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Clim INVEST
Tailored climate risk information for financial decision makers

Addressing challenges of physical climate risk analysis in financial institutions

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DISCLAIMER

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FOREWORD BY THE CLIMINVEST CONSORTIUM

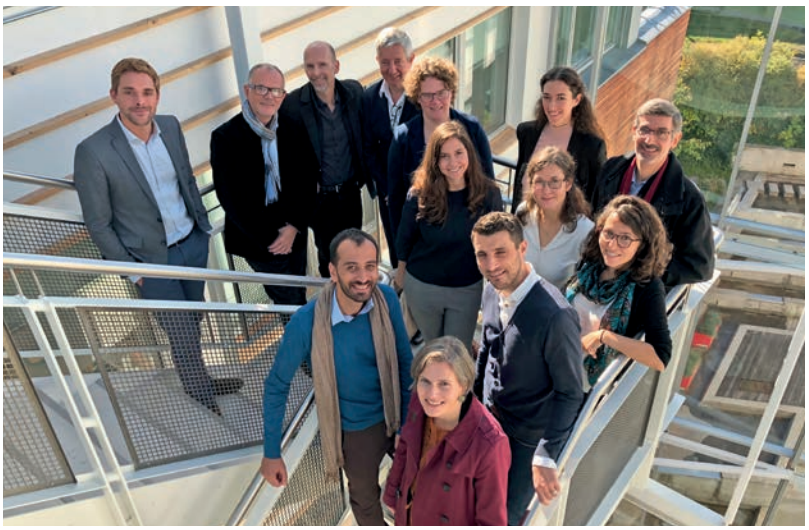
As the financial cost of climate hazards such as flooding and heat stress rises, investors are looking for more transparency and precision in physical climate risk assessment tools. The ClimINVEST research project aimed to improve the level of knowledge and transparency in physical risk assessments.

Bringing climate scientists and financial actors together, we focused on the following questions:

- what information on physical risks is available for investors?
- how can investors better secure the value of their portfolios against physical climate risk?
- what risks require immediate attention from investors?

Early on in the project key challenges identified by financial stakeholders included the lack of awareness and capacity within their institutions to understand and take steps to manage the risk of climate change impacts. To support capacity building and integration within financial institutions the ClimINVEST project has developed publicly available resources including **an interactive online platform** with indicators, maps, case studies, videos, and factsheets.

The ClimINVEST project has taken steps towards improved transparency and information flows, but we still have further to go in developing transparent and systematic approaches. We look forward to further collaborative efforts with the financial sector as we prepare for our changing climate.



Consortium members

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Executive Summary

While climate impacts are materializing and regulators are taking action against the climate threat to financial stability, financial actors are urged to manage their exposure to physical climate risks and disclose how they are doing so.

A European research collaboration to develop physical climate risk information for the financial sector

Started in 2017, the ClimINVEST project gathered European climate experts to work together with financial institutions to better understand the challenges of physical climate risk management in finance and develop information and resources.

The project partners and financial actors collaborated directly in a series of workshops and exchanges in the Netherlands, France and Norway to make climate risk analysis more accessible and demonstrate its potentialities in the specific contexts of the participating institutions.

Key findings are publicly available for financial actors to get started on physical climate risk analysis. The **online resources** include factsheets, video presentations, reports, and an interactive online platform showcasing climate indicators and case studies of physical climate risk analysis.

The four challenges of physical climate risk analysis: what has changed

ClimINVEST identified four main categories of challenges that were partly addressed in the project.

Challenge 1. The black box of climate services: it is now partly opened

Service providers have developed proprietary and heterogeneous methodologies to help financial actors analyze their exposure to physical climate risks. As standards on physical climate risk analysis do not exist yet, the limited explanation on these methodologies and underlying data sources has reduced the capacity of financial actors to understand them and potentially use them for decision-making. The ClimINVEST project raised attention of service providers on this issue and helped improve the transparency on key methodological choices, with constraints due to proprietary model confidentiality. This reveals a patchwork in available services that financial users can navigate by gaining capacity to ask the right questions to service providers.

Challenge 2. The tragedy of the horizon: it is not a justification for inaction now at financial institutions

Climate change is a threat to financial stability, partly due to misalignments between short-term decision-making in the financial sector and the expectation that climate impacts are essentially a problem in the distant future. Financial actors may view this 'tragedy of the horizon' as a reason for inaction now.

Nevertheless, as financial actors gain more insight into climate risk issues, they understand that physical impacts are already being realized with damage costs. Some financial institutions are also interested in long-term climate conditions, such knowledge allowing them to seize business opportunities with their clients and for broader strategic developments.

Challenge 3. The data: financial actors can already act on existing data

Physical climate risk analysis requires relevant and specific climate data and asset-level or portfolio-level data and information. While most climate data is openly available, navigating the multitude of data sources and types of data can be challenging and may require complex processing systems. Further, asset-specific data is needed for every individual case and often confidential, which makes it difficult to collect for large portfolios. The ClimINVEST factsheets and interactive online platform offer guidance to identify the relevant data needed for physical climate risk assessments in different sectors and illustrate the relevant use cases of a range of climate indicators and counterparty-level data.

Challenge 4. Estimating financial impacts: it is not vital for managing climate risks

Financial actors have pointed the need to make progress on the quantification of financial consequences from climate risks. General estimates of climate change losses in a sector or region have been previously conducted. However, calculating the cost of climate impacts on individual assets or portfolios proves challenging due to data constraints, asset connectivity and uncertainties in risk modelling.

The banking institutions participating in the ClimINVEST project concluded that while estimation of financial impacts was helpful for integration in main financial risk models and metrics, it is not vital for managing risks quickly. Considerations about the financial consequences from potential climate impacts can be drawn from qualitative information as well, as it is done in some cases with climate risk scoring methodologies. The banks can leverage such scores in their risk decision-making provided that the underlying methodology is transparent and that relevant detail is provided about the type and materiality of potential impacts.

What is next

Financial actors participating in the ClimINVEST project identified the action points outlined below for the broader financial sector to keep moving forward with physical climate risk management.

Capitalizing on existing resources for increased capacity building

Physical climate risk analysis requires specific expertise that the majority of financial actors had not yet acquired. The ClimINVEST project developed a range of resources that diverse teams at financial institutions can use to mainstream this expertise within their institutions on main aspects of climate risk analysis. The financial institutions participating in ClimINVEST also mention that experimenting physical climate risk analysis on their own portfolio is a powerful first step for demonstrating the utility of such analysis (including to the board) and for engaging diverse teams on decision-useful developments.

Starting with pilot risk assessments

By taking part in the framing of physical climate risk analysis on a sample portfolio, financial actors can make better connections between the climate risk analytical process and their internal capacities and needs. To foster the relevance of these tailored exercises, the ClimINVEST participating institutions recommend internal collaboration with diverse teams. Combined involvement of Risk and ESG teams helps explore the range of needs and potential solutions to be prioritized.[1]

During ClimINVEST exchanges, the French participating banks, given the complexity of quantifying the effects of physical climate risk on their SME counterparties' probability of default, prioritized a two-step approach. It includes a country/sector risk screening resulting in a climate risk score, followed with in-depth discussion on counterparties identified as climate risk hotspots in order to start managing climate risk.

Mobilizing a broader ecosystem on climate risk management

Financial actors have a key role to play for the integration of physical climate risk in the financial sector. However, combined action of a broader range of actors is needed to quickly overcome the challenges.

Service providers can sustain and improve the transparency of the tools they offer, including their underlying scenario assumptions, data sources and methodologies. **Climate scientists** can provide explanations and improve data accessibility to help other actors overcome some of the complexities of physical climate risk. **Financial actors** can seek further collaborations with a broader range of stakeholders, including insurance companies and municipalities, who could quickly help identify, collect and share data that is comparable and reliable enough for climate risk management at financial institutions. Sustained action of **regulators and supervisors** can enable physical climate risk to be on top of risk managers' agendas via supervisory expectations, climate stress-testing pilot exercises, development of standards for physical climate risk analysis, and climate risk disclosure requirements for financial and non-financial companies.

1 As explained in the TCFD, the board should also be involved at some point for ensuring appropriate mobilization of resources and convert this experience into a strategic asset.

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Introduction

The consequences of climate impacts on the economy are already exposing the financial sector to major financial risks and opportunities. The insurance system is falling short to cover all the loses from extreme events. Munich Re shows that insurance companies covered only USD 28,900 million of the USD 68,500 million of damages that resulted from the most impactful climate events in 2018 in the US, Japan, Cuba and Taiwan (Munich Re, 2019). Climate conditions will continue to evolve in the next decades, as a consequence of greenhouse gases (GHG) emitted in the atmosphere since the 19th century.

Following Mark Carney's seminal speech on Breaking the tragedy of the horizon in 2015, climate change has been more widely recognized as a threat to financial stability (Carney, 2015). Since then, the financial sector has been urged to integrate climate impact considerations, as part of their risk management. Climate-related financial disclosure frameworks have emerged along with the development of specific climate services to help financial actors understand their exposure and vulnerability to climate hazards.

However, the integration of physical climate risks into financial institutions' decisions has faced several key challenges. Financial actors have not always seen the point of managing these risks that have been described as long-term issues. The available methodologies developed by service providers have not been widely used, perhaps due to a reported lack of transparency. In addition, the implementation of the analysis suffers limitations in data availability and capacity to estimate the financial consequences of physical climate risks.

The ClimINVEST project started in 2017 with the aim to investigate these challenges. The project facilitated direct collaboration between a consortium of climate experts and a range of financial institutions in France, the Netherlands and Norway. This collaboration led to the development of publicly available resources to help financial institutions address the challenges, from raising climate risk awareness in their institution to interpreting the results of physical climate risk analysis on their portfolios.

This project capstone report gives an overview of the work done in ClimINVEST and highlights the steps taken to bridge the gap between physical climate risks and financial risk analysis and decision-making. It also provides guidance for further action at financial institutions.

Section 1 of this report introduces the ClimINVEST project and details how financial actors can use the publicly available ClimINVEST resources to address some of their needs on physical climate risk management. **Section 2** explains ClimINVEST key lessons to make progress in addressing some of the major challenges of physical climate risk analysis. **Section 3** of this report formulates priority action points for financial actors and their stakeholders to move forward on physical climate risk analysis and management.

1. The ClimINVEST project: leveraging collaboration between European climate experts and financial actors

1.1. ClimINVEST objectives and organization

The ClimINVEST project worked to improve collaboration and information flow between climate science and financial actors, promote approaches that connect climate hazards with financial impacts, and facilitate disclosure of climate risk in investment portfolios in accordance with the TCFD recommendations.[2]

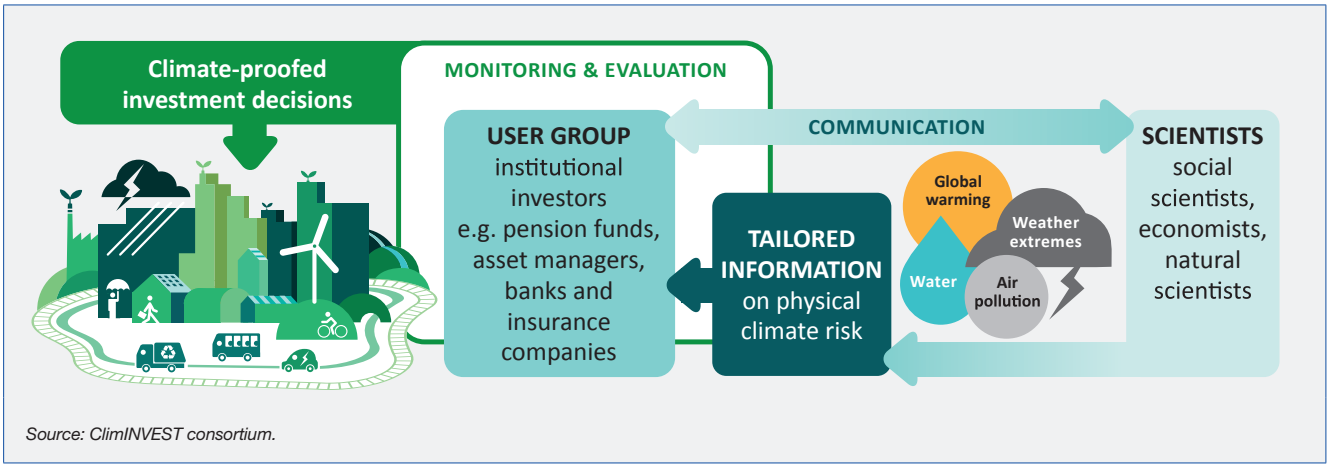
ClimINVEST has adopted a participatory approach bringing together climate experts and selected groups of financial actors in Norway, the Netherlands and France. The financial actors and scientists have met regularly in each country over the three years of the project in interactive workshops called "science-practice labs".

The science-practice labs (SPLs) guided and informed the achievement of the project main objectives: understanding the needs of financial actors in terms of physical climate risk analysis; build their capacity to understand the possibilities and limitations of such analyses; and co-design and co-develop climate services to address their needs.

While the themes and composition of SPLs varied in Norway, the Netherlands and France, the three country-specific parallel efforts followed the same guiding principles. A first round of surveys was conducted at the beginning of the project to identify the main categories of financial actors' needs on physical climate risk. The following SPLs were organized as interactive workshops. A central part of these workshops was the direct collaboration of climate experts and financial actors on the development of case studies demonstrating physical climate risk analysis. This iterative process helped financial actors and climate experts increase their mutual understanding about and make progress on the availability of climate and counterparty[3] data, methods to quantify financial impacts and climate risk information formats that can be used for financial decision-making.

This collaborative process led to identification of challenges to physical climate risk assessments and disclosure, the development of internal capacities at the participating financial institutions, as well as a range of public deliverables that are referenced below.

FIGURE 1 - CLIMINVEST OBJECTIVES AND STRUCTURE



Source: ClimINVEST consortium.

2 The industry-led Task Force on Climate-related Financial Disclosures (TCFD) was established by the Financial Stability Board. In June 2017, it released its final recommendations for financial and non-financial organizations to voluntarily disclose how they integrate in their decisions the financial risks and opportunities related to climate change.

3 The counterparty is the entity that receives funding from the financial institutions, for example a project, a company or a government.

1.2. ClimINVEST resources

ClimINVEST provides publicly available resources that financial actors can use to integrate physical climate risks in their internal processes and disclosure. Financial actors can use the ClimINVEST resources to address various needs that may arise in the integration process, as shown below.

MAPPING INFORMATION NEEDS ON PHYSICAL CLIMATE RISKS

The Investors' needs report provides detailed analysis of financial actors' needs in France, Norway and the Netherlands. Findings are summarized in the Investors' needs chapter in Handbook of Climate Services.

GAINING CAPACITY ON PHYSICAL CLIMATE RISK ANALYSIS

Getting familiar with the concepts of climate risk analysis

The Factsheet and presentation on climate risk introduce the main steps and characteristics of a physical climate risk analysis in finance as well as the main data building blocks that are needed.

Guidance on the data and their relevant use

The Climate modelling 101 factsheet and presentation introduce the basics of climate modelling and the uncertainties that come with them. More specifically, the NGFS occasional paper chapter 37 discusses the relevance of climate scenarios to analyze and manage uncertainties about future climate conditions.

The Factsheets and presentations on floods, heat waves and drought introduce how climate indicators can be used to describe these climate hazards. They illustrate the other types of data – mainly exposure, sensitivity and adaptive capacity of the counterparty – necessary to analyze physical climate risks on a counterparty.

The report on Assessing climate physical risks for financial decision makers provides financial actors with further guidance on the suitable data strategies for each step of a climate risk analysis.

Opening the blackbox of available climate services

The Getting started report reviews the main methodologies that pioneer service providers have developed for physical climate risk analysis in finance. It comprises comprehensive and comparable factsheets on each climate service as they stood in 2018. The NGFS occasional paper chapter 35 synthesizes findings of the report.

CARRYING OUT PHYSICAL CLIMATE RISK ANALYSIS

Data with user-friendly guidance and visualization tools

The ClimINVEST interactive online platform comprises a climate indicator database on drought, heatwave and flood risks that can be visualized in dynamic maps with a European coverage. It comprises guidance on interpretation of the indicators.

Case studies demonstrating climate risk analysis

The following case studies were developed in collaboration with financial institutions:

- Exposure of a European agricultural portfolio to potentially harmful high temperatures.
- Exposure of a French real estate portfolio to risks from heatwaves, intense rainfall and drought.
- Exposure of a major European city's heat distribution network to increasing temperature.
- Climate risk screening of an international multi-sector equity portfolio including increasing temperatures, heatwaves, changing rainfall patterns, rainfall extremes, storms, drought and sea level rise.
- Climate risk screening of the Norwegian railway system including drought, heatwaves and flooding risks.
- Climate risk screening of "The Wall" shopping center in the Netherlands including risks from pluvial and fluvial floods, drought and heat.

The ClimINVEST interactive online platform provides dynamic storytelling on several of these case studies. The case studies are also described along with other examples in dedicated factsheets and presentations (*e.g.* The Wall case study) and in the Assessing climate physical risks for financial decision makers report.

While the quantification of financial impacts from climate risks remains a major challenge, the ClimINVEST project carried out research on the quantified economic loss of heat-induced reductions in outdoor worker productivity in Europe.

Moving forward with the challenges

The present ClimINVEST capstone report provides financial actors with guidance for addressing major challenges of physical climate risk analysis and management.

The ClimINVEST consortium provides further guidance for collaboration between financial actors and climate experts in a set of academic papers: Facilitating Climate-Smart Investments; **Climate services for the financial sector: understanding the needs and challenges** (submitted); **How to make climate risk assessments relevant for the financial sector – lessons learned from real estate cases in the Netherlands** (submitted).

2. Addressing challenges of physical climate risk analysis

Financial and non-financial companies are becoming increasingly aware of climate-related risks as demonstrated by gradual progress in climate-related financial disclosure (TCFD, 2020).[4] The financial sector identified several major challenges to conducting physical climate risk assessments and disclosure.

The following section outlines the main challenges and progress that was made to address them based on collaboration between climate experts and financial institutions for the ClimINVEST project. The challenges outlined below include: the black box issue in available climate risk information and analytical tools; misalignment in time horizons of climate risks and financial decisions; limited accessibility of the data and lack of guidance for data use; limited capacity to quantify the financial consequences of physical climate risks.

2.1. The black box challenge

Lack of transparency in existing methodologies and tools

The increase of awareness about physical climate risk in the financial sector has come along with efforts of several service providers[5] to develop methodologies for physical climate risk analysis in finance. Their methodologies adopt diverse approaches and can provide different types of outputs including qualitative risk scoring and quantitative estimates of potential financial impacts (Hubert *et al.*, 2018; UNEPFI and Acclimatise, 2020).

The service providers have not fully explained the details of their proprietary methodologies for financial actors and broader stakeholders to be able to compare their coverage and scope. Given the current lack of an established standard to carry out physical climate risk analysis for finance, the limited public communication from service providers creates a lack of transparency about what their methodologies effectively measure.

Financial actors are asking to open the 'black box' of climate risk analytical tools and ask for guidance to help them appreciate the robustness and relevant use case of each tool. This is a necessary step for financial actors before they can consider using some of these tools for their decisions.

Overarching principles of climate risk analysis

The different approaches on physical climate risk analysis essentially seek to address the same type of question: "what are the potential impacts of climate change on the financial institution?". However, these approaches can differ significantly in their scope of analysis and methodological choices.

To help navigate this diversity of applications and methods, ClimINVEST looks at physical climate risk analysis through the common lens of the "climate impact chain" framework detailed in Gallo and Lepousez (2020). ClimINVEST considers physical climate risks as a collection of climate impact chains bringing together climate hazards with resulting physical impacts, and their consequences in terms of financial impacts at the level of counterparties in a portfolio and the financial institution itself.

This framework can be used to identify systematically the step-by-step effects of climate risks in the economy. **Figure 2** illustrates the use of the climate impact chain framework in the case of an investment in the Norwegian railway company. "Climate hazards" are the climate conditions that are potentially harmful for the investor's counterparty. They can trigger "physical impacts" on the resources of the counterparty along its value chain and in its broader environment. The resulting "financial impact" can be read on OPEX, CAPEX, sales, etc. of the counterparty and affect in turn the investor's return.

4 The TCFD's 2020 status report shows an increase in the number of financial and non-financial companies disclosing information on climate-related risks and opportunities. The disclosed information is also more and more detailed and increasing in quality.

5 The "service providers" are mainly for-profit organizations (*e.g.* consultancies; data, market intelligence and analysis providers) specialized in climate related issues. They also comprise for-profit organizations that are not specialized in this topic as well as public bodies. See Hubert and Cardona (2020) for more details.

FIGURE 2 - APPLYING THE IMPACT CHAIN FRAMEWORK TO PHYSICAL CLIMATE RISK SCREENING OF THE NORWEGIAN RAILWAY SYSTEM

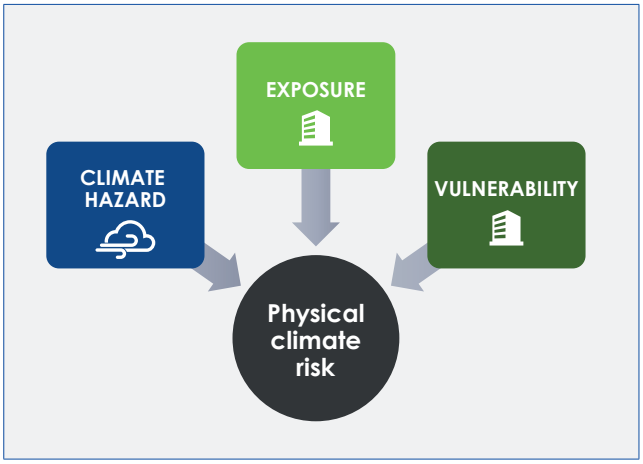
Climate Hazard	Physical impact	Financial impact	Investor impact
Drought	Dried vegetation, risk of wildfires	• Cost of clearing debris; • Alternate routes for passengers; • Potential liability risk	• Increased demand for loans, credit lines, insurance coverage; • Potential reduced client capacity to repay loans; • Increased insurance claims; • Increased portfolio exposure to risk; • Cross-cutting effects on other sectors (tourism, industry)
Heat wave	Buckled tracks, derailed trains ; staff and passenger heat stress, sagging power lines	• Cost of repair to tracks and power lines; • Installation and operation of AC systems; • Reduced revenue from delays and potential cost of alternate routes	
Extreme precipitation and storms (rain and snow)	Submerged tracks and equipment failure, delayed or derailed trains, debris from landslides and avalanches	• Cost of repair to tracks, trains, power lines and debris removal; • Lost revenue from delays, potential cost of alternate transport; • Increased cost of insurance and financing	

Source: ClimINVEST interactive online platform (https://tinyurl.com/climinvest).

To go through the analysis of these impact chains, the methodologies usually combine three main types of data blocks, as shown in **Figure 3**. **"Climate hazard"** data provide climate indicators on the acute or chronic hazards (*e.g.* floods, drought, heat waves, long-term pattern shifts in precipitation or ice melt) as well as a selection of climate scenarios. **"Exposure"** data focus on the aspects of the counterparty (*e.g.* location of key points of a company's value chain) or financial institution (*e.g.* portfolio value) that are exposed to climate hazards along a certain time horizon. The **"vulnerability"** data characterize the degree to which a counterparty or financial institution is unable to cope with adverse effects of the climate hazards they are exposed to.

Vulnerability comprises two aspects. First, data on the **"sensitivity"** can be used to characterize the degree to which the counterparty may face material losses when the hazards occur. Second, data on the **"adaptive capacity"** describes the ability of a counterparty or of the financial institution to adjust effectively to climate hazards, and perhaps benefit from it. These are compatible with the building blocks of the IPCC climate risk framing, which is consistently employed by climate scientists.

FIGURE 3 - THE MAIN DATA BUILDING BLOCKS OF PHYSICAL CLIMATE RISK ANALYSIS



Source: ClimINVEST (2020b) Climate risk factsheet

Opening the box of available climate services

Diverse scopes of analysis

The building blocks of physical climate risk analysis are used in different ways in a multitude of analytical approaches. Several pioneering service providers accepted to open the box of their methodologies on climate risk analysis to the ClimINVEST consortium and financial users. The detailed information is available in the report "Getting Started on physical climate risks analysis" (Hubert *et al.*, 2018) and summarized in Chapter 35 of the 2020's NGFS Occasional paper (Hubert and Cardona, 2020).[6] Each methodology is presented following the data block typology explained above, and with explanations on the impact chains that they look at.

The range of services reviewed in 2018 shows that the methodologies cover different aspects of the impact chain

6 By the time the researchers carried out the review in 2018, the methodologies have continued their evolution. Updates can be found in UNEP FI and Acclimatise (2020).

framework. Some methodologies go through to financial impacts at the financial institution level or at the real economy level. Others focus on the geographic mapping of climate hazards; this is useful to characterize the relative importance of a hazard in different geographies, but not sufficient to characterize portfolio risks in terms of exposure, sensitivity and adaptive capacity.

In addition, for the same type of counterparty in the same location, methodologies can focus on different perimeters of physical impacts and financial impacts, and different aspects of the counterparty's value chain and broader business environment. The perimeter of specific climate impacts is not always fully clear due to limited transparency on the underlying methodological assumptions or the types of data used for the analysis.

Climate data: different levels of clarity on their use

The service providers are generally clear about the category of climate hazards they assess, such as "drought" or "floods". However, more precise information about the underlying climate data can be useful for financial actors to make use of the climate risk information.

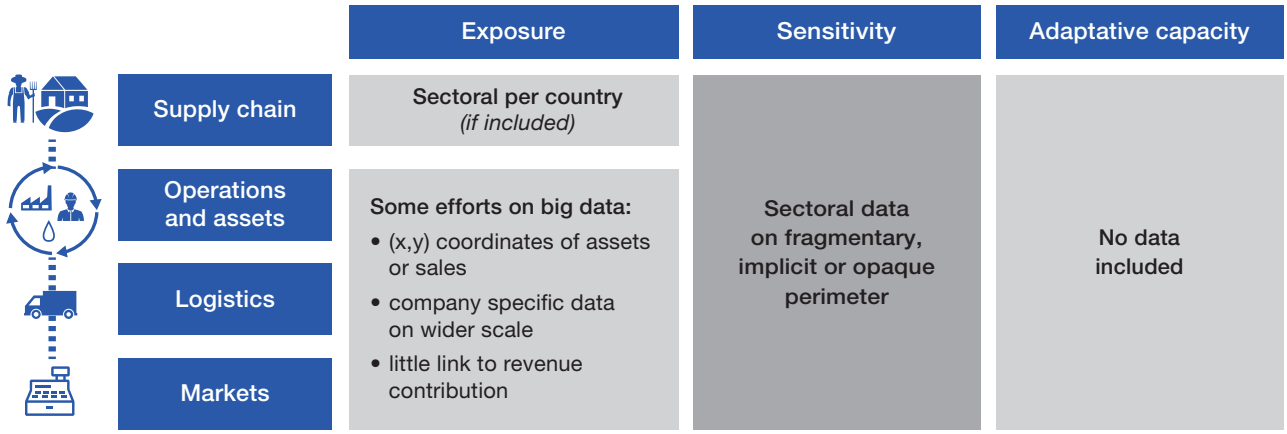
For instance, "floods" is a generic word that covers a diversity of climate hazards with different implications in terms of counterparty vulnerabilities and financial consequences. The asset can be exposed to "fluvial floods" defined as an overflow of the river systems that can be caused by continuous rainfall over weeks or snow melt. A relevant type of adaptation measure for this is to set up dikes, potentially in the frame of local land use planning policies. An asset can also be exposed to "pluvial floods" that are linked directly to local heavy precipitation. In the case of pluvial floods, dikes are of less use, and the adaptation measures may rely on other solutions such as drainage systems near or integrated to the asset. Financial actors may thus engage in discussions with their counterparties on their adaptation needs to floods in a different manner, based on what type of flooding they are exposed to: "fluvial floods", "pluvial floods" or other types of floods. Different climate indicators can be used to analyze the type and propensity of climate hazards, such as flooding and their potential financial consequences, as detailed in **Section 2.3**.[7]

Some of the available services provide detailed explanations about their indicators and are publicly available (*e.g.* the WRI's Aqueduct Water risk atlas) but it is often not the case.

Counterparty level data: availability and transparency issues

Comprehensive analysis of physical climate risks at the corporate counterparty level remains particularly complex due to data scarcity on several aspects. This is reinforced by the need to carry out the analysis on multiple companies in portfolios. As summarized on **Figure 4**, the service providers have developed efforts to address the data challenges, but there is still a need to collect more granular information to characterize sensitivity and adaptive capacity at counterparty level. In addition, the service providers bring different levels of transparency on the data sources and how this impacts the robustness of the climate risk analysis.

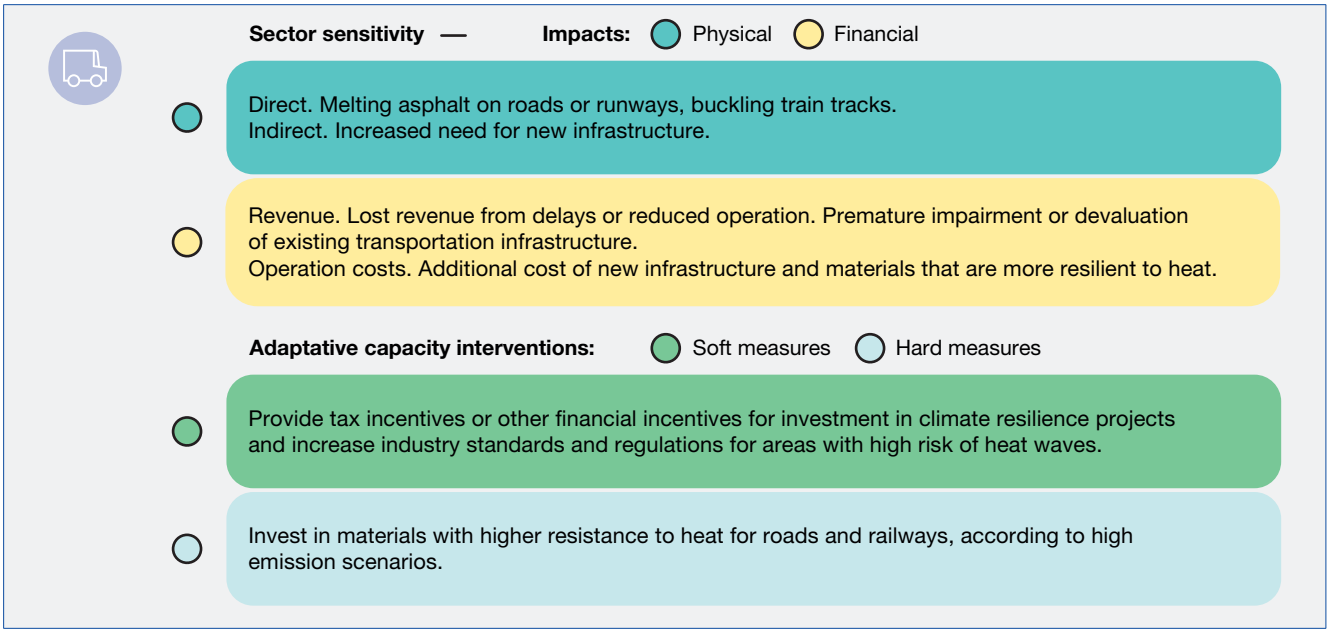
FIGURE 4 - DATA LIMITATIONS IN A SAMPLE OF SERVICE PROVIDERS' METHODOLOGIES ANALYZING CLIMATE RISK ON CORPORATE COUNTERPARTIES



Source: Hubert and Cardona (2020).

7 The ClimINVEST factsheets comprise more information about the types of hazards hiding behind "droughts", "floods" and "heat" and some examples of sectoral vulnerabilities and adaptive interventions related to these hazards.

FIGURE 5 - EXAMPLES OF SENSITIVITY FACTORS AND ADAPTATION INTERVENTIONS IN THE TRANSPORTATION SECTOR IN FRONT OF HEAT HAZARDS



Source: ClimINVEST (2020e) Heat and physical climate risk factsheet.

Navigating the multiple sensitivity factors and adaptation interventions in the real economy

The complex set of sensitivity factors and adaptive capacity of the counterparties can play a crucial role for financial actors' overall physical climate risk. Financial actors may need to understand them, to be able to appreciate the robustness of any climate risk analytical approach. Such understanding can also help them engage with counterparties on their sensitivity and adaptive capacity to climate impacts, in order to collect data on these subjects and help their counterparties build their resilience to climate risks.

While counterparty-specific information is likely to be relevant, financial actors can start understanding the main sensitivities and adaptation interventions of their counterparties on a sectoral basis. **Figure 5** provides examples on heat risks for the transportation sector. Other sectoral examples can be found in ClimINVEST Factsheets on heat, floods and drought. The factsheets provide examples and outline factors that play a role in determining the vulnerability of assets, such as construction materials and design, surrounding land use, connectivity, dependency or time horizon.

2.2. Time-horizon challenges

Challenges from discrepancies between time horizons of decision-making in finance and available information

Mark Carney's 2015 seminal speech on "Breaking the tragedy of the horizon" pointed out that decisions in the financial system do not exceed years whereas the highest impacts from climate change might materialize in decades. He further warned that when climate change becomes a leading issue in the financial sector it might already be too late.

While financial loss due to climate change has already become apparent, financial actors struggle to make climate information useful for their needs. Investors make financial decisions over short (a few months) to medium (a few years) periods of time, while future climate projections span over decades. For example, the integration of long-term climate change in counterparty credit risk modeling is problematic, when the latter relies on the modeling of cyclical credit risks with short-term rating horizons.

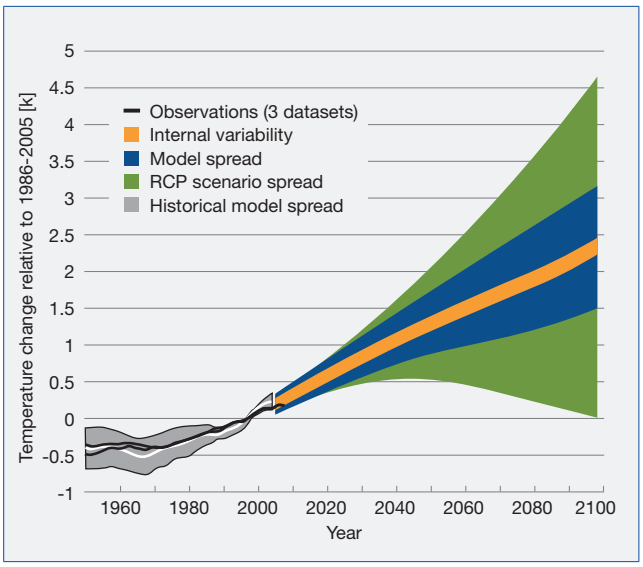
Information about the long-term is not useless for financial actors

Information is widely available about the long-term climate

To represent the potential long-term evolution of climate, scientists use complex climate models that produce "climate simulations". These simulations can be developed for any past, present and future time period. Scientists call them "climate projections" when focusing on the future, and "long-term climate projections" when focusing on 2050 and more distant time horizons. It is important to underline that climate simulations are often presented as averages of climate conditions over 20-30 years. For instance, simulations for 2050 consider climate conditions from 2036 to 2065. Therefore, a 2050 simulation represents the average conditions over 30 years.

Long-term climate projections are based on assumptions about the future trajectory of greenhouse gas (GHG) emissions from human activities. Such trajectories can be represented through emission scenarios (called RCPs, i.e. Representative Concentration Pathways). These scenarios are a plausible and simplified representation of future climate conditions. As shown on **Figure 6**, the main uncertainty in these long-term climate projections is related to the choice of emission scenario as we do not know how human behavior and policies will change over longer time periods.

FIGURE 6 - SOURCES OF UNCERTAINTY IN PROJECTED GLOBAL MEAN TEMPERATURE



Source: Kirtman et al. (2013).

Climate scientists and initiatives such as the TCFD recommend exploring climate projections from various scenarios when carrying out physical climate risk analysis. Long-term information of the climate conditions is relevant for all sectors but especially for investments in assets and portfolios with long lifetime (*e.g.* real estate, infrastructure, etc.). More information and references about climate modelling and scenarios can be found in the Climate Modeling 101 ClimINVEST factsheet.

Financial actors are interested in information that goes beyond the coming years

Some of the banks collaborating in the ClimINVEST project clarified that information about climate conditions in the long-term is important for strategic purposes. Despite the limitation of their loan duration to 5 – 7 years, banks seek to develop long-lasting business relationships with their clients. Information about climate change in the long-term can be interesting for the banks to engage in a dialogue with their counterparties on how they may take strategic milestones to adapt to climate change or grasp business opportunities in this field. This may lead the bank to propose some additional funding solutions to the counterparty. More broadly, the bank may use climate information about the long-term to inform their strategic thinking and planning for development of new markets.

Theoretically, long-term climate information could also be used for asset valuation models such as discounted cash flow models, which are designed to integrate all information that impact future cash flows without a limit in time horizons. However, it is important to acknowledge that a range of practices – such as the choice of a discount rate – may undermine the importance of what happens in the long-term.

Climate information can be used to describe short-term horizons too

Climate change has already started

Financial consequences of climate impacts are already materializing. Past GHG emissions will linger in the atmosphere for decades if not centuries. This phenomenon is driving an increase in the magnitude and frequency of climate hazards and will continue to do so in the coming decades no matter what we do to limit GHG emissions (Clapp *et al.*, 2017). Therefore, climate adaptation mechanisms become as important as mitigation of emissions.

Raising awareness about present and near-term climate risks

While some investors are more familiar with climate hazards, other financial institutions explained that they had started to worry about potential climate impacts only after suffering unexpected losses from recent extreme weather events. Many other financial institutions are likely not fully aware of or concerned about how climate conditions may impact them in the short-term (NGFS, 2020).

To help raise awareness and build capacity within financial institutions about the current exposure of multiple sectors and locations to climate risk, the ClimINVEST project has provided examples of past materialization of climate risks and subsequent financial impacts. They are available in the ClimINVEST interactive online platform and supporting hazard factsheets and videos.

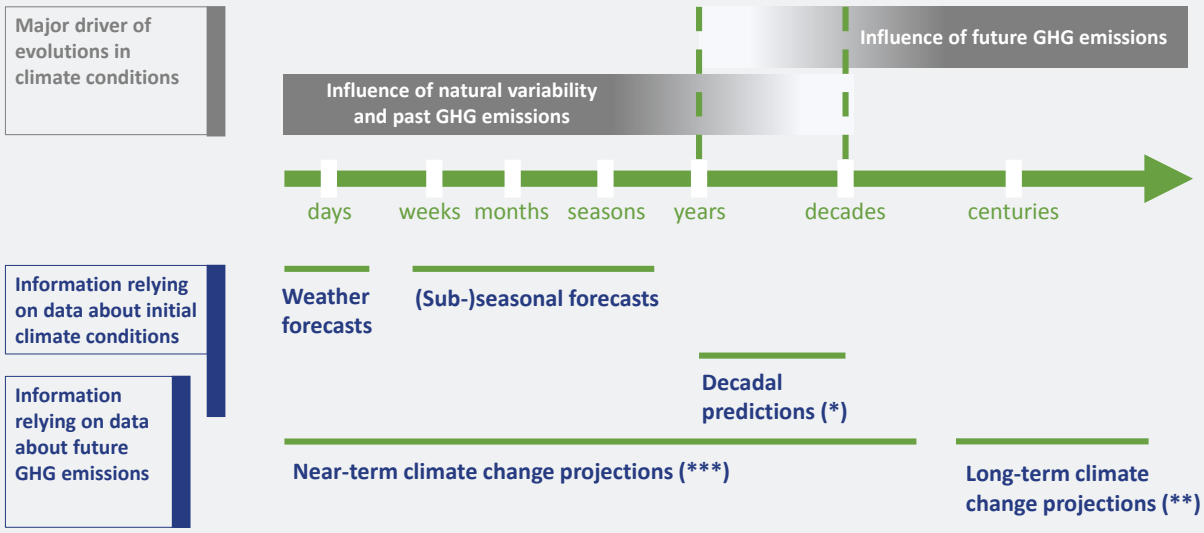
Available climate information on the different time horizons

As illustrated in **Figure 7**, information about climate conditions beyond the next decades is widely available as "long-term climate projections" and various types of information can also be used to describe climate conditions in the closer future. For instance, "seasonal and sub-seasonal forecasts" as well as "decadal predictions" provide information about climate conditions for time horizons that range from the coming weeks up to the coming years. However, such climate forecasts and predictions are highly uncertain.[8]

8 While near-term predictions, such as seasonal and sub-seasonal forecasts and decadal predictions show potential for early warning systems and planning (*e.g.*, in the energy and agricultural sectors), they remain limited in their skill to predict extreme events, such as storm surges or heat waves (Schwierz *et al.*, 2006).

In ClimINVEST, climate scientists have calculated a series of indicators that describe climate conditions from the past up to 2040 based on "near-term climate change projections" (available on the **interactive online platform**). It is important to note that these indicators represent averages of climate conditions, and have been calculated based on the "worst-case-scenario" (RCP8.5). The ClimINVEST hazard factsheets and the interactive online platform showcase selected climate indicators for drought, flood and heat hazards. Case studies from different sectors demonstrate how these indicators can be used in physical climate risk analysis.

FIGURE 7 - CATEGORIES OF CLIMATE INFORMATION AND MODELING STAKES DEPENDING ON TIME HORIZONS



(*) Under development. Can help assess general climate trends but will not provide robust statistics for extreme events.
(**) Typically large variability of the results depending on future GHG emission scenarios.
(***) Less sensitive to the choice of a future GHG emission scenario than long-term projections. To be interpreted cautiously as they are primary built to study the influence of future GHG emission trajectories.
NB : these stylized points of attention do not fully reflect the higher complexity of climate information depending on geographies, hazards, time horizons, etc.

Source: Hubert et al. (2021) modified from Kirtman et al. (2013).

Describing climate conditions of the coming weeks, months or even years is challenging due to the chaotic nature of natural climate variability that can prevail over these time horizons.[9] Future GHG emissions will have a prevalent effect on the evolution of climate conditions when looking at more distant time horizons (typically the next decades and centuries). The different categories of climate information rely on specific technical choices that address differently the chaotic nature of climate variability and future GHG emissions. Climate change projections rely on statistical averages of climate variables calculated over decades where the natural climate variability is averaged out.[10] They also consider a GHG emission scenario to account for the influence of human activities on the climate. The choice of such scenario has much more impact on the long-term projections than on near-term projections, where natural variability dominates.

2.3. Data challenges

Challenges to make sense of available data, identify and fill the major gaps

Climate risk analysis requires a broad array of granular information as physical climate risks are determined by local conditions and context. The consequences of climate hazards may spread on counterparties in the real economy through cascading impacts across their whole value chain and their broader business environment. The resulting financial impacts on the counterparty may depend on its sectoral characteristics, but also on the specific organization of its value chain, on how it interacts with its broader business environment, on its resources to cope with climate hazards, etc. This requires a lot of data at the counterparty level and represents a major challenge as most financial actors may want to assess their climate risk exposure on portfolios that comprise typically thousands of counterparties.

9 Climate varies naturally due to several phenomena, including the internal dynamics of the climate system (*e.g.* atmospheric circulation, land-atmosphere and ocean-atmosphere interactions) that scientists call "internal climate variability", but also some natural phenomena that are external to the climate system (*e.g.* changes in solar luminosity, volcanism and changes in the Earth's orbit).

10 For instance, 2020 climate projections are built as an average of climate conditions over decades, typically over a 2006 to 2035 time period.

Obtaining specific data at counterparty level can be problematic. With the gradual evolution of voluntary and mandatory climate-related disclosure frameworks for non-financial companies, the availability of this information has only started to increase. Service providers have been struggling to address the challenge of data scarcity through big data techniques and other approaches. Furthermore, there is limited transparency on the data sources that each service provider has identified and mobilized and large gaps are identified in available services. These gaps need to be addressed to characterize key aspects of complex value chains and the risk and adaptive capacity of the counterparties.[11]

While the need for increased availability of granular data has been identified, financial actors have received little guidance on the level of climate and counterparty data granularity that is effectively sufficient for their climate risk analyses. Such guidance may help financial actors appreciate the robustness of their climate risk assessments as well as engage with their counterparties to fill in the major data gaps.

On the side of climate data, a lot of information is already available for all regions of the world, about a range of climate hazards and with increasing resolution. However, this information remains very technical and only climate scientists and experts have been trained to make use of it. In addition, the available climate services do not provide comprehensive guidance on the nature and meaning of the climate indicators that they use. Such information is crucial for financial actors to interpret the results of any climate risk analysis.

Providing guidance on the meaning and relevant use of climate indicators

Defining climate indicators

Climate indicators are combinations of climate variables, such as precipitation, temperature, humidity, etc., derived from climate models. Climate scientists have developed hundreds of indicators to serve different types of hazard assessments. Simpler indicators such as maximum daily temperature (TXx) can reveal patterns about the incidence of heat waves over long periods of time. More complex indicators, such as the heating degree days (HDD) are typically used by real estate companies and energy providers to understand the energy needs of buildings.

Understanding of the climate indicators used to characterize the hazards

Each specific climate hazard can be described with a range of climate indicators that provide different insights about the hazard, for instance the duration or maximum intensity of a heatwave or rainfall event. In addition, different climate indicators can be relevant to analyze different types of financial consequences of a same broad category of hazard. The ClimINVEST project has developed several case studies to highlight this issue. For instance, a climate risk screening was conducted on The Wall, a shopping centre in Utrecht, accessible through a major highway. The analysis shows that the asset is exposed to pluvial floods with different intensities and frequencies leading to different types of financial consequences. The Wall shopping center is exposed to extreme rainfall events of 70mm over 2 hours, that today have a probability of occurrence of 1/100 each year.[12] This type of event might cause damage to the structure of the building and potentially loss of the stocks. Less severe rainfall events will also occur more frequently and temporarily disrupt the traffic flow on the highway, generating operating loss. These chronic moderate floods may require adaptation intervention to better drain the highway while the more extreme ones might ask for additional adaptation measures at the scale of the shopping centre itself.

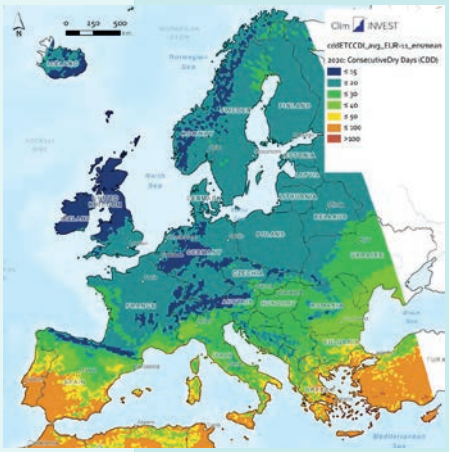
It is important to understand what information indicators convey about each hazard and how they should be complemented. The **ClimINVEST interactive online platform** provides guidance on the relevant use of specific climate indicators on heat waves, floods and drought as illustrated in **Figure 8**. The platform offers high-resolution (10 km x 10 km) data on a number of climate indicators over all Europe and provides clear definitions for each of them. Furthermore, it demonstrates how indicators can be used and complemented with additional information, in a series of case studies from different sectors.

It is also important to understand which climate variables and time spans are included in the indicators. For instance, 1-in-100 year flood and rainfall calculations have been based on historical data; given the increased frequency of extreme events in the past ten years, these metrics and approaches need to be reevaluated (ClimINVEST, 2020d).

11 See Section 2.1 on the Black box challenge for more information about the data gaps identified in the approaches developed by service providers.
12 With climate change, the probability of occurrence will increase in the future.

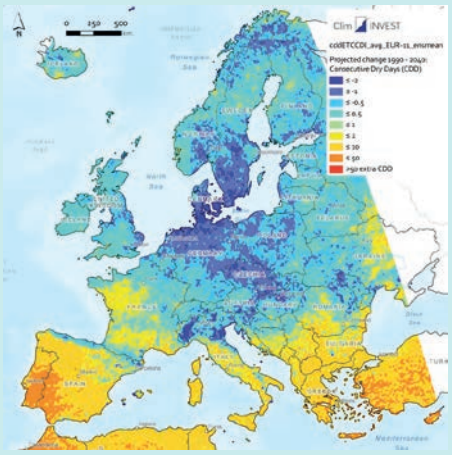
FIGURE 8 - CLIMINVEST INTERACTIVE ONLINE PLATFORM: EXAMPLES OF MAPS ON DROUGHT INDICATORS

Climate indicator	Definition
Maximum number of consecutive dry days	Maximum number of consecutive days per year when daily precipitation is under 1mm per day. The indicator lists the length of a single longest period and not the number or frequency of such periods. This indicator is used to help identify and describe the length of drought events, chronic or seasonal drought patterns or recurring flashfloods. It does not describe temperature trends nor does it consider precipitation frequency or intensity for the rest of the year, which are important factors to consider when assessing exposure. *E.g. higher precipitation in spring and longer dry spells in summer would have opposite effects on water resources.*



Left: Maximum number of consecutive dry days per year around 2020 (averaged over projected values for the period 2011-2030).Dark blue is fewer than 15 days, red is over 100.

Right: Projected change in maximum number of consecutive dry days per year in Europe from 1990 to 2040 Indigo is two fewer days per year, red is over 50 extra days per year. The visualization demonstrates that regions with ongoing dry periods will see further increases in dry periods in the future. The 1990 value was obtained as the average value for historical model runs from 1981-2000, whereas the 2040 projection is the average of projections for 2031-2050.



Source: ClimINVEST (2020c) Drought and physical climate risk factsheet.

Climate indicators can include assumptions on counterparties and their broader environment

When financial actors carry out or interpret physical climate risk analysis, they may keep in mind that climate indicators sometimes convey hypotheses about the characteristics of their counterparties in portfolio and the evolution of their broader business environment.

Climate indicators can describe climate hazards that are relative to a specific socio-economic context. As explained in the drought factsheet, "water stress" describes the water deficit for a specific community, accounting for the difference between this community's water demand and the water resources. As explained in the flood factsheet, data on land use (*e.g.* agricultural practices) is important to define how a soil is susceptible to become impervious and thus more prone to floods.

Climate indicators often include a threshold value describing how the magnitude or recurrence of climate conditions goes beyond the coping capacity of a given counterparty. For instance, ClimINVEST carried out climate risk analysis of potentially harmful high temperatures for an agricultural portfolio. The hazard was characterized with an indicator on the frequency of hot days that can cause damages to the crop and reduce its yield. Based on literature review, the "hot day" temperature threshold was set at 30°C to reflect that crop yields have a large negative sensitivity to temperatures around 30°C (IPCC, 2014). This is used to provide insights about the potential operational losses for a farm arising from heat. (Gallo and Lepousez, 2020).

Furthermore, climate indicators applied to long-term horizons also include some assumptions about the evolution of socio-economic activities. Climate change in the long-term depends widely on the current and future greenhouse gas emissions from human activities, which remain unpredictable. In order to reflect this, climate scientists provide climate indicators about the long-term that are built conditionally to one emission scenario among several potential ones. This is explained in more detail in **Section 2.2** of this report, and in the Climate modeling 101 factsheet.

Providing guidance on how to deal with the climate and counterparty data needs

The case for financial actors to collaborate with climate experts on tailored analysis

The ClimINVEST project experimented with the direct collaboration between financial actors and climate experts during workshops where several case studies were developed. The ClimINVEST interactive online platform provides an overview on several of these case studies. An array of case studies are also described along with other examples in dedicated factsheets and presentations (*e.g.* The Wall case study) and in the "Assessing climate physical risks for financial decision makers" report (Gallo and Lepousez, 2020).

Such collaboration enables financial actors to formulate the questions they want to investigate with the risk analysis, which provides clues to climate experts on the type of challenges it represents in terms of data availability and discuss solutions. Financial actors' portfolio information and internal capacity to collect data also help climate experts calibrate their analysis and develop efforts for data collection accordingly. For instance, if a financial actor has the zip code of their counterparty's headquarters as the unique localization data, this provides climate scientists with the minimal required data to carry out first analyses. However, it might be problematic to characterize properly some climate hazards that might require more precise spatial information. This is the case of floods that need information about the local topography, or drought that requires information about land use. Precise data location is all the more crucial for capital-intensive sectors that rely heavily on long-lasting assets that might be damaged by climate events.

Providing clues on counterparty level information that can be useful

The appropriate data granularity needed to analyze the exposure of a given counterparty to physical climate risk should be assessed carefully. In the case of a company, some sectoral information may be useful to identify major vulnerabilities and how they relate to climate hazards. Some specific information about the company is also necessary to map the key aspects of its value chain, the characteristics and climate resilience of the broader business environment, and how the company interacts with it. The sensitivity and adaptive capacity of the company may also depend on some technical aspects (*e.g.* the building material of the operation sites might be more or less resilient to temperature variations), on its bargaining power, on its strategy to address the risks and opportunities of climate change.

The ClimINVEST project provides some clues on the type and granularity of relevant data for counterparty level analysis in a range of case studies, as illustrated in **Figure 9**. Each factsheet on climate hazard also comprises examples on sensitivity and adaptive capacity factors to floods, heat stress and drought in diverse economic sectors. These examples can help financial actors engage in targeted discussion with their counterparties on their adaptation needs, or discussion with their climate service providers on the robustness of their approach.

FIGURE 9 - EXAMPLE OF DATA NEEDS TO ASSESS FLASH FLOOD RISK FOR LOW-LYING TRAIN TRACKS

	Climate hazard	Asset exposure	Vulnerability	
			Asset sensitivity	Adaptive capacity
Data input	Climate indicators, scenario selection, grid resolution.	Location of the asset (addresses or GPS coordinates), financial value of the asset, time horizon.	Sector sensitivity, design, construction materials, age, connectivity, area land use, elevation.	Insurance, early warning systems, liquidity reserves to implement potential adaptation measures.
Source	Climate models or bridge platforms *e.g.* Copernicus.	Climate hazard maps, financial statements, addresses or GPS coordinates.	Construction proposals and blueprints, local topography, electricity grid and invoices.	Satellite imagery, municipal government hazard maps, local policies.
Example	Number of days when rainfall exceeds 50mm in western Norway for a high emission scenario (see ClimINVEST Flooding fact sheet for more details).	The next ten years, train tracks from point A to B, value of annual tickets sold for route, probability that the flash flood will happen.	Elevation of tracks, and-use surrounding the tracks.	Ability to install protective walls or buffers to absorb flood waters.

Note: As outlined in the red box, the sources of data input for asset sensitivity and adaptive capacity are less definitive and perhaps challenging to access.
Source: ClimINVEST (2020b) Climate risk factsheet.

2.4. Estimating financial impacts of physical climate risks

Quantification of financial impacts from climate risks faces data issues

Translating climate data into physical and financial impacts requires impact functions that need to be calibrated for each individual case.

When carrying out the climate risk analysis at corporate counterparty level, the assessment of financial impacts may require counterparty-specific information about its value chain, bargaining power, strategy, etc., in addition to information about its broader business environment (*e.g.* how land use planning policies influence the climate resilience of the company's production area). This makes defining impact functions even more data intensive as financial institutions are invested in diversified universes.

When carrying out portfolio risk screening at sectoral and country level, the task remains complex as damage functions only exist for a handful of sectors and locations (Auffhammer, 2020). In addition, the robustness of impact functions used in even well-known integrated assessment models (IAMs) is not always easy to assess due to limited transparency (Diaz and Moore, 2017). This makes it difficult to generate accurate quantified information about physical risks on a given investment.

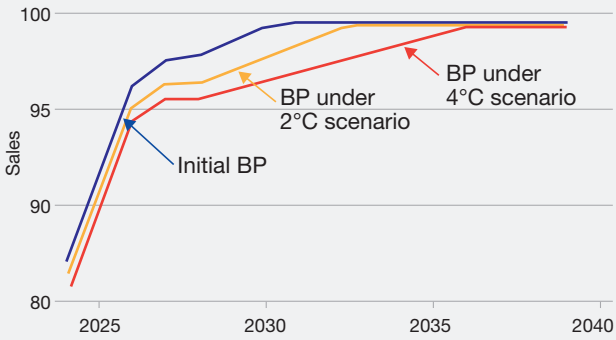
Demonstrating how the feasibility of quantification varies with different factors

The ClimINVEST case studies illustrate some key factors that condition the capacity to estimate financial impacts. Those comprise the complexity of the counterparty (*e.g.* complexity of the value chain), the size of the portfolio and diversity of counterparties, the existence of impact functions and availability of data needed to use them, and more broadly the capacity to access data on counterparties and financial models. In addition, uncertainties on climate scenarios and climate model uncertainties can play a major role (see **Figure 6** and the Climate modeling 101 factsheet for more information about sources of uncertainty).

The ideal case when all the data is available

An ideal case would be the quantitative assessment of the impact of increasing temperatures on the sales of a heat distribution network, detailed in ClimINVEST report Gallo and Lepousez (2020). For this case study, the researchers were able to quantify the retrospective impact function of heat variations on sales thanks to the availability of data on the company's previous sales and a climate indicator on natural heat conditions (HDD - "Heating Degree Days") that correlates with the demand for heat. The HDD indicator was projected in two alternative scenarios where global warming reaches 2°C or 4°C. The researchers were also able to inform the financial institution's due diligence process by integrating projected impacts of heat on sales into the business plan (BP) considered by the financial institution, as illustrated in **Figure 10** below.

FIGURE 10 - PROJECTED IMPACT OF HEAT VARIATIONS ON COMPANY SALES IN DIFFERENT CLIMATE SCENARIOS



***NB:** This Figure is for illustrative purpose only. It shows how the achievement of the business plan (BP) objectives can be delayed by 3 to 7 years when accounting for climate change.*

Source: Gallo and Lepousez (2020).

What it takes to build a reliable impact function on a specific scope of analysis

Research developed by Orlov *et al.* (2019) for the ClimINVEST project illustrates how the development of reliable impact functions can require complex interdisciplinary work and data sources. Such functions are developed in specific geographic, temporal and socio-economic contexts and the temptation to generalize these functions to other contexts needs to be considered with great caution. Orlov *et al.* (2019) investigate how worker productivity is influenced by temperature, especially in sectors which require labor outdoors, such as construction and agriculture sectors. They use an interdisciplinary approach, combining meteorological, epidemiological, and economic analysis to determine the cost of heat-induced reductions in outdoor worker-productivity in Europe. The study results show that in the ten most affected European countries, average direct economic losses in agriculture accounted for USD 59-90 per worker in agriculture and USD 41-72 per worker in construction during the heat waves in August 2003, July 2010 and July 2015.

The use of impact functions can face operational challenges

In other instances, reliable estimation of financial impacts is not possible for several other reasons. The ClimINVEST case study on real estate portfolios illustrates some of these difficulties (and the next section below illustrates how climate risk scores were used to address this challenge). The researchers collected data from three French banks who participated in the project. They synthesized a fictitious

portfolio with 435 lines and representative of the French real estate market.

Some impact functions exist concerning financial impacts on real estate arising from certain types of hazards. However, in practice they could not be used. This is linked to limited data availability about the characteristics of the buildings in portfolios (reduced to zip codes and large categories of building type of use, without all details needed to characterize the climate vulnerabilities of each building). In addition, the impact functions for hazards like floods require precise environmental data that involve specific modeling work. Such exercise was out of the scope of the analysis, due to the size of the portfolio combined with limited data availability on other aspects (more information is available in Gallo and Lepousez (2020)).

Assessing physical climate risks can be all the more difficult for counterparties with more complex value chains. They represent a potentially large amount of complex climate vulnerabilities to identify and analyze, and difficulty to collect data on all the most important aspects.

Qualitative information can simplify the management of the financial consequences from climate risks

Considerations on financial impacts can be integrated at different degrees in qualitative climate risk information

Certain types of climate risk scores embed some level of consideration about financial impacts to a company, based on sectoral data and assumptions. Some methodologies consider the potential vulnerabilities on different aspects of a company's financial statements with sectoral data and assumptions on the typical characteristics of a company's value chain in this sector. Based on this, the methodology can formalize how climate hazards may impact the company on its major financial vulnerabilities. This sectoral vulnerability approach helps to focus the perimeter of analysis only on the climate hazards and types of financial impacts that lead to financially material climate risks. As a last step, using a map of the relevant climate hazards in the counterparty's key geographic exposures provides a first screening of financial climate risk hotspots in a portfolio.

The ClimINVEST case study on a European agricultural portfolio analyzes the exposure of wheat to potentially harmful high temperatures (Gallo and Lepousez, 2020). The analysis does not quantify the financial impacts of heat on farms since it does not include specific impact functions and since no specific information was available on farm level and its business environment. However, the analysis does provide general insights about the potential operational losses from heat. The climate indicator for potential harmful high temperatures is based on a 30°C threshold reflecting the domain of temperatures that is strongly detrimental to crop yields (IPCC, 2014).

It is important to note that the relevance of this sectoral vulnerability-based approach can be discussed in several cases. The exposure and vulnerability may depend on specific characteristics of the company and its business environment. For example, sectoral data could bring some relevant information about the vulnerability of the car industry to floods (*e.g.* the typical capital intensity of the car sector could be combined with general estimates of the cost of damages on industrial infrastructures, if the information exists). However, the vulnerability in this sector may also depend much on company-specific characteristics such as the precise location of the production sites, the capacity of the workers to reach the production sites, etc.

In general, climate scores provide information at a coarser level than what is required for reliable quantification of financial impacts. However, some financial institutions highlighted their utility for risk management and for raising awareness.

Some financial institutions can leverage climate risk scores for their risk management

During the ClimINVEST project, some of the French banks explained that they can use climate risk scores for their risk management process. Screening physical risk hotspots through a score is a way to simplify their need for exhaustive and granular estimation of financial impacts from climate risks on all counterparties.

First attempts to integrate physical climate risks at financial institutions usually focus on the main metrics and analytical processes used to manage financial risks within the institution. In the case of credit risk, this can focus for instance on integrating climate issues in counterparty's probability of default or credit ratings. However, the underlying modeling tools that generate these metrics are not always fit for integrating physical climate risks. This can relate to the incapacity of credit rating methodologies to account for disruptive and non-cyclical events, or a bias of these models in favor of historical data whereas climate change is unprecedented and cannot be extrapolated from the past; or also discrepant time horizons (Laurens-Villain *et al.*, 2020). In addition, such integration also faces the lack of the necessary information to provide reliable estimation of financial impacts on the counterparties arising from climate hazards.

Some financial institutions such as the French Development Agency (AFD) decided to add a separate climate risk scoring methodology to their risk management processes. The score is based on a sector-country screening of climate risks and provides warning flags on clients for credit officers to engage with the counterparties. The AFD also developed a ready-made questionnaire to engage discussions with potential new counterparties during the due diligence process, in order to discuss the awareness of the counterparties about the identified risks and whether they have potential adaptation strategies. (Laurens-Villain *et al.*, 2020).

Transparency matters on the scoring methodology and output

Financial actors participating in the ClimINVEST project pointed out that clarifications about the scoring methodology and output are paramount to interpret this information and make it useful for risk management decisions.

For instance, the participating banks mentioned that it is particularly useful to look at separate scores per category of hazard, and obtain details about the main types of climate impacts that are included in the score, in order to engage in discussions with counterparties on specific vulnerabilities and adaptation needs. They also recommend looking for explanations about low-scores vs. high-scores in terms of consequences for the counterparty (*e.g.* counterparty needs retrofitting of some specific installations vs. counterparty needs complete rebuilding of assets). Financial actors also point out the need to understand how the normalized scores can be compared with each other (*e.g.* is it possible to compare the risk scores for different types of hazards?).

3. Moving forward: priority areas of action for financial actors and their stakeholders

After three years of collaborations between financial actors and climate experts, the ClimINVEST project was finalized with a stock take of physical climate risk integration at twelve financial institutions. These include retail as well as corporate and investment banks, public financial institutions, asset managers. The stock take exercise revealed some of the good practices that the institutions have developed to make progress on awareness raising, climate risk analysis and management. It also revealed the needs and challenges that these active institutions are currently facing and that may call for collaborative action of a wide range of stakeholders.

Building on ClimINVEST stock take, the following sections of the report share advice for financial institutions to organize their integration of physical climate risks. The final section highlights the current frontiers of climate risk integration and how to move forward with collaborative action of a range of stakeholders.

3.1. Building expertise within financial institutions

Inter-departmental capacity building is needed on physical climate risks and opportunities

Climate risks and opportunities concern current portfolios, upcoming deals and strategy and can require intervention of the board, risk managers, ESG officers, portfolio managers, client advisors, etc. These diverse teams all need some level of understanding of climate risks and opportunities to enable proper mainstreaming of these issues at the institution level.

However, physical climate risk is a highly technical domain that has not been part of the usual fields of expertise at most financial institutions. Training is required for financial actors and needs to be tailored to the specific needs of different teams.

Case studies on the institution portfolio are a good introduction to physical climate risks

The financial institutions that participated in the ClimINVEST project recommend to present case studies of climate risk analysis on their own portfolios as an introduction to climate risk analysis. Using examples from the institution portfolio helps all teams understand the risks within their own organizations and position them to find solutions that are tailored to their needs.

In addition to raising awareness about the propagation of climate impacts and their materiality, it helps the teams engage in dialogue for preparation of technical developments for risk analysis. Such a process may benefit from the presence of climate experts who helped building the case study.

The replication of case studies in different portfolios can be useful as each type of portfolio may face specific climate risks and opportunities, and as it may involve different teams in the risk analysis process.

Case studies need to be complemented with further resources

Diverse types of additional resources should help the teams build further expertise depending on their positions and how they integrate physical risk analysis.

The top management may need salient takeaways of case studies on their own portfolios to incorporate into strategic decisions. To escalate the priority level, they may also need general key messages from regulatory authorities in the financial sector about the materiality of climate issues, and from climate researchers about the capacities, limitations and perspectives to address these risks.

The teams who may participate in more technical aspects of climate risk analysis and management may want to gain technical knowledge about the concepts and limitations of climate risk, available analytical approaches and risk management solutions, and the interpretation of climate data. Involvement in the co-design and deployment of pilot tools for climate risk analysis is a good opportunity to build such expertise. The teams can also gain knowledge through direct exchange with climate scientists and from ClimINVEST resources available online.

3.2. Develop pragmatic approaches to start managing the risk quickly

Tailored approaches combined with efforts to address long-term challenges

Several financial institutions are making progress with the integration of physical climate risks despite the need for further data and the difficulties to quantify estimates of potential financial losses on large portfolios.

As illustrated in **Section 2.4**, some of the financial institutions in the Netherlands and France are currently moving forward with simplified analytical approaches such as high-level risk screening of their portfolios in different sectors and countries. This is used to identify risk hotspots and pinpoint where further analysis is needed. It also leads sometimes to more

in-depth analysis and engagement with the counterparty to collect specific data that were missing. In parallel, these financial institutions acknowledge the need for relevant and quality data to be made more widely available.

This approach may not be replicable within all types of financial institutions, depending on their internal organizations, capacity to collect data from counterparties and capacity to carry out the analysis on large portfolios. It is important that financial institutions explore their own internal capacities and develop solutions tailored to their needs as explained below.

Internal and external collaborations are helpful

These pragmatic approaches are developing where financial institutions are in the dynamics of mobilizing their internal teams and experts to develop tailored approaches. These developments also typically involve the intervention of external climate experts.

The financial institutions participating in ClimINVEST final stock take find benefits in the participation of diverse teams in the process. While involvement of the risk teams is key, the participation of other teams such as ESG or front office teams have proved fruitful. Cross-team participation helped identify technical and organizational constraints but also solutions that could be developed to integrate climate risks in decision-making.

Discussions between climate experts and internal teams also helps build mutual understanding about what can be done, in which timeline, and finding appropriate alternatives. Case studies on the institution's portfolio involving climate experts were mentioned to be a good way to explore issues and solutions of climate risk analysis.

Structuring governance for successful action

Robust governance at the institutional level can help identify and analyze the exposure of the financial institution to climate risks (which can be related to strategic thinking; assessment and management of risk at balance sheet, portfolio, or counterparty level; and due diligence). Governance structures can also support addressing the questions as recommended by the TCFD (2017).

All twelve financial institutions interviewed at the end of ClimINVEST are increasingly involving different teams in their governance of climate risks and reported some successful ways to organize collaborations. Most of them are structuring specific teams around climate-related risks. Such teams are usually mixing ESG and risk divisions and sometimes also other teams such as AI developers or the front office. Several institutions recommend the active participation of the risk teams, while other financial institutions are using informal exchanges in diverse teams.

3.3. Action from an array of stakeholders is needed for sustained improvements

The financial actors participating in the ClimINVEST final stock take also expressed their evolving needs for raising awareness, analyzing and managing physical climate risks as summarized in **Table 1**. This calls for further action within financial institutions, combined with action from financial regulators, counterparties, and a wider array of stakeholders.

Enabling environment and the role of regulators and supervisors

Some financial actors mention that sustained requests from regulators and financial supervisors are key for signaling the need to keep physical climate risks on top of the financial institutions' priorities. As financial actors tend to dedicate a limited amount of resources to climate-related risks, there might be a competition between resources allocated to physical climate risks and resources allocated to the risks arising from the transition to a low-carbon economy. They warn that too much emphasis on transition risks compared with physical climate risks in the initiatives of supervisors and regulators may be detrimental to mobilization of teams on physical climate risks.

In addition, given the crucial need for training of financial actors on climate risks, several organizations suggest that regulators may play a role to stimulate and scale-up the training of financial actors on sustainability issues including physical climate risks. Demonstrating skills on this subject could for instance become a requirement in regulatory qualifications to work in the financial markets (Finance for Tomorrow, 2020; Evain and Cardona, 2021).

During the ClimINVEST stock take, the financial actors mentioned that regulators and financial supervisors can also help with the need to standardize methodologies for physical climate risk analysis. For instance, the regulators can specify in mandatory climate-related disclosure frameworks the type of information that the financial institutions are expected to disclose about their exposure to physical climate risks. This may steer harmonization of the methodological choices for physical climate risk analysis that financial actors carry out in-house or with service providers. The regulators of financial and non-financial companies could also collaborate to improve mandatory disclosure frameworks for companies in the real economy in order to provide financial actors with relevant data for physical climate risk management (NGFS, 2020).[13]

13 For more examples of regulatory and supervisory fields of action, see the NGFS paper on environmental risk analysis (NGFS, 2020).

Mobilizing a broader ecosystem of actors to collect quality data

Financial actors are calling for further scoping of climate risk analysis, which suggests addressing further data gaps as mentioned in **Table 1**. The main issues to be addressed are the scope of data as well as ensuring its quality, public availability and standardization to allow for combinations and use of the data in different contexts. The standardization of the data may call for intervention of standard setters.

Beyond asking for more usable data, the financial actors are now reflecting on how the data could be made available more efficiently. Some financial actors are asking for guidance about the relevant counterparty data they could ask for and collect through engagement. However, this is not applicable to all financial institutions and counterparties. Financial actors are also exploring the role that different stakeholders could endorse to collect the data. The majority of the financial actors who participated in the ClimINVEST stock take recommend the centralization of counterparty and climate hazard data by one authority, standardization and quality check of the data, as well as free availability. They also acknowledged the need to account for confidentiality issues. As one example approach, several financial institutions in Norway are developing a "knowledge bank" in partnership with multiple local authorities to harvest local data for climate risk analysis. However, this is not openly available due to confidentiality issues.

Financial actors are also looking for sectoral level data about vulnerabilities per hazard and potential propagation channels of climate risks – from physical impacts on the whole value chain of a company to consequences on its financial vulnerabilities. Addressing this sectoral data need would contribute to improving the translation of climate impacts into financial impact terms. Actors expressed a preference for publicly available, comparable and quality checked data. Such a development may also benefit from collaboration between experts in different fields, including sectoral experts from diverse financial institutions. The collaboration could be organized by independent third parties that would help make this information public and widely adopted.

Collaborate with service providers and other actors to make climate risk information more relevant for decision-makers

Work on climate risk information format that fulfills the needs of internal decision-makers

Several financial actors call for helping build trust in service providers' methodologies and make the results more accessible. They recommend sustained efforts from service providers to explain in a standardized document their major analytical choices and the factors that influence the results the most. Using widely accessible and quality checked data is also considered helpful to build trust. More guidance on the relevant technical choices is also recommended to discuss the reliability of the approaches. Such guidance document should be developed by third parties who are yet to be determined but could, for example, involve climate researchers.

Further, financial actors look for information formats that catch the attention of their internal decision-makers while they also use information on a broader set of risks. The service providers could further adjust their information formats following additional exchanges with financial actors. In particular, the financial actors participating in ClimINVEST stock take look for a climate risk information format that clarifies the types of impacts and their severity, and that allows for comparison of materiality with other risks to be managed. These clarifications would be especially relevant for increasing the incorporation of climate risk scores in decision-making. They also call for an information format that is concise and standardized.

In addition, some of the financial institutions participating in the ClimINVEST stock take highlighted anew the need for improving the translation of climate risk to financial risk. There is much more work to be done.

Work on climate risk information that conveys key aspects of climate risks: the case of scenario uncertainties

The evolution of climate conditions in the future remain uncertain because of several factors as explained in **Section 2.2** of this report. In particular, long-term climate conditions depend a lot on the scenario of future greenhouse gas (GHG) emissions from human activities. This uncertainty about scenarios should not hinder action. Financial impacts of climate hazards are already materializing, and the scenarios are useful to show different stories for decades into the future.

While information on climate conditions in alternative GHG scenarios can be very relevant, especially for evaluation of climate impacts in the longer term such as in the second half of the century, financial actors are not necessarily equipped to make use of information about several alternative futures which have not been assigned with an expected likelihood. Potential solutions may exist in literature about scenario-based decision-making that has been applied in different industries (Kalra *et al.*, 2014; Depoues *et al.*, 2019).

TABLE 1 - SYNTHESIS OF FINANCIAL ACTOR UPDATED NEEDS IN FRANCE, THE NETHERLANDS AND NORWAY

Financial actors need	Way forward
Risk awareness	
Enable increased awareness	Sustained regulatory/supervisory requests on physical climate risk.
Demonstrate materiality	• Climate risk analysis on the institution's own portfolio. • Inclusion of short-term exposure with explanation on financial impacts and their potential severity. • Development of outlooks including about the lock-in of climate change dynamics in the coming decades, and the perspectives of climate risk insurability.
Increase knowledge	• Introduction on physical climate risk principles. • Clarification of technical terms.
Risk analysis	
Increase scope	Coverage of all relevant climate hazards and impacts for a given portfolio. Including (but not limited to): liability insurance; economy-wide impacts; quantification of financial losses.
Build capacity on technical choices	Guidance on: how to prioritize the different types of climate risks and climate risk information; how to prioritize the types of data and the relevant scenarios.
Obtain data at sectoral level	Data that is publicly available, comparable and quality checked. Sectoral vulnerabilities per hazard and potential propagation channels (from physical impacts on the whole value chain to consequences on financial vulnerabilities).
Obtain data on corporate counterparties	Publicly available, comparable and quality checked data from large companies on their revenue split per sectoral activity and geography, their value chain structure/location; their sensitivity and adaptive capacity to climate impacts.
Obtain data on climate hazards	Data on local climate hazards, that is publicly available, quality checked, updated and standardized in a widely accepted format. The data should cover various climate indicators on a range of hazards (*e.g.* soil subsidence) and be formatted for internal use, for instance as hazard maps.
Obtain data on broader range of time horizons and temporal dynamics	• Retrospective information (10 last years) with explanation about contribution of climate change to past financial losses. • Climate data and materiality of climate risks in the present and including outlooks on next 5 to 10 years and major drivers of evolutions.
Develop data collection dynamics	1/ Mobilization of relevant stakeholders (*e.g.* municipalities and other public organisms; reinsurers; authoritative personalities in the relevant domain) to create publicly available databases with appropriate management of confidentiality issues. Relevant stakeholders may provide local data for climate risk analysis. Large corporates may contribute with data. As SMEs have limited capacity to provide specific data, a sectoral approach can be relevant. Collecting data on sectoral vulnerabilities and climate hazard maps may help on that matter. 2/ Guidance on what is important to know about the counterparty to appreciate the vulnerabilities in its value chain in order to engage with the counterparty and collect and prioritize the data.
Clarify the future trends of climate risk analysis in finance	• Guidance on the implications of the EU taxonomy and stress-testing exercises for climate risk analysis at financial institutions. • Clarification about who should carry out the analysis at counterparty level (*e.g.* banks; counterparties; third parties).
Risk management	
Increase trust and understanding of climate risk information	• Documents clarifying scope of impacts and their propagation channels, major analytical choices, factors that influence the results the most. • Use of public, quality checked and standardized data sources.
Increase relevance of climate risk information format for decision-makers	• Concise and standardized information. • Clarification (and potentially quantification) of the types of physical and financial impacts, their severity and materiality compared with other risks. • Presentation of information on diverse climate scenarios.
Enable engagement with counterparties on their adaptation needs	Guidance including climate-related financial vulnerabilities at sectoral level with explanation of the risk propagation channels.
Disclosure	
Increase relevance of disclosed information from financial institutions	Guidance on what to disclose about physical climate risk and how (more precise than TCFD current guidance).

Note: This Table summarizes the needs expressed by twelve financial institutions from France, the Netherlands and Norway at the close of the ClimINVEST project. This includes retail as well as corporate and investment banks, public financial institutions, asset managers. These needs are an update from what was expressed by financial institutions in early stage of the ClimINVEST project and presented in de Bruin *et al.* (2019).

Source: ClimINVEST project surveys carried out in 2020.

Concluding remarks

Much of the needs expressed by financial actors call for collaborative action of various categories of stakeholders to make further progress on physical climate risk analysis and management in the financial sector. Financial institutions need to engage with service providers and researchers to provide their teams with further training and obtain more decision-useful information about their exposure to physical climate risks. Financial regulators and supervisors can play a crucial role to help financial actors prioritize physical climate risk management and increase the provision of quality and standardized data and tools for physical climate risk analysis. The financial institutions participating in the ClimINVEST final stock take also highlight that an array of stakeholders can help organize data collection and contribute with the analysis, including *e.g.* rating agencies, municipalities, companies, and insurance companies.

While efforts are being made – as illustrated by the ClimINVEST project and other initiatives – a lot of work still needs to be done and requires broader mobilization of the financial ecosystem and other actors to mitigate the pressing damages of climate change.

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