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The Predictive Power of Stress Tests to Tackle Climate Change

Contents

Foreword

Climate change has become observable in every continent and has started to influence national economies. The complexity of climate change poses tremendous challenges for all industries. In the era of increased global warming, we must make headway with climate-related analysis to quantify its material impacts. Building projections using plausible trajectories is essential not only to measure risks, but also to seize opportunities in the transition towards a low-carbon economy.

Increasing the pace of the low-carbon transition relies on the decision-making processes of economic actors. As the impacts of climate change on the economy and society increase, the importance of developing informed and strategic responses becomes fundamental to deal with the associated uncertainty related to climate change. Consequently, climate risks have risen to the top of the agenda for the financial industry. Financial institutions have a significant responsibility to take action against climate change, and the urgent assessment of climate risks is necessary to make the right decisions. Banks have an important role to play.

leveraging existing approaches and transforming methodologies is a core part of establishing climate-related exposures. To exhaustively build a climate-related plan of action, financial institutions must go further in climate scenario analysis and climate stress test methodologies to provide a 'what-if' analysis reflecting potential future conditions.

We are in contact with banks from all over the world, actively discussing the implementation of climate stress test frameworks, the level of progress in terms of climate scenario development and governance which needs to be applied in relation to climate risk assessment. The core insights of this paper are the following:

- Financial institutions have an important role to support the low-carbon transition and the starting point is to identify climate-related risks and opportunities.
- The development of a climate stress test will become a regulatory requirement in the years to come, therefore a quantitative assessment using advanced analytics is needed. Current climate assessment tools do not adequately cover the impact of transitional and physical risks, there is a need for more comprehensive methodologies.
- Stress test frameworks leverage forward-looking scenarios to outline the financial impact of climate change, and the output can be used in other processes, including strategic decision making. A use case we conducted on the automotive industry portrays the material shifts of risk-related KPIs due to climate change.
- The success of climate stress test implementation depends on effective change management and governance.

Insights are globally valid, as the nature of the problem and related challenges concern every country, and collective action needs to be taken to exhaustively understand climate risk and opportunities. This report will provide further insights on the topic of climate risk assessment, yet one thing is certain: climate risk assessment and climate stress tests for the financial system are emerging in order to make uncertainty more certain.

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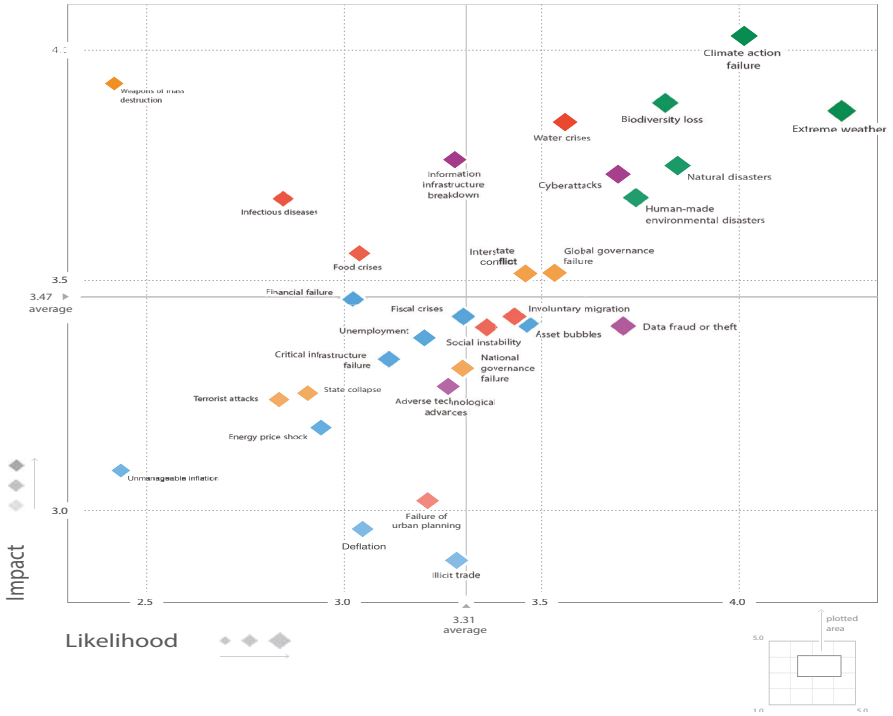
1.Introduction to climate risk assessment in the banking sector

The science of climate change has been actively researched over the past decades. As scientific consensus has emerged and the understanding of climate change has improved, the complexity and the uncertainty of the issue has developed. The frequency of abnormal natural phenomena has increased globally and climate change has emerged as a major disruption factor in today's economy. The OECD has announced that, in the absence of mitigation actions by 2100, global GDP could decrease by up to 12%[1].

Climate change is perceived to generate the most significant risks to the global economy[2] According to the World Economic Forum's 2020 Global Risks Report, climate related global risks 'extreme weather events', 'failure of climate-change mitigation and adaptation' and 'natural disasters' are classified as top three risks in terms of likelihood. According to the results of the Global Risks Perception Survey conducted by World Economic Forum, they are considered more likely to happen than data fraud and cyber-attack risk in the scope of global risk[3]. In terms of both likelihood and impact, climate-related risk is considered a top risk, which demonstrates the need for a climate risk assessment.



Therefore, climate change introduces different risks that can affect the stability of the financial system, especially for financial institutions. Even though climate risk could become a global and systemic financial risk for financial institutions[4], it is poorly understood by financial institutions.
The urgency of assessment regarding the non-linear, unpredictable and irreversible nature of climate change requires the creation of a comprehensive climate risk assessment approach. **Banks should develop an exhaustive methodology such as climate stress testing,** which will enable financial institutions **to assess climate risks to support and seize opportunities from the transition**.

Climate-related risk channels

Climate-related financial risk can have an impact on financial stability through three types of risks:

- Physical risks arising from extreme meteorological and climatological events;
- Transition risks arising from the transition to a low-carbon economy;
- Liability risks which are triggered by the increased compensation paid to economic actors affected by climate change.

As a primary assessment of climate risks, both types of climate risks should be included in analyses. When liability risks are substantiated based on the results of climate change-related lawsuits, they should be also included in scenario-based climate analysis.

1 *OECD (2016). The Economic Consequences of Climate Change*
2 *The Global Risks Report (2020). Retrieved from https://www.weforum.org/reports/the-global-risks-report-2020*
3 *An uncertain event or condition that, if it occurs, can cause a significant negative impact for several countries or industries within the next 10 years.*
4 *AFEP (2018). Shift Project Report on Climate Risk Analysis*

Overview of climate risks	Types	Origin of the Risk	Sector Examples	Importance
Physical Risk	Acute Risks Chronic Risks	A physical risk is the risk resulting from extreme events due to climate change.	Energy-related sectors: Reduced output, damage to infrastructure, changing seasonal demand and increased electricity losses due to the increased frequency of extreme events	The unpredictability related to extreme events in terms of time frame, frequency and magnitude increases the disruptive impact of physical risks.
Transition Risk	Policy and Legal Risks Technology Risks Market Risks Reputation Risks	Climate risk resulting from mitigation challenges as societies decarbonize. To stimulate a low-carbon transition, governments will need to take action which will naturally impact the economics of borrowers.	Energy-related sectors: Risks associated with GHG emission reduction policies such as carbon taxation, constraints on consumption to support the low-carbon energy transition. Agriculture sector: Risk arising from policies aimed at changes in land-use and farming practices.	The speed of socio-economic responses significantly affects the impact of transition risks, they are material even in most sustainable climate scenarios.

Effective climate risk-related portfolio management relies on addressing physical and transition risks. Considering climate-related exposures in a quantitative framework is the most prominent way to embed climate risks in strategic decision-making processes and ensure successful portfolio management.

Growing agenda on climate-related risk at international level

The 'Tragedy of the Horizon[5] ' started to be broken after the COP 21, which led to an international climate agreement -Paris Agreement - which aimed to keep global warming below 2°C following analysis provided by the International Panel on Climate Change (IPCC). Moreover, IPCC provided many reports on scientific work for climate-related policymaking, which includes giving notice on the increasing global average temperatures. The IPCC predicted that, if action is not taken, temperatures will exceed the Paris Agreement target as early as 2030.[6]

Climate risk assessment continued to gain popularity in the scope of climate disclosures with the establishment of industry-led group Task Force on Climate-related Financial Disclosures (TCFD) in 2017, as well as increased regulatory momentum regarding climate change-related issues. Improved disclosure led to an increase in the interest of quantification of climate-related risk assessment.

Momentum towards quantifying climate risks in the financial sector has been established with the help of private and public stakeholders, research institutions, business intelligence firms and think tanks, which are working actively on climate risk assessment. Even though there were numerous reports published by many actors including regulatory authorities, academic institutions, NGOs, think tanks, etc., the subject of climate risk assessment related policies remained vague and in the form of recommendations as they aimed to introduce climate risks and facilitate

5 BIS (2015). Mark Carney: Breaking the tragedy of the horizon – climate change and financial stability https://www.bis.org/review/r151009a.htm

6 IPCC (2018). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C.

their integration. Initial methods have been developed by institutions to move forward with the climate risk assessment, which focused on methodologies similar to stress tests of financial institutions. Stress tests are now considered key elements to understand, quantify and forecast the financial impact of climate risk in order to assess physical and transition risks in different plausible scenarios.

Large economies are starting to invest in research on robust forward-looking approaches to establish climate-related decision making to decrease the uncertainty surrounding the effects of climate change at local and regional levels[7]. That is the reason why central banks started looking into the assessment of climate-related risks to measure the resilience of the economy on a regional level. For that purpose, the Network for Greening the Financial System (NGFS) was established by the central bank of France (Banque de France) in 2017 to bring together central banks to analyze the transmission channels of climate-related risk and to develop best practices.

In the following year, NGFS published the report on 'A Call for Action' which ignited collective action by central banks, supervisors, and policy-makers to integrate climate risks in financial stability monitoring and supervision.

Regional initiatives

Europe:

- In 2016, the European Systemic Risk Board published the report 'Too late, too sudden: Transition to a low-carbon economy and systemic risk', to demonstrate the potential impacts of the transition to a low-carbon economy within its benign scenario and an adverse scenario. The report signals the arrival of 'carbon stress tests' in the case of material climate-related systemic effects and highlights the importance of research and consultation to reconfigure policies.
- England: The Prudential Regulation Authority (PRA), which is the financial services regulatory body of the United Kingdom, announced that exploratory stress tests will be set for insurers and banks to examine the UK financial system's capacity to withstand climate-related risks, including physical and transition risks. Currently, exploratory climate scenarios have been added to the 2019 Insurance Test. According to the PRA discussion paper published in December 2019, the biennial exploratory scenarios for banks will be launched in the second half of 2020 and the results will be published in 2021[8]. Climate risk modeling will be conducted on 30-year horizons and the exercise will include three scenarios which depend on the speed of the policy action (early policy, late policy, no additional policy scenarios).
- France: In the last quarter of 2019, in Paris, the central bank of France (Banque de France) announced the arrival of climate change stress tests for French banks and insurers in which financial institutions would be stress tested against two or

three adverse climate scenarios, following the reports of NGFS and ACPR which will be published in the first quarter of 2020. The tests will consider multiple modeling horizons such as 2025, 2030 and 2040, which are significantly higher than current 3-year time-horizons of stress tests (see section 2.1). The tests are expected to consider physical and transition risks aggregated on a sectoral and geographical level.

- The Netherlands: The central bank of the Netherlands, De Nederlandsche Bank (DNB), performed an energy transition risk stress test exercise that includes a stress test in risk management, and concluded on the existence of an impact on the assets of Dutch banks, insurers and pension funds. According to the stress test it conducted, there are substantial losses for Dutch banks due to climate change.
- National stimulation was supported by European-level action. The European Commission published guidelines on reporting climate-related information while funding a significant amount of institutions working in the climate risk assessment field. The European Central Bank president highlighted the importance of central banks in mitigating global

7 *OECD (2017), Investing in Climate, Investing in Growth*

8 *Bank of England (2019). Retrieved from https://www.bankofengland.co.uk/paper/2019/biennial-exploratory-scenario-climate-change-discussion-paper*

warming, and assured the European Parliament by stating that the discussion on central banks' role is considered a priority. Europe cannot achieve its 2030 goals without urgent action during the next 10 years, and the financial community will play a major role in promoting sustainable stability. European supranational organizations are therefore working actively in view of adopting a long-term EU strategy for climate action in 2020, which is observable in the European Banking Authority's Action plan on sustainable finance. The plan clearly states that banks should identify their vulnerabilities to climate-related risk and quantify the relevance of the exposures that could be affected by physical risk and transition risk.

- EBA is developing a climate risk assessment methodology to identify banks' vulnerabilities and to quantify the exposures which will be impacted by physical risks and transition risks. The aim is to help financial institutions to understand and conceptualize their climate risks.

North America:

- Canada: In its 2019 Financial System Review, Bank of Canada listed climate change among the top concerns for the economy. Bank of Canada announced a plan to integrate climate shocks, and started working on ways to apply a stress test to assess resilience.
- USA: The USA initiated a withdrawal from the Paris Agreement. Alongside this, a senate bill was introduced[9] to make the Federal Reserve study climate-related risks and their impact on the financial system. The Climate Change Financial Risk Act will lead the central bank to establish a union between climate scientists and economists, in order to make progress with climate change scenario analysis and financial stress tests. The Fed signaled the incorporation of climate change, which will be taken into account when setting monetary policy.

Asia/Pacific:

- Australia: The Australian Prudential Regulation Authority and the Reserve Bank of Australia are expected to adopt a series of stress tests to measure the impact of policy shocks related to climate change (e.g., potential policies to limit emissions).
- China: Bank of China adopted a macroprudential framework that gives incentives to banks to finance green activities, and work on climate stress tests is expected.
- Singapore: The Monetary Authority of Singapore has announced key measures to promote green finance, and mentioned climate-related scenario tests in the Financial Stability and Stress Testing Report of 2019 in order to measure the impact on general insurers
- There is undeniable worldwide regulatory pressure on banks in terms of assessing climate risks. On each continent, different levels of policy actions are emerging. According to PRI's The Inevitable Policy

9 *Climate Change Financial Risk Act of 2019 (2019) Retrieved from: https://www.schatz.senate.gov/imo/media/doc/Climate%20Change%20Financial%20Risk%20Act%20of%202019.pdf*

Response project, policy announcements will accelerate between 2023 and 2025[10]. The development of a climate stress test will likely become a regulatory requirement in the years to come, and it is expected to be included in the next stress test exercise of the European Central Bank. Therefore, the bottom line is that banks need guidance and an exhaustive methodology to assess climate risk using advanced analytics.

All economic figures are affected by climate-related risks; banks are impacted in a particular way since through loan-related activities, banks are linked to many sectors which can be vulnerable to the physical and transition risks imposed by climate change. In addition to the regulatory spotlight as climate-related risks increase each passing year, incorporating the assessment of climate-related systemic risks has started to receive more attention by financial institutions, which is demonstrated by numerous recent initiatives related to the topic.[11] Climate risks' impact broadly differs depending on banks' portfolio management strategies and the socio-economic conditions in which they operate.

Therefore, in general, some banks can be more vulnerable to climate risks than others. For instance, within the scope of corporate loans, banks in underdeveloped countries have some disadvantages since there are fewer corporates assured and less Nationally Determined Contribution (NDC)[12] implementation, which increases the impact of climate risks. Nevertheless, banks are largely diversified in different sectors, and successful portfolio management decisions can help financial institutions to seize opportunities if they identify, evaluate and build a strategy according to climate risk assessment. Financial institutions, especially banks, are a vital element for making progress with risk assessment.

10 *UNPRI (2019). Retrieved from https://www.unpri.org/climate-change/the-inevitable-policy-response-policy-forecasts/4849.article*

11 *Deloitte (2019). Climate Risk: Regulators sharpen their focus*

12 *UNFCCC definition: Nationally determined contributions (NDCs) are at the heart of the Paris Agreement and the achievement of these long-term goals. NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change*

2. Current risk assessment tools used by banks

A typical risk management approach consists of four stages: risk identification, risk evaluation (or measurement), monitor and possibly reporting on the risk. The approach should take into account the potential guidance of regulatory authorities. The aim is to assess the likelihood of the risk playing out, to judge the magnitude of the material impact on the institution's portfolio, to estimate the likely timeframe and duration over which the risk plays out and the velocity with which corresponding materialization can be expected, noting that with some risks (like cyber) the risk arrives suddenly and strikes with immediacy, and other risks - such as macroeconomic downturns - a slow-burning impact can be expected.

Banks' lending, market portfolios and allocation of asset classes constitute an important part of bank balance sheet management. Therefore, it is essential to review the existing risk management frameworks of banks to understand when and how to add a climate component.

Carbon footprint and budget approaches

As financial stability is threatened by climate change, stakeholders have engaged more in climate risk assessment within the scope of risk management. The earliest frameworks have been developed to ensure that financial institutions start taking climate risks into account. Climate risk assessment frameworks can be categorized into the following:

- Frameworks which assess the impact of financial institutions on climate change;
- Frameworks which assess the impact of climate change on portfolios.

Alignment-related tools to reduce institutions' carbon footprint have increased the recognition of transition risks. Specifically after the creation of climate-related reporting frameworks and the establishment of the TCFD (see annex), many banks started to make progress on reducing their emissions. However, these frameworks - which mainly consist of scenario-related targeting and carbon footprint alignment tools - do not adequately cover the impact of transitional and physical risks and are currently used

Simplified typology of decision-making processes in the context of traditional risk-related banking activities [13]

	Front Office Functions	Risk Management Processes
Banking Portfolio	Lending	Making provisions for losses regarding IFRS 9 standards
		Setting a loan limit
	Changing the composition of a bank loan portfolio	Checking portfolio compliance with risk appetite
Market portfolio	Increasing or reducing a position	Setting an investment limit
	Changing the composition of a market portfolio	Checking portfolio compliance with risk appetite
Assets and Liabilities	Defining the optimal allocation between major asset classes	Checking the institution's solvency (compliance with the risk appetite framework and the regulatory ratio)
	Defining the institution's optimal financing	Checking the institution's liquidity (compliance with the risk appetite framework and with the LCR and NSFR regulatory ratios)
		Checking compliance with stress tests (internal and regulatory)

13 *I4CE (2019). For another approach to climate risk in finance: Taking uncertainties fully into accoun*t

in internal operations. They rarely cover investment and financing activities (so-called scope 3 emissions)

The Science Based Target initiative (SBTi) is a joint initiative between Carbon Disclosure Project (CDP), UN Global Compact (UNCG), World Resources Institute (WRI) and the WWF. It allows companies to develop a greenhouse gas emission reduction target to limit global warming well below 2°C, which is consistent with the recommendations made by the science community. Target setting elements consist of transforming the carbon budget or GHG budget, when applicable, to an emissions scenario, and represents an allocation of the available carbon budget. Targets are marked out by scenarios to establish key benchmarks and the minimum ambition. A sector-based approach is being developed to increase target granularity. The aim is to be aligned with today's necessities (e.g., Paris Agreement goals) and to help companies gain a competitive advantage in the low-carbon transition.

ESG heatmaps

ESG heatmaps provide an assessment of ESG risks per portfolio in terms of a heat score. Outside-in, the heatmaps published by UNEP FI Principles for Sustainable Insurance (2018)[14] can provide a starting point, while financial actors need to map the information to their portfolios, in the long run considering the EU taxonomy for ESG risks in this mapping. In particular, heatmaps can serve to identify ESG risk concentrations in existing portfolios.

Re-insurance companies issue Catastrophe bonds (CAT) and insurance-linked securities (ILS)to hedge their ESG risks, while investors in such securities are ESG risk takers. Since the underlying ESG risk factors are not tradeable, the valuation of these securities is based on the real-world probability measure rather than the risk neutral probability measure.

ESG risk-based methodologies fall short in creating quantitative results which can be applied to multiple risk management processes and strategic decision making. Assessing financial risks from climate change is an intricate process, therefore new tools and approaches such as climate stress tests need to be developed to systematically assess physical and transition risks.

Sector Policies

To ensure that the risks management system is controlled coherently, new risk assessment approaches such as climate risk assessment must include limits and related standards concerning the banks' main risks, as well as different risk strategies for each sector. For this purpose, an EU taxonomy was published to provide details on activities which are considered environmentally and socially sustainable.

Defining sector policies is a way that banks take appropriate measures to meet their sustainability standards. Sector policies evolve over time depending on regulations, on discussions made between financial institutions and their various stakeholders. Currently, banks' common sector policies revolve around setting targets to encourage the financing of climate-friendly sectors and adopting policies to exit sectors which have the most negative impact on climate change. For instance, many banks have stopped funding coal and other industries. However, as climate risks are not integrated effectively in risk assessment methodologies, portfolios which are more exposed to physical and transition risks are not yet identified. Banks need to go further in identifying sectors and sub-sectors which are more sensitive to climate risks. Depending on the nature of the portfolio, these sub-sectors can be found even in greenest, non-polluting sectors.

Stress Test Methodologies

Stress tests analyze how portfolios, and therefore banks behave under various hypothetical macroeconomic scenarios of the future and are formed by a set of assigned variables. A typical stress test includes a scenario, accompanied by a

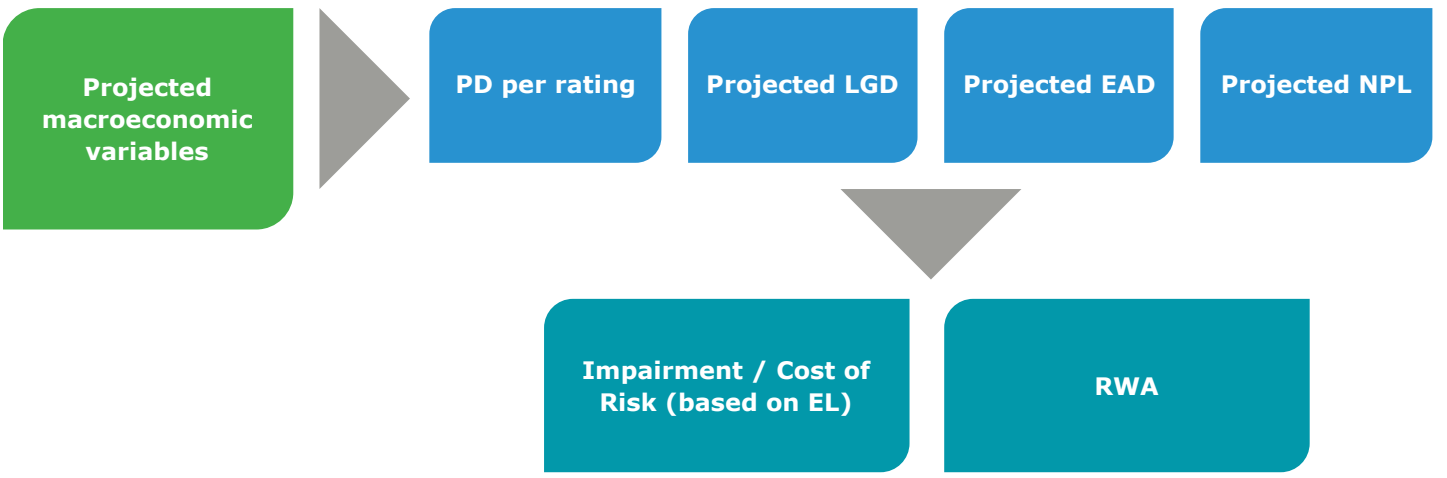
CRITERIA	THEME	RISK CRITERIA	RISK MITIGATION EXAMPLES & GOOD PRACTICE	ECONOMIC SECTORS																						
				Agriculture/ Livestock	Agriculture/Fishing	Agriculture/Paper & Forestry	Chemicals	Defense	Electronics/ Technology	Energy/Operation	Construction/Coal	Construction/Hydro Dams	Construction/ Nuclear	Exploration & Construction/Oil & Gas	Production of Fossil Fuel Vehicles from Oil & Gas	Finance (depending on client and/or transaction)	Gambling	Healthcare/ Pharmaceutical/ Life Science	Infrastructure/ Construction	Food/Beverage Manufacturing	Garment Manufacturing	Real Estate	Utilities (Waste & Water)	Mining	Transport/Shipping
Environment	Climate change	Air pollution, greenhouse gas emissions, and transition risks	Disclosure of climate-related emissions in operations and/or products (e.g. CO2, CH2, N20, HFCs, PCFs, SF6)																							
			Breakdown of fuel/material/carbon intensity mix relevant to the client or transaction (e.g. power generating mix or by economic sector intensity)																							
			Environmental & social impact assessment (ESIA) covering negative health impacts, mitigation and decommissioning where relevant																							
			Decarbonisation transition plan/targets																							
		Physical risks (e.g. heat, wildfire, extreme precipitation, flood, windstorm, tropical cyclones, sea level rise, water stress)	Nature-based solutions (e.g. sustainable flood or coastal defence management, broader climate resilience adaptation plans)																							

14 UNEP FI Principles for Sustainable Insurance (2019) Retrieved from https://www.unepfi.org/psi/wp-content/uploads/2019/02/PSI-Guidance-for-non-life-insurance-underwriting.pdf

covering narrative, a set of models for evaluating a range of risks under stress, followed by both a quantitative or qualitative impact assessment of the outcomes, and commentary on remediation or strategic management responses. A stress test involves a portfolio level assessment (top-down mechanism) reinforced with borrower-level calibration (bottom-up mechanism).

Following the global financial crisis, regulatory stress testing exercises have increased, and stress test outcomes became more essential as they inform regulators on banks' resilience to a range of stresses and their potential systemic effects. Current stress test exercises are applied over a period of 3 to 5 years. The scope of the exercise covers credit risks, market risks, securitization risks, sovereign risks, net interest income risks, operational & conduct risks and forbearance under baseline, adverse and severely adverse scenarios.

The methodology within the scope of credit risks can be summarized below:



Probability of Default (PD): PD describes the likelihood of a default over a particular time frame. It provides an estimate of the likelihood that a borrower will be unable to meet its debt obligations.

Loss given default (LGD): LGD is the share of an asset that is lost in case of default and its projections are based on the bank's recovery rate

Exposure at default (EAD): EAD is the total value to which a bank is exposed at the time of a loan's default.

Non-performing loan (NPL): Non-performing loans or exposures are those that satisfy either of the following criteria: (a) material exposures that are more than 90 days past due; and (b) the debtor is assessed as unlikely to pay its credit obligations in full without realization of collateral, regardless of the existence of any past due amount or of the number of days past due.

Expected loss (EL): The sum of the values of all possible losses i.e., PD*LGD*EAD

Risk-weighted asset (RWA): Within the scope of credit risk, RWA is a measure for capital requirements compliant with imposed capital adequacy requirements. It affects the amount of capital the bank needs to retain.

A robust stress test exercise can help banks make better decisions during potential downturns and can facilitate the development of related action plans. Financial institutions should see stress tests more than just meeting the requirements imposed by new mandatory exercises and see it as a tool to have an exhaustive understanding of potential risks. For example, a bank can establish a more aggressive strategy in certain loan segments to take more market share going forward, by assuring the existence of sufficient capital to withstand extreme stress scenarios. Beyond strategic decisions, banks can enhance performance and internal governance by incorporating stress test results in other banking activities.

Challenges related to adding a climate component to existing stress tests

Climate scenarios can be used in a similar manner as macroeconomic scenarios and estimate the impacts of credit risk parameters which can be used when calculating the change in P&L. Therefore, stress tests can be transformed into a climate stress test, however there is still much to be done:

- **Integrating portfolio level and borrower level analysis mechanisms related to climate scenarios** Shifts in risk parameters need to depend on both the portfolio level sector effect and on different response rates of counterparties
- **Lack of high-quality historical data** Climate stress tests must capitalize on existing data, but as climate-related historical data is not sufficient, top-down approaches must be combined with intensive bottom-up mechanisms.
- **Extending scenario time frames** Depending on the maturity of certain portfolios, a methodological transformation is needed to forecast by using climate scenarios which cover up to more than 50 year-long periods.
- **Integrating transition risk assessment in the short term** As the impact of climate risks - especially transition risks - are starting to materialize faster in shorter periods, a significant increase in financial risk parameters is expected in the short/ medium term.

Existing Internal Capital Adequacy Assessment Processes (ICAAP)

The risk appetite and closely related decision-making strategies can be only executed with the existence of a robust risk culture which will ensure banks operate in accordance with their risk appetite.

Banks are not forced to choose a specific risk quantification technique, however 'it is the responsibility of the institution to quantify its risks and to determine projections' (ECB Guide to ICAAP, 2018). As forward-looking stress tests enable banks to forecast their capacity under normal and stressed conditions, embedding stress testing into ICAAP will lead to effective definition, monitoring and reporting of the risk profile. It is fundamental to incorporate a stress testing framework in ICAAP to achieve a clear definition of capital adequacy to form methodologies used to evaluate capital adequacy.

Risk appetite includes the sensitivities of risk type metrics used for scenario analysis and stress testing. Therefore, the integration of the climate component to traditional stress tests can create a positive feedback loop

between banks' high-level strategic plans on sustainability, by generating the information flow necessary for the continuity of sustainable portfolio management.

The risk appetite statement will be affected by the integration of climate risks, as it is closely related to risk management practices and sensitivities. As ICAAP processes transform with the climate stress tests, banks can forecast the climate related evolution of sectors and climate-related financial impacts, and thus maintain a consistent climate strategy.

The current practices of banking institutions are not adequate for the integration of climate modeling. *To add a climate component to existing banking activities, existing risk assessment tools need to be transformed. It is not sufficient to apply climate quantification in only some of the decision-making processes, therefore outputs of climate stress tests should be consistently utilized in all risk management related activities. Therefore, banks need to evolve their existing risk methodologies to introduce climate stress test methodology and related governance.*

3.Building an appropriate climate stress testing framework in the scope of corporate loans

Stress test analysis has the capacity to answer questions a bank might have on climate-related risk. Therefore, banks can leverage the macroeconomic and financial stress testing framework and integrate a climate component to make climate stress tests coherent with their existing methodologies.

- The ideal climate-related stress test methodology should include the following:
- Portfolio Analysis
- Scenario Selection
- Stress Test Methodology
  - Top-down Mechanism
  - Bottom-up Mechanism
- Calibration
- Impact Assessment

Stress testing offers combined depth and flexibility to incorporate both qualitative and quantitative considerations from a range of risks, and an aggregate analysis that links the risks with their financial implications and a remediation plan (strategic actions).

Step by step approach to climate stress-testing

Step 1 - Portfolio Analysis
Understanding the portfolio is a key step in building climate stress tests. As a climate risk assessment requires extensive resources, data and analysis, the most vulnerable sectors need to be prioritized. This can be done via portfolio analysis, which consists of reviewing existing portfolio asset allocation in terms of defined sectors and sub-sectors. For this purpose, three crucial analyses need to be performed.

First, sector exposure needs to be checked to detect primary concern sectors. Secondly, more detailed analyses need to be performed. For instance, the geographical distribution of the portfolio needs to be assessed to verify:

- The proportion of assets in zones which are more exposed to a substantial increase in physical risks (i.e., potential intensity of extreme weather events)
- The geographies where low-carbon transition speed is low and therefore transition risks are significantly elevated

A maturity analysis of the portfolio is fundamental for choosing the horizon of the climate-related analysis, as a methodological transformation is required to integrate longer horizons of climate scenarios. The sectors which have longer horizons will be better suited to applying a climate risk-related assessment, since the current portfolio is exposed to climate risks to a greater extent.

The horizons of the current stress test methodologies are not coherent with the climate risk occurrence horizon. Within the scope of corporate loans which have relatively shorter maturity, differing horizons of physical and transition risks should be considered in order to interpret the climate risk impact on banks' different strategic processes:

Expected time horizon at which climate risks will likely materialize		Banks' Strategic Processes					
		Banking Portfolio		Market Portfolio		Assets & Liabilities	
		Loan-related Activities	Risk Appetite Framework	Investment-related Activities	Risk Appetite Framework	Solvency & Liquidity	Compliance
Climate-related Risk Channels	Physical Risk	Short-term material effects	Long/Medium-term material effects	Short-term material effects	Medium-term material effects	Medium/Short-term material effects	Long/Medium-term material effects
	Transition Risk	Short-term material effects	Medium-term material effects	Short-term material effects.	Medium-term material effects	Short-term material effects	Medium-term material effects

Source: Authors

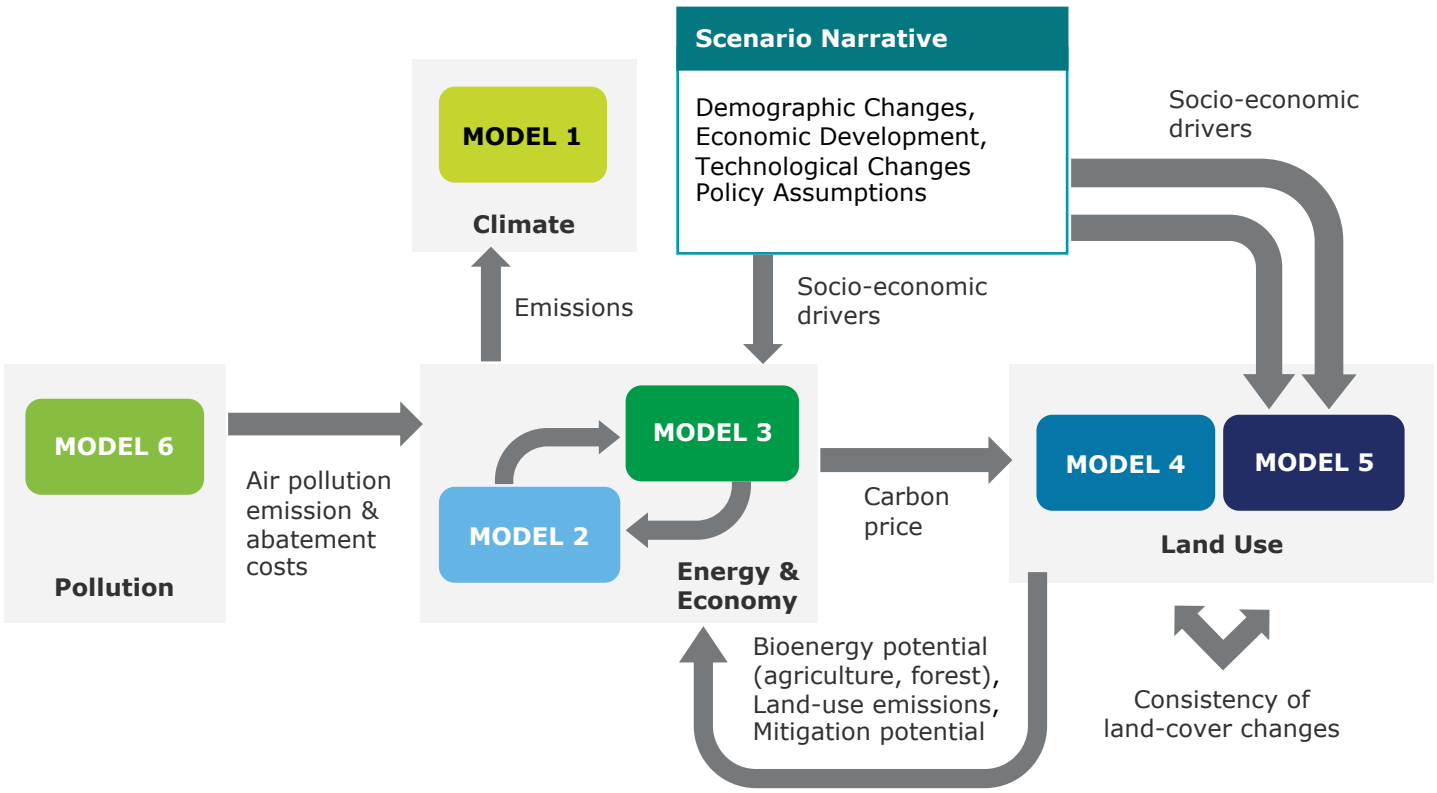
Horizon selection should take into account both the maturity of the portfolio and expected time horizons at which climate risks will likely materialize.

Step 2 - Scenario Selection

A forward-looking scenario analysis enhances strategic thinking and provides meaningful insights on climate-related risks and opportunities. To ensure meaningful pathways, scenarios need to be chosen to be transparent, granular, reliable and complex enough to integrate different kinds of parameters and to assess their impacts.

To perform stress tests, financial institutions need to establish downscaled climate scenarios. Thus, they need to leverage reference climate scenarios. Temperature-based scenarios created by research institutions are the most advanced type of reference scenarios, however as they are not primarily created for financial risk assessment, they need to be modified

For example, reference scenarios should be geographically downscaled depending on the nature of the portfolio. To model different climate-related modules simultaneously, there are climate scenarios which can simultaneously demonstrate relations between different domains such as the economy, energy and the climate:[15]



Advanced climate scenarios provide a climate output which demonstrates the interlinked impact between socioeconomic, demographic, macroeconomic and technological evolution. Thanks to integrated assessment modeling (IAM) techniques, advanced reference scenarios provide a complete set of outputs which are key to model transition risks. The combination of different IAM models (which are compatible with global climate models) can make the scenario's narrative more fitting with the objectives defined for the climate-related assessment. Complex scenarios which consider both mitigation and adaptation challenges to shock portfolios' resilience can lead the banks to consider physical and transition risks.

15 *Representation adapted from the IIASA IAM Framework*

Reference Climate Scenarios
The International Panel on Climate Change (IPCC) use the following scenarios:

RCPs: Representative Concentration Pathways (RCPs) were developed primarily for evaluating parameters related to physical risks, and it is a set of climate scenarios based on different levels of GHG concentration. Each RCP targets a different level of radiative forcing and shows how the climate system develops accordingly without taking into account socio-economic changes.

RCP 2.6, 4.5, 6.0 and 8.5 are the four main RCPs scenarios arising from the Intergovernmental Panel on Climate Change's (IPCC -GIEC) 2014 fifth assessment report (AR5).

RCP 2.6

Developed by PBL Environmental Assessment Agency, Netherlands

RCP 2.6 predicts a future where there is an ambitious reduction of GHG emissions which becomes net negative before 2100, align with the Paris Agreement.

RCP 8.5

Developed by International Institute for Applied Systems Analysis (IIASA) Austria

RCP 8.5 predicts a future without any policy changes adopted therefore it is equivalent to Business-as-Usual Scenario. As radiative forcing increases the intensity of climate risk increases.

RCP 4.5

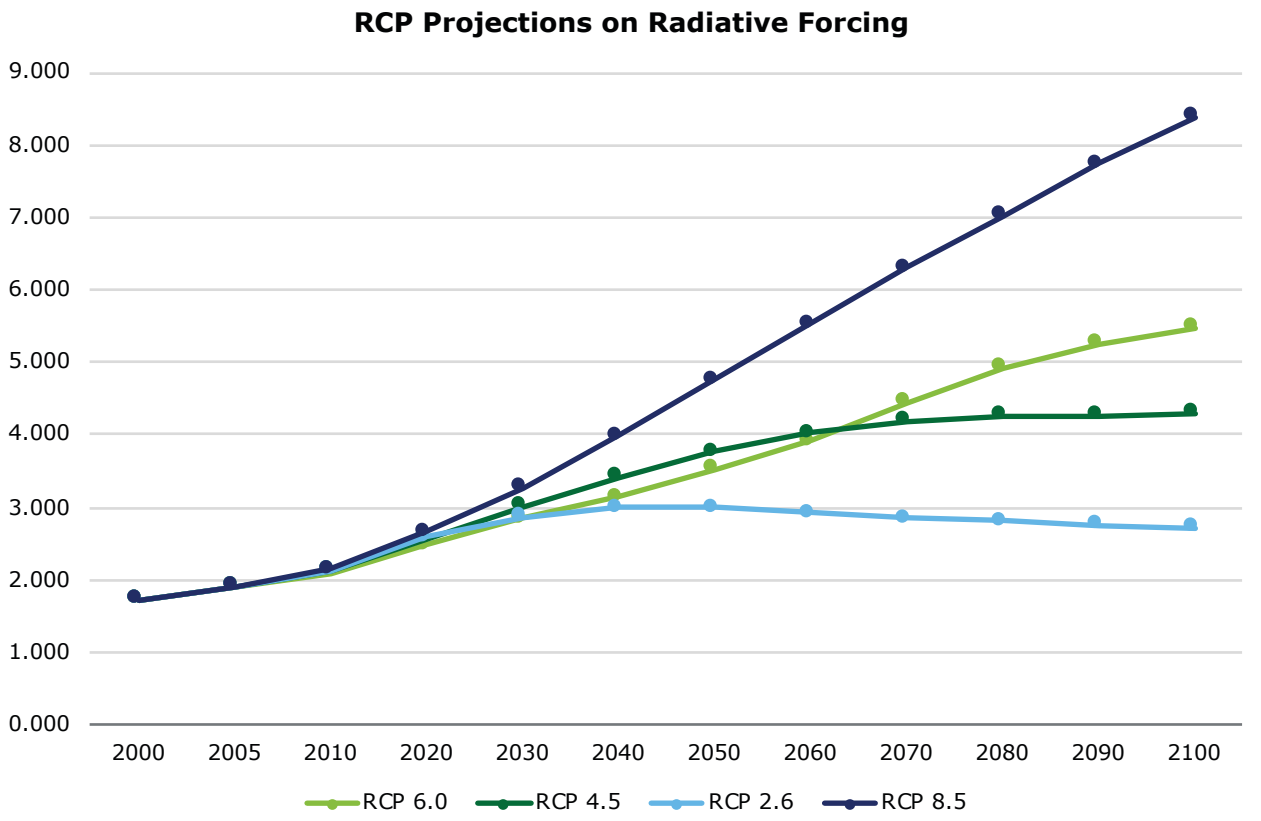
Developed by Pacific Northwest National Laboratory, USA

RCP 4.5 predicts a future where total radiative forcing is stabilized shortly after the year 2100, emissions peak around 2040.

RCP 6

Developed by National Institute for Environmental Studies (NIES) Japan

RCP 6 predicts a future where total radiative forcing is stabilized shortly after the year 2100, emissions peak around 2080 and then decline.



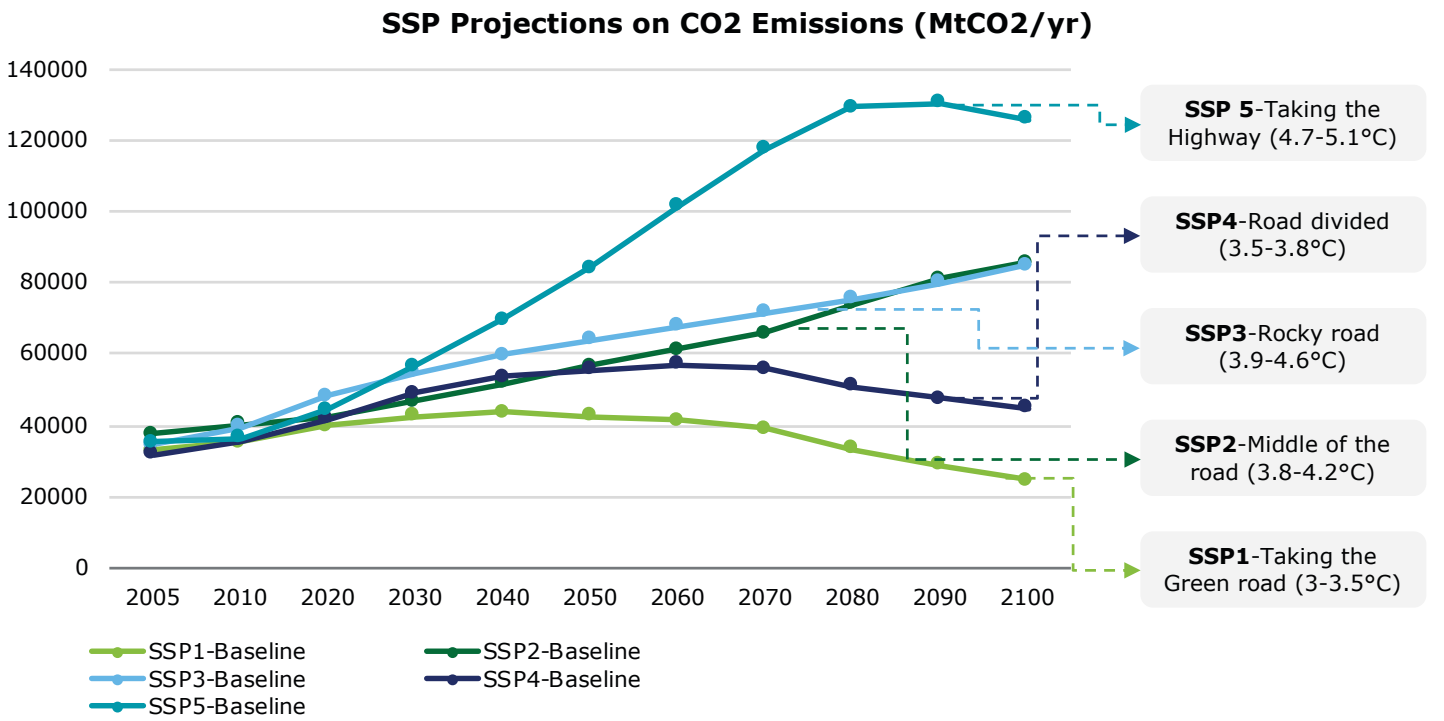
Each RCP corresponds to a different rate and magnitude of climate change.

SSP: The Integrated Assessment Modeling Consortium (IAMC), formed by research institutions worldwide, developed Shared Socio-economic Pathways (SSP) which will be included in the IPCC's 6th Assessment Report. The scenarios represent diverse qualitative descriptions related to the achievement of sustainable development goals (SDGs) and project interrelated changes in socio-economic, energy, land-use and GHG emission systems until the year 2100.

The scenarios are:
SSP 1: Sustainability (Taking the Green Road), SSP2: Middle of the Road, SSP3: Regional Rivalry (A Rocky Road), SSP4: Inequality (A Road Divided), SSP 5: Fossil-fueled development (Taking the Highway)

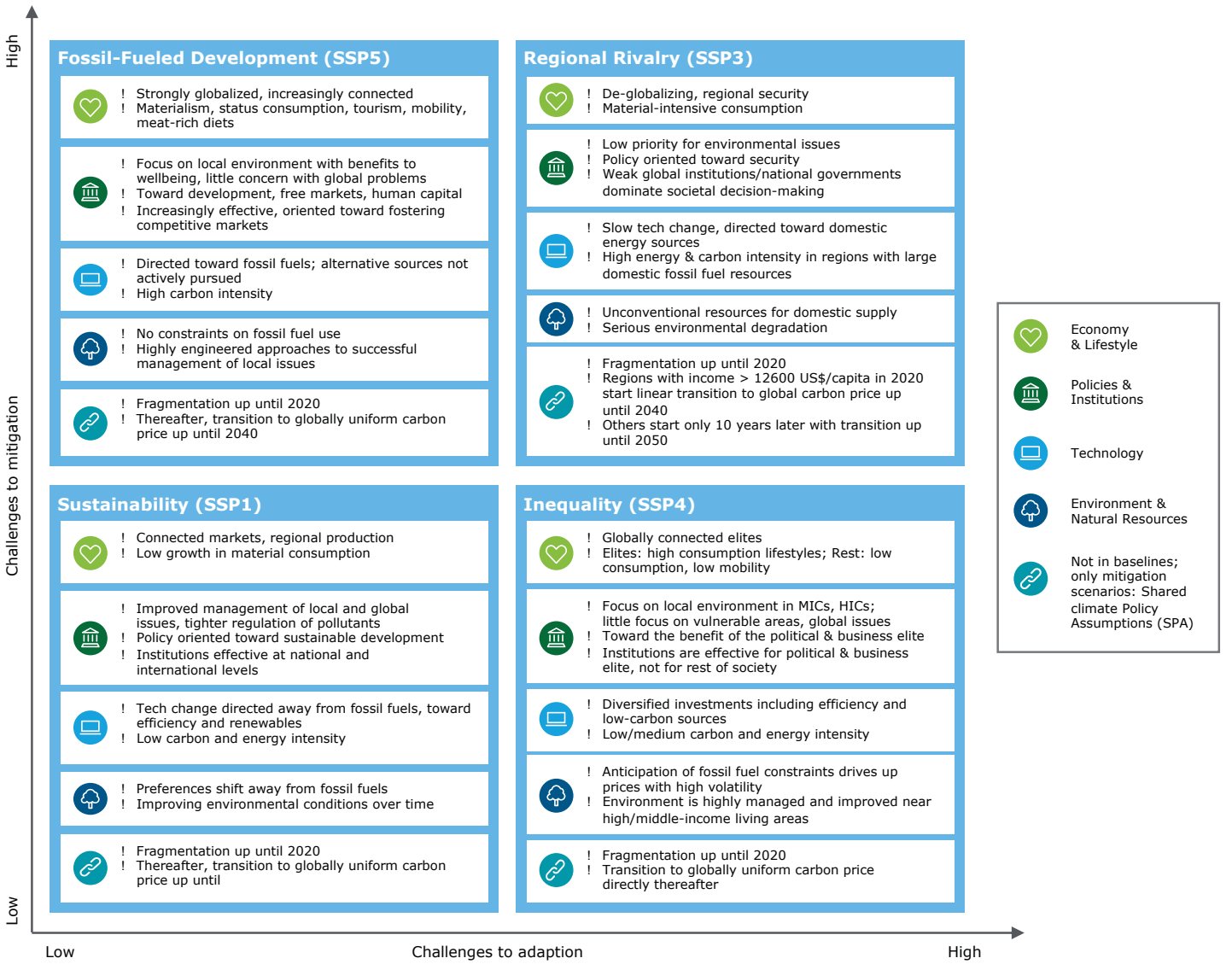
The narratives enable the exploration and examination of socioeconomic developments related to climate change impacts and the resulting vulnerabilities. Scenarios are designed to address the level of mitigation and adaptation achieved globally:

Projections are made by different integrated assessment models and the most representative outputs are named as marker scenarios. Marker scenarios are selected by research institutions among several hundred scenarios.

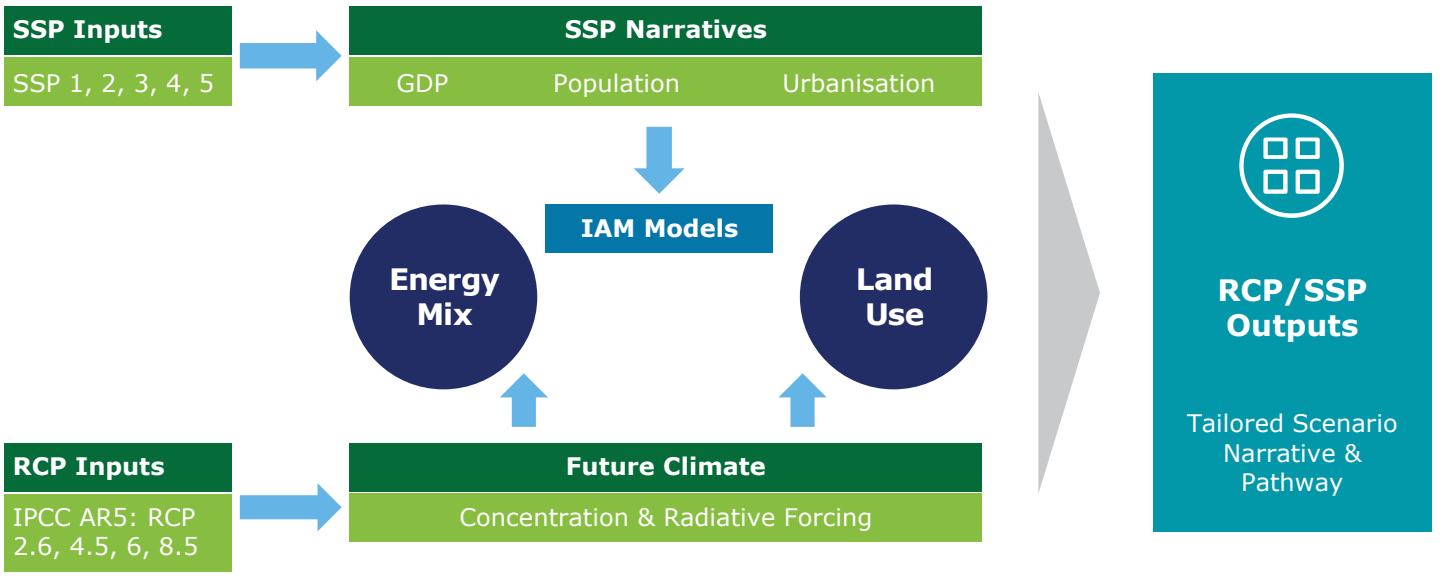


Each SSP portrays a different rate and magnitude of climate change.

Each SSP is formed by different sets of qualitative assumptions in terms of the economy, policy reactiveness, technological acceleration, resource use and shared climate policy assumptions, which is by definition not included in SSP-baseline scenarios (corresponds to the mapping with RCP 8.5):



Adapted from: Bauer et al. 2017



SSP scenarios can be mapped to RCP scenarios and used together

Financial institutions should also consider increasing the stress by amplifying the level of disorder of low-carbon transition.

The choice of scenarios is extremely important for institutions to correctly model plausible pathways. Due to the complexity of climate modeling, banks need to rely on existing climate scenarios as reference scenarios. Some banks will prefer to formulate their own forward-looking climate scenarios; however this requires the development of tremendous in-house capacities to undertake climate-related analytics. Science-based reference scenarios offer the modeling expertise of leading research institutions. By using similar drivers in scenarios, results can be compared between different sectors and between banks. Some major banks think it is fundamental to take into account multiple scenarios. Certain medium-sized players prefer to use reference scenarios that consider the link between social and regulatory policy actions.

Handling sector specificities:
Each sector will be affected differently by climate change, and critical climate risk drivers should be included to identify the correct climate risk exposure. Sector-related climate impacts need to be included in sector scenarios.

Climate scenarios should be extended to narratives by adding key drivers which will enable them to perform a granular climate risk assessment. Creating a sector narrative enables the scenario to be tailored, provides a consistent context regarding input assumptions and helps have a systemized output after performing quantitative projections. Related determinants and the scope of influence of demographic, national and international policy actions, macro-economic, technology-related and consumption-related variables need to be considered while forming narratives. For each identified sector, it is essential to form climate narratives which can model the evolution of that sector. Narratives need to be set and explicitly cover the required aspects of climate-change impact to comprehensively assess risks. To ensure the quality of scenarios and narratives, the financial institution should consult climate experts, sector experts, risk experts and economists, which will also facilitate the validation process

Step 3 - Quantification via Stress Test Modeling

Stress test modeling via financial climate shocks is achieved by two different complementary approaches, a top-down macro analysis, reinforced with a bottom-up micro analysis. **The aim is to incorporate shocks at portfolio and borrower level to calculate systematic and idiosyncratic risks, which maximizes the power of the climate risk assessment.**

The top-down mechanism enables the bank to perform portfolio level-assessment. The methodology needs to be adjusted to the different sizes of enterprises present in the corporate portfolio. For example, the level of treatment might differ for SMEs depending on the data availability and quality. The aim of the top-down analysis is to describe the evolution of credit quality under different magnitudes of climate change. As scenarios are based on climate-related, macroeconomic and financial variables related to the sector, the forecast of variables will represent sector transformation. This can be translated into the impact on risk parameters; therefore the analysis leads banks to forecast the portfolio's credit quality related to climate risks.

The bottom-up mechanism allows the banks to ascertain the vulnerabilities at counterparty level, so a lot of external data needs to be collected. It is an accurate process which adds tailored sensitivity to the analysis. As actors in the portfolio have differentiated responses to climate change at different rates of transition, bottom-up analysis results in the incorporation of actors' varying sensibilities. It is important to apply the bottom-up approach to the most significant counterparties to cover a material part of the portfolio. According to PRA[16] 'counterparty-level assessment should aim to cover 80% of participants' 'nominal exposure' in the scope of corporate loans.' There are multiple qualitative and quantitative ways to map sector and geographic vulnerabilities of counterparties and to assess their financial impact. The granularity of the assessment, hence the identified vulnerabilities of counterparties' business models, needs to be justified.

Quantification is performed by deriving the financial effect of physical and transition risks on credit risk parameters which can impact the balance sheet of individual institutions. The transmission channel of climate risks determines the choice of risk KPIs (PD, LGD, EAD etc.) which will shift under different climate scenarios. With top-down and bottom-up mechanisms, the risk parameters are altered. To eliminate overlaps between two mechanisms, the coherence of assumptions, methodology and the output should be inspected. For this reason, calibration is carried out.

Step 4 - Calibration

Calibration is performed to consolidate the top-down and the bottom-up parts of the assessment. It is crucial to ensure consistency between different mechanisms and various methodologies used for different sizes of actors. The aim is to maximize the operationality of each model. To facilitate calibration, banks' existing metrics can be used. Leveraging existing parameters and data will augment the operationality of the climate stress test and increase its applicability. Internal bank data can shape sector drivers which are essential to extensively cover the evolution of a sector in different climate scenarios. Specifically, environmental and macroeconomic expert judgment can be used in order to improve the calibration and the quality of models. In cases where banks lack internal data on borrowers such as data on borrowers' key operating assets, their locations etc., external data sources should be used. Geographical data becomes fundamental for sectors that are more prone to location-based climate risks.

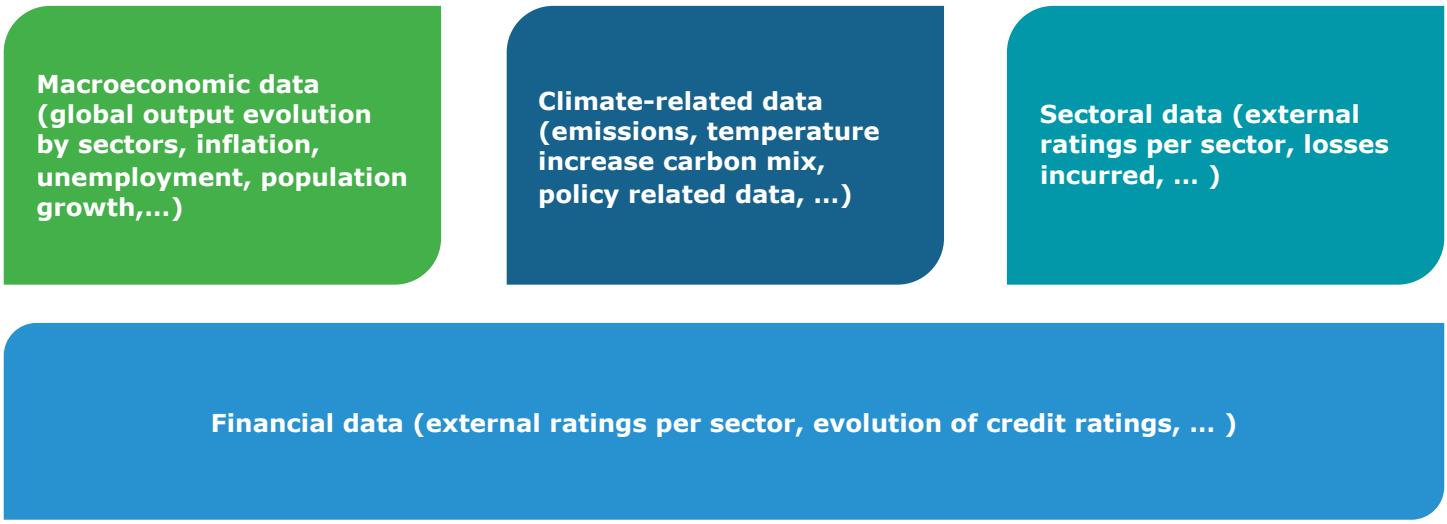
Data requirements related to climate risk assessment

Building such a climate stress test methodology would require a large amount of data, gathering both banking portfolio data and external data regarding economic and climatic forecasts.

A combination of internal and external data is needed to perform a climate risk assessment. Internal data consists of risk KPIs and related metrics such as PD, LGD, EAD at loan origination. The shift between these metrics in a Business as Usual scenario and in a climate stress situation becomes key to assess the impact of climate scenarios on the Expected Loss financial data of the analyzed portfolio. Asset-based data and maturity-related data is also necessary to build the methodology accordingly.

16 *PRA (2019) Discussion Paper: 2021 Biennial exploratory scenario on the financial risks from climate change*

External data is grouped into three different types:



Different types of data are needed to explain the shift created by climate-related parameters on financial parameters.

Internal data

- Carbon-related data (e.g., carbon intensity exposure/assets/portfolio)
- Share of income exposed to sectors
- General information about the borrower, loan details, financial data of the analyzed portfolio
- Risk KPIs at loan origination (PD, LGD, EAD, ...)
- Duration of exposures

External data

- Evolution of credit ratings
  – S&P
  – Moody's
- Performance indicators of exposures and assets
  – MSCI, ...
- ESG ratings

In terms of external data, open-source data is increasing and getting more robust and reliable with the help of scientific actors. Banks should leverage the existing data rather than using resources to obtain or create new databases. Moreover, as the quality of historical data cannot represent the non-linear impacts of climate, external datasets based on present-condition information offer a more profound benchmark to interpret results.

Use-Case in the Automotive Sector

Deloitte has worked with a major French bank to incorporate a climate stress testing framework in the scope of corporate loans to study transition-related risks and opportunities:

Portfolio Analysis

After performing a portfolio analysis, the automotive sector was identified as one of the sectors which are prone to climate risks. The time horizon was chosen to be 2030.

Scenario Selection

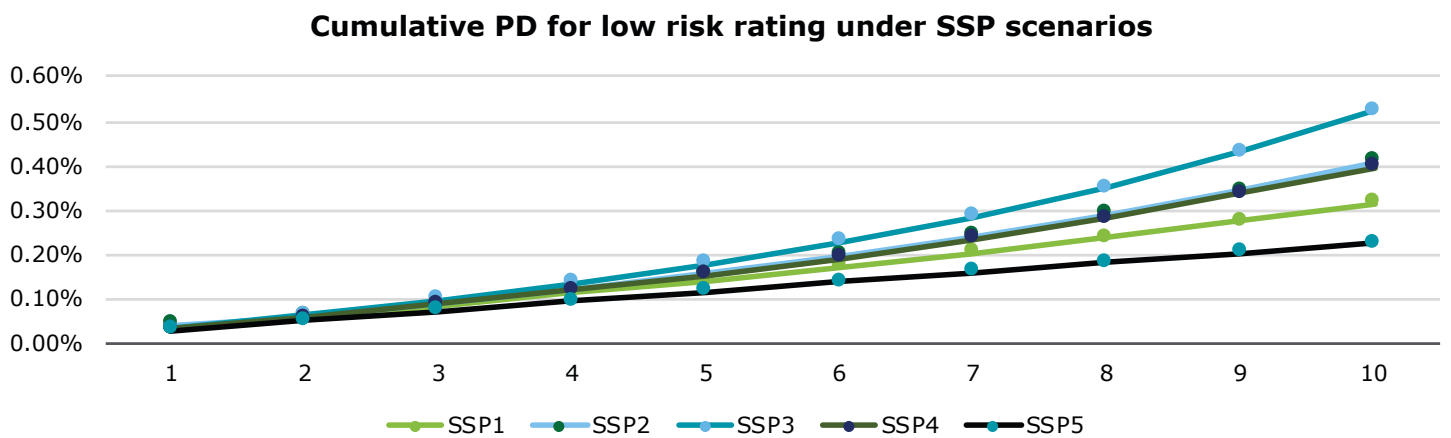
SSP 1/RCP 8.5 (baseline of sustainable scenario), SSP 3/RCP 8.5 (baseline of slow development scenario) SSP 5/RCP 8.5 (baseline of fossil-fueled development scenario) were chosen. Sectoral parameters were added which directly affect the sale and production of automobiles.

Stress Test Modeling/ Calibration

A statistical model was produced to determine a relationship between key sectoral macro and financial variables and climate-related variables. For the top-down approach, statistical downscaling was applied. Environmental data was extracted on significant actors for the bottom-up approach.

Assessing Impact

A material impact was observed on PD therefore in ECL and RWA and the solvency ratio. In 2030, a significant increase was observed in RWA and ECL nearly doubled under SSP 3 scenario.

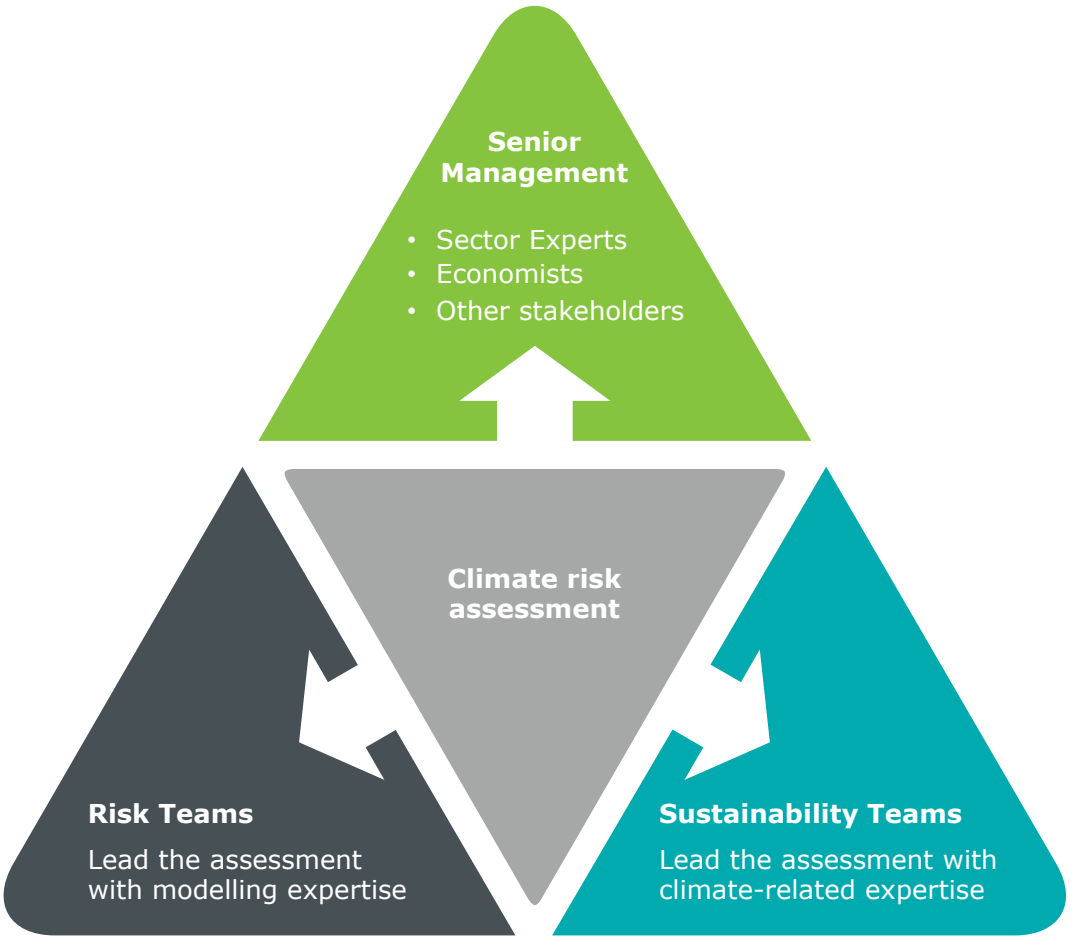


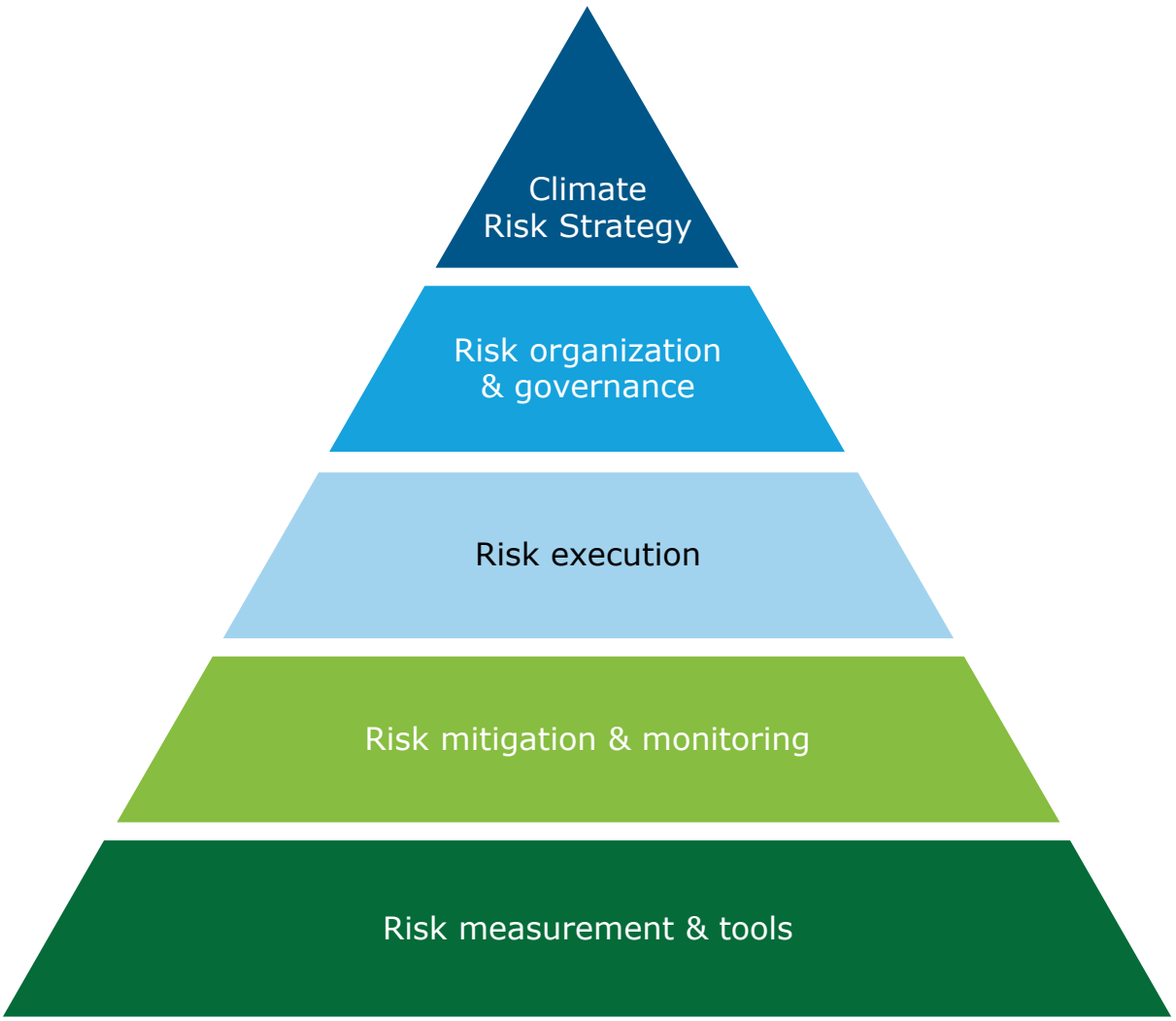
The bank decided to increase the provisions of the automotive sector due to the results of the climate stress test.

4.Enhancing climate-related governance

Climate risk assessment involves the active engagement of multiple departments. Financial institutions need to reorganize their governance to ensure that all aspects of climate risks are owned, monitored, measured and communicated. Risk management and corporate social responsibility teams need to work together in order to reflect climate risks in different banking activities and raise awareness. Financial institutions need to ensure the diverse composition in knowledge and skills to determine the most effective way to integrate climate considerations and perform opportunity assessments with the help of identified material climate risks. Executive incentives should be based on methodology outputs and should aim to promote a long-term climate plan of action.

The success of implementation depends on effective communication, which will lead to the creation of multi-functional teams and new synergies:





The climate risk assessment should be coordinated and reported to the board to turn climate risk quantification into climate intelligence, and to integrate climate strategies across the firm. When CSR and risk teams collaborate and share responsibilities on climate risk assessment, new KPIs related to sustainable development can be defined and the continuity of the climate risk assessment will result in modified governance.

How can Deloitte help?

ClimWISE, a leading solution to build resilience to climate change
Deloitte has developed ClimWISE, a dynamic decision-making tool for management which helps financial stakeholders manage their portfolios. It is an end-to-end solution adaptable to banks' existing risk management methodologies.

ClimWISE assesses the ability to integrate into a low carbon transition by identifying the transformation capacity of counterparties' business models. Moreover, Deloitte's tool facilitates concentrating quantification efforts on risk areas and seizing opportunities.

ClimWISE evaluates the capacity of business models to integrate into a low carbon transition by a high-performance tool.
Being an approach that responds to expected regulatory changes, ClimWISE evaluates sectoral and geographical sensitivity with a global heatmap and can perform specific climate stress-tests based on science-based scenarios and models. The tool assesses transition risk under the constraints of different climate risk scenarios and leverages the portfolio by identifying and reporting transition climate risk exposures.

- Robust identification of the concentration of transition risk on portfolios of financial activities
- Sectoral and geographical downscaling of climate scenario-related inflection points
- Use of the most up-to-date, reliable external datasets to quantify the impact of various transitional risk indicators
- Outside-in, Merton-like top-down approach to estimate losses and identify climate-related opportunities
- A modular bottom-up approach, counterparty sensitivity analysis
- Quantification of climate-related risks by leveraging the traditional stress test methodology

With ClimWISE, do not get lost in transition, lead it!

Annex: Implementation of the TCFD recommendations – holistic project approach
Implementing the TCFD recommendations will most likely become a core requirement of regulatory compliance regarding climate risk management in the near future. Therefore, sketching the project roadmap is a challenge for today. At Deloitte, we build a holistic project approach leveraging the knowledge of a major international consultancy firm and bringing together our tools and enablers such as ClimWISE.

TCFD Recommendations		Project Activities
Governance Disclose the organization's governance around climate-related risks and opportunities.	a) Describe the board's oversight of climate-related risks and opportunities. b) Describe management's role in assessing and managing them.	1) Identify climate risks in the organizations' portfolios, and assess the organizations' capacity to identify, measure and manage them: • Develop a specific climate risk heatmap for the organization • Leverage outside sources such as PSI heatmaps, EU taxonomy, PRI risk indicators, etc. 2) Identify climate-related opportunities, and assess the organizations' capability to exploit them 3) Establish overall responsibility of board and senior management regarding climate risks – from vision to implementation plan: • Risk strategy and risk appetite • Roles and responsibilities • Policies and processes • Management reports 4) Set up organization-wide strategic approach – implementation plan:
Strategy Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term. b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, financial planning. c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.	

TCFD Recommendations		Project Activities
Risk Management Disclose how the organization identifies, assesses, and manages climate-related risks.	a) Describe the organization's processes for identifying and assessing climate-related risks. b) Describe the organization's processes for managing climate-related risks. c) Describe how processes for climate-related risks are integrated into the organization's overall risk management..	• Understand impact of climate change on the organizations' risk profile • Identify need to adapt strategy and governance • Set clear targets, planning and budget • Assign responsibilities and reporting lines for the project • Ultimately, implement amendments to policies and processes 5) Establish risk management cycle 5.1) Risk identification • Use heatmaps (see activity 1) to identify climate risk concentrations (esp. energy-intensive industries, mortgage collateral and project financing) • Perform scenario-based sensitivity analyses (esp. risk/shock types, sectors and time horizons) 5.2) Risk assessment • Perform dedicated climate risk stress tests for loan portfolios (e.g., in the context of ICAAP) using ClimWISE methodology: (a) Input: Socioeconomic pathway based on integrated assessment models (b) Bottom-up analysis: Impact on selected individual companies (c) Top-down analysis: Impact on loan portfolio (d) Output: Scenario PDs and LGDs per obligor • Perform dedicated climate risk performance analysis for investment portfolios using Deloitte's methodology based on big data and advanced analytics: (a) Cluster companies that disclose carbon/GHG indicators, and classify non-disclosing companies accordingly (b) Calculate asset value sensitivities (betas) w.r.t. carbon/ GHG indicators 5.3) Risk avoidance/mitigation & risk monitoring • Amend risk appetite statement with dedicated climate risk limits • Amend credit and collateral policies with dedicated climate risk rules
Metrics and Targets Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.	a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process. b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 GHG emissions, and the related risks. c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.	

TCFD Recommendations		Project Activities
		• Amend client and transaction acceptance with dedicated climate risk rules • Encourage clients to transfer risk (e.g., by taking out climate risk insurance) • Mitigate impact of physical climate risks on the organization's operations 6) Set up climate risk disclosure report • Carbon footprinting • Green/brown exposure • Company engagement • Ratings and research • Scenario analysis • Impact metrics

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