CLIMATE FINANCIAL RISK FORUM

CLIMATE FINANCIAL RISK FORUM GUIDE 2022

SCENARIO ANALYSIS GUIDE FOR BANKS

Contents

This chapter represents the output from the cross-industry Scenario Analysis Working Group of the Prudential Regulation Authority and Financial Conduct Authority's Climate Financial Risk Forum. The document aims to promote understanding, consistency, and comparability by providing guidance on how to use scenario analysis to assess financial impact and inform strategy/business decisions.

This CFRF guide has been written by industry, for industry. The recommendations in this guide do not constitute financial or other professional advice and should not be relied upon as such. The PRA and FCA have convened and facilitated CFRF discussions but do not accept liability for the views expressed in this guide which do not necessarily represent the view of the regulators and in any case do not constitute regulatory guidance.

Any references to external organizations (e.g., case studies or examples) should not be interpreted as endorsement by CFRF and are only for case study purposes.

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This paper has been written by the Banking sub-group of the Scenario Analysis Working Group of the Climate Financial Risk Forum (CFRF).

It is largely written by practitioners, for practitioners, and is intended to support banks and building societies in developing their scenario analysis to manage climate risk and prepare for climate action. The focus here is on Climate Scenario Analysis for banks and building societies. It is one of the several initiatives being taken forward by the CFRF Scenario Analysis Working Group, with other Scenario Analysis papers focused on insurance and asset management.

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Introduction

Purpose

This chapter was written by a cross-industry working group under the auspices of the Climate Financial Risk Forum (CFRF). It aims to provide the latest thinking as scenario analysis capability continues to mature across the UK banking industry, expanding upon the future areas of focus identified in the CFRF Scenario Analysis chapter published in 2021.

The content is aimed at banks and building societies of all sizes but may also be of interest to other financial institutions. It outlines current practices that are used or in development at some of the larger UK banking groups, while also serving as a manual for banks that have made comparatively less progress in this area. For brevity, banks and building societies are collectively referred to as banks throughout this chapter.

Scenario analysis is an increasingly vital pillar of banks' efforts to manage climate-related financial risks and to ensure that their strategy and business model are resilient in future climate scenarios. The 2022 GARP Annual Survey report indicated that over 80% of the firms surveyed had undertaken climate scenario analysis; of these, 75% applied it within the last year (see Figure 1 of the survey). For banks, there are both internal and external drivers for the use of scenario analysis. From an internal perspective, scenario analysis is a crucial enabler for banks as they test the resilience of their strategy to different climate pathways and define their risk appetite at a client and portfolio level. From an external perspective, supervisors in the UK and elsewhere expect firms to use scenario analysis over multiple time horizons to inform their strategy and business planning and identify and determine the impact of climate-related financial risks that might arise in a range of scenarios and time horizons[1]. Supervisors also expect banks' scenario analysis capabilities and approaches to evolve over time.

Executive Summary

The chapter is structured around four key topics:

Section 1 evaluates the benefits and challenges of working with a range of different publicly available scenario families. It sets out a framework for selecting the appropriate time horizon for scenario analysis, depending on the objectives of the exercise. It identifies principles that banks could have in mind as they select the most relevant and appropriate scenarios; including whether the characteristics of the scenario in question are compatible with the objectives of the exercise, sectoral and geographical coverage, and the granularity and scope of scenario variables. The section draws on case studies to demonstrate how banks might calibrate their choice of scenarios based on the objectives and principles described in the chapter.

Section 2 outlines how banks can use sensitivity analysis for key variables to add credibility to scenario analysis and, in some cases, produce more decision-useful information to management. Sensitivity analyses can be used independently from scenario analysis as a "deep dive" into one or more input variables – both by banks that have not yet run scenario analyses internally with more limited modelling resources, and by banks that have run scenario analyses and are looking to test the sensitivity of outputs to changes in input variables. The section also outlines how sensitivity analysis can be used and communicated, the principles for conducting robust sensitivity analysis, and provides case studies that explore the effect of changes in carbon prices on expected credit losses and other transition risks on loss given default.

[1] PRA SS3/19 on Enhancing banks' and insurers' approaches to managing the financial risks from climate change, paragraph 3.14.

Section 3 explores the key elements to consider when managing physical risks and assessing client adaptation plans. In many banks, scenario analysis capabilities are relatively less advanced for physical risk than transition risk. This section aims to facilitate improved understanding of the transmission channels through which physical risks might materialise for banks' wholesale and retail counterparties; it provides examples of physical risk adaption strategies that clients may choose to adopt, and gives an overview of relevant data fields that banks may choose to collect to understand better their client's adaptation readiness. As with transition plans, banks should be collecting information on their clients' adaptation plans and assessing the credibility of those plans. This section sets out several considerations for banks as they begin this exercise and progressively integrate physical risk adaptation plans into their scenario analysis.

Section 4 considers how to effectively incorporate the outputs from scenario analysis in banks' decision-making processes. The section provides a non-exhaustive list of potential use-cases for scenario analysis across a bank's business and risk management activities and product offerings and provides high level guidance on how climate scenario analysis might inform those processes.

Uncertainties and constraints

Scenario planning and analysis can help to strengthen and sharpen an institution's business decision-making abilities. However, due to the uncertainty surrounding climate change and the lack of data required for modelling such a complex process, climate scenario analysis modelling is invariably subject to limitations. Banks must make sure these uncertainties and constraints related to climate scenario assessments are recognized and conveyed effectively. Two such key limitations and uncertainties have been highlighted below.

1. **Proportionality**
The CFRF is intended to be as practically and widely accessible as possible in considering each of these elements, as climate change is expected to impact a broad spectrum of financial institutions, potentially in different ways. As the CFRF continues its work and enhances the guidance and materials that are made available, it is important to ensure that they can be used in a proportionate manner. The use of the tools and the guidance detailed in this chapter needs to be commensurate with the nature, size and complexity of the firm that intends to use it. For example, some aspects of the guidance on downscaling a scenario in many countries may be more relevant to firms with climate risks that span multiple jurisdictions as opposed to UK-centric firms. The CFRF should therefore be used for the benefit of the firms using it, enhancing their identification, modelling, monitoring and management of climate risks and should not be interpreted as regulation or requirements against which a firm is assessed. The key purpose of the CFRF is sharing good practice and ensuring this is done in a proportionate manner.

2. **Unintended consequences of climate risk mitigation action**
Whilst a key driver for the CFRF is to assist firms in understanding and managing their exposure to climate-related risks, we would encourage firms to consider the potential unintended consequences of any mitigating actions. For example, as firms in the UK housing market prepare for the transitional risks of climate change on their mortgage portfolios, many lenders have begun to monitor and act on the proportion of their portfolio's exposure to homes with lower energy efficiency (EPC) ratings. Whilst this action might appear to 'green' the portfolio, this has the potential of penalizing less well-off borrowers who cannot afford to improve their home energy efficiency with retrofitting. In certain circumstances, it could lead to a new generation of 'mortgage prisoners' who are subject to higher energy bills and mortgage rates, further impacting their affordability. Unless such an action treats customers fairly and supports a 'just transition' there is a danger that such a mitigation could have potentially adverse impacts. Whilst CFRF focusses on the risk of inaction in managing climate risk, the mitigating actions should be carried out in a manner that gives regard to such unintended consequences.

1. Climate scenario selection

Why scenario analysis?

There are two types of financial risks associated with climate change: the risks that arise as the economy moves from a carbon-intensive one to a net-zero emissions, known as transition risks; and risks associated ultimately with an increase in global temperature, known as physical risks. Physical risks include among others, flood risk, subsidence, coastal erosion, storms and wildfires, extreme freeze and thaw, heat stress and drought-related damages.[2]

Whether banks are looking to manage the climate risks on their portfolio and/or assess the impact of their own lending and trading activities on the climate, scenario analysis serves as an important instrument for risk and business analysis. Climate scenarios were until recently exclusively the domain of climate scientists. Over the last few decades, social and economic policy analysts have also contributed heavily, making them more amenable for risk management at an institutional level. The aim increasingly is to assess the future vulnerability to climate change in a range of different ways, including financial risks. A deeper appreciation of future outcomes through climate scenarios can serve as a useful basis for understanding climate risks. The analysis can also provide a basis for planning and sharpening mitigation, resilience, and adaptation strategies.

This section reviews some of the different objectives for climate scenario analysis as relevant to Banking. It provides a steer on how to negotiate the increasingly dense and evolving landscape of climate scenario families. Even where the scenario is not intended to serve as a forecast, and merely as a projection or description of one possible future outcome, a scenario compresses a large amount of information. Depending on the scenario family, this might include economic, environmental and policy variables, several modelling choices and various important policy and behavioural assumptions. Banks therefore need to not only interpret and condense large amounts of information but also make this relevant to their business needs and their portfolios.

This section provides some guidance on how to address both these challenges. Firstly, each bank may at a certain point in time have a (different) objective or ‘use-case’ when interpreting or developing a climate scenario. Secondly, there are many climate scenarios (or scenario families) to choose from. This section sets out different objectives (use cases), before examining how to choose a scenario (family) based on the objective at hand.

What makes up a climate scenario?

A climate scenario typically pulls together a range of climate-related environmental variables, makes several modelling or analytical choices and then aggregates this together with a set of assumptions, supported with meaningful narrative. The macro-economic variables such as GDP and interest rates, may be related to climate-related variables such carbon prices, extreme weather indicators and other environmental patterns or outcomes. The modelling choices will touch on the time horizon, the time steps, the coverage of climate-related risk factors and so on. The assumptions would relate to behaviours of all economic agents, the future of technology, including but not limited to energy-mix, innovation, policy, timing and similar considerations. These different considerations make it necessary for someone selecting climate scenarios to assess the relevance and suitability of all this information for a bank’s portfolio and the purpose at hand.

Objectives for climate scenario analysis

An important first step for banks to engage with climate scenario analysis therefore involves

[2] Increasingly, there is also recognition of the potential litigation risk associated with climate change, and some would view this as a third category. See for reference the CFRF SAWG 2022 Insurance Litigation Risk guide.

setting out the user's objectives for climate scenario analysis. What will the scenario be used for? Table 1 below sets out some banking objectives for climate scenario analysis. Guidance is provided on a number of factors that should be considered when selecting a scenario for a particular use-case. This is an aspirational list. It could take several attempts and possibly years before a bank looks to cover the multiple use-cases. Therefore, banks working off this list are best to be guided by the principle of proportionality (as explained in the introduction). Where resources for scenario analysis are limited, they should prioritise the application areas that are most material and urgent.

Table 1: Some objectives for climate scenario analysis [3]

Objective or use-case	Typical time horizon (years)
Reference scenario with negligible climate impact (Counterfactual) A reference scenario that, by design, does not give any regard to climate risks – neither transition risk nor physical risk. Its purpose is primarily to provide a benchmark for other climate risk analysis. By not including any specific climate-related policy actions – other than any previously implemented – or any further physical risks and, therefore, implicitly assuming there is no additional forward-looking financial risk from climate change, it frames a reference point. Banks can assess the relative impact on credit risk or capital or liquidity in this reference scenario (which assumes negligible climate impact) and then compare the same in another climate scenario, using the difference in impact to pin down the pure *climate* impact.	Varies; it can be a choice made by the user to align with other climate scenarios
Internal base case This scenario would be the bank's perspective on the climate, macro-economic, and possibly also the socio-economic outlook and would be inclusive of both transition and physical risks. Corporate planning and budgeting would be the primary purposes. Variables, such as carbon price and expected behaviours of economic agents, would play a key role, as would assumptions about technology. Physical risks should also feature, ideally based on the latest climate and environmental science. The severity of the physical risk events would then determine the relative influence of physical versus transition risks. If the projection period is 5 years or less, it is likely that transition risk drivers would dominate.[4]	5-10; typically aligned to the bank's long-term strategy and/or corporate planning cycle
Testing business model resilience under transition risks The purpose of this scenario would be to assess the business model resilience of the bank's financial plan to severe but plausible shocks posed by the climate transition. The selective focus could serve as a basis for assessing capital and/or liquidity adequacy posed largely by transition risks. An important determinant on whether the scenario is suitable for capital and liquidity adequacy assessment would be the implied severity. Is it a collection of one of more shocks or is there	3-5; aligned to the bank's medium-term strategic outlook or corporate planning cycle. but could stretch

[3] Classification of the use-cases in this guide builds on top of the one presented in the last year's CFRF Scenario Analysis guide on p.16. It reflects the evolution of scenario analyses. See https://www.fca.org.uk/publication/corporate/climate-financial-risk-forum-guide-2021-scenario-analysis.pdf

[4] These could be developed by leveraging specific elements of already published regulatory scenarios such as the CBES (Climate Biennial Exploratory Scenario), NGFS (Network for Greening the Financial System) or ECB (European Central Bank).

Objective or use-case	Typical time horizon (years)
sustained climate stress? An adverse change in policy, coupled with a sequence of extreme physical events that influence policy action, can be expected to be one typical scenario feature. This could lead to rapid adverse adjustments in valuations of high-carbon assets, test resilience of corporate business models, drive change in levels of indebtedness of households, which could collectively feed into macroeconomic impacts at a sector and economy-wide level.[5]	out up to, say, 10 years.
Testing operational and business model resilience under physical risks The purpose of this scenario would be to assess the operational resilience of the bank's financial plan to physical climate stress. The selective focus on acute and chronic weather events at the shorter horizon allows a bank to evaluate its operational resilience and also those of its clients and customers and take actions to build resilience, mitigate and where necessary adapt. In the UK, an example of this type of stress might be a series of very severe floods, storms and possibly sustained above-average temperatures. The interest is in understanding business continuity through the bank's portfolio and those of its clients and customers, but also portfolio valuations and impacts on creditworthiness. Science-based guidance would be required in assessing the severity of climate-related events for inclusion in such scenarios as these would have to be incremental to weather-related stress.[6]	1-3; the shorter horizon allowing for an analysis of near-term physical risk shocks
Portfolio alignment for decarbonisation A scenario that serves as the basis for a bank's decarbonisation planning. Interest in such planning is typically driven by Net Zero commitments, Paris alignment and/or other decarbonisation commitments that involve target-setting in the future. As portfolio alignment could involve rebalancing, the decisions made have strategic implications and therefore also implications for financial resources and client engagement.[7] The time horizon for this type of scenario analysis varies, but should align with any bank-specific decarbonisation targets. Key drivers in this scenario would be transition-risk focused with changes in technology, policy and behaviours of economic agents during the climate transition. For this use-case, it is currently common to provide a detailed projection at the sectoral level, noting the differences in each sector's fossil fuel	10+; could stretch 30 years or beyond and will depend on bank's long-term decarbonisation plans

[5] These might draw on climate policy drivers from scenario families such as the CBES, NGFS or ECB scenario family, (e.g., onset of disruptive transition from CBES Late Action / NGFS Disorderly scenarios) ; IEA (International Energy Agency), DDPP (Deep Decarbonization Pathways Project) scenarios; or short-term scenarios [e.g., UNEP-FI (United Nations Environment Programme Finance Initiative) NIESR scenarios].

[6] The assessment might draw on natural Catastrophe modelling, climate simulations. The recent 2022 ECB short-term physical scenario is one calibration of such a scenario.

[7] For references on mobilising capital for climate solutions for the firm's Net Zero strategy, see also the CFRF 2022 guide on "Mobilising Investment into Climate Solutions – Phase 1 Report"

Objective or use-case	Typical time horizon (years)
intensity, its capacity to abate and adapt to technological innovation.[8]	

Scenario selection criteria

As the table above indicates, scenario selection can be a complex choice. Consideration needs to be given to the scenario horizon, internal business relevance, application area, and the granularity and coverage of climate risk factors. But scenarios are also accompanied with assumptions and modelling choices. It is therefore helpful for a bank to having a working criteria list for scenario selection. While the considerations will vary from bank to bank, below are some selection criteria.

1. Time horizon: The scenario's coverage should span the intended time horizon of the analysis. Certain physical risks will require a long horizon scenario for the events to unfold and the narrative of, say, socio-economic behaviours or climate events to fully play out; others, such as acute physical risks, if carefully calibrated, may be assessed at shorter horizon. The 2022 GARP Annual Survey (Figure 6) showed that the most commonly used time horizon for climate scenario analysis is 10 to 30 years.

2. Coverage: Scenarios are underpinned by various assumptions of transition risk (e.g. policies and commitments made by governments, the energy demand outlook, technological developments), physical risk (e.g. sea-level rise in various countries), and integration of macroeconomic impacts. Hence, it is important to establish the range of outcomes that need to be considered. Some scenarios highlighting a disorderly transition may be well-suited to assess the downside impact from an abrupt transition risk, but may exclude certain key markets or sectors relevant to the bank's portfolio.

3. Purpose of the scenario analysis exercise and risk factor coverage: As noted in Table 1, an important first step is to select a scenario that is designed to fit the primary objective of the exercise. The coverage of risk factors is key. This may require a careful assessment of the sector and geographical coverage of the scenario and its match to the in-scope portfolio. The 2022 GARP Annual Survey (Figure 9) indicated that nearly 70% of the firms selected a scenario based on the criteria that it assessed the risks that could arise if the Paris Agreement objectives are met.

4. Granularity of scenario variables: Scenario variables may be available at different granularity. An example of this is flood risk data. It is available at different resolutions in different scenario families (e.g. in some, at square metre by square metre in others at square kilometre by square kilometre). Similarly for transition risk, the granularity will differ by sector and the richness of the information can impact the quality of the analysis. Because of the complexity of running climate scenario analysis on a bank's banking or trading book, it is not always the case that the more granularity is necessarily better.

5. Assumptions and limitations: Given the inherently exploratory nature of scenario analysis, it is important to ensure the assumptions and limitations of the scenarios selected are understood and considered in the decision-making and mitigating actions. For example, assessing the short-term impact to a portfolio modelled under a long-term scenario may not fully capture the risks due to interconnectivity of risks, tipping points and feedback loops which increase over time and may be more suited in describing the long-term climate uncertainty. In a high transition risk scenario, assumption may also be made about the dynamics of policy behaviour and technological innovation. These influence business outcomes and will need careful evaluation.

[8] A typical example would be a scenario from the IEA family or produced by the UK Climate Change Committee.

Scenario families

A good starting point for climate scenario selection is working with one or more known scenario families. Depending on their focus they typically build in socio-economic implications, macro-economic considerations and climate science. This section provides an overview of some climate scenario families. As banks' scenario analysis capabilities mature over time, they may consider moving away from readily available scenarios (and scenario families) and constructing fresh bespoke scenarios or adapting existing scenarios to better match their objectives and portfolios. Table 2 provides an overview of one collection of well-referenced scenario families that banks could use to get started.

Table 2: Overview of reference scenario families

Scenario	Key Characteristic and Coverage	Implied temperature rise (°C)	Time horizon	Examples of Use Case
Scenarios published by international and governmental bodies				
International Energy Agency ("IEA") - Stated Policies - Announced Pledges - Sustainable Development ("SDS") - Net Zero Emissions ("NZE") Link	The IEA scenarios explore different assumptions about how the energy system might evolve, based on government policies, socioeconomic factors, technology development and energy prices and affordability. **Coverage:** Transition risk variables across key regions and select sectors (energy).	1.4 – 2.5	2050	IEA NZE scenario can be used to inform the bank's strategic decarbonization targets (e.g. Net Zero targets). Figure 8 of the 2022 GARP Annual Survey showed that the most popular scenario used for assessing alignment to Net-Zero or a particular temperature pathway was the IEA SDS scenario.
Network for Greening the Financial System ("NGFS") (Phase 3) - Net Zero 2050 - Below 2C - Divergent Net Zero - Delayed Transition - Nationally Determined Contribution - Current Policies	The NGFS scenarios provide a reference for understanding how climate change (physical risk) and climate policy and technological trends could evolve under different scenarios corresponding to a range of higher and lower risk outcomes. The latest Phase 3 scenarios include enhanced modelling of (acute) physical risks.	1.5 – 3+	2100	NGFS scenarios can be leveraged to create an internal base case scenario Disorderly scenarios (Divergent Net Zero and Delayed Transition) can be used to test business model

Link	**Coverage:** Transition and physical risk variables across key regions and sectors, and key macroeconomic indicators.			resilience under transition risks. Figure 8 of the 2022 GARP Annual Survey showed that the most popular scenario used for assessing transition risk was the NGFS Disorderly scenario.
Intergovernmental Panel on Climate Change ("IPCC") a) Representative Concentration Pathways ("RCP") - RCP 2.6 - RCP 4.5 - RCP 6.0 - RCP 8.5 b) Shared Socio-Economic Pathways ("SSP") - SSP1-1.9 - SSP1-2.6 - SSP2-4.5 - SSP3-7.0 - SSP5-8.5 Link	The IPCC RCPs describe the climate impact of a range of possible future greenhouse gas emissions ("GHG") and the consequent GHG concentrations leading to resulting change in global temperatures at various future points (e.g. 2050, 2100) relative to pre-industrial levels. **Coverage:** A wide range of climate variables are projected for each RCP/SSP (for example, temperature, precipitation). These are then used as input for downstream research centres/climate data vendors who model physical climate hazards such as floods, hurricanes/cyclones and droughts.	1.5 – 4.3	Short-term and long-term (up to 2100)	Test operational and business model resilience under physical risks Figure 8 of the 2022 GARP Annual Survey showed that the most popular scenario used for assessing physical risk was the RCP 8.5 scenario.
UK Climate Change Committee ("CCC") Link	The UK's Sixth Carbon Budget report provides balanced and alternative pathways to achieve net zero greenhouse gas emissions in 2050 in the UK. **Coverage**: transition risk variables for a wide range of sectors (including transport, buildings, manufacturing	1.5	2050	UK CCC scenario can be used to inform the bank's strategic decarbonization targets (e.g. Net Zero targets)

	and construction, electricity and agriculture and land use).			
Deep Decarbonisation Pathways Project ("DDPP") Link	The DDPP framework examines the conditions including policies and technological requirements needed to achieve the countries' emissions reduction goal for 16 countries and the key impacted sectors. **Coverage:** transition risk variables as well as key macroeconomic indicators.	1.5	2050	Test business model resilience under transition risks
United Nations Environment Programme Finance Initiative - National Institute of Economic and Social Research ("UNEP-FI – NIESR") 3 scenarios Link	Short-term macroeconomic climate scenarios covering sudden rise in carbon price, spike in oil price and trade war. **Coverage:** transition risk variables as well as key macroeconomic indicators.	NA	3-5 years	Test business model resilience under transition risks over a short-term horizon
Scenarios published by central banks and regulators				
Bank of England 2021 Climate Biennial Exploratory Scenario ("CBES") - Early Action - Late Action - No Additional Action Link	The 2021 CBES exercise explored two scenarios leading to net zero greenhouse gas emissions (Early Action and Late Action) and a scenario which primarily explores the physical risks from climate change. **Coverage:** transition and physical risk variables as well as macroeconomic indicators	1.8 – 3.3	2050	CBES scenarios can be leveraged to create an internal base case scenario Late Action scenario can be used to test business model resilience under transition risks No Additional Action scenario can be used to test business model resilience under physical risks.

European Central Bank 2022 Climate Stress Test ("CST") - Short-term transition risk stress, - Orderly - Disorderly - Hot House - Drought & heat risk shocks - Flood risk shocks Link	The 2021 CST considered a short-term transition risk scenario based on abrupt increase in carbon price, and 3 long-term transition risk scenarios based on early and delayed implementation of climate policies, and a scenario where no new climate policies are implemented. The physical risk shocks explored the instantaneous impact of 2 separate climate events. **Coverage:** transition and physical risk variables as well as macroeconomic indicators	1.5 - 3	Short-term (1-3 years) Long-term (2050)	ECB scenarios can be leveraged to create an internal base case scenario Short-term physical risk scenarios can be used to test operational and business model resilience under physical risks

Most of the scenarios mentioned in the table above were not created specifically for the analysis of climate risks by banks. They often need to be adapted, expanded and enriched to be relevant for banks' needs. The next section evaluates with the help of examples how the use-case drives the choice of scenario family.

Short-term dynamics and sectoral impacts are important for banks. These can often be missing from the off-the-shelf scenario families. One solution therefore is to create bespoke in-house scenario expansion tools. The first case study below illustrates the development of short-term climate macro scenarios for planning and budgeting purposes.

Case Study - Short-term climate macro scenarios

This case study illustrates how to define short-term macroeconomic scenarios for assessing resilience of a bank's business model to transition risks, one of the use-cases identified earlier in Table 1.

Climate scenarios were integral to the first few regulatory climate stress tests. In these tests, several participating banks were required to work with long-term scenarios. These were produced by using established IAMs (Integrated Assessment Models) that link the energy system, macro-economic indicators, land use and climate science models to evaluate the technological and economic feasibility of achieving climate change mitigation goals. This selection is justifiable because the transition and physical risks associated with the energy transition and changes in the physical climate will take many decades to fully materialize. Those scenarios are useful for long-term strategic planning and evaluation of business models. The NGFS scenario family has been an important choice, with the CBES and ECB stress scenarios drawing on this scenario family.

However, for planning and budgeting purposes banks may need to use shorter-term climate scenarios and cover a range of risk drivers that impact the business. It is important therefore to assess the key climate risk drivers over that planning horizon for incorporation into the overall scenario process. Long-term scenario analysis of a disruptive transition to a low-carbon economy (e.g., Late Action CBES scenario) demonstrated that a sharp increase in carbon prices could increase credit risk significantly over a relatively short period and this risk was heterogenous across sectors and sub sectors. That is why it is important to explicitly include climate transition assumptions into the macroeconomic scenarios considered by banks for their budget and planning purposes and ensure this analysis can be disaggregated, at least at the sector level.

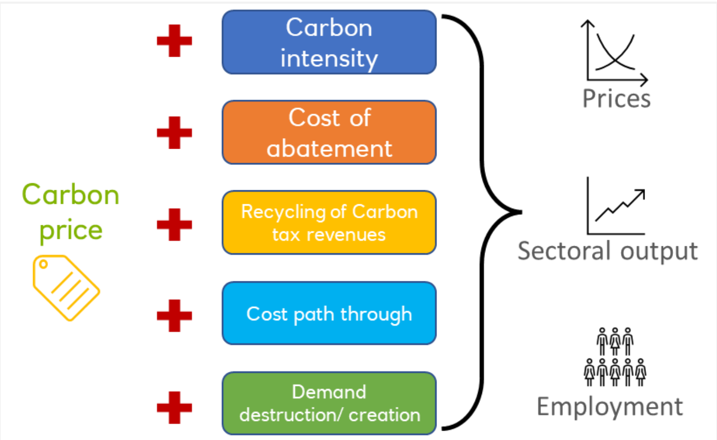
The domain for short-term scenarios in a bank is typically macroeconomic modeling. Very few short-term scenarios, as produced by economist desks, directly incorporate climate transition assumptions. Even those models that do are typically aggregated at the country level; they do not disaggregate sectors to sufficiently capture each sector's sensitivity to a short, sharp increase in carbon prices.

A UK bank therefore undertook a project to develop its own approach to modelling the impact of transition factors on key macroeconomic variables at a sector level. In collaboration with specialist climate risk advisors, the bank created a transition risk calculator which estimates the impact of implicit carbon prices and transformations in the energy systems through demand destruction and demand creation on sectoral GVAs (Gross Value Added), GDP, consumer prices and employment.

The calculator is based on a so-called Input-Output modelling approach and considers the following factors:

1. *Emissions intensity (direct and through supply chain)* – the higher the emissions intensity the larger the carbon cost impact on that sector;
2. *Cost of abatement* – sector specific current and projected marginal abatement cost curves to estimate cost effective abatement across different sectors;
3. *Recycling of government carbon tax revenues* – in some scenarios government might collect significant carbon tax revenues, which can be used to stimulate demand in selected sectors;
4. *Ability to pass through cost increases to consumers* – elasticity of demand and potential to pass through costs determines how sensitive output prices are to cost increases as a result of climate policy;
5. *Demand destruction/demand creation* – direct projections of demand for different types of high- and low-carbon goods and services related to the particular policy scenario.

Figure 1: Overview of the Input-Output modelling approach



The benefit of this approach is its simplicity and tractability. Input-Output tables provide a rich sectoral picture, which is relevant for analysis of the corporate loan book. The approach above can be applied to all kinds of short-term macroeconomic scenarios that banks use for planning and stress testing purposes.

The approach does have important limitations. The approach is static and does not allow for substitution and changes in behaviour in response to higher carbon prices; unless these are imposed manually as specific examples of demand destruction or demand creation. For that reason, this scenario generation process is best applied in the short-term, when options for substitution are very limited.

Case Study – Mortgages

This case study describes how a bank could apply the principles of scenario selection for selecting a climate scenario that is especially relevant to a mortgage portfolio.

The starting point for selection should be clarification of the objective of scenario analysis. In this instance, suppose the bank's aim is to assess financial risks in its residential mortgage portfolio and identify climate-related physical risks across its key markets over the next 10-20 years. Suppose also that the key markets for the bank's residential mortgage portfolio are Hong Kong and the UK.

The next decision point would be the time horizon**.** For a mortgage portfolio, a longer-term scenarios would be best. Suppose the primary interest is on chronic physical risk impact with the aim of estimating losses over the next 10-20 years. This could be described as a test of long-term business model resilience under physical risks, which is a hybrid of the use-cases described in Table 1, centred on business model resilience under physical risk but also a long-term internal base case. A potential choice of scenario family for this could be the NGFS scenario family.

Coverage is the other obvious consideration. Choosing a scenario that provides coverage of Hong Kong and the UK with expandable details on the physical risk variables for these regions will be key. This rules out IEA scenarios. That family would not be appropriate for this analysis given its focus on transition risk.

Granularity of the scenario variables is another consideration. A scenario family that covers a wide enough range of physical risk hazards to span the UK and HK risks would be best. Flood-related risks would be very relevant for the UK. Tropical cyclones may be more relevant for HK. The wider the coverage of the scenario family across these hazards, the more relevant would be the outcomes from the climate scenario analysis.

If the objective is to isolate the financial risks due to physical risks, macroeconomic coverage could be avoided. If, on the other hand, the objective is to quantify the holistic view of all climate-related financial risks, macroeconomic variables in both these regions could have an impact on the results (e. g. acute weather events leading to business disruption and rising unemployment rates or lower GDP growth) and should be available from the chosen scenario family.

Given the above considerations, from objective to time horizon to regional coverage, one favourable choice of scenario family would be the IPCC's RCP scenario family. Another choice would be the recent UK CBES scenario family, giving special attention to the 'No Additional Action' scenario.

Even with this principle-based selection process, the user should be cognizant of the assumptions and limitations. Firstly, there is the inherent uncertainty in the modelling of future physical risks. Modelling the magnitude and frequency of specific physical risk events, even when based on environmental science, is inherently uncertain. The scenario outcomes should be interpreted probabilistically and couched within an uncertainty range, not treated as projections with pin-point accuracy. Projections also may not take into account location-specific mitigation plans, e. g. the presence or planning of flood defences. This uncertainty around the realization of physical hazards and existing mitigants should therefore be allowed for in the impact analysis. Results, be they for estimation of expected credit losses, wider profit and loss estimation or capital adequacy, would need to be appropriately caveated for the uncertainty.

2. Sensitivity analysis and climate scenarios

Introduction to sensitivity analysis

Sensitivity analysis is a kind of "what if" analysis. When conducting sensitivity analysis, a risk manager would typically explore how one variable ("target variable") affects the change in another variable ("input variable"), typically in isolation of other variables. When proceeding in this way, sensitivity analysis can be thought of as an exercise that is supplementary to scenario analysis. It adds intuition on the dependencies between variables, either qualitatively or quantitatively.

In doing so, it also introduces efficiency into the process by narrowing the scrutiny to a smaller set of variables. In the context of climate risk, a good example of sensitivity analysis would be the exploration of the impact of carbon prices increasing by, say, X% on (expected) credit losses in, say, a particular carbon-intensive holding sector, holding everything else constant. A full scenario analysis, on the other hand, would entail assessing the impact of multiple variables such as sector-level production, price levels, and environmental variables, amongst others, on the portfolio in question.

In practice, sensitivity analysis can be run in different ways. In some cases, sensitivity analysis is a standalone activity. The model may be developed and implemented by a third party, and the risk manager conducts sensitivity analysis as a "deep dive" exercise on an existing calibration. In other cases, it is layered on top of a fully customised scenario analysis tool, with sensitivity analysis carried out as a follow-on activity to a full model run.

Benefits and limitations

Sensitivity analysis can add credibility to scenario analysis, since it can help evaluate how stable the analytical conclusions are to a wider range of possible inputs. For example, sensitivity analysis may help generate a range of possible results to complement a specific scenario analysis output e.g., losses are expected to be in the range £ X-Y million for carbon prices in the range £ A to B / tonnes CO_2. Depending on the use case, sensitivity analysis can, arguably, provide more effective information for decisioning in a shorter period of time than a holistic scenario analysis.

Sensitivity analysis can therefore also require fewer modelling resources than scenario analysis. Though appropriate model governance remains important in both cases. Ideally, the sensitivity analysis presumes a set of relationships between the input and target variable(s) has been defined and implemented through one or more internal scenario analysis runs. This relationship could be defined internally through a customised model or by deploying an existing external scenario (e.g., CBES exercise) implemented by a third party.

A key limitation of sensitivity analysis is its inability to fully attend to non-linearities or co-dependencies between multiple variables. Its singular focus on a set of input variable(s) and a target variables, preempts that. This could occasionally lead to conclusions that are too simplistic or perhaps misleading. This could be particularly important in the context of climate scenarios when there are many variables that interact with one another, generating non-linearities or 'tipping points'. It can therefore be challenging to judge in exactly what situations sensitivity analysis gives reasonable results. One potential mitigant is to run multiple scenarios and develop a picture of the relationship over a very wide range and then select either the most conservative result or then average across the output range. Another mitigant is to communicate the results for a specific use case and explicitly highlight the caveats of the approach.

Using and communicating the outputs of sensitivity analysis

Sensitivity analysis can be used in many ways:

- To prioritise vulnerabilities in the portfolio for further analysis. For example, if a bank identifies that expected credit losses are increasingly more sensitive to carbon prices rather than interest rates in a particular climate scenario, then it may be worth applying resources to conduct a richer scenario analysis centred on the dynamics of carbon prices without putting too much emphasis on the accuracy of the latter.
- To confirm the credibility of certain models underpinning scenario analysis when presenting to senior management e.g., to demonstrate how stable the results of scenario analysis are under a range of different input variable values.
- To communicate “tipping points” or thresholds e.g., determine at what point the impact on the target variable changes more than proportionately to the change in the value of the input variable(s).

Principles for conducting sensitivity analysis

It is helpful to have some guiding principles for conducting sensitivity analysis. A selection of these are listed below:

1. Applicability: Use expert judgement to assess the applicability of the sensitivity analysis e.g., if the bank’s primary activity is mortgage lending, then it would likely be more meaningful to explore the sensitivity of changing interest rates on the portfolio than carbon or other commodity prices;
2. Scenario and Model selection: Select an underlying scenario and model from which to develop a relationship between two variables e.g., at least one internal or external scenario analysis exercise.
    - It will generally be more meaningful to use results from internal scenario analysis exercises as the base case, given the direct applicability to the bank’s portfolio. However, results from external scenario analysis exercises or third party models can also be used to conduct impact analysis;
3. Choice of Input variable: Define input variable(s) for the analysis e.g., carbon price
4. Choice of Target variable: Define target variable(s) for the analysis e.g., expected credit losses
5. Granularity: Define the level of granularity for the analysis e.g., for a specific sector, asset class, country and/or counterparty.
    - If the underlying scenario is not available at the appropriate level of granularity, the bank can consider scaling up/down the relationship using expert judgement. E.g., if a bank is using results from a certain regulatory scenario, but believes that its own portfolio is 20% more carbon-intensive than the average UK bank, it can consider scaling the relationship between carbon price and expected credit losses accordingly;
6. Relationship: Define the relationship between the input and target variables based on the underlying scenario e.g., X% change in carbon price leads to $ Y million expected credit losses
    - Banks can consider using the average or most conservative relationship from multiple scenarios, which may be more reliable than using only one scenario. Note that this relationship effectively determines the transmission channel through which an input variable affects a target variable
7. Recalculation: The target variable should be recalculated based on a different value of the input variable. This might be, for instance, a change in the carbon price level and use the relationship to recalculate the expected credit loss;
8. Communication of the assumptions: Clarify the appropriateness of the assumption and/or limitations of the relationship. This might mean pointing out that it is assumed the pre-defined relationship between the input variable and the target variable continue to hold across their respective ranges.

To bring the use-cases of sensitivity analysis to life in the context of climate risk management two cases studies are presented below.

Case Study – Sensitivity analysis of carbon prices and expected credit losses in the corporate loan book

We work through an example in the corporate loan book. Assume a bank wants to explore how expected credit losses ("target variable") in its corporate loan book may be impacted by different carbon prices ("input variable"). Suppose also that the bank has not conducted its internal scenario analysis exercise. It decides to leverage the results from a regulatory climate scenario, such as the CBES exercise, to conduct a sensitivity analysis.

1. Applicability: The bank believes its portfolio is comparable to the portfolios of the banks that participated in the CBES exercise, and therefore determines that scenario details are relevant and applicable;
2. Scenario and model selection: CBES results for Early Action Scenario as well as a Counterfactual Scenario;
3. Input variable: Carbon price in $ / tCO_2 [9];
4. Target variable: % change in expected credit losses[10];
5. Granularity: Credit portfolio ;
6. Relationship: The model suggests $1 / t$CO_2$ increase in carbon price leads to 0.26% increase in expected credit losses (derived based on table below).
   - It should be noted that this relationship represents an average over time (2025-2050), although there is a visible time trend too, i.e., higher carbon prices lead to higher expected credit losses in the near-term compared to the long-term. A bank may therefore choose to use the near-term relationship ($1 / t$CO_2$ leads to 0.5% increase in expected credit losses) to assess near-term sensitivity. This would better support short-term analysis;

Table 3: Relationship between carbon prices and expected credit losses (CBES)

Variable	2025	2030	2035	2040	2045	2050	Average
Input variable: Carbon Price (CP) $/tCO2	-	-	-	-	-	-	-
Early Action (EA)	226	302	449	595	742	889	-
Counterfactual (CF)	28	27	25	24	22	21	-
Change in CP (EA - CF)	198	275	424	571	720	868	
Target variable: Expected losses (EL) £bn	-	-	-	-	-	-	-
Early Action (EA)	40	90	130	150	180	200	-
Counterfactual (CF)	20	40	60	80	100	120	-
Increase in EL (EA/CF)	100%	125%	117%	88%	80%	67%	-
Relationship: % Increase in EL/ $ Change in CP	0.5%	0.45%	0.28%	0.15%	0.11%	0.08%	0.26%

7. Recalculation:
   - Example A: The bank would like to know how expected losses would change if the carbon price increased by $400/t$CO_2$. This can be calculated as 400*0.26%=104%.
   - Example B: The bank would like to know at what level of carbon price increase will expected losses increase by 100%. This can be calculated as 100%/0.26% = $385/t$CO_2$;
8. Communication of the assumptions:

[9] Source: CBES carbon prices
[10] Source: CBES expected losses (Chart 4.2)

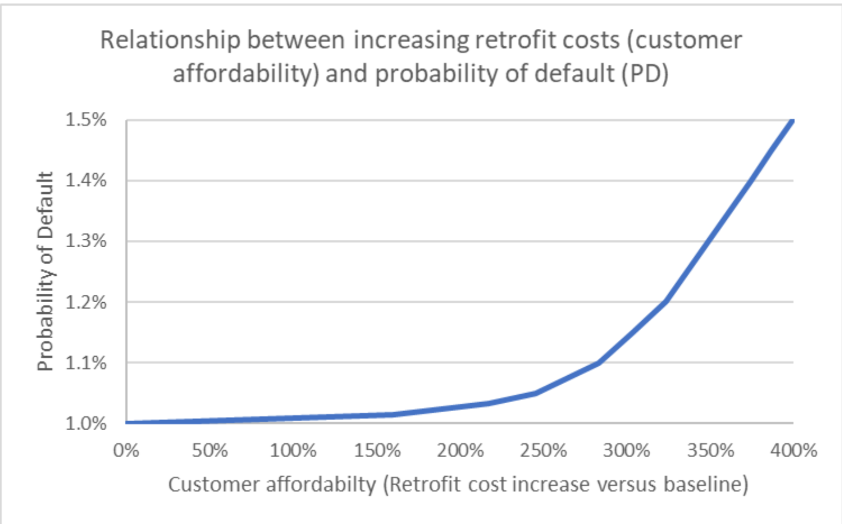
- Assumes portfolio is comparable to the portfolio of UK banks who participated in CBES
- Assumes average relationship between expected losses and carbon prices holds over time
- Does not account for interactions with other variables e.g., potential non-linearities in expected losses as carbon prices increase.

Case Study – Sensitivity analysis for a residential mortgage portfolio

A second example might be from the home loan market. A bank with a large residential mortgage portfolio can use sensitivity analysis on its internally derived climate scenario model to better understand the extent to which its mortgage-based portfolio is impacted by changes in climate-related variables. The target variable here might be the impact on mortgage impairments and the input variable might be retrofitting costs. Another input variable in this context might be a proxy variable for flood risk, which is an important physical risk driver for the UK, with mortgage impairments being another determinant.

Applying the principles for sensitivity analysis in this context, we have the following:
1. Applicability: The bank has already performed internal climate scenario analysis on its portfolio or is able to assess its base case from externally available CBES results;
2. Scenario and model selection: Scenarios that cover (i) transition risk and hence allow affordability to be measured and/or (ii) a scenario that focuses on flood risk to bring out physical risk;
3. Input variables: (i) Stressed increases in retrofitting costs, an indicator of the climate transition on affordability and/or (ii) a proxy variable for increased likelihood of flood risk, calibrated at postcode level and/or for the total portfolio;
4. Target variable(s): (i) Probability of default and/or (ii) percentage change in expected credit losses;
5. Granularity: At the level of the mortgage portfolio (or some subset of it cut by geography or demography or credit risk profile);
6. Relationships: (i) Suppose that the underlying climate scenario-based model suggests a that 1-notch increase in the average energy efficiency rating (as captured through an EPC rating in the UK) with a resultant retrofit cost increase of X% results in a Y% increase in PD (as illustrated in Figure 2). (ii) Suppose that the flood risk exposure or credit losses increase with the proportion of the uninsured portfolio (as illustrated in Figure 3);

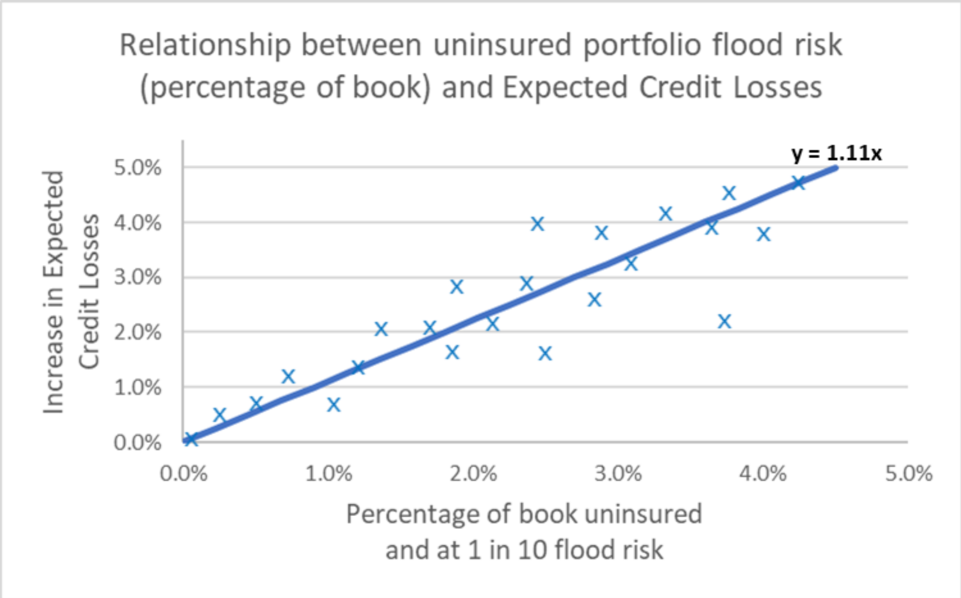
Figure 2: Relationship between customer affordability (based on impact of increased retrofit costs assumptions) and probability of default



The baseline retrofit costs in the chart above reflect the base costs in the selected scenario. The sensitivity shows how the PD changes as the base costs increase. As illustrated in

Figure 2, if the average mortgage portfolio with a PD of 1% moves from EPC rating C to B via retrofitting in an Early Action scenario, at an average cost of £10,000 and subsequently the average cost of retrofitting increases to £40,000 per property (due to demand materially outstripping supply requiring customers to retrofit to ensure they are still mortgageable), then the average portfolio PD increases to 1.5%.

Figure 3: Relationship between Uninsured portfolio flood risk and ECL



7. Recalculation: (i) Explore modelling assumptions for different affordability via higher costs of transition and identify whether curves are impacted and/or (ii) Run flood risk impacts with different uninsured percentages, for example, the illustration graphically represented above suggests that there is a 1.11x ratio between expected credit losses and insurance coverage, as illustrated in Figure 3;

8. Communication of the assumptions: Document assumptions / assert extrapolation basis / state limitations and variables excluded. Consider whether outputs can inform credit decisioning.

3. Scenario analysis for physical risk and climate adaptation

Physical risks and their importance to climate scenario analysis for banking

Various climate risk analysis exercises, including those recently run by central banks or conducted internally by commercial banks, have explored, through scenario analysis, the importance of physical risks, especially those that would materialise should governments around the world fail to enact policy responses to global warming. An example of one such scenario, where physical risks are prominent, would be the 'no additional action' scenario run during the 2021 UK CBES exercise.

An important early finding of some of these scenario exercises has been that in a 'no additional action' type scenario, corporate sectors or households that were most exposed to physical risks faced a material reduction in access to lending and insurance. Banks can be expected to react to the elevated physical risks by reducing lending to properties facing greater physical risks. Insurers would substantially increase the premiums they charge to insure against such risks, making insurance coverage almost unaffordable, a reality already witnessed in some countries faced by severe climate change-induced flash floods. This reaction from banks and insurers is a financial response to the significant losses they may have projected over the horizon of an adverse scenario; a business decision that helps them curtail the drop in returns on their financial assets[11].

Recognising the slower than expected progress currently being made globally against the climate emergency, and the potential projected impact of the losses from physical and transition risks for insurers and banks, among others, it is in the interests of banks to give recognition to both physical and transition risks when undertaking scenario analysis. For example see PRA's supervisory statement 3/19. As banks' borrowers and trading counterparties can be expected to make some plans to react to the adversity, it is reasonable to expect banks to also explore more directly the nature of their clients' (wholesale lending) and customers' (retail lending) *adaptation plans*. How will the customers and clients cope with the full range of physical risks they are exposed to? An understanding of the response options needed would allow banks to better differentiate the readiness of their different customers or client groups. Factoring these adaptation plans in their business decision-making would also give banks a fuller and more realistic evaluation of the net physical risk on their books and, in turn, support better risk management of the expected loss profile.

This section of the document therefore provides some insights on what an adaptation plan is, what might be included in such a plan, mechanisms through which physical risk impact a bank and finally how banks should give regard to the credibility of adaptation plans.

Adaptation plans

Climate change is already having visible impacts across the globe. The average global temperature forecast for 2022 is between 0.97°C and 1.21°C above the average for the pre-industrial period (1850-1900). The IPCC Sixth Assessment Report (AR6) stated that the aggregate reductions implied by the current Nationally Determined Contributions (NDCs) to 2030, would still make it impossible to limit global warming to 1.5°C. Anthropogenic global warming and sea level rise is expected to continue for decades, even if GHG emissions were cut significantly, due to the time scales associated with climate processes and feedbacks. Given

[11] In the UK CBES exercise, it was estimated that life insurers could expect to face a significant drop in forward asset valuations at the longer horizons resulting in a potential 15% overall impact on total market valuations. UK and international general insurers, respectively, projected a rise in average annualised losses of around 50% and 70% by the end of the no additional action scenario.

this lock in of physical risks over coming decades, there is a greater recognition that households, corporates, governments and the public sector must work through a number of response options to mitigate the impact of adverse climate change. These taken together form their adaptation plan, for different timeframes, both their short term and medium-term plans.

Giving regard to adaptation plans, especially credible ones can significantly enhance the value of climate scenario analysis.

Table 4 provides some items that would form the basis of an adaptation plan[12]. Inclusion of the bank's own adaptation plans and/or those of its clients in the climate scenario would have the effect of reducing the level of adversity in a climate scenario.

Table 4: Identification of adaptation opportunities. Each category is represented by multiple illustrative examples

Adaptation category	Examples
Awareness raising	Positive stakeholder engagement
	Communication of risk and uncertainty
	Participatory research
Capacity building	Research, data, education, and training
	Extensions services for agriculture
	Resource provision
	Development of human capital
	Development of social capital
Tools	Risk analysis
	Vulnerability Assessment
	Multi-criteria analysis
	Cost/benefit analysis
	Decision support systems
	Early warning systems
Policy	Integrated resource and infrastructure planning
	Spatial planning
	Design/planning standards
Learning	Experience with climate vulnerability and disaster risk
	Learning-by-doing
	Monitoring and evaluation
Innovation	Technological change
	Infrastructure efficiencies
	Digital/mobile telecommunications

Impact mechanisms for physical risk

When exploring clients' and customers' response options, by assessing their adaptation plans and supporting them on it, banks will find it helpful to catalogue the type of impact different mechanisms make, through which physical risk factors can manifest on their portfolio. Table 5 provides a high-level illustration of some impact mechanisms.

[12] A recent reference for assessing the quality and comprehensiveness of an organisation's adaptation strategy is provided in the ACT Adaptation Methodology note.

Table 5: Portfolio impact mechanisms

Impact mechanism	Wholesale and Small-Medium Enterprises (SMEs)	Retail
Direct physical impact – Damage	Direct physical damages are the most obvious and immediate physical risk a corporate faces from climate change. This might include potential damages to physical assets and other infrastructure owned by the corporate, directly, as a result of climate -related events.	As with the Wholesale portfolio, direct physical damages can be the most obvious and immediate physical risk retail customers may face from climate change. For loans secured by a physical asset, there is the potential for direct damages to the immovable asset and the contents, further exacerbating the stress and the indebtedness of the borrower.
Direct physical impact – Business interruption	Lower revenues and profitability for corporates and SMEs that are forced to modify or shut down operations temporarily.	Lower income from a residential or commercial property letting in an area now more exposed to adverse physical risks. Possibly lower rental yields, voids and subsequentially lower interest coverage ratios.
Indirect physical impact - Change in economic activity or economic value	Indirect physical risks could generate greater systematic macroeconomic impacts. These could exacerbate the direct impact. Countries or regions more exposed to climate change may experience permanently (or sustained) lower economic activity, output and productivity.	Retail customers in countries or regions that are more exposed to severe physical risks may face economic downtown or reduced economic activity, which could be coupled with weak markets and sustained poor credit environment, impacting their indebtedness. These outcomes could play out at national level or more locally within a region.
Indirect physical impact - Supply chain	Profit and loss (P&L) impact on corporates or SMEs whose supply chain operations are adversely impacted because of adverse physical risks, occasionally making some business models non-viable.	Not specifically relevant to retail loans, except through inflationary pressures in the wider economy through supply chain pressures.
Increased running costs, for example, higher costs of insurance premiums	As insurers increase their premiums to budget for greater physical risks, the higher insurance costs and/or lower insurance coverage, may become unaffordable for businesses and households, exposing them to financial risk during adverse physical risk events.	

Whilst the examples listed above provide a credit risk perspective, there would also be impact mechanisms that elevate other principal risks, especially but not only operational risk, reputational risk or market risk.

Physical risk adaptation plans

According to the United Nations' United in Science Report 2022, the likelihood of the mean global temperature temporarily exceeding 1.5 °C above pre-industrial levels for at least one of the next five years is 48% and is increasing with time. As such, adaptation plans are crucial to lower the risks from climate impacts.

Adaptation plans to mitigate risk can be specific to an individual client (their business interruption planning activities) or pegged to those drawn up by other stakeholders (e.g. government or local council plans). Where a bank has identified that the gross risk posed by a particular group of households or a particular corporate client is material, a proportionate approach should be taken to understand the client's adaptation plan and its potential impact on mitigating risk.

Select examples of physical risk adaptation strategies that could be explored are provided below:

- Asset build or management
  - Building of flood defenses - should consider both the internal approach as well as any government intervention
  - Disposal/relocation of strategic assets
- Risk pooling
  - Putting in place sufficient insurance coverage
  - Supply chain contingency planning to minimize potential disruptions caused by climate events (e.g. increasing safety stock, building relationships with multiple suppliers to reduce dependency, say, on a single warehouse)
- Tapping into opportunities
  - e.g. planting different types of crops that are better suited to different temperatures
- Revision of BAU business planning processes and facilities management (e.g., Orsted A/S)

It is likely that for retail and SME lending the adaptation plan assessment will rely on alignment with published Government plans[13] and how the insurance sector will adapt coverage practices to retail and small business clients, since these are currently key mitigants for this type of lending.

Credibility of climate adaptation plans

Banks will need to invest further effort in determining the credibility of adaption plans or mitigants provided by customers and client groups[14]. The following high-level evaluation criteria are suggested for assessing the credibility of a climate adaptation plan.

- The adaptation plan is shared as a public commitment by the counterparties and/or the government;
- The counterparty or government's credibility is judged not just by its ambition, but also the delivery track record;
- The commitment and involvement of the senior management of the organisation is taken into account;
- Any technologies referenced should ideally be in use today and any key products or resources ideally already be sourced or have a clear pathway of becoming accessible and feasible;
- An assessment of the cost effectiveness of the proposals has been carried out;
- Constraints or adverse effects of putting the plan into practice have been carefully assessed

[13] For UK government see as an example the UK National Adaptation Programme (2018-2023)

[14] The credibility assessment of the adaptation plans for retail and SME customers may rely on several assumptions, which are best made transparent through the use of compact questionnaires or surveys, even if these are not as exhaustive as large corporate adaptation plans.

and, preferably, also resolved.

The credibility assessment approach highlighted above is customized for climate risk. But the principles are consistent with how banks assess the credibility of scenario analysis management actions in other risk management contexts. For example, under the UK capital framework's Pillar 2B, banks are expected to assess the credibility of management actions submitted for an Internal Capital Adequacy Assessment Process (ICAAP) stress or a Recovery Plan stress in a similar manner.

Own climate adaptation plans

Alongside client and customer adaption plans, banks should also consider developing their own adaption strategies and approaches. These would follow the same credibility and viability approach outlined above and could potentially inform business strategy and financial planning outputs.

There are a range of options that can be explored. Some of the approaches available include[15]:

- Reducing exposure to physical climate risks
  e.g. Divesting from sectors or regions highly vulnerable to physical risk, while maintaining regard to potential concerns around financial inclusion;
- Risk pooling
  e.g. Grouping assets together and purchasing block re-insurance;
- Identifying new opportunities
  e.g. Pivoting the new lending strategy to lower risk regions or products such that there is greater support for adaptation projects or green technology and innovation.[16]

Including climate adaptation in scenario analysis and influencing customers and clients to share their plans is best progressed in proportionate manner. Smaller organisations need to be able to demonstrate that they have considered several material risks but may lack the resource and/or the data. Hence, the climate adaptation analysis may need to start qualitatively before progressing to a more structured or quantitative analysis.

Case studies

Some case studies are presented below to help provide a better appreciation of physical risk-driven climate adaptation assessment.

Case Study - Wholesale credit

For the Oil & Gas sector, as an example, companies with reserves in locations highly exposed to the physical impacts of climate change will face more disruptive events and potentially higher costs for extraction in the future, if mitigating actions are not taken. Production may have to be halted and a plant secured to allow for the passage of tropical storms, or coastal infrastructure will need to be raised to account for storm surges and sea level rise. Risks of accidents and spillages in ecologically sensitive locations could also increase as pipelines are exposed to more extreme weather events that they may not have been designed to withstand.

Some of these physical risk impacts have already begun to manifest. For instance, Hurricane Ida[17] caused a record 55 spills in the Gulf of Mexico and created historic disruptions to the supply

[15] Refer to OECD Environment Working Paper on Climate-resilient Finance and Investment which proposes principles for climate resilience-aligned finance
[16] For examples of some financial instruments linked to sustainability, refer to section 2 of the CFRF 2022 guide on "Mobilising Investment into Climate Solutions – Phase 1 Report"
[17] Nichols, W., Clisby, R., 2021. 40% of oil and gas reserves threatened by climate change. Maplecroft, 16 December. Available: https://www.maplecroft.com/insights/analysis/40-of-oil-and-gas-reserves-threatened-by-climate-change/

of both crude oil and refined products.

Case Study – Singapore

The Environment Risk Questionnaire (ERQ) Guide published by the Association of Banks in Singapore (ABS) in conjunction with the Monetary Authority of Singapore (MAS) has a comprehensive physical risk section. ABS are currently exploring with MAS and other stakeholders how data requested by the questionnaire may be obtained centrally on behalf of the industry in a digital format via a central data repository under Project Green Print and shared with lending banks after seeking client permission. Such an approach will significantly streamline the process, avoid duplication, and improve data quality. However similar practice is yet to be seen in other geographies.

Examples of physical risk ERQ questions include:

- Has the customer faced/expected to face any impact from physical risk?
- When would the impact be expected to materialise?
- How did such risk arise?
- What are the measures implemented by the customer to address impact of such risks?
- Provide key asset locations of the customer, including both operating assets and collateral assets.

Case Study – Retail

Across residential real estate, property owners in locations highly exposed to flood risk could face direct damages or changes in values. For example, properties in the western regions of Germany are at risk of extreme river and flash flooding, with the risks already starting to materialise. In 2021, the flooding in Rhineland-Palatinate and North Rhine-Westphalia is increasingly becoming accepted as linked to the effects of climate change. As well as highlighting the potential for substantial asset damages, the flooding also highlighted the sizeable insurance coverage gap with building insurance density as low as 43% and content insurance even lower at 24%[18].

Other examples include seaside towns susceptible to coastal erosion. As businesses and people working for these businesses leave the area, the local market could begin to weaken. Critically where an asset is located in a weak market, the depreciation linked to physical risks such as coastal erosion is more prominent. This will also impact any small-medium enterprises and businesses left behind who may no longer be able to operate in the weaker market as they did before[19].

Case Study - UK flood risk

The CBES guidance suggests that flood defenses will degrade over time, and that a linear degradation should be incorporated into CBES analyses. Flood risk data vendors, can provide both “defended” and “undefended” flood risk data. Some flood risk analysis can use a ‘flood risk defense factor’ which already considers the natural degradation (and renewal) of flood defenses. This allows for the appropriate modelling of current and future flood defenses. Incorporating government adaptation plans and such flood defense information can be is critical for modelling the risks across the retail mortgage book.

Listed below in Table 6 are some important data fields for physical risk adaption plans for Retail

[18] Ambiental Technical Solutions Ltd. 14 December 2021. How Climate Change is Impacting Extreme Weather Events in Germany. Available: https://www.ambientalrisk.com/interpreting-flood-risk-in-germany-under-a-changing-climate/

[19] Department for Environment, Food & Rural Affairs and Environmental Agency. 18 February 2021. Changes in property values on eroding coasts. Available : https://assets.publishing.service.gov.uk/media/602e6851e90e076606603759/Changes_in_asset_values_on_eroding_coasts._Technical_Summary_.pdf

customers.

Table 6: Physical Risk adaptation plans data considerations

Consideration	Relevance	Data and assumptions
Location of asset	Asset location is a key consideration for physical risk and will determine the requirement for any adaption plans. Some wider considerations are whether the location of the asset is fixed and option and cost of relocating the asset i.e., low cost of relocation means a lower cost of adaption.	Postcode/latitude -longitudes Property or moveable asset Local/ regional economy
Type of Asset/ Business	Some assets are more susceptible to physical risks whilst other assets may be able to be repaired. For instance, a car swept away may be completely written off whereas a property may only experience some smaller contents damage[20].	Asset class Lending type Secured/ unsecured
Existence or development of government schemes	Does the local Government have any plans for adaption which apply to the retail customers for example FloodRe schemes, relocation schemes which may mitigate losses/risks? It is also critical to understand the mechanics of how such a scheme impacts the lending/loan. As part of this, it is also important to consider the reliance on government schemes. If the market is solely supported by government schemes, there could be a substantial risk associated with the withdrawal the related government schemes.	FloodRe schemes Government strategy E.g., UK Flood and Coastal Erosion Risk Management Strategy[21]
Insurance	Insurance acts a key mitigant from physical risk for retail customers. Some key considerations are insurance coverage (% with insurance), type of insurance (% with the right insurance e.g., property and contents cover) and level of damage cover (does the maximum pay-out cover the LGD?). Other insurance considerations include general market trends. Will premiums increase and the level of cover reduce over time across higher risk assets? This could impact the amount covered by insurance as well as increase running costs. Insurance is generally considered an essential, but as costs rise, could this change and/or ultimately impact affordability? Another key risk to consider is that often insurance terms are far shorter than loan terms. This risks	Current cost of insurance Market trends on insurance coverage in case studies

[20] The same applies to SMEs where some industries will be far more protected from climate related physical risks such as a capital goods company that can rely on online services versus an agricultural farmer who relies on annual crop yield.
[21] UK Government. 07 June 2022. Flood and Coastal Erosion Risk Management Strategy Roadmap to 2026. Available : https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-strategy-roadmap-to-2026s

	creating a gap whereby insurance may not be renewed during the loan term. Lenders risk assuming that their customers continue to renew their insurance as required within mortgage terms and conditions (T&Cs).	
Type of lending and protection	The type of lending may also impact the approach for adaption. For example, the mindset of Buy to Let (BTL) landlords may differ from an Owner Occupier. The BTL landlord may be open to relocation whilst an owner occupier may be inclined to stay. Government schemes may also focus on protecting and mitigating activities on specific persons or businesses for instance the FloodRe schemes are not available to BTL landlords but available to owner occupied properties. This may also be relevant for government relocation schemes. Ability to price in risk and increased costs. For instance, BTL landlords in a strong market may be able to price in any increases in insurance premiums and the same applies for SMEs retailing consumer staples or essential goods.	Revenue generating properties or whether the property is a second home Ability for sector and industry to pass on costs to consumers Government history on physical risk to sectors and industries

Integration into scenario analysis

Physical risks are an integral element of climate scenario analysis. They have many impact mechanisms, several of which are discussed above. Given the typical horizons at which climate scenario analysis is carried out, e.g. 10 years or more, it is important that banks include clients' and customers' adaptation plans. The response options will add more realism to the climate modelling and risk management. Numerous examples of climate adaptation strategies have been provided. It is difficult to predict how well the economies will adapt and this will have a big impact on physical risks. Hence it is important for banks to represent this uncertainty in scenario analysis and to consider developing scenarios with varying levels of adaptation.

As the amount of information that needs to be processed can be substantial (even for a modestly- sized portfolio), third-party support can be invaluable in developing understanding around physical risk and adaptation strategies. If third party resource is adopted, a clear understanding is needed of the outputs, key assumptions and limitations.

Climate adaptation has an important role to play in bringing realism to climate scenario analysis. But it may be needed to be progressed in a proportionate manner. Smaller banks may first need to demonstrate that they have fully considered the material risks and assessed the response options qualitatively and possibly only selectively based on materiality, while paying the path to a more efficient inclusion of a full inclusion of clients' and customers' climate adaptation plans. When engaging with corporates and SMEs they also need to be cognisant of potential unintended consequences, for example, potential conduct risks from their business strategy to reduce lending or change lending policy at a critical time, especially to certain customer groups[22].

[22] Deloitte. 27 July 2022. Greening the mortgage portfolio: the challenges and conduct risks faced by lenders. Available : Greening the mortgage portfolio: the challenges and conduct risks faced by lenders

4. Embedding climate scenario analysis in decision making

Background and context

Previous sections have focused on scenario selection, sensitivity analysis and the inclusion of physical risk and climate adaptation plans. This section focuses on embedding climate scenario analysis in the business. Banks can use the outputs of climate scenario analysis in various ways. This can range from managing climate-related risks to identify 'green' opportunities that inform business strategies. This section explores a number of potential use-cases for scenario analysis across a bank's typical business and risk management activities and product offerings, whilst providing guidance for how scenario analysis can be effectively embedded in the decision-making processes of a bank to support these activities.

Prior to implementing climate scenario analysis, banks should consider a range of company specific factors and general principles. A non-exhaustive list of general considerations is provided here.

Banks should consider incorporating climate consideration within their business strategy and financial planning outputs. Once that position is approved, scenario and sensitivity analysis can be introduced to test that strategy for specific vulnerabilities that climate change may pose to the bank or the markets that it operates in. The level of scenario analysis undertaken should be proportionate and aligned to the materiality of climate related risks and opportunities faced by the bank.

Within the CFRF Scenario Analysis Chapter (June 2020) two timeframes were referenced:

- 1-5 years, which is the period during which boards typically operate to develop risk appetite, strategy and business plans;
- 3-5 years, a period in which banks can choose to assess the resiliency of their business model to macroeconomic stresses within the financial system over the capital planning horizon.

Scenario analysis across each of these timeframes are considered within this section:

- Baseline: A first step is establishment of a baseline view (this links with Section 1 – Climate Scenario Selection) and identifying a reference scenario whose narrative is compatible with the bank's internal baseline view. Externally available climate scenarios may specify a baseline which may employ very different macroeconomic, or policy assumptions compared with those employed directly by the bank. This could make comparisons of outcomes between the bank's own baseline and to those indicated in the scenario analysis exercise meaningless. Aligning assumptions, where practical to do so, is key to ensure meaningful interpretation of the results.

- Scenario selection: Banks would do well to identify the most appropriate and relevant scenarios for the portfolio/asset class under assessment, the business unit, or the group. This should take into consideration the socioeconomic context, geographies, climate policy landscape, emissions pathways, time horizon and climate outcomes (e.g., degrees of temperature increases), along with any other relevant components of the scenario. The scenario should be selected from industry-recognized and widely used sources with appropriate levels of documentation. Please refer to Section 1 for further information on the scenario selection process.

- Scenario output metrics: steps should be taken to select the most appropriate outputs to inform the use-case, considering both qualitative or quantitative outputs. This could include overall business strategy viability and alignment, or financial metrics such as earnings impact, credit risk ratings or capital ratios. The output variables should be consistent with any metrics or measures that are already used to inform the given use-case where possible to aid comparability. The bank should regularly review and confirm that the scenario, input data and output variables remain appropriate for the process. This is key to ensuring any decision-making is based on the latest science-based scenario.

- Understanding assumptions and limitations: there are several uncertainties and limitations associated with using scenario analysis, given the inherently exploratory nature of the activity. Climate scenarios can involve extremely long time-horizons and uncertain climate feedback loops and tipping points. This elevates the uncertainty in modelling future scenarios. It is important to ensure that users of scenario analysis and other stakeholders are aware of these assumptions and limitations to ensure the results can be interpreted and used appropriately in decision-making.

- General considerations: other practical considerations will also inform the shape of scenario analysis conducted within a bank. The materiality of climate risk to the business model will be an important factor in determining the level and nature of scenario analysis undertaken. Also, the nature of a bank's infrastructure will influence the deployment and maintenance of modelling solutions.

Business processes where climate scenario analysis may be useful

When considering where climate scenario analysis may be most useful for an organisation, it is helpful to start with the organisation's business process universe and assess applicability and materiality of climate risks to the process. To help inform this activity, Table 7 sets out a non-exhaustive list of relevant processes typically conducted in the banking industry, alongside high-level guidance on how climate scenario analysis might inform these processes.

Table 7: Business process applicability to climate scenario analysis

Processes to consider	Relevance of climate scenario analysis outputs
Client selection, onboarding and lifecycle management	Consider assessing clients for alignment to decarbonization targets and climate-related financial risk appetite at a client and portfolio level.
Pricing	Consider assessing whether pricing is adequate at a client and portfolio level, accounting for climate-related financial risks.
Product propositions and approval	Consider assessing whether climate-related financial and non-financial risks associated with the product structure have been adequately assessed and disclosed where appropriate.
Climate ambition setting and external commitments	When setting Net Zero targets appropriate transition pathways are selected by sector and portfolio. It can increase confidence in these external commitments if they are grounded in scenario analysis outcomes. [23]

[23] For related guidance, refer to section 3c of the CFRF 2022 guide on Mobilising Investment into Climate Solutions – Phase 1 Report

Processes to consider	Relevance of climate scenario analysis outputs
Credit analysis and application	Sanctioning of credit proposals can be informed by scenario analysis, including the identification of potential risks and associated mitigants.
Business continuity planning and location strategy	Climate scenario analysis can inform business continuity planning (e.g. avoid/manage physical risk concentration across different sites) and location strategy (e.g. assessing physical risks at a site level across various time horizons).
Third parties and sourcing process	Climate-related Net Zero and/or other external commitments for third party suppliers can inform strategic decision making.
Regulatory stress tests	Need to ensure relevant regulatory requirements are fulfilled and that the building blocks to deliver such requirements (e.g., data, people, process) are in place
Internal stress tests and sensitivity analyses	Ensure capabilities are developed to conduct internal climate scenario analysis, proportionate to size and complexity of the organisation.
Reverse stress tests	Ensure climate scenarios are appropriately considered in reverse stress testing scenarios, potentially identify material risks in the portfolio due to concentration in certain geographies or sectors.
Risk reporting	Ensure mainstream risk reporting packs include climate risk related metrics many of which are informed through scenario analysis.
Single name and portfolio level risk appetite	Ensure climate-related financial risks are adequately considered when setting single name exposure caps and portfolio level risk appetite metrics.
ICAAP	Ensure climate risks are reflected and/or considered whilst assessing capital adequacy, e.g. via assessing how the Pillar 2 macroeconomic scenario compares to a severe but plausible climate scenario within the time horizon.
Internal Liquidity Adequacy Assessment Process (ILAAP)	Opportunity to assess whether climate related risks can materially impact liquidity, e.g., via assessing whether there are sectoral or geographic concentrations with elevated climate risk amongst the primary sources of liquidity.
Macroeconomic forecast and Expected Credit Loss/Impairment calculation	Opportunity to progressively integrate the bank's view on the currently observed transition pathway into baseline macroeconomic projections and, consequently, Expected Credit Loss (ECL) calculations.

Processes to consider	Relevance of climate scenario analysis outputs
Risk modelling and quantification (e.g., PD, LGD models, country risk ratings)	Opportunity to consider incorporating climate scenario analysis and associated learnings in internal risk models, e.g. consider identifying principal drivers of climate risk through scenario analysis, and explore whether those variables/drivers are reflected in the existing risk models.
Credit authorities and approval	Enables an assessment of whether the creditworthiness and relevant credit parameters (e.g. the tenor, type of collateral) are impacted by climate related risks.
Corporate and financial planning (typically 3-5 years forward planning)	Opportunity to progressively integrate climate-related risks in corporate planning, both in the base view and testing resilience of the corporate plan against severe but plausible climate scenario(s) proportionate to the size and complexity of the firm.
External disclosures	Opportunity to leverage climate risk scenario analysis to deliver several of the Taskforce on Climate-related Financial Disclosures (TCFD) recommendations, e.g. assessing resilience of the firm's business strategy under various scenarios.

Results of the 2022 GARP Annual Survey (see Figure 4) indicated that more than 60% of the firms are using climate scenario analysis for assessing the financial impact of climate-related risk, risk identification, supporting strategy development, regulatory requirements or external disclosures.

Practical aspects of embedding climate scenario analysis in select organisational processes

From the longer list of processes set out in Table 7 above, this section focusses on two case studies, with actionable principles on how outputs of climate risk scenario analysis may inform these two processes. These case studies are client on-boarding and credit approval.

The details below provide useful context and explanation to the examples in the table. Besides providing guidance on use-cases, they demonstrate the wide range of data requirements and also the impacts this can have on the bank.

Case Study - Onboarding

A commercial bank could utilise both company-level and sector-level scenario analysis outputs in the onboarding process for new clients. This could involve:

- Calibrating sector-level risk appetite lending limits for industry sectors or sub-sectors using climate scenario assumptions for sectoral asset devaluation or lost earnings. This could be particularly relevant for sectors facing elevated transition risk in the nearer term, such as upstream oil & gas or thermal coal mining. Prospective clients would then need to be screened against these sector-level parameters prior to progressing to full lending application.
- Requesting and collecting climate scenario-specific input data in the onboarding due diligence process to facilitate company-level modelling throughout the life of the loan/product. This could include geo-location of client assets that could be pledged as

collateral, the emissions generated by the company or forward-looking capital expenditure plans for transition plan assessments. Non-existent or poor-quality input data is a persistent challenge in climate modelling exercises, hence, this step could be important to ensuring robustness of outputs in downstream processes.

- Incorporating a climate scenario stress into the financial analysis of the company as part of the credit assessment, by calculating climate-adjusted financial metrics.
- Identifying sustainable financing opportunities for clients with high emissions or poor transition plans and specifying climate transition KPIs as part of the lending application.

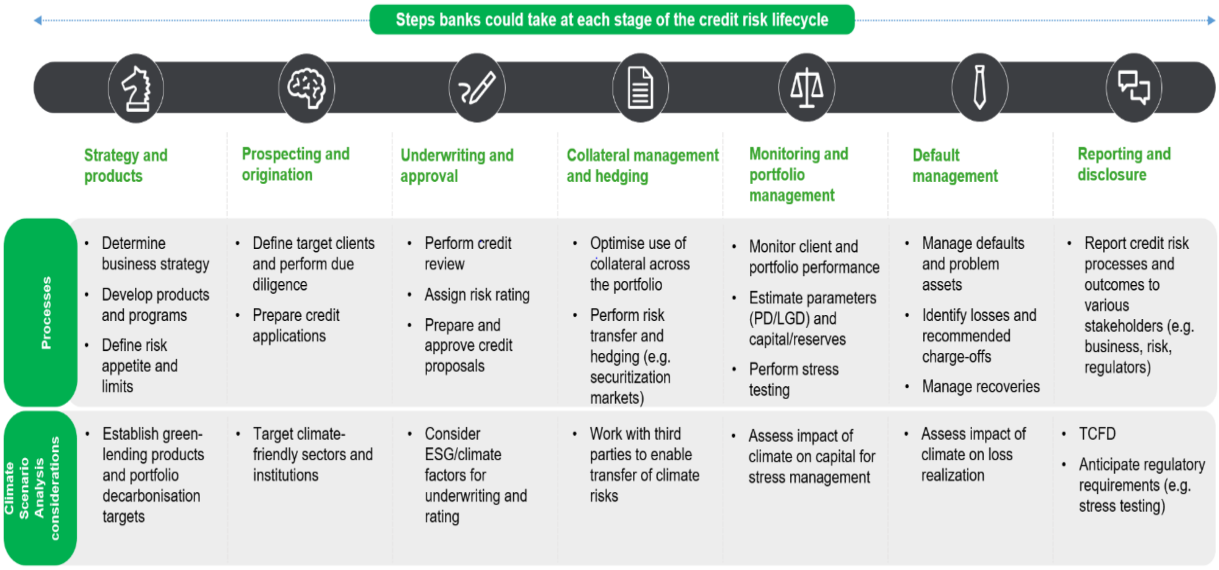
As an example, a new prospect client that is a conglomerate, Client A, is introduced to the bank. The client complies with domestic sustainability policies and has received several local awards for its ESG commitment. However, its climate-related objectives differs from Bank policy with the customer targeting net zero by 2060 rather than 2050 and using a narrower GHG definition, which only captures carbon dioxide and not other emissions, such as methane and nitrous oxide. Below are the key climate principles and considerations the bank should take when considering whether this client should be onboarded.

Table 8: Climate principles and considerations when on-boarding corporate clients

Principles	Client	Considerations
Data gathering – physical risk	Provided all asset locations to the bank	Client A is transparent. However, scenario analysis can help identify the level of expected physical risk.
Data gathering – emissions	Disclosed emissions	Client is transparent. However, Client A reveals that i) its NZ target is 10 years later than the bank's expectation and ii) its applies a narrower definition of GHGs. Scenario analysis can assist in understanding the gap that Client A presents to the bank's standards and, hence, suitability to on-board.
Data gathering – transition and adaptation plans	Transition plans are high level and lack substance / measurables	The lack of insight on how Client A intended to meet its already lagging transition goals would make decision-useful scenario analysis and, hence, risk management, more difficult.
Alignment to external commitments (e.g., Net Zero targets)	Client is targeting a 2060 NZ date rather than 2050	Risk of reputational damage through association of supporting a client whose NZ targets and calculation methodology do not reconcile with the financial institutions externally communicated targets. Negative reputational impact following failure to comply with externally communicated commitments leading to damaging investor activity and loss of business due to adverse media reaction. Regulatory activity could result in fines for non-compliance with the code of conduct and in a worst-case scenario, remove the banking license thus preventing the financial institution from operating. Depending on facilities requested by Client A, scenario analysis would provide insights on the ability of the Bank to meet its own financed emission targets, which would likely be more difficult if Client A was on-boarded.

Case Study - Credit approval

The below chart highlights the different stages of the credit risk lifecycle process and the climate scenario analysis assessments which banks can consider at each stage.



This case study illustrates how scenario analysis can be used to support the credit approval element of the credit risk lifecycle, even if individually a client may not be a comparatively significant GHG emitter.

As an example, a credit request is being assessed for a new-to-bank client, Client B, who is a market leader in providing internet connectivity services to offshore oil rigs. This is deployed via cables connected to the oil rigs with the client charging a fee to the rig owner to provide an internet connection for commercial use on the rig and personal use for the workers stationed there.

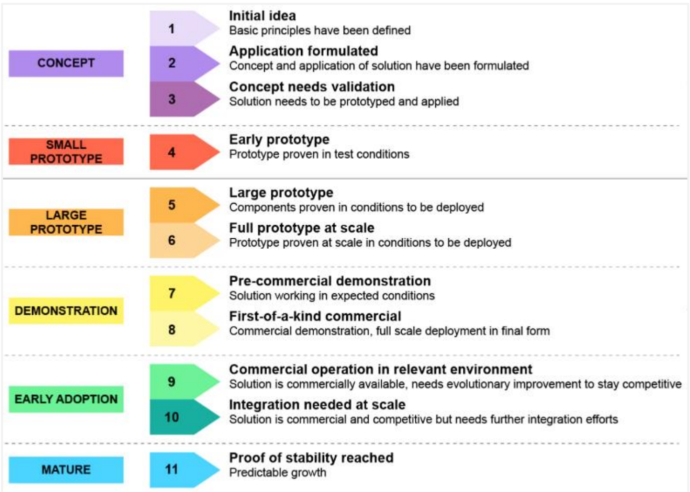
Table 9: Application of climate scenario analysis to the credit approval process

Principles	Client B	Additional considerations
Scenario analysis outputs – physical risk	Client's internet connectivity pipelines are coupled to offshore oil rigs (their customers). There is a risk that ongoing decommissioning activities in the sector could reduce the number of offshore oil rigs (customers) and therefore demand for services, in turn reducing income	Scenario analysis can provide insight to potential damage to client oil rigs and the undersea cables themselves in different physical risk hazards and consequent impact on Client B's financial position.
Scenario analysis outputs – transition risk	Client intends to transition into providing internet connectivity to offshore wind farms and the remaining oil rigs which will require increased digitisation. This appears acceptable in principle but lacking the detail to understand the cashflow implications of the transition to renewables	Scenario analysis can assist in calculating the level of expected revenue required to compensate for the loss of income from the decommissioned rigs and potential diminution of value of Client B's cable assets.

Principles	Client B	Additional considerations
Credit parameters - PD	Potential to downgrade the rating should decommissioning pace / reduced income post-transition impact covenant / debt performance	Scenario Analysis could help understand what would have to happen and, at which point a downgrade would be justified. The credit officer could then, in theory, structure the proposal to ensure this risk is mitigated.
Post sanction monitoring	Conditions of sanction Increase in carbon prices at lower threshold (e.g., if approaching USD 100) as client B is particularly sensitive to carbon price changes to decommissioning and renewable outlook and how could these impact deal viability	The scenario analyses should be dynamically reviewed and updated to reflect the latest decommissioning / transitioning position to ensure the most accurate and up-to-date understanding of the risks can be maintained.

The introduction to this section mentioned the use of climate scenario analysis in also identifying opportunities for banks, which will in turn have their own associated risks to be managed. This is prevalent in transition technology assessments which is a key consideration for banks in achieving their net zero ambitions. Each client and sector will have their own transition pathway based on their business model and the maturity level of the technology available at that time. The use of scenario analysis is an essential tool for banks to assess this pathway and identify both risks and opportunities.

The International Energy Agency (IEA) provides a technology readiness level scale (see below) which is used throughout the banking industry to provide a consistent framework to assess the maturity level of the technology. This is interlocked with several of the net zero pathways of the IEAs own scenario analyses and can be applied in each bank's individual scenario analyses. It is the responsibility of each bank to consider which level of technology readiness fits into their own risk appetite when considering scenario analysis, with the IEA providing further guidelines on their website.



Concluding comments

This chapter provided guidance on numerous topics around climate scenario analysis. Understanding the different use-cases for scenario analysis, and the benefits and drawbacks of using different scenario families should allow banks to make more risk-informed business decisions. As banks' scenario analysis capabilities mature, the need for more granular data will also continue to grow as will the availability of external enablers for scenario analysis. This guide should also serve to inform those banks that are selecting data vendors and collecting data from clients.

The chapter also provided some intuition on complementary tools such as sensitivity analysis. It was shown that sensitivity analysis can support decision-making and can, in some instances, fast track impact assessment. Recognising the climate emergency, this chapter also provided information on the inclusion of physical risk and climate adaptation plans. Giving regard to these should further enrich climate scenario analysis at banks.

Despite the substantial progress made here, the practices contained in this guide do not represent the endpoint of banks' scenario analysis journey. Supervisors and other market stakeholders will expect banks to continue to make progress, with scenario analysis becoming increasingly integrated into banks' risk management and decision-making processes, as highlighted in the last section of this chapter.

All the themes explored in this guide could benefit from further exploration. Additional consideration of how scenario analysis can support banks' execution of their transition plans would be useful as the development of transition plans (both inside and outside of the banking industry) becomes more widespread, noting especially the industry-wide commitments to net zero. The modelling of physical risk within climate scenarios also needs further exploration. Further analysis is also needed on how banks can leverage existing their stress testing infrastructure and capabilities for different climate scenario analysis use-cases. Knowing what can be leveraged, and where the gaps are, would help banks identify where investment in new capabilities is required for climate scenario analysis and stress testing.

Climate scenario analysis practices will continue to evolve in conjunction with developments in public understanding of how climate risks are materializing and the impact they have on natural capital. Future iterations of this guide could also explore the relevance of scenario analysis in better understanding the nature and climate nexus and go on to evaluate the impact of nature-related financial risks on banks.

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