissions reduction activities, but less so than that of the strong mitigation case (A). In selecting this scenario, we also considered whether to use a simple "fixed policy" assumption, but this storyline was considered unrealistic, given the progress made in recent UNFCCC negotiations and national emissions reduction pledges already announced but not yet in policy. Moderate action will be required by firms to build and budget to prepare to be resilient to the higher warming that current mitigation policy efforts imply and the hazards that will bring. **This scenario is closest to the IPCC SSP2-4.5 and the NGFS current policy scenario.**
- **Scenario C. Backtracking**. This scenario is on in which current climate policy aims are not met. Global emissions rise relative to current levels and remain

[70] E.g. Climate Action Tracker (2023). 2100 Warming Projections: Emissions and expected warming based on pledges and current policies. December 2023. https://climateactiontracker.org/global/temperatures/.

[71] We have chosen not to select NGFS scenarios directly for our study of physical risk because these focus on uncertainty in emissions and have not been used as input to the most comprehensive climate models, which are the best source of hazard information.

well above levels in the moderate action case (B). This scenario will require firms to perform contingency planning for a world in which policy backtracking occurs with accelerated global warming and this translates to more significant hazards. We have several options of how to choose the high emissions scenario, and one option would have been to simply to consider the current worst case of SSP5-8.5. However, this scenario doesn't capture the recent cost reductions and market penetration of low carbon technology. Following discussion with the CFRF AWG, we selected the lower SSP3-7.0 pathway scenario over the SSP5-8.5 one. **This scenario is closest to the IPCC SSP3-7.0 but does not have a clear NGFS comparator.**

Whilst we have made suggestions for possible emissions scenarios for the A, B and C cases alternatives may be considered as summarised in the tables below. These tables compare the emissions scenarios which form part of the "ABC" risk framework.

The columns with "E2030 Kyoto gases" refer to the combined global emissions of Kyoto gases in units of CO_2e/yr. Warming is reported in degrees Celsius as median (5th and 95th percentile) as simulated using the FAIR reduced complexity climate model. The SSPs and RCPs responses were produced using FaIRv1.6.2 while the NGFS temperature responses were produced with the MAGICC6 model. These two different but comparable reduced complexity models are set up to sample the uncertainty in global temperature response and use the same versions and calibrations that were used in the IPCC 6th assessment (AR6 report). The NGFS numbers provided are from the NGFS phase IV scenarios dataset.[72]

Table A1: Scenario A – Potential strong mitigation emissions scenarios.

Scenario	E2030 Kyoto gases $GtCO_2e$/yr	E2050 Kyoto gases $GtCO_2e$/yr	E2100 Kyoto gases $GtCO_2e$/yr	Warming range at 2030	Warming range at 2050	Warming range at 2100	Notes
SSP1-1.9	32.3	9.2	-8.3	1.47 (1.16-1.87)	1.50 (1.14-2.02)	1.27 (0.94–1.83)	
RCP2.6	40.2	21.7	6.1	1.32 (1.1-1.61)	1.53 (1.20-1.97)	1.49 (1.13–2.03)	Would require low ECS to limit warming to 1.5C without overshoot
NGFS net zero 2050	35.9-37.1	2.9-8.4	0.7-5.9	1.49 (1.18-1.91)	1.58 (1.17-2.29)	1.33 (0.95-2.24)	
NGFS low demand	20.2-30.8	3.3-7.6	-0.3-4.9	1.50 (1.18-1.93)	1.49 (1.10-2.30)	1.11 (0.76-2.29)	
NGFS below 2C	41.5- 47	18.2-25.5	4.9-10.2	1.49 (1.18-1.89)	1.73 (1.26-2.44)	1.69 (1.14-2.61)	
NGFS delayed transition	51.4-56.3	13.0-20.3	4.8-8.7	1.49 (1.18-1.84)	1.77 (1.30-2.50)	1.62 (1.15-2.66)	

[72] Richters et al., (2024); https://zenodo.org/records/10807824.

Table A2: Scenario B – Potential moderate action emission scenarios.

Scenario	E2030 Kyoto gases $GtCO_2e/yr$	E2050 Kyoto gases $GtCO_2e/yr$	E2100 Kyoto gases $GtCO_2e/yr$	Warming range at 2030	Warming range at 2050	Warming range at 2100	Notes
SSP2-4.5	59.9	58.4	21.9	1.49 (1.20-1.81)	1.92 (1.53–2.44)	2.59 (1.95–3.58)	
RCP4.5	55.0	55.3	27.9	1.40 (1.1-1.71)	1.86 (1.47–2.38)	2.41 (1.82–3.32)	
NGFS current policies	53.0-55.8	51.0-56.7	40.0-61.5	1.49 (1.18-1.84)	1.96 (1.47-2.66)	2.87 (1.98 -4.38)	

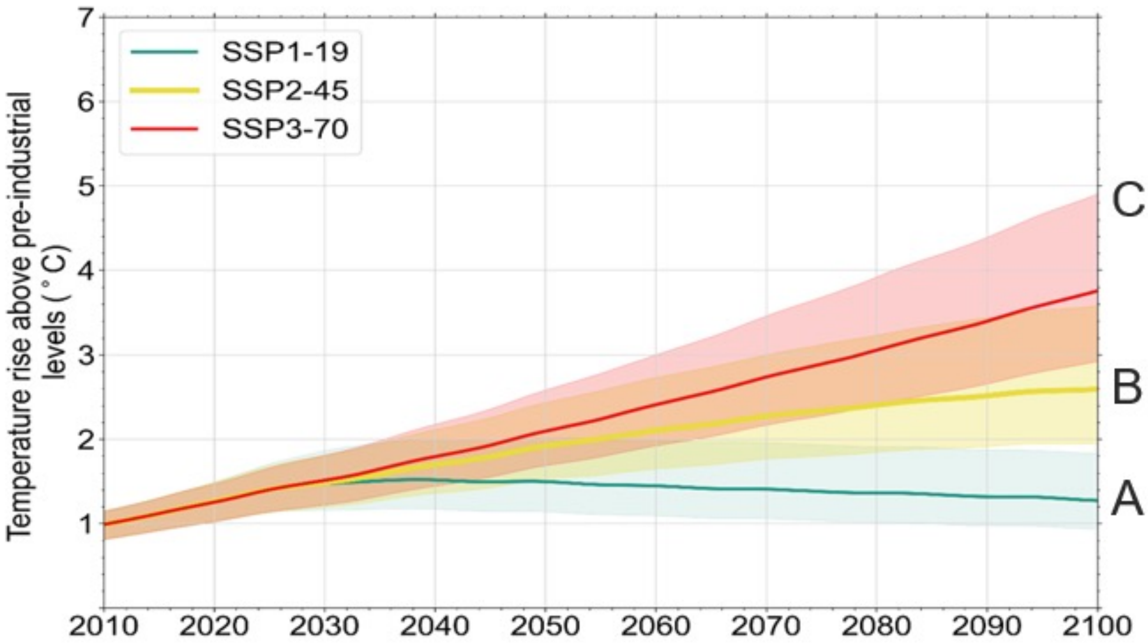
Table A3: Scenario C – Potential backtracking emissions scenarios.

Scenario	E2030 Kyoto gases $GtCO_2e/yr$	E2050 Kyoto gases $GtCO_2e/yr$	E2100 Kyoto gases $GtCO_2e/yr$	Warming range at 2030	Warming range at 2050	Warming range at 2100	Notes
SSP3-7	71.6	85.1	113.2	1.51 (1.22-1.81)	2.10 (1.69–2.58)	3.76 (2.92–4.91)	
RCP6	48.4	61.5	64.2	1.31 (1.06-1.58	1.70 (1.36–2.11)	2.92 (2.24–3.88)	May be too low to represent full potential back tracking
RCP8.5	73.2	102.7	139.9	1.52 (1.23-1.85)	2.28 (1.81-2.90)	4.46 (3.39–6.05)	May be too high when considering developments in renewables

Step 3: Applying the climate response uncertainty lens

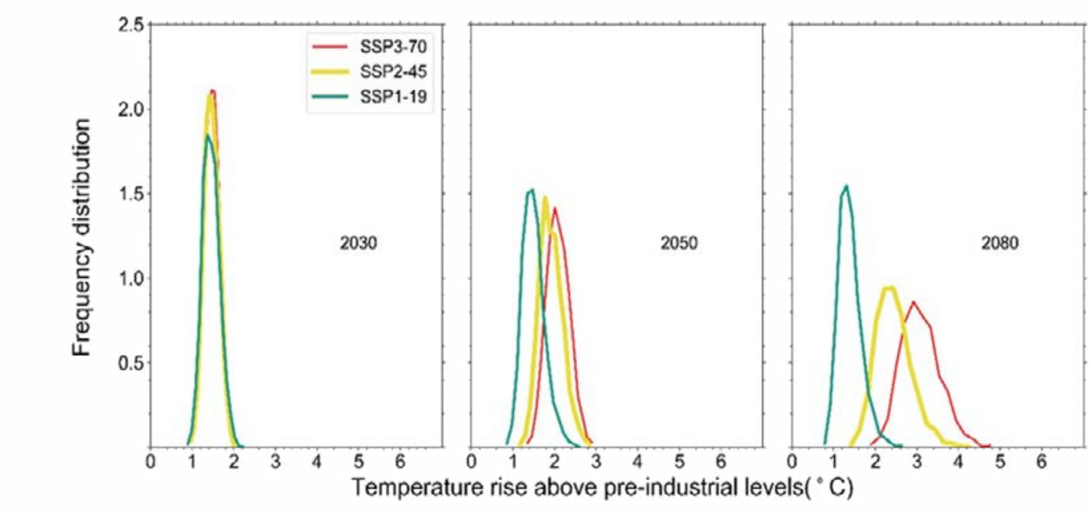
Step 3 requires adding the global climate response variable. For the next 10 years or so, as a result of the lagged response of the climate to changes in emissions, uncertainty in the climate response dominates over uncertainty in the emissions and therefore the range of hazards that need to be prepared for.

Figure A2: Global mean near surface temperature rise for the chosen emission scenarios estimated with a simple climate model FAIR v1.6.2, tuned to emulate more complex climate models used in the IPCC 6th assessment. The thick lines show the median warming for each case and the shaded area shows the 5th to 95th percentile range. Red corresponds to the backtracking case (C), yellow current policy case (B) and green strong mitigation (A).



Further into the future, the emissions scenario uncertainty starts to become more important and comparable to the degree of uncertainty in the climate response to emissions. The spread in both emissions and global climate response uncertainty increase over time (Figure A2).

Figure A3: Frequency distribution of global mean warming for the three emission scenarios shown in Figure.



Green is the strong mitigation A scenario; yellow is the moderate action B scenario; red is the backtracking C scenario shown at 2030, 2050 and 2080. The global mean warming response has been calculated using a reduced complexity climate model with 2237 different model variants, covering different but plausible realisations of aspects such as the sensitivity of the climate system to changes in atmospheric greenhouse gas concentrations and how the earth's carbon cycle changes as a result of climate change.

For physical climate risk assessment beyond 10 years, financial institutions should at least consider:

- the median global climate response of the strong mitigation scenario A (SSP1-1.9);
- the median and 95th percentile global climate response of the moderate action scenario B (SSP2-4.5) – although noting divergence only becomes significant between the two after 2050; and
- the 95th percentile of the global climate response to the backtracking scenario C (SSP3-7)[73].

For periods between 5 years and 10 years, it may only be necessary to use the moderate action scenario B, although users may wish to consider the 5th and 95th percentiles of the climate response alongside the median.

[73] Our suggestion to use the median response for scenario A is based on this being the optimal but currently lower likelihood outcome. Our suggestion to use both the median and the 95th percentile outcome for scenario B is based on this being the current most likely outcome. The use of the 95th percentile for the high emissions case is consistent with using this as a reasonable worse case for contingency planning.

Table A4: The levels of global warming relative to pre-industrial levels estimated using the FAIR simple climate model for the ABC emissions scenarios in 2025, 2030, 2050, 2080 and 2100.

Emissions uncertainty	Scenario A Strong mitigation			Scenario B Moderate mitigation			Scenario C Backtracking		
Climate uncertainty	5th	50th	95th	5th	50th	95th	5th	50th	95th
2025	1.13	1.41	1.71	1.14	1.41	1.68	1.14	1.40	1.66
2030	1.16	1.47	1.87	1.20	1.49	1.81	1.22	1.51	1.81
2050	1.14	1.50	2.02	1.53	1.92	2.44	1.69	2.10	2.58
2080	1.02	1.36	1.91	1.85	2.40	3.23	2.41	3.06	3.92
2100	0.94	1.28	1.83	1.95	2.59	3.58	2.92	3.76	4.91

The coloured columns represent the percentiles we recommend are used for risk assessment in the ABC framework. The table highlights the concept of temperature overshoots in the strong mitigation A scenario. This results mainly from assumptions in this emission scenario that large-scale artificial removal of greenhouse gases from the atmosphere will allow the temperature to decline in the second half of the century. However, some changes, such as sea-level rise will continue to and beyond 2100.

As shown in Figure A3 and A4, the spread in global warming responses is driven both by the deviation in potential emissions and the uncertainty in climate response. It should also be noted that while the values in Table A4 are generated with a simple model, in a more complex model (or the real atmosphere) you would expect to see additional spread due to natural variability – i.e. day to day, year to year weather. This means it is prudent to consider tail as well as median levels of risk.

In step 4, which requires looking at local climate response, it is important to include this natural variability. In the near future of 1 to 5 years this is likely to be the dominant driver of the spread in local climate response.

Step 4: Applying the local climate response – hazard data – lens

The fourth step, the actual risk assessment, will need to be applied at a physical asset level and focuses on understanding selected local hazard responses. This is currently not included in the NGFS scenarios but is something, as the CFRF AWG data survey indicates, many financial services firms are already doing to assess current hazard exposure. Although it is important to emphasise there are many data gaps and usability issues.

For some parts of the world – where local on-the-ground local climate data is sparse – this will require the use of information from global climate models, which provide information at a resolution of 50km-150km. However, to improve the accuracy of risk assessments, it is preferable to use hazard data from regional and local climate models that simulate finer spatial detail. In the UK, for example, data on a scale of 2.2km is now available. This has the advantage of better representing extremes of, for example, rainfall – vital for modelling flood and drought risk – and cycles of daily temperature and rainfall.

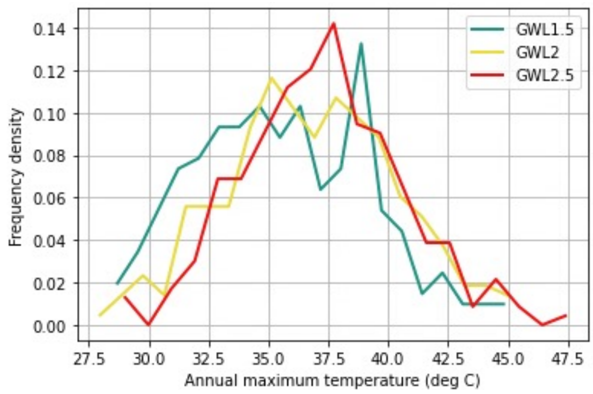
One of the challenges with implementing step 4 is local hazard data may not actually be available to be mapped to the scenarios of interest for the ABC framework. A pragmatic approach is needed – and a next best alternative should be used. This could be to use existing climate data placed onto global warming levels consistent with Figure 25 at the time period of interest.

As an example, we consider here heatwave risk in 2050 – as illustrated by the Met Office UK Climate Projections (UKCP) forecasts for annual maximum temperature – under a:

- A scenario using median climate uncertainty scenario (green line); a global warming level of 1.5°C is used as a proxy for this scenario at 2050.
- B scenario using median climate uncertainty scenario (yellow line); a global warming level of 2°C is used as a proxy for this scenario at 2050.
- C scenario using 95th percentile climate uncertainty scenario (red line); a global warming level of 2.5°C is used as a proxy for this scenario.

Figure A4 shows the results of the analysis for the annual maximum temperature and indicates that a wide range of local climate responses are possible – in this case a range of more than 10ºC. This is important and shows the value in using this level of analysis to support the setting of physical risk appetite and the development of risk appetite statements at firm level. It also illustrates how the hazards and imperative to support adaptation to avoid asset stranding are heightened as the risk of higher levels of global warming increase, as shown by frequency distribution shifting to the right with higher degrees of warming.

Figure A4: Frequency distribution of a sample of 240 UKCP local simulations of the UK annual maximum of the daily maximum temperature based on the ABC framework. Natural variability and model response uncertainty on the GWL are both represented.



In addition, in the context of linking physical risk assessment to adaptation opportunity creation, it will – in practice – be necessary to extrapolate findings to consider mitigation measures, relating for example indoor temperature risks to opportunities to invest in building cooling measures, which is where taxonomies can be useful.

Annex B: Assessing the usefulness of hazard data

Assessing the suitability of hazard data

1. **Does the proposed dataset contain information on the type of hazard being considered?**

   For instance, to assess overheating risk, temperature data is needed. For a study on flooding, precipitation data is needed. For consideration of drought or water availability, both rainfall and temperature (or evaporation) data are required.

2. **Does the proposed dataset cover the time horizon of interest? Or the most appropriate forecast lead time?**

   For assessments of risks in the near term, say between a few months and 5 years, users should consider seasonal or decadal predictions – or the near-present segment of climate projections. For periods more than a few years – say five years – into the future, users should select climate projections such as CMIP6 or UKCP data.

3. **Does the proposed dataset provide suitable temporal granularity?**

   If a user is interested in extremes (95th percentile events), then daily information will likely be needed, and possibly even sub-daily information. For looking at longer-term trends and mean quantities, monthly, annual or decadal granularity is likely sufficient. Some datasets with coarse time granularity (by which we mean data that is available only in steps that are longer than the period over which extreme events are experienced), can still be useful if metrics such as the hottest or wettest day of the year are pre-calculated from higher temporal granularity data underlying the coarse data provided to users.

4. **Does the spatial domain of the dataset cover the region of interest?**

   Regional model simulations are clearly only useful if they include the region of interest to the user.

5. **Is the spatial granularity sufficient for the analysis?**

   For instance, data that is provided as a continental-scale means will not be suitable for sub-national scale assessment of physical risks.

   Even when suitable data is available, it is useful to ask are the appropriate indicators are needed for the assessment available? For instance, if we are interested in high temperatures, are daily, monthly and annual maximum temperatures available? If not then we must ask again, can suitable processing be performed?

Advanced level questions include:

6. **Are the climate model simulations suitable for assessing the uncertainty to the standards desired in the analysis?**

   Multiple emission scenarios are needed to assess uncertainty in long-term climate futures beyond the 2040s. Initial condition ensembles allow investigation of the uncertainty from natural variability and the return period of particular extreme weather events. Perturbed parameter and multimodal ensembles allow for assessment of the response to different forcing scenarios.

7. **When an analysis looks beyond around 2040 it is useful to have multiple emission scenarios (as described in the previous question). It is necessary to ask which emission scenarios are available?**

   When an analysis looks beyond around 2040 it is useful to have multiple emission scenarios. It is necessary to ask which emission scenarios are available? Where there are insufficient scenarios available it is possible to use high scenarios to examine global warming levels as an alternative approach.

8. **What type of post-processing has been performed on the data?**

   Methods such as bias-correction, spatial and temporal aggregation, or threshold detection are examples of processing that might be applied to raw climate model data. Sometimes the type of post processing can be important to the usefulness of data for a given application. If raw data is used it will be necessary to ask what type of post-processing will need to be applied and who will perform it.

Assessing the credibility of hazard data

When assessing the credibility of hazard data it is often appropriate to use a range of different sources of evidence. This might include considering multiple modelling and non-modelling lines of evidence, including past climate analogues (for instance considering sea-level records from the distance past for climates comparable to those of the future period). The rationale for the choice of evidence and approach for choosing the evidence should be explained and be transparent.

1. **Is the dataset reliable?**

   It is useful to understand how well present day and historic data produced by the model match observational climate data. The causes of any differences should be understood, and the consequences of these biases considered. For example, do biases lead to the model data simulating more or less extreme rainfall events than seen in the observations. It may be possible to bias correct the data rather than discarding it when biases are found, but this should be done with care by experienced climate analysts.

2. **Is the dataset robust?**

   This can be tested through a number of routes, primarily by comparing the model outputs to the outputs of similar modelled datasets that may be available. In doing so it is important to understand if a given model performs in similar ways to other models of a similar type, and understand the differences. For instance, if our selected dataset uses a model that projects warming that is considerably higher than other models of a similar type we would need to consider if this was for a credible physical reason. If we can't explain why a chosen model is an outlier then we may wish to switch to an alternative.

3. **Is there a strong theoretical underpinning for the model and its results?**

   It is appropriate to consider if the description of any model or other methodology used to produce climate hazard data is suitably transparent, and ideally model descriptions and assessment evidence should be easy to obtain and use. It is prudent to ask if the theoretical underpinning of the model is appropriate for the use it is being put to, and to consider how model limitations and caveats might relate to the particular application being considered. For instance, when considering short lived intense rainfall, we might want to establish if the model has been formulated to be able to explicitly represent atmospheric convection. For an application looking at warming over cities we might want to understand if the exchange of heat, moisture and momentum within the model takes account of urban characteristics, which are different to those in more rural areas.

Assessing the legitimacy of hazard data

1. **Has the data been developed by a scientifically credible organisation(s)?**
   These could include national meteorological services (e.g. UK Met Office), national scientific bodies (e.g. NASA), international collaborative projects (e.g. Coupled Model Intercomparison Project – CMIP), universities. Independent agencies, organisations and businesses can also be considered credible sources of climate data (e.g. European Centre for Medium-Range Weather Forecasts – ECMWF, Berkeley Earth, European Environment Agency – EEA).

2. **Is there any suggestion of political, social or economic influence that could influence the hazard data?**
   Whilst it is the aspiration of scientists to develop objective, independent science, influences such as funding sources and national political agendas can direct research. Statements such as funding sources, independence from governments etc. are usually stated on the organisational websites for reference.

Annex C: Summary of data use survey

As part of the work of the CFRF AWG, a survey was conducted of the members of the adaptation working group, with some additional financial institutions also invited to complete the survey. The summary findings are listed below.

In short, the survey found that motivations for climate adaptation varied, with reporting requirements emerging as primary drivers. Respondents varied in their approach to decision making – favouring medium-term planning for strategic activities and longer horizons for risk management strategies.

In the section on information and tools for adaptation to physical risk, respondents indicated a diverse array of information currently being used for decision-making on adaptation. Among the 13 respondents for this section, most reported employing third-party scenarios (92%) and climate impact information (85%) to inform their adaptation strategies. Metrics from third-party data providers, as well as asset location information, were also extensively used, each by 77% of respondents. Surveyed organisations predominantly use information for risk assessment and management, alongside informing investments, scenario analysis, adaptation planning, advocating for green strategies, and making infrastructure investments. Moreover, respondents emphasised the importance of trusted sources, cost-effectiveness, and applicability when selecting information sources. They revealed that they rely on various sources for adaptation-related information, including external third-party providers like MSCI and Moody's Risk Management Solutions, academic research institutions, government agencies such as Defra and the Environment Agency, and even local grassroots-level sources like community-based environmental groups and city councils. Respondents highlighted obstacles to use such as data availability, quality, and interoperability, compounded by resource constraints and legal considerations. Despite these hurdles, there was a clear appetite for additional information types, particularly corporate and government plans, to enrich decision-making processes.

The last section of the survey illuminated the varied ways weather and climate hazards impact organisations and how information is currently used among respondents. Surveyed organisations are currently impacted by and expect a wide range of weather and climate hazards to impact their activities and investments, including extreme heat, heavy rainfall, floods, increased precipitation, coastal change, high winds and drought. Climate projections emerged as the most frequently utilised type of information, followed closely by inter-annual/decadal predictions and observations from historical weather stations and satellites. Respondents utilising climate projection information employ diverse metrics such as multidimensional flood risk indices, WBGT, and Marsh McLennan Flood Risk Index, alongside various return periods and damage functions. They consider a broad spectrum of future emissions scenarios, including NGFS and IPCC scenarios, to capture uncertainty in climate responses, with some considering national and regional UK-specific scenarios. Additionally, organisations integrate climate impact information alongside hazard data, incorporating projected crop yield changes, flood depth and damage functions, and aggregated physical impacts for listed equity and corporate debt.

Sources of weather and climate hazard information vary, with primary sources including the IPCC, NGFS, National Meteorological and Hydrological Services or government agencies, and commercial providers like Weather Peril and Moody's RMS climate projections. These types of information are instrumental in informing decisions related to probability and impact analysis, risk pricing, and engagement with companies. However, respondents also highlighted challenges in information processing, updating frequency, and perceived information quality, underscoring the need for improvement in these areas. Respondents emphasised cost, ease of access, trust in the source, coverage, applicability, and frequency of updates as crucial factors influencing their decision-making when sourcing weather and climate hazard information. Additionally, there was a notable demand for enhanced real-time local authority data, comprehensive guidance on understanding climate risk, and educational resources for the asset management community, signalling a desire for further support in navigating the complexities of climate adaptation.