RESULTS OF EXPLORATIONS OF THE CS MARKET FOR THE FINANCIAL SECTOR

H2020 – SC5-03b
Research and Innovation Action

Grant agreement 730500

EU-MACS European Market for Climate Services

23/12/2018

Deliverable 2.1

Version 1

Dissemination level:
Public

Due date of delivery: 31 July 2018
Actual date of delivery: 23.12.2018

Lead beneficiary: Acclimatise
Lead author(s): Robin Hamaker-Taylor (Acclimatise)
Contributing Authors: Adriaan Perrels (FMI); Laura Canevari (Acclimatise); Väinö Nurmi (FMI); Tuukka Rautio (FMI); Amanda Rycerz (Acclimatise); Francesca Larosa (CMCC).

Version table		
Date	**Name, Party**	**Description**
February 2018	Robin Hamaker-Taylor, Adriaan Perrels	Inception
November 2018	Adriaan Perrels	Addition of chapter 9
November 2018	Robin Hamaker-Taylor, Adriaan Perrels	Construction of chapter 10
December 2018	Robin Hamaker-Taylor, Adriaan Perrels	Robin Hamaker-Taylor, Adriaan Perrels

Internal review table		
Date	**Name, Party**	**Description**
July 2018	Ines Vaittinen, ENOLL	Draft review
9 July 2018	Alastair Baglee, Acclimatise	Draft review
10 July 2018	Peter Stegmaier, U Twente	Draft review
16 August 2018	Anna Haworth, Acclimatise	Draft review
14 September 2018	Adriaan Perrels	Draft Review

Contributors (Consortium Party, person):

FMI	Adriaan Perrels; Väinö Nurmi; Tuukka Rautio
HZG-GERICS	
CNR-IRSA	
Acclimatise	Laura Canevari; Amanda Rycerz; Alastair Baglee; Anna Haworth
CMCC	Francesca Larosa
U_TUM	
U_Twente	
JR	
ENoLL	

LIST OF ABBREVIATIONS

Abbreviation	Full name and explanation
2Dii	2 Degree Investing Initiative
ADB	Asian Development Bank
AFD	Agence Française de Développement [French Development Agency]
AMO	Atlantic Multi-decadal Oscillation
ANU	Australian National University
ANZ	Australia and New Zealand Banking Group Limited
AODP	Asset Owners Disclosure Project
BBVA	Banco Bilbao Vizcaya Argentaria
BNG	Bank Nederlandse Gemeenten
C3S	Copernicus Climate Change Service [part of COPERNICUS]
CCKP	Climate Change Knowledge Portal [World Bank]
CDP	Carbon Disclosure Project
CDSB	Climate Disclosure Standards Board
CFA	Chartered Financial Analyst
CGE	Computable General Equilibrium [models]
CICERO	Centre for International Climate and Environmental Research
CISL	University of Cambridge Institute for Sustainability Leadership
CMIP	Coupled Model Inter-Comparison Project
COP	UNFCCC Conference of the Parties
COPERNICUS	The European Union's Earth Observation Programme
CORDIS	Community Research and Development Information Service [European Commission]
CS	Climate Services
CSPP	Climate Smart Planning Platform
CVRA	Climate Vulnerability and Risk Assessment
DFI	Development Finance Institution(s); DFI for the purposes of this report includes national and subnational development banks, multilateral development banks, and international finance institutions.
DNB - Netherlands	De Nederlandsche Bank [Central bank of the Netherlands]
DNB - Norway	Den Norske Bank [partially government owned bank]
DRM	Disaster Risk Management
EBA	European Banking Authority
EBRD	European Bank for Reconstruction and Development
EAC	Environmental Audit Committee, UK House of Commons
ECB	European Central Bank
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variables
EEA	European Environment Agency
EIB	European Investment Bank
EIT Climate-KIC	European Institute of Innovation and Technology Climate Knowledge and Innovation Community
ENSO	El Niño Southern Oscillation
EO	Earth Observation
EOTAP	Earth Observation for a Transforming Asia and Pacific

ERA-NET	European Research Area Network
ERG	Eastern Research Group
ESM	European Stability Mechanism
ESG	Environmental, Social and Governance
ESIA	Environmental and Social Impact Assessment
EU	European Union
EUFIWACC	European Financing Institutions Working Group on Adaptation to Climate Change
EU-MACS	European Market for Climate Services
EY	Ernst & Young
FFEM	Fonds Francais pour l'Environnement Mondial [The French Global Environment Facility]
FI	Financial Institution(s)
FSB	Financial Stability Board
G20	Group of Twenty
GCECA / GCA	The Global Center of Excellence on Climate Adaptation. As of September 2018, GCECA is known as the Global Center on Adaptation (GCA).
GCM	General Circulation Model
GCP	Global Canopy Programme [UK-based]
GFDRR	Global Facility for Disaster Reduction and Recovery
GIC	Global Investor Coalition on Climate Change
GINN	Global Impact Investing Network
GIS	Geographic Information System
GIZ	Gesellschaft für Internationale Zusammenarbeit GmbH [German development agency]
GRI	Global Reporting Initiative
HLEG	EU High Level Expert Group on Sustainable Finance
ICMIF	International Cooperative and Mutual Insurance Federation
IDF	Insurance Development Forum
IEA	Institute for Environmental Analytics
IFC	International Finance Corporation [World Bank Group]
IFoA	Institute and Faculty of Actuaries
IGCC	Investor Group on Climate Change
IIGCC	Institutional Investors Group on Climate Change
IORP	Institution for Occupational Retirement Provision
IPCC	Intergovernmental Panel on Climate Change
IVM	Institute for Environmental Studies – Free University Amsterdam
KfW	Kreditanstalt für Wiederaufbau [Reconstruction Credit Institute; German Development Bank]
LMF	[Oasis] Loss Modelling Framework
LULC	Land use and land cover
MDB	Multilateral Development Bank
NAP	National Adaptation Plan
NAS	National Adaptation Strategy
NATHAN	Natural Hazards Assessment Network [Munich RE]
NCAR	Nation Center for Atmospheric Research
NCCARF	National Climate Change Adaptation Research Facility [Australia]
NCFA	Natural Capital Finance Alliance

NCEI	National Centers for Environmental Information [USA]
NFRD	Non-Financial Reporting Directive
NGFS	Network for Greening the Financial System
NGO	Non-Governmental Organisation
NOAA	National Atmospheric and Oceanic Administration [USA]
OECD	Organization for Economic Co-operation and Development
PIK	Potsdam-Institut für Klimafolgenforschung [Potsdam Institute for Climate Impact Research]
PRA	Prudential Regulation Authority
PRI	Principles for Responsible Investing
PwC	PricewaterhouseCoopers
RBC	Royal Bank of Canada
RCCAP	Regional Climate Consortium for Asia and the Pacific
RCP	Representative Concentration Pathways
RMS	Risk Management Solutions
SASB	Sustainability Accounting Standards Board
SDGs	Sustainable Development Goals
SEAP	Sustainable Energy Action Plan
TCFD	Task Force on Climate-related Financial Disclosures
TEG	Technical Expert Group on Sustainable Finance (European Commission)
UBS	Union Bank of Switzerland
UK	United Kingdom of Great Britain and Northern Ireland
UKCIP	UK Climate Impacts Programme
UKSIF	UK Sustainable Investment and Finance Association
UNE / UNEP	United Nations Environment, formerly known as UN Environment Programme (UNEP)
UNEP FI	United Nations Environment Programme Finance Initiative
UNEP GRID	UNEP Global Resource Information Database
UNFCCC	United Nations Framework Convention on Climate Change
VBDO	De Vereniging van Beleggers voor Duurzame Ontwikkeling [The Dutch Association of Investors for Sustainable Development]
WB	World Bank
WISC	Wind Storm Information Service [Copernicus]
WMO	World Meteorological Organisation
WRI	World Resources Institute
WTP	Willingness to pay

GLOSSARY OF TERMS

Term	Definition
Asset – financial	Liquid, non-physical assets Also known as securities, or financial instruments. These include stocks (equities), bonds (debt securities), cash etc.
Asset – physical	Facilities, buildings, land, roads, or other assets with a physical presence. Often referred to as 'real' assets.
Buy-side and sell-side actors	In capital markets, buy-side actors are those who are involved with making investments. These typically include hedge funds, investment managers, institutional investors, and smaller retail / individual investors. The buy-side reviews sell-side research before taking an investment decision. Sell-side actors are those that facilitate decision making of the buy-side actors. These include investment banks, commercial banks, or stock brokers. These firms track stocks and performance of companies. They research into financial reports, balance sheet and publicly available data, which results in recommended target prices and a recommendation to buy or sell an asset (including real assets or financial assets).
Climate model	Quantitative methods to simulate the interactions of the important drivers of climate, including atmosphere, oceans, land surface and ice. They are used for a variety of purposes, from the study of the dynamics of the climate system, to projections of future climate.
Climate service	The European Roadmap for Climate Services defines climate service as "…the transformation of climate-related data — together with other relevant information — into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management (DRM)" (European Commission, 2015). Abbreviated as CS. Upstream CS refers to raw earth observational data (e.g. coming from the European Union's (EU) Copernicus Climate Change Services (C3S) programme). Downstream CS refers to, for example, a local climate vulnerability assessment or highly processed information stemming from upstream climate data. Broad examples of climate services products (up- and downstream) include: • climate data records; • climate models and projections; • seasonal / medium range forecasting; • regional downscaling of data sets; • mapping and analysis tools;

	• web-based or other portals to access and process climate-related data; • climate risk assessments; • vulnerability assessments; and • publications / guidance documents about climate-related risks and opportunities.
Climate service - seasonal forecast	A prediction of weather tendencies (often expressed as probabilistic deviations from long term averages typical for the considered period and area) stretching from approx. 1 month to 6 months or more.
Climate service - long term forecast	A prediction of climate conditions for a certain area and for typical time units (diurnal to annual) referring to decadal or multi-decadal averages several to many decades ahead.
Climate information service	This is meant to denote climate services that particularly focus on provision of climate data and directly related non-climate data (e.g. on immediate impacts), without accompanying consultancy (beyond technical advice on data fitness). Next to offering plain data access, this also includes provision of quality assured tailored climate data for a particular purpose.
Climate scenario	A plausible representation of future climate that has been constructed for explicit use in investigating the potential impacts of anthropogenic climate change. Climate scenarios often make use of climate projections (descriptions of the modelled response of the climate system to scenarios of greenhouse gas and aerosol concentrations), by manipulating model outputs and combining them with observed climate data (IPCC, 2013)
Climate services scenario	One of four categories of climate services offerings, as characterised in the Constructive Technology Assessment (CTA) exercise shown in this document (see chapter 2). Not to be conflated with climate scenario.
Constructive Technology Assessment (CTA)	Constructive technology assessment describes a particular form of technology assessment where challenges and uses of new technologies and innovations are anticipated and the results of the analysis are fed back into the ongoing development, implementation and societal embedding of an innovation. The overall ambition is to broaden technology development and implementation by including a broad range of aspects and actors. CTA plays an important role early in the development process. Therefore, tools applied in the field of CTA are especially suitable for research projects which are often at the beginning of the innovation process. The technology here is climate services products (University of Twente, 2018).
Copernicus Climate Change Services (C3S)	C3S is the EU's provision of climate data and information, which is collected in its earth observation programme, Copernicus. C3S will provide key indicators on climate change drivers such as carbon dioxide and impacts, for example, reducing glacial extent. The aim of these indicators will be to support European adaptation and mitigation policies in a number of sectors (Copernicus, 2018).

Defined benefit (DB) and defined contribution (DC) schemes	DB scheme: In DB schemes, the employer guarantees scheme members a certain income on retirement, often expressed as a percentage of their final or average salary (EAC, 2018). A set payout is promised. Defined contribution (DC) scheme: In DC schemes, the saver's income on retirement depends on the performance of the pension fund investments. The saver, rather than the employer, takes the risk that the investments may not perform well (Ibid). A set contribution from the employer is promised.
Earth observation (EO)	Gathering of information about planet Earth's systems (e.g. physical, chemical and biological) via remote sensing technologies supplemented by earth surveying techniques, encompassing the collection, analysis and presentation of data.
ESG	Environmental, social and governance (ESG) is a generic term used in capital markets and used by investors to evaluate corporate behaviour and to determine the future financial performance of companies.
Financial market – capital market	A financial market where longer-term debt is bought and sold. Corporates and others use capital markets to issue financial products such as bonds or equity to raise funds. Institutions include stock markets, commercial banks, insurance companies and governments.
Financial market – derivatives market	A financial market where financial products such as futures or options are sold via contracts. A derivative is a contract based on one or more underlying assets.
Financial market – money market	A market for shorter-term lending. Financial products such as Certificate of Deposits, acceptances, or US Treasury bills. Participants include
Fintech	New technology which improves and streamlines existing processes and delivery of financial services. A portmanteau of 'financial technology.'
Financial services sector	Financial Services includes: • Insurers, reinsurers; • Asset/Investment managers and owners; • Banks (development, commercial, investment, retail); • Ratings agencies; and • Advisors, academics, and sector organisations, and service providers working to serve the sector.
Financial Stability Board (FSB)	The FSB is an international board that monitors and makes recommendations pertaining to the stability of the global financial system. Established in 2009, the FSB succeeded the Financial Stability Forum (FSF). The FSB includes all G20 members, FSF members, and the European Commission. While the Board was initiated by the G20, and the G20 endorses its policy agenda, the FSB and the G20 are independent.

G20	An international forum for the governments and central bank governors from the world's largest industrialised and emerging economies. Members include: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, the Republic of Korea, the Russian Federation, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States, the European Union, and Spain. The EU is represented by the European Commission and by the European Central Bank (G20, n.d.). The G20 economies account for around 85% of the gross world product (GWP), 80% of world trade, two-thirds of the world population, and approximately half of the world land area. The G20 aims to discuss policy pertaining to the promotion of international financial stability. It seeks to address issues that go beyond the responsibilities of any one organisation.
MARCO	MArket Research for a Climate Services Observatory (MARCO) is EU-MACS' sister project, also funded by Horizon 2020. This project provides detailed insight into the market for climate services in Europe, in line with the challenge of enabling market growth outlined in the EC's "A European research and innovation roadmap for climate services (2015)". The project's key objectives are to: assess the EU market of climate services; validate and enrich the market assessment with case studies; forecast future user needs and assess market growth until 2030; unveil opportunities and promote market growth. Learn more at: http://marco-h2020.eu/
Scenario Analysis	An approach which evaluates a range of hypothetical outcomes by considering a variety of alternative plausible future states (scenarios) under a given set of assumptions and constraints. Not to be confused with climate scenarios.

Contents

List of Boxes

List of Figures

List of Tables

NON-TECHNICAL SUMMARY

By and large, finance actors and climate services (CS) providers operate in separate worlds which are just now starting to interact. Important exceptions include insurance/reinsurance and development finance institutions. These worlds each have their own jargon, technical experts and important subdivisions /segments. The complexities of each of these worlds can make it difficult for them to interact and additionally creates a research challenge when trying to reach both groups at the same time. Nonetheless, the EU-MACS project seeks to partially bridge the gap between users and providers of CS which operate in different worlds, as does this study.

This study in the finance sector's use of CS is the first known of its kind. The study presents a baseline of current demand and supply of CS across a range of segments of the finance sector. Demand is differentiated greatly by the context that financial institutions operate in. Insurance companies are interested in understanding the changing frequency and severity of extreme events under climate change, in order to price insurance premiums and products accordingly. Banks with investments in climate sensitive industries including agriculture have a vested interest in understanding seasonal drought impacts on crop production. Investors, including pension funds with long-term investments, may be more concerned with stranded assets and the transition risk this poses to their portfolio.

Important changes in the regulatory landscape facing the finance sector regarding environmental and climate risks are underway. Financial regulators, central banks and governments around the world are increasingly interested in understanding climate risk as a risk to global financial stability. While this change is indeed global, European actors are leading the way. Climate risk disclosure frameworks, mandated or otherwise, can directly encourage the use of CS and therefore grow demand in Europe and beyond.

Insurers and Development Finance Institutions (DFI) are mature CS users. The insurance segment was seen to primarily use upstream CS and services which are integrated into wider services, such as catastrophe modelling. DFIs encountered in the study showed a strong demand for advisory services, relating to the project or investment level. As some leading insurance actors and DFIs are now starting to provide CS themselves, for their own and external use.

Commercial banks appear to be in the early stages of their CS use. While there are some examples of direct use of maps and apps, such as flood maps and climate data portals, there is a strong demand for the translation of climate data into information which can be integrated in stress testing and risk assessments. Portfolio level analysis is currently important to this segment, mostly driven by interest in responding to disclosure frameworks. Collaborative efforts are important in this segment, as actors are currently developing capacities to utilise climate data and information.

CS demand is nascent in other segments. Rating agencies have potential to increase CS use as they try to better incorporate climate risk into ratings. Investors have yet to reach consensus on preferred CS types and features. In the investment space, there is not yet consensus on whether upstream CS are needed, or more translated, downstream CS are preferable. While there are some early movers in these other segments, demand is generally lagging behind insurance, DFIs, and commercial banks.

There is now a steady supply of CS, both in general and increasingly for services specifically developed for financial services. There is, for example, a healthy supply of climate and climate-related data provided via data portals and websites and a growing body of climate change impact studies provided as either academic or grey literature. Both these types of CS typically lack utility for financial actors, as translation

into meaningful information for financial institutions is needed. Advanced CS users within the finance sector produce CS which can be used by other segments in the wide finance sector. Other providers include conventional climate advisory firms and financial and accountancy service firms, the latter of which are starting to offer and incorporate climate analysis relating to physical climate risks into their offerings. It is important for all CS providers to be able to align with existing risk management platforms and procedures, as finance actors are interested in integrating climate data and information in these channels.

Despite the evolving regulatory landscape which is driving the growing demand and supply of CS, there are numerous factors which slow the uptake of CS in the finance sector. These factors are wide ranging and include a lack of awareness among, and within, financial institutions around climate impacts and on climate data and information. For example, common misconceptions which hinder demand include misinformed perceptions such as 'climate change is only a long-term issue', or that 'impacts are mostly associated with extreme weather, rather than incremental changes in climate variables'. While this is evolving, there is still a strong perception amongst investor stakeholders that physical climate risk is not material. Another barrier to growth in the uptake of CS is that financial institutions have limited bandwidth to consider CS amongst higher profile changes in their operational landscape such as Brexit or more pressing short-term priorities including developments in fintech. Chapter 7 covers these demand-related barriers and other relating to the supply of CS in more detail.

There are notable data and information gaps and unmet needs, which represents important innovation potential in the CS market. These include data with improved spatial resolution and quality, particularly for extreme events and in developing country contexts. The potential attribution of extreme events to climate change, and teleconnections between different hazards and impacts also needs more clarity, as does the uncertainty associated with different climate datasets. Users were interested in guidance on the interpretation and use of data with uncertainty. There also needs to be further development of adaptation indicators to enable decision-makers to better evaluate different options, including cost, and facilitate tracking of adaptation progress. Furthermore, educational tools, capacity building programmes and knowledge sharing platforms, covering topics such as available information portals, interpreting climate data, including levels of uncertainty, and combining climate and non-climate data are needed. These and other gaps are discussed in chapter 8.

Given the in-depth look at financial services-related CS supply and demand taken by this study, it is highly relevant to both CS providers and users, as well as policy makers. CS providers can use this report to familiarise themselves with some of the traits and needs of finance actors. Finance actors may use the report to gain an overview of available CS on the market, as well as what peers are using. In addition to presenting a baseline of current CS use and supply, this study provides the CS product mix, a tool/heuristic which can be used by both users and providers to advance their use and provision. Finance actors can consult this matrix when formulating their own CS needs. Providers can also use the matrices which document current encountered demand across various segments of the finance sector, as shown in this report, to understand current demands and target their offerings. In addition to CS users and providers, this report is also relevant for policy makers as chapter 10 presents suggestions on how to alleviate barriers to CS uptake.

1. INTRODUCTION

1.1. EU-MACS project

To support further product development and effective widespread uptake of climate services, as a means to boost mitigation of and adaptation to climate change as well as capabilities to cope with climate variability, the European Commission (EC) has included several actions in its current research programme Horizon 2020 (H2020). Essentially these actions follow from the logic to implement the European Research and Innovation Roadmap for Climate Services (European Commission 2015).

EU-MACS and its sister project MARCO deal with analysis of the climate services market. In addition, demonstration calls were launched on the added value of climate services for supposedly high value added sectors with hitherto little uptake of climate services (SC5-01-2016-2017), while other actions focus more on networking activities interlinking to better connect relevant players (e.g. the ERA-NET for Climate Services (SC5-02-2015) and the project funded under the Coordination and Support Action (SC5-05b-2015) called Climateurope.

In the context of these H2020 calls, one important EC programme is the COPERNICUS Climate Change Service (C3S). C3S aims to generate a comprehensive, coherent and quality assured climate data set to support mitigation and adaptation planning, implementation and monitoring. In due course, coping capabilities of (current) climate variability will be addressed.

In this framing, the EU-MACS project – European Market for Climate Services – analyses market structures and drivers, obstacles and opportunities from scientific, technical, legal, ethical, governance and socioeconomic vantage points. The analysis is grounded in economic and social science embedded innovation theories on how service markets with public and private features can develop, and how innovations may succeed.

1.2. Scope and remit of this report

This report is Deliverable 2.1 of Work Package 2 (WP2) in the EU-MACS project. It summarises the work of Task 2.1 and 2.2. WP2 of EU-MACS focusses on the climate service (CS) market structures, drivers, obstacles and opportunities in the financial services sector in Europe and beyond. WP2 is one of three sector specific work packages, the other two being Tourism (WP3) and Urban Planning (WP4).

With a focus on the financial services sector, WP2 was designed to satisfy several objectives:

- Identify barriers and enablers shaping climate services take-up in Europe and beyond;
- Explore current climate services offerings with stakeholders and gather feedback;
- Suggest matching between CS supply and demand and develop mechanisms for channelling user needs into CS development;
- Identify best practices and policy recommendations to increase the uptake of climate services in the financial services sector (regulations, education and training, and investment needed).

The results of WP2 are reported in three different types of deliverables:

- D2.1 (this publication) is a report, which gives a thorough account of the applied methods, the findings and, the consequent recommendations for policy makers, CS providers and users of climate services from the financial sector;

- D2.2 comprises web-text presenting engagement protocols, and aims to assist actors with typical questions related to the various obstacles and opportunities; and
- D2.3 is a policy brief, which summarises options for CS market enhancement and related innovations for the finance services sector, and provides recommendations for measures by different actors.

1.3. Key terms and concepts

The Glossary at the beginning of this report aims to serve the reader throughout the report by clarifying recurring terms and abbreviations. The introduction of climate services to the financial sector implies that two different worlds meet, each with their own jargon and sometimes different understandings of similar terms and concepts. It would be laborious to discuss all terms mentioned in the Glossary. It is important, however, to clarify a number of key terms and concepts in this section.

1.1.1. Climate services

Abbreviated as CS throughout this report, this term is adopted in climate policy making and climate expert circles and be described as '*the transformation of climate related data – often together with other relevant information - into customised information products, offered as such or embedded in consultancy and/or education*' (European Commission, 2015). EU-MACS has interpreted the European Roadmap definition of CS to primarily be dealing with:

- capturing the effects of climate change (e.g. changes in extremes);
- preventive adaptation to climate change (e.g. changes in building codes to enhance resilience to extremes, or the reassessment of indemnity insurance policy contents);
- analysis of climate change effects on renewable energy production (productivity effects, damage risks), as well as possible consequences of energy efficiency standards in buildings in future climate; and
- description and analysis of climate variability (so-called seasonal climate services).

More detailed examples of climate services are provided in the Glossary.

It is essential is that these services employ climate data and related information as an indispensable building block, even though often other types of information are added (e.g. socio-economic information). The term 'climate data' is not a definite term, rather it is a phrase used to denominate a range of data products that relate to climate. These include observational data and climate data records, climate models, and climate projections. EU-MACS Deliverable 1.3 (Hamaker, Jiménez Alonso, Rycerz, Baglee, & Stegmaier, 2017) provides further discussion on types of climate data.

In the financial services sector it has become quite common to refer to all actions and effects related to climate change, climate change impacts, climate mitigation, and climate adaptation by the single term 'climate'. Consequently, CS are easily understood to also encompass all kinds of carbon-related information, such as greenhouse gas emission monitoring and reduction data and efforts. The carbon footprinting of an asset, portfolio, company, or sector, for example, is often seen as a climate service, even though most carbon footprinting activities do not require *climate* data.

It should also be appreciated that some consultancies, research and expert organisations are providing CS without necessarily using that term. For example, a number of hydrological information services offered by

various engineering firms and hydrological expert organisations could be termed 'climate services', where they contribute to one or more of the bullet points above.

1.1.2. Risk and uncertainty

In EU-MACS risk is understood as an uncertain outcome of a process, of which at least a tentative expected value and/or tentative confidence intervals be can given. Even though risk is in the first place often associated with loss, it can also represent options for gain, either because one actor's loss is another one's gain or because proactive behaviour can turn loss risks into profit opportunities. Uncertainty here means that no, or no meaningful, expected value can be attributed to an outcome, meaning no confidence interval can be established or it is very large. If such estimates, even if tentatively, cannot be given after reasonable extra (re)search effort, the state can be termed 'deep uncertainty'.

1.1.3. Market for climate services

EU-MACS Deliverable 1.2 defines a market as '*a medium, physically located or virtual, where supply and demand of near substitutes of products and services meet with the purpose to engage in mutually beneficial transactions between suppliers and demanders; a perfect market is fully transparent for all actors in terms of prices and product features, whereas no actor has a dominating position, and new suppliers and users can easily enter*' (Larosa & Perrels, 2017).

Market transactions make up only part of all CS activities. For example, a national meteorological office supplies information to other public bodies as an obligatory activity. Another significant segment of CS generating activities is actually conducting research and development (R&D) work rather than service delivery (EU-MACS Deliverable 1.1, Cortekar et al. 2017 and Deliverable 1.2, Larosa and Perrels 2017). A part of the development work has been acquired in competition from R&D funding programmes. Yet, in that case the market (if any) refers to an R&D auction, rather than a market for climate services. In order to encompass all CS activities, without suggesting these are all market activities, in Deliverable 1.2 the term *climate services field* has been introduced.

It may be expected that so-called *seasonal climate services*, which often address tangible operational benefits through loss prevention and production optimisation, will be quite often offered under market conditions. On the other hand, *climate change adaptation-orientated climate services* often serve broader interests and are subject to larger uncertainties, and hence it may be expected that a smaller share is provided through market transactions. Nevertheless, a substantial part of the current non-market CS activities could evolve into market transactions.

1.1.4. Climate services value chain

Just like many other products and services, the generation of CS passes through several stages. Upstream activities include climate observations, data reprocessing and validation, and modelling. Midstream activities include, for example, regional downscaling of General Circulation Models (GCMs). Downstream activities see the introduction of non-climate data and advisory elements. The value added of CS is typically expected to grow when moving from upstream to downstream, as the economic applicability in decision making grows.

1.4. Structure of this report

Chapter 1 provides the introduction to the EU-MACS project, and how this deliverable (Deliverable 2.1) sits within the wider project. Chapter 2 provides an overview of the methods used to engage with the financial services sector during Work Package 2 (WP2) of the EU-MACS project. The scope of the study is discussed, including which geographies and segments of the sector were targeted. The stakeholder selection and interview processes, as well as important limitations of the study are described here as well. This chapter finishes by providing the framework used to analyse and present the results in this report.

In Chapter 3, the primary activities and contexts of the financial services sector are described. This chapter orients readers who may be climate service providers to various segments of the sector and main actor groups. It serves as a primer on important similarities and differences among these segments, in terms of their typical exposures and resulting interest in CS. It touches briefly on varying approaches to risk management in the sector though does not provide a comprehensive review of risk management systems present in the sector. This chapter will be most useful to climate service providers who are not familiar with these subtleties; readers who are from within the finance sector may not find this background information necessary.

Chapter 4 brings into focus background drivers for the uptake of CS in the sector. The EU-MACS project has come about during a time of great change in the climate risk regulatory and governance landscape, broadly speaking, and in the financial services sector in particular. This chapter draws on both on literature reviews and early stakeholder interviews to review recent and emerging initiatives relating to climate risk governance and discusses their implications for the CS market. Chapter 4 is the main area of the report where motivations to use CS are covered.

Chapter 5 presents results from stakeholder interviews and engagement, which helps establish the baseline of current CS demand, or use, in the sector. Results for demand are presented by segment of the sector, as engagement with users tended to be within an individual segment of the sector. Chapter 6 provides the results from stakeholder interviews and engagement on current supply or provision of CS. The findings of this chapter are presented in a high-level manner, at sector level. Both the demand (chapter 5) and supply (chapter 6) sections of this report utilise the terminology of the CS product matrix[1] in order to structure the presentation of results.

Chapter 7 builds on the previous two chapters to provide the encountered barriers to the uptake of climate services. It presents results in terms of supply, demand, and matching barriers.

Chapter 8 summarises important unmet needs in CS provision, and persistent gaps in climate data, as encountered during stakeholder engagement. This chapter can serve as a guide for areas where CS innovation is needed in the financial services sector, though this should not be taken to be an exhaustive list of all gaps in the financial services CS market.

In Chapter 9, a macro vantage point is assumed by taking into account that the financial sector is very responsive to intra-sectoral mismatches in standards and principles. Eventually some explorations are made by means of a simple adoption model, while changing various features in the information regime.

Chapter 10 presents conclusions and recommendations regarding the alleviation of barriers in the financial services-related CS market.

[1] A heuristic developed for the purposes of stakeholder engagement, as described in chapter 2).

2. METHODOLOGY

2.1. Scope of the study

The geographical scope of this study includes the current 28 European Union (EU) Member States. While the majority of stakeholder engagement took place within these bounds, we recognise that many financial services providers maintain international portfolios and activities. As such, we did not seek out international stakeholders such as those based in North America and Australia, though they were not excluded when the opportunity to engage with them arose.

The financial services sector is defined as asset owners and investment managers, banks (with all its variety of sub-categories, e.g. commercial, retail, investment, development, universal), as well as insurers and reinsurers, of all sizes. We are aware that other important actors in the financial ecosystem also include regulators, ratings agencies, academics, and investment consultants working with one or more of these groups, so members from these groups were consulted as well where possible.

This study is one of the first of its kind and adopted a broad scope that allowed for a wide range of perspectives around climate risk management and CS to be observed throughout the wider financial services sector. This broad stance should help inform future research and innovation assessments by providing direction into which segments of the sector would benefit from more in-depth analysis around climate service needs and supply.

2.2. Stakeholder selection

The selection of an initial list of stakeholders was achieved through approaching Acclimatise's and other consortium partners' existing contacts in the financial services sector, and, in particular, those who are currently using or would potentially use climate data and information. These contacts are primarily major (large) financial institutions in segments such as development finance institutions (DFIs), commercial banking, asset owners (i.e. pension funds), and insurance. In these early consultations, stakeholders recommended further contacts to pursue in a wide range of similar or related segments. To supplement these recommendations, the authors targeted stakeholders at relevant industry-specific international events in Europe, attending conferences in Spain, the UK and France.

Existing contacts on the CS provider side were contacted, including meteorological offices, consultancies, and actors who straddle the user/provider divide, such as multi-lateral development banks (MDBs) and reinsurers.

Throughout the EU-MACS study, Acclimatise was simultaneously involved in two other financial services and climate-related projects: (1) UNEP FI's working group of 16 international banks piloting the TCFD recommendations and (2) EBRD and Global Centre of Excellence on Climate Adaptation (GCECA)[2] developing climate risk disclosure recommendations for corporates[3]. These projects allowed for further

[2] As of September 2018, GCECA is known as the Global Center on Adaptation (GCA).

[3] Representatives from these organisations were brought together to advise on a set of recommendations which build on the Task Force on Climate-related Financial Disclosure (TCFD) guidance on physical climate risk and opportunities. The expert working groups in the initiative included participants from Agence Française de Développement, Allianz, APG Asset [cont'…] Management, AON, the Bank of England, Barclays, Blackrock, Bloomberg, BNP Paribas, Citi, Danone, the Dutch National Bank, DWS Deutsche AM, the European Investment Bank, Lightsmith Group, Lloyds, Maersk, Meridiam Infrastructure, Moody's, S&P Global Ratings, Shell, Siemens, Standard Chartered, USS and Zurich Alternative Asset Management.

stakeholder engagement opportunities and observations of CS barriers and enablers in the sector. Participants of these projects at times provided examples and testimony which has been used in this report, following full consent.

The UNEP FI's project provided access to many of the international commercial banks participating in the initiative. The EBRD GCECA project allowed access to representatives from a variety of segments of the financial services sector. This included investment managers, asset owners, central banks (and associated regulators), commercial and universal banks, insurance actors including providers and a broker, ratings agencies, a public financial institution, and large corporates.

In addition to these stakeholders, we approached experts working at the nexus of climate and financial services sector. We started with our existing contacts in this space, and pursued new contacts made throughout the course of the project. These included independent consultants, sector associations and NGOs.

Annex 1 provides information on stakeholders engaged in the study. 65 organisations were engaged in this study. This includes 43 users; 11 providers; and experts. Users were 56.4% banking (including development finance institutions), 25.6% investment, 15.4% insurance, and 2.5% other. Stakeholders were located in the following countries and regions: Australia, Brazil, Canada, Finland, France, Netherlands, Norway, Spain, Switzerland, UK, USA; pan-Europe; international.

2.3. Stakeholder engagement

2.3.1. Interviews

Interviews with users, providers, and experts were conducted in a phased approach. First, semi-structured interviews with users and providers were carried out. Early consultation with these groups helped establish a map of stakeholders and information flows in the sector, as well as important background motivations in the sector such as the evolution of climate risk and its governance. This phase also allowed for further stakeholder groups and segments of the sector to be targeted for engagement. A sample of the interview guidelines can be found in Annex 2..

A second phase of interviews employed the Constructive Technology Assessment (CTA)-based CS scenarios[4] developed in EU-MACS Deliverable 1.4 (Stegmaier & Visscher, 2017). The core CTA rationale is to shape innovation by bringing together all stakeholders in the early stages of the technology's development. CTA in EU-MACS has been appropriated and interpreted to help shape CS and CS markets. Concretely, our consortium partners from the University of Twente (UT) devised a set of CS scenarios: the 'maps & apps scenario', the 'expert analysis scenario', 'climate-inclusive consulting scenario', and the 'sharing practices scenario' (see Table 1). Without a workshop context the CS scenarios can be understood as CS product-market segments, to which the reader can add details (and thereby arrive at own 'scenario cases' if you like). These use-cases include description of users, providers, technologies, value creation and potential tensions (including the organisational use context). A CTA-based exercise around these use-cases was devised along with UT partners, in order to further tailor a typical CTA style workshop to suit the financial services sector. A typical workshop where stakeholders are brought together in one location for at least half a day was tailored down to a shorter exercise which could be carried out in a one or two-hour meeting, with just one or two stakeholders. This tailoring of the typical CTA workshop to the financial services sector was necessary, as early stakeholder discussions revealed typical financial services stakeholders are pressed

[4] Not to be confused with climate scenarios. In the CTA context CS scenarios indicate various climate services use-cases.

for time, and some are hesitant to discuss their experiences and preferences openly with other members of the sector. The WP2-tailored CTA exercise was further tailored to specific categories of financial sector actors. This involved presenting relevant examples (to the stakeholders present). During the CTA exercise, a ranking exercise for desirability and feasibility, and discussion around the users' preferences was facilitated. For providers, the CTA-based CS product matrix was used as a guidance for discussion rather than as an exercise in every instance. Annex 4 provides more information on the CS scenarios and EU-MACS Deliverable 1.4 (Stegmaier & Visscher, 2017) discusses the CTA approach in the EU-MACS project in more detail.

Table 1: Climate services product-segment or scenario matrix – core characteristics of the climate services' product-segments

	Generic	Customised
Focussed	Maps & Apps: • Generic climate services • Freely or cheaply available … • … to all users including policy makers, managers, entrepreneurs and citizens E.g.: portals and platforms showing hazard maps	Expert Analysis: •Scientific, professional, commercial, monodisciplinary advisory services relating to climate data and information • Tailored to specific decisions and decision-makers E.g.: analysis of the effects of climate change for a specific location and problem; advisory services such as a standalone risk assessment
Integrated	Sharing Practices: • Mutual services on … • … adapting and mitigating climate change in specific environments • Available to all users E.g.: peer to peer information sharing platforms; case study databases; public discussion fora	Climate-inclusive Consulting: • Professional, commercial and … • … transdisciplinary climate services • Tailored to specific decisions and decision-makers E.g. integration of climate data and information into other consulting services; project finance feasibility studies including climate related analysis

2.3.2. Interactive questionnaire

An interactive questionnaire was developed to complement the interviews described above. This allowed for the research to step beyond the findings of the interviews, which principally covered the obstacles, opportunities and prerequisites for the use of CS. For example, the development of an online questionnaire provided an opportunity for an exploration of the thresholds to the potential use of CS, as well as provide concrete, albeit simplified, CS examples for participants of the questionnaire to evaluate. Thereby the questionnaire explored the willingness-to-pay (WTP) of financial sector actors in conjunction with the apparent confidence such an actor has in the eventual usefulness or accuracy of the considered climate service.

From feedback and from the low number of respondents we could infer that the questionnaire was regarded as challenging. While the questionnaire admittedly had more challenging aspects, the modest turnout and feedback also provides some indication that many financial firms have not yet well-established views on climate services, or for that matter not on climate change risks or climate policy risks. The survey was intentionally anonymous, even though there was an option to submit an email contact for further

inquiries. Yet, we happen to know what type of financial organisations have filled the questionnaire, being one central bank, one fairly large commercial bank, and a national umbrella organisation of indemnity insurance companies. The questionnaire and results are displayed in *Annex 3*. The results have been used to corroborate findings discussed in chapters *5 – 7* and are also discussed in Chapter 9.

2.4. Limitations

This study was not able to examine, in detail, all of the CS needs and obstacles for all segments of the financial services sector. Many potential stakeholders approached during the early phases of this study were not able to participate due to their lack of time and because many have not formed clear preferences regarding their CS needs. Further, it was difficult to always reach the stakeholders in large organisations who directly use climate data and information.

The stakeholder contacting and engagement process was extended to allow for most segments of the sector to be approached. This lead to a perhaps shallower, but wider engagement with the sector. Existing initiatives the authors were involved in, such as the TCFD pilot with commercial banks were observed in a strict Chatham House Rule manner rather than engaged with via planned stakeholder engagement activities such as a CTA-based exercise.

This study mostly targeted large international financial institutions as these organisations have been vocal about their action on and interest in climate change. Further, we had longstanding relationships with this type of actors. This means that other smaller financial institutions such as public-sector banks as well as associations of banks (e.g. Sparkassenverband in Germany) were mostly left out of this study. In Germany and to a lesser extent in Austria, these are indeed significant as a group. Yet, the individual size of these banks is often modest, implying that an occasional inclusion of such a bank may poorly represent the scope of CS 'readiness' of these small and diverse banks. Some Sparkassen are also related to a Landesbank ('provincial bank'), which originally also had (societal) regional development objectives, but have adopted ever more common commercial behavior (even though still with some regional/local development emphasis). All in all, the drivers of these banks can be quite diverse. We nevertheless interviewed a Finnish and Dutch bank specially meant for local and sectoral public authorities, in order to capture the perspective of smaller financial institutions, as well as possible links with the urban planning perspective (WP4). The operations of the two interviewed banks are quite similar and inter alia linked to urban investment & financing needs. They have indeed started to think about and to some extent act on systematic inclusion of sustainability principles, but their legal risk-taking limitations means that they cannot transform as fast as large banks. In the future, it could be worthwhile to conduct a deeper analysis with these types of institutions.

This report aspires to address a range of audiences – from financial services actors looking to understand climate data and information to climate service providers looking to understand how they may align with the interests of finance actors. As a consequence, the report tends to present information at a high levels of generalisation rather than present detailed background information on each segment of the sector.

2.5. Framework of this analysis

This assessment of the CS market in the financial services sector has both a micro and macro level focus. By micro level we refer to obstacles and challenges for a single prospective user or a group of users in one segment of the wider sector. The micro level analysis also includes analysis of the individual transaction level between a provider of CS and a user of climate services. The micro-level analysis demonstrates how users who are trying to access and effectively use CS, and providers who are trying to develop their

services, can encounter consecutive and simultaneous obstacles. We distinguish three main domains of obstacles:

- Demand related obstacles and mechanisms- those preventing users from articulating a need for climate services;
- Supply related obstacles and mechanisms- those that prevent the development or offering of effective product portfolios; and
- Matching related obstacles and mechanisms- those factors that delay, prevent, or distort matches of arisen CS needs and climate service offering.

Obstacles encountered in the matching phase may be attributable to practical, operational level obstacles such as an unclear presentation of the CS portfolio on offer. They may also relate to deficiencies rooted in structural problems in demand and supply side market conditions. Matching obstacles are those that are revealed once the CS demand and supply has arisen.

By macro level we mean the current preconditions (structures, rules, trends) in the financial sector and in CS provision which, to a significant extent, predetermine the success potential of the actual matching processes at the micro-level. We therefore review important changes in framework conditions facing the sector, such as changes in the governance of climate risk. We show a conceptual model for analysing the likelihood of taking up CS, which can help to assess at aggregate level, what are the most crucial obstacles and drivers to be addressed in order to engender significant uptake of CS in the financial sector.

3. SETTING THE SCENE: BACKGROUND ON THE FINANCIAL SERVICES SECTOR

The financial services sector can be divided into several main segments, including insurance, banking and investors. Many other actors are involved including, for example, regulators, service providers (accountancy, risk analysis, risk ratings, legal consultancy). While there are overlaps between the activities of primary segments (e.g. insurers are often asset owners and/or managers) these segments generally have distinguishable contexts in which they operate. The contexts of these segments can lead to a varying degree of exposure to climate risk and therefore create diversity in demand for climate related data and information. This chapter takes each of these main segments in turn, and provides their contexts with regard to typical activities, timescales, and regulatory environments. It therefore helps set the scene for why these groups might be motivated to use climate services (CS). The CS needs and preferences, as encountered during stakeholder engagement, are discussed in further detail in Chapter 5. Worth noting is that generalisation is necessary here to illustrate key differences between these segments. Individual actors will have unique contexts, depending on factors including their size and location. Moreover, regulatory differences across countries can cause differences in sector profiles between countries.

3.1. Financial services providers

3.1.1. Insurance

Insurance is used by individuals, business, governments, and insurers themselves as a means of transferring risk, as shown in Figure 1 (Acclimatise, based on Grossi and Kunreuther 2005). In exchange for an annual premium, primary insurance companies provide coverage to a policyholder against a range of natural and man-made disasters to protect against physical damage, liability, and the loss of revenue earning capacity. Reinsurance provides coverage to insurance companies when a disaster or event exceeds a threshold monetary value (e.g. EURO 1 billion) or a number of claims occurring at the same time. The main categories of insurance include life insurance and non-life or general insurance. Non-life insurance includes car, property, business, and liability insurance. Life insurance provides cover for premature death or retirement (De Haan, Oosterloo, & Schoenmaker, 2009). Reinsurance brokers are another important part of the insurance segment, who often work to provide insurers better rates for their reinsurance contracts. The insurance segment is heavily involved in investment in addition to providing coverage to others' risks, and the brokerage of these contracts. The insurance segment in Europe is the largest institutional investor in Europe (Insurance Europe, 2016) as the premiums insurers receive are invested until claims or benefits become due.

Insurance companies are interested in understanding the potential for climate change and climate variability to impact their solvency. Insurers face stringent regulatory requirements around the amount of capital they must hold to reduce the risk of insolvency (EY, 2017a). In 2015, 14 different insurance-related directives were consolidated into the Solvency II regime, which is now the primary regulatory framework for insurance in Europe (PRA, 2015). Insurers monitor their exposures from climate-related impacts and price products accordingly on an annual basis. They also need to ensure the performance of their own investments under a changing climate. Meeting these needs is necessary to ensure that claims on damaged property or losses in earning capacities following extreme events or disasters can be met.

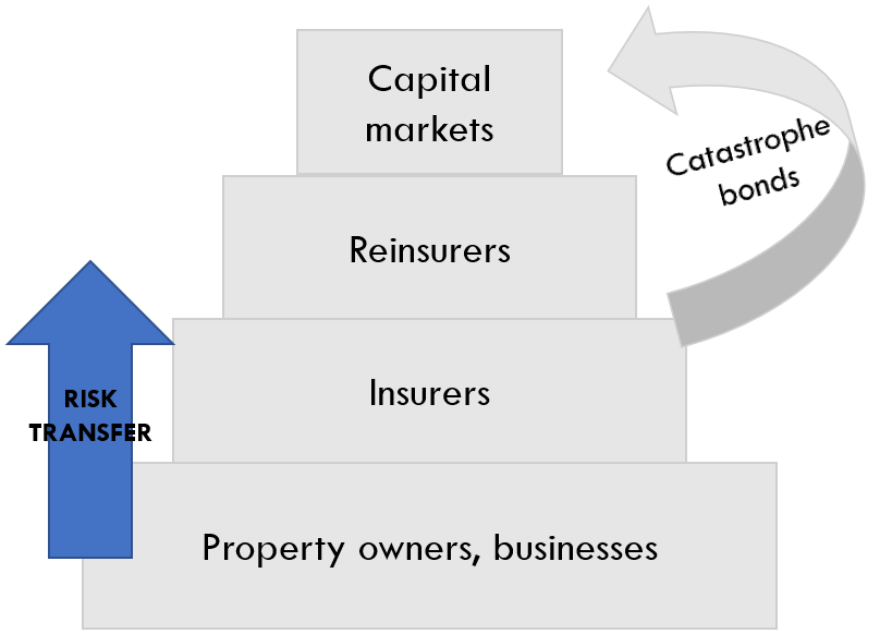

Figure 1: Transferring risk in the finance sector (Acclimatise 2018; Grossi and Kunreuther 2005)

Insurers who are heavily involved with certain types of insurance products may be more interested than other insurers in climate change and variability, and associated CS. Those offering general insurance and reinsurance indemnity policies for property or business interruption, including for agriculture, for instance, are more directly exposed to physical climate risks than those primarily involved in life insurance.

Areas of innovation in the insurance segment are also areas of the sector which are potentially interested in climate data, including index-based (or parametric) insurance or catastrophe bonds ('cat' bonds) as these products are contingent on an extreme event happening. Parametric insurance, an emerging alternative to traditional indemnity policies, pays out benefits should an adverse event occur, rather than paying out for an estimated loss as indemnity insurance would (GlobalAgRisk, 2012). Policyholders chose the level of payment they would like to receive in the event of the covered natural disaster, making a corresponding payment (Ibid). Cat bonds have been around longer than index-based insurance and are a way that insurers can use capital markets as an alternative or supplement to reinsurance to cover losses from disasters (or as a risk-transfer mechanism, see Figure 1). An insurer will issue a bond and, if a disaster strikes, the insurer can access the funds. If losses exceed a certain amount, then the interest on the bond (or principal) is forgiven (Grossi & Kunreuther 2005). Resilience bonds are a further innovation, which are a variation on cat bonds. Re:focus partners (2017, p. 3) explain: a resilience bond offers a 'resilience rebate' which 'can serve as a source of predictable funding which sponsors (insurance policyholders) can proactively invest in projects that strategically reduce risk'. This funding allows cities or governments, for example to upgrades coastal protections or establish reinforcements against physical climate impacts. Climate data and information will be needed to evaluate the resilience benefits of these bonds.

3.1.2. Banking

3.1.2.1. Development Finance Institutions

Development Finance Institutions (DFIs) have similar activities to commercial banks yet may have different outlooks on climate change and variability. Many DFIs such as multilateral development banks (MDBs) have commercial lending terms, for example, though are also committed to ensuring the development-related projects they invest in are resilient. Moreover, even though DFIs apply target levels for ROI in order to ensure overall viability of an investment, they may not maximise profit in the way a commercial bank might. Instead other criteria, concerning development goals of host countries, also weigh in. DFIs may also be quicker in absorbing the Sustainable Development Goals (SDGs) as a basis for identification of investment needs. Further, multi-lateral development banks (MDBs) such as the as the World Bank, the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB) will often have mandates from donor governments directing them toward minimum investments in resilience, and management of physical climate risks, essentially mandating their interest in climate change.

Due to the nature of their lending and investments in development-related projects, these organisations must carefully assess the resilience of their investments. DFIs such as EBRD, EIB, AFD (French Development Agency) and KfW (German Development Bank), for example, have reporting requirements on the climate resilience impacts of their investments, as well as goals to invest certain percentages of overall investment into resilience. These organisations often need to report to shareholders on what benefit their financial investments are achieving, and as such screen potential investments to assess their climate resilience (see EIB, 2015). Shareholders include national governments from Europe, North and South America, and Asia who hold these institutions accountable for what they are delivering in terms of climate resilience. These actors need to ensure that the development they are achieving via their investments is not eroded by a changing climate. Further, DFIs may be interested to demonstrate their climate leadership by sharing knowledge with in-country banks they lend to, and as such, will need to ensure they have their house in order first.

3.1.2.2. Commercial banking

Commercial banks offer a range of products aimed at corporate clients, such as corporate lines of credit and loans to small to medium enterprises (SMEs) through to major corporations. These are the primary set of banks engaged with in the EU-MACS study, as opposed to retail banks.

Banking encompasses a range of activities including money transfer and depositing services, credit facilities for trade, mortgages, loans and related funding services for companies. The banking segment of the financial services has numerous sub-divisions in terms of size and activity, including banks focussing in commercial, retail, investment, and development activities. Banks face a suite of risks, including credit, operational, market, liquidity and reputational risks, among others. Factors driving these risks include regional or sectoral productivity losses, significant trade disturbances, failures (bankruptcy) of clients and major failures in financial information systems (as a result of natural or manmade hazards).

International and European banks continue to face stringent regulatory environments, centering around governing their minimum capital requirements. Complying with international regulatory frameworks such as the Basel Standards, are a constant concern for banks (EY, 2018). In Europe, the Basel Accords are transposed into law via the Capital Requirements Directives (CRD), with the newest iteration

(Basel III) being transposed via the 2013 Capital Requirements Directive IV (CRD IV). Stress testing is an essential component of these requirements and is a key way banks show supervisory authorities that they can meet capital requirements in managing, for example, market and credit risk (Dent, Westwood, & Segoviano, 2016). Large banks develop their own stress test models, but often participate in concurrent stress testing organised by banking regulators, where the entire balance sheets of several banks are tested according to commonly applied criteria. Since 2014, for example, the Bank of England (BoE) has carried out an annual concurrent stress test with the largest UK banks and building societies. BoE also asks banks not involved in their annual concurrent test to carry out their own stress tests, under BoE guidance. BoE explains 'banking stress tests examine the potential impact of a hypothetical adverse scenario on the individual institutions that make up the banking system, and the system as a whole. This allows us to assess banks' resilience and make sure they have enough capital to withstand shocks, and to support the economy if a stress does materialise' (Bank of England, 2018). Worth noting is that stress testing timeframes relate to the timeframes banks operate in. That is, banks usually stress test in the short to medium term, typically out to 9 quarters to a maximum of five years. This is because typically banks' loan books / portfolios churn over within 3-5 years. Generally speaking bank loans or credit products tend to have short life cycles and their assets have high liquidity, or can be converted to cash quickly (Federal Reserve, 2014) thereby rendering long-term risks of lesser concern.

Banks perceive physical climate risks less concerning than other risks or manageable. There is still a misperception that physical climate risks only happen in the long term, so managing physical climate risks may be seen as less urgent. Furthermore, banks can typically take out insurance against asset losses caused by natural hazards, as well as require borrowers to have policies.

However, banks with loan books focussed in sectors vulnerable to climate impacts may have a more pronounced interest in climate change impacts and climate variability. For example, banks may be concerned about climate-related risks to their agriculture portfolio resulting from a large scale, multi-year, severe drought increasing borrowers' probability of default, and may be interested in developing new financing products for such circumstances. This may also be the case for those with high concentrations of loans in real estate, infrastructure, or in certain geographical regions prone to extreme events.

Lending businesses are built on long term relationships with clients, driving longer term consideration of risks. Loans may be short term, but banks have a vested interest in the continued existence (and success) of their clients - as this will mean future potential for further business opportunities[5].

3.1.3. Investment

Investors are a diverse group of actors which sit at the top of a complex investment chain, (see Figure 2)**.** The main categories of institutional investors, or asset owners, include pension funds (public or private), insurance companies (life, health, or property and casualty), and sovereign wealth funds (governments) (Brigandi & Ortel, 2018; De Haan et al., 2009), among others. Next in the investment chain are investment consultants, which help asset owners work to define their investment goals, beliefs and develop investment strategies around these, and develop a mandate around these to direct their investing. More often than not asset owners employ asset managers (also called investment managers) to carry out their mandate, though some manage their own investment activity. Asset managers take different approaches to achieving

[5] As discussed by Jan-Peter Onstwedder, Managing Director, Citi, at the EBRD-GCECA Advancing TCFD Guidance on Physical Climate Risks and Opportunities conference, 31st May 2018.

these mandates, typically investing in a diverse set of asset classes, such as equity (stocks/shares), bonds (debt securities/fixed income products), or funds which are composed of a basket of assets.

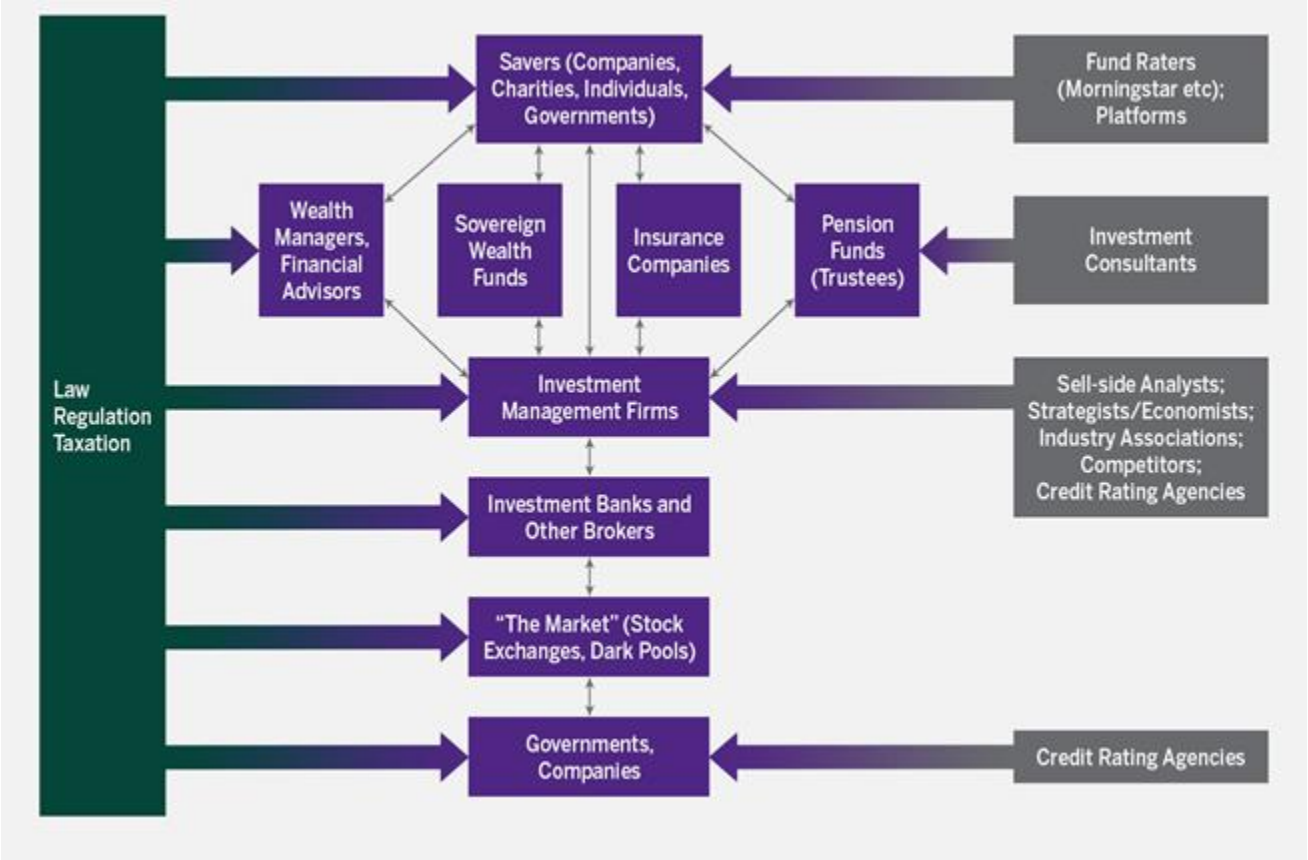

Figure 2: Mapping out the investment chain (Arjaliès, Grant, Hardie, MacKenzie, & Svetlova, 2017)

Some asset owners already have a growing awareness of climate change and its potential impacts on their investments. Typically, interest has been around low carbon and the energy transition (away from fossil fuels). Global awareness around managing climate-related transition risks on investments have grown in recent years, in part to the success of the Paris Agreement. This has impacted public opinion and increased pressure to divest in assets which contribute to climate change, and which may decrease in value due to growing climate mitigation policy. This shifting awareness has led some asset owners to shape their mandates to reflect their changing preferences and has resulted in growing asset manager awareness, and thus retreat from investments in carbon intensive industries such as oil and gas, or thermal (coal) generation.

Interest in physical climate risks may also be lagging in part due to the fact that investors are often far removed from the physical assets underlying their portfolios. Some direct investment into property or projects does occur, though generally speaking, investors are quite distant from underlying physical assets themselves. The perception among asset managers may be that when physical climate impacts happen, these impacts may not to reverberate up to the top of the chain. Figure 3 shows a stylised diagram of the investment chain and the relationship of it to physical assets.

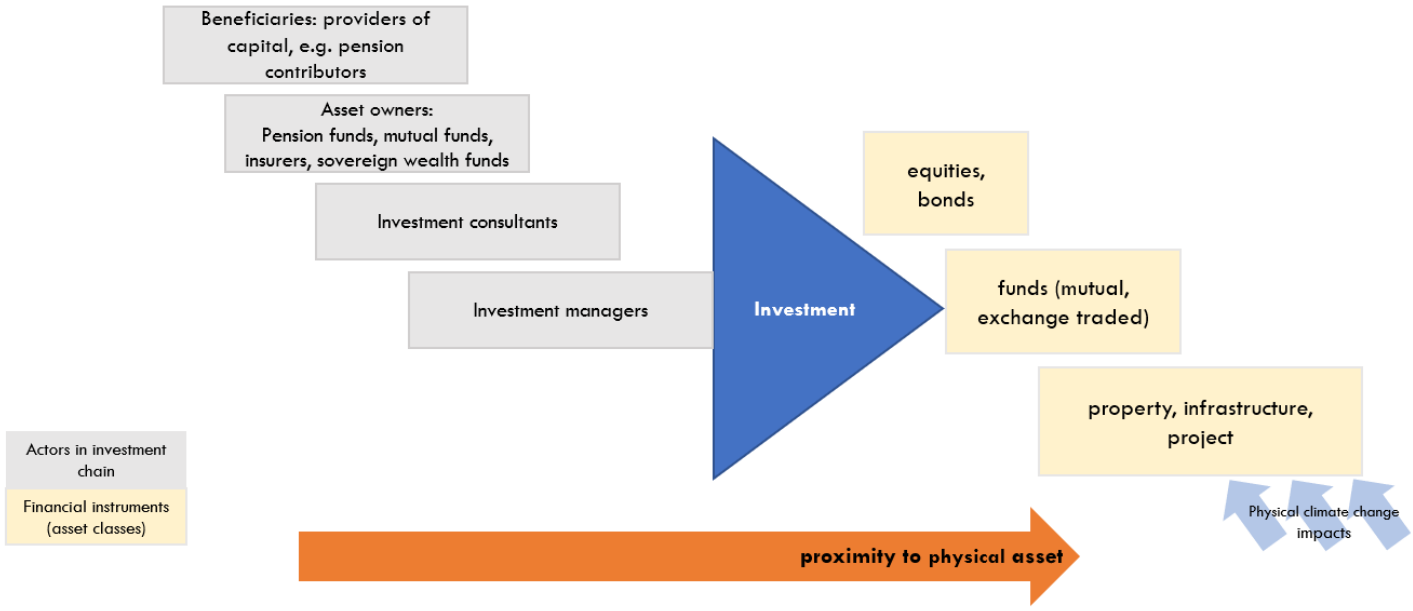

Figure 3: Stylised investment chain and its relationship to physical assets

Investors' varying time horizons will influence interest in climate change. The varying investment horizons of institutional investors is a key difference between actors in this segment (De Haan et al., 2009). For example, pension and sovereign wealth funds have a relatively long investment horizon whereas mutual funds have short-term investment objectives. Short term is approximately 1-3 years whereas longer term could be upwards of 50 years (2Dii & The Generation Foundation, 2017).

Those with a longer-term view may be more interested in climate change impacts. This seems to be increasingly the case, at least in Europe, but in practice action has tended to mainly concentrate on retreat from carbon intensive or dependent assets, as mentioned above. Those with a longer-term outlook may also be more interested in passive investment. Passive investment is an increasingly common approach where investment is made, for example, into a fund, which tracks a market index. By tracking an index, the fund is supposedly diverse as it should have a wide range of assets from various sectors and geographies. Passive investment can provide desirable returns without the costs associated with actively managing investments. Those participating in this kind of investment may be less concerned with climate impacts because: a) they are removed from physical assets; b) they are removed from the potential to engage with individual companies around their climate resilience; and c) the diversity associated with investing in a fund can lead investors to assume they are protected from physical climate impacts in one sector or geography.

3.2. Other actors in the financial services sector

In addition to insurance, banking, and investment, a non-exhaustive list of other actors relating to the financial sector includes:

- Regulatory and supervisory bodies, such as central banks and financial market authorities (e.g. the UK Prudential Regulation Authority (PRA) or the European Banking Authority (EBA));

- Financial sector support services, such as risk assessment experts, accountancy firms, financial-juridical and fiscal consultancy firms, exchanges, etc., including rating agencies;
- Sector associations, including those which work to advise their members on a number of issues, such as the Institute and Faculty of Actuaries (IFoA), and those which specialise in a climate change or environment-finance nexus such as the Institutional Investors Group on Climate Change (IIGCC) in Europe, the Investor Group on Climate Change (IGCC) in Australia and New Zealand; and
- Non-governmental actors such as Principles for Responsible Investing (PRI) and UNEP FI which work to engage with their membership on climate issues and provide tools and programmes for action.

This range of actors will have varying degrees of interest in climate change and variability. Recently, regulatory authorities have started to see climate risks as financial risks and have started to consult those they regulate on their management of climate risks. This has worked as a catalyst of the wider sector's interest in the issue. These additional actors may not often directly use climate services themselves, though are important for CS providers to be aware of as they have proven to play an important role in the uptake of CS in this sector. Chapter 4 discusses evolving motivations to use CS, where many of these tangential organisations have played an important role in driving interest in climate data and information.

4. Background Drivers of Climate Service Uptake

The way that environmental and climate-related risks are understood in the financial services sector, by its members, regulators, and interest groups, has evolved in notable ways in recent years. A recent report from the UN Environment Inquiry into the design of a sustainable financial system provides a first account of the evolution of policy and regulatory action in the financial system. The report documents how the Inquiry 'uncovered a 'quiet revolution' in how financial regulators, central banks and governments around the world are working to align financial systems with sustainable development' (UNE, 2018, p. 5). Both mandatory and voluntary climate risk disclosure frameworks have emerged, interest of European Member States' regulators in climate risk has grown, and top down action on creating and facilitating a sustainable financial system is underway at the EU policy level.

Climate risk disclosure frameworks, mandated or otherwise, can directly encourage the use of CS and therefore grow the CS market in Europe. Other important developments in the governance landscape provide indirect encouragement of the CS market by creating increased awareness of climate risk and climate action more generally. This chapter discusses these important changes in the framework conditions facing the CS market in the financial services sector. Chapter 9 will also include a similar short discussion on how legislation is needed to set things in motion. Further, a short discussion on the role of legislation in CS uptake is available in EU-MACS Deliverable 1.2 (Larosa & Perrels, 2017).

4.1. Climate risk is increasingly understood as a financial risk

Analysis as early as 2010 has paved the way for the consideration of climate risk in the financial services sector. The International Finance Corporation's (IFC) publication Climate Risk and Financial Institutions (Stenek, Amado, & Connell, 2010), for example, provides numerous examples of how changes in availability of climatically sensitive inputs, such as water, can reduce levels of production or increase downtime in sectors important to investors. Additionally, the report provides examples of how climate change may affect some of the assumptions made in financial analysis. In doing so, this early publication helped characterise climate risk as a financial risk, suggesting it ought to be considered as more than a reputational risk, like other environmentally-related risks tended to be.

Climate risks have been categorised as Environmental Social and Governance (ESG) risks, as 'climate' is associated with the 'E' in ESG. Recent analysis shows that the consideration of ESG factors in investment decision-making analysis has improved over recent years (CFA Institute, 2017), including the 'E'-related factors. Yet, many actors in the financial sector tend to categorise ESG risks as ethical concerns and this has historically allowed investors to write-off ESG concerns as non-financial or immaterial. For example, investments with low ESG ratings have long since been seen as unethical (Larsen, 2017), although they have not necessarily been framed as a financial risk.

The UK Law Commission clarified this point in its 2014 report Fiduciary Duties of Investment Intermediaries, asserting that ESG factors can in some cases be considered material risks and as such are financial factors, which are separate from 'specifically "ethical" considerations, such as a decision not to invest in or withdraw investment from an industry to show ethical disapproval' (EAC, 2018, p. 14; Law Commission, 2014) (see further section 4.2 for further discussion on fiduciary duty).

While climate will likely always be seen as an ESG risk (or consideration), it has become a risk which is now elevated to be on par, or nearly, with other financial risks. Sarah Barker, Special Counsel at MinterEillision, and Non-Executive Director at Australian pension fund Emergency Services & State Super, stated 'the

perception of climate change was previously seen as something in the realm of public relations/community relations, it was seen as an ethical issue. This has absolutely been flipped on its head in the last two years, [and] there is now acceptance of the fact that climate change is a financial risk' (pers. comm. 2017). Barker and Girgis (2017) explain the year 2017 was a step-change for climate risk integration and disclosure, citing how the World Economic Forum[6] rated 4 of the top 10 risks to the global economy as associated with climate change, and citing other evidence such as BlackRock's (the world's largest investor) inclusion of climate risk disclosure as part of their 2017-18 Engagement Priorities (see BlackRock, 2017; World Economic Forum, 2017). There is an increasing number of studies showing that an overwhelming majority of the environmentally conscious investment funds has equal or better performance than funds without particular profiles e.g. (Friede, 2015). In turn, mounting evidence on climate change impacts in combination with growing evidence on adequate performance of ESG emphasised investments translates into increasing willingness among institutional investors to more actively account for the different types of climate change risks (Krueger, 2018).

Top down action from the G20 has cemented climate risk as a financial risk. On the eve of UNFCCC's Paris conference (COP 21) and the Paris Agreement, the G20 asked the international Financial Stability Board (FSB) to broadly consider climate risk. The FSB subsequently formed the Task Force on Climate-related Financial Disclosures (TCFD), who went on to compile recommendations for both financial institutions and corporates that encourage them to analyse and publicly disclose their climate risks. In doing so, the Task Force mapped out the ways in which climate risk can have financial impacts. The FSB's interest in climate as a risk to financial stability and the TCFD's recommendations thus firmly cemented climate change as a strategic risk - helped along in part because this was a bottom-up initiative comprised of members of financial institutions and corporates from key sectors (See section 4.4 for further detail on the TCFD recommendations).

An important indication of the elevation of climate risk as a strategic risk, is the issuance of a risk alert by the Institute and Faculty of Actuaries (IFoA) in 2017 just before the final TCFD recommendations were published. The alert asks that all actuaries, whichever field they are working in, to consider how the implications of climate change might affect the advice they are giving, their actions and decision making. The risk alert also directs actuaries to consider the TCFD recommendations and its supplemental guidance for the financial services actors (IFoA, 2017).

In 2018, the Geneva Association published a report based on interviews with executives from globally active insurance and reinsurance companies. It states: 'Only recently, the focus of the climate change debate has moved from being mainly a scientific, environmental and social responsibility issue to one of the core drivers of socio-economic development and risk management. With rising socio-economic costs associated with physical risks of climate change, there is increasing evidence of a paradigm shift in governments' approaches, from 'inaction' or 'post-disaster reaction' towards a comprehensive and more integrated risk management approach' (Golnaraghi, 2018, p. 7).

4.2. Interpretation of fiduciary duty

Fiduciary duty is not a static concept, and there is no single definition of it, making the concept subject to re-interpretation in different eras and jurisdictions. The way fiduciary duty is understood and interpreted is evolving. In the financial services sector, the current evolution is away from a narrow interpretation of

[6] In its annual *Global Risks Report*.

profit maximisation toward one which could allow for consideration of climate risk. Box 1 provides further exploration of the concept.

Box 1: Defining fiduciary duty

> Sullivan, Martindale, Feller, & Bordon (2015) elaborate on fiduciary duty, stating 'Fiduciary duties are imposed upon a person or an organisation who exercises some discretionary power in the interests of another person in circumstances that give rise to a relationship of trust and confidence. They are of particular importance in asymmetrical relationships; these are situations where there are imbalances in expertise and where the beneficiary has limited ability to monitor or oversee the actions of the entity acting in their interests' (pg. 11). Essentially, fiduciary duty is a fiduciary acting in good faith in the interests of beneficiaries, impartially balancing conflicting interests of different beneficiaries, avoiding conflicts of interest and not acting for the benefit of themselves or a third party.

Fiduciary duty has historically been interpreted by many in the financial services sector as maximising short-term investment returns, which for a time was reinforced by legal decisions. The 1984 case, Cowan v Scargill, in England for example, resulted in a judgement that was perceived to require that profit maximisation should be placed above all other considerations (Allianz, 2017). As ESG factors grow in importance, some in the finance sector continue to see this narrow definition of fiduciary duty as a reason why they cannot consider longer term risks and ESG risks, including climate change. The logic goes that action on these topics, or the incorporation of these into decision making, would inhibit their ability to maximise financial returns (stakeholder interviews, 2018; Sullivan et al., 2015)

Sullivan et al (2015) find important shifts in the interpretation of fiduciary duty have been made in the decade since 2005, following from the landmark UNEP FI Freshfields report (UNEP FI, 2005). That report found the opposite of Cowan v Scargill: a lack of consideration of ESG factors could be in fact breaching fiduciary duty. Now, many investors take ESG into account in their investment process, which allow them to 'make better investment decisions' (14). Slowly, fiduciary duty is not the 'obstacle it is commonly assumed to be' (Allianz, 2017; Sullivan et al., 2015).

The extent to which an expanded definition of interpretation of fiduciary duty is adopted is not homogenous across the sector in Europe, however. In the Netherlands, for example, a range of finance actors have demonstrated their understanding of fiduciary duty involves the integration of climate-related risks and opportunities into their financial decision-making (van de Kieft et al., 2018, p. 3). In the UK, large actors such as Aviva have been seen to adopt a similar stance (see Aviva, 2015, 2016). Yet, the Environmental Audit Committee (EAC), during its 2018 Green Finance inquiry has heard testimony from UK regulators that there is ongoing widespread misinterpretation of fiduciary duty, leading pension trustees to exclude considerations of climate change (EAC, 2018). This comes after the Law Commission clarified in 2014 that 'pension trustees are legally required to take into account factors which are financially material to risks or returns when making investment decisions, regardless of whether or not those factors might sometimes be considered to be environmental, social and governance (ESG) factors (EAC, 2018, p. 13). The EAC (2018) goes on to suggest 'the [UK] Government should clarify in law that pension schemes and company directors have a duty to protect long-term value and should be considering environmental risks in light of this' (pg. 16) and suggests there will be a legislative proposal to clarify institutional investors' and asset managers' duties in relation to sustainability considerations in 2018.

There are top-down efforts at the European level to expand the interpretation of fiduciary duty as well. The European Commission action plan for sustainable finance should help to usher in an expanded interpretation of fiduciary duty which supports the consideration of climate risk (see section 4.3.5 for further discussion). This, and efforts at member-state level, such as that in the UK, will drive demand for climate data and information in the financial services sector in the future. Box 2 details how fiduciaries would need to engage with climate risks, this pointing to potential needs for climate services for fiduciaries, were they to interpret their duties to include consideration of climate risk.

Box 2: Ways fiduciaries would need to engage with climate risks (Sullivan et al., 2015, p. 17)

Fiduciaries need to be able to show that they have identified and assessed the risks (to companies and to their portfolios). In the case of climate change, for example, this would require them to:

- Show that they have recognised relevant risks (even if they are sceptics on the issue of climate change);
- Analyse how climate change might affect investment returns over the short, medium and long-term;
- Explicitly manage the risks, and not assume that the risks are automatically managed by other risk management strategies;
- Interrogate and challenge the individuals or organisations (e.g. investment managers, companies) to ensure that these risks are being effectively managed;
- Establish processes that enable them to demonstrate the actions they have taken.

4.3. European regulatory interest in climate risk

4.3.1. Article 173

France has recently become the first country to institute mandatory climate-related risk disclosure requirements for a range of actors, banks and institutional investors. The Energy Transition for Green Growth Law (aka 'Energy Transition Law'), was adopted in late 2015, and Article 173 of this law requires various disclosures from companies, banks, and institutional investors depending on their size and circumstances. Narrowing down to investors, **Box *3*** provides a summary of the requirements Article 173 sets out for institutional investors.

Box 3: Article 173 disclosure requirements for investors (Mason, et al , 2016, p. 7).

1) Reporting on the integration of ESG criteria, including:
   a) The general approach with regards to the consideration of ESG issues in investment policy and risk management;
   b) For an asset management company, the list and percentage share of funds (in assets under management) that integrate ESG criteria;
   c) The methodology used for analysing the criteria and justification of that approach;
   d) Information on the results of the analysis and actions taken.
2) Reporting on the integration of climate change-related risks, including:
   a) Both physical risks (exposure to physical impacts directly caused by climate change) and transition risks (exposure to the changes caused by the transition to a low-carbon economy);
   b) An assessment of the contribution to meeting the international target of limiting global warming and to achieving the objectives of the French Low Carbon Strategy (which was adopted in November 2015 and includes sector-specific targets and carbon budgets).

Hundreds of investors are targeted by Article 173, including pension funds, insurance and reinsurance companies, investment firms and asset managers. This regulation is driving the uptake of climate services as investors will require access to data and information to first understand and then disclose the climate risks on their enterprise. Assessment of future physical and transitional risk will likely require the use of risk assessment and / or climate models to facilitate disclosure requirements (EY, 2017b; PRI, 2016).

A survey of 23 entities subject to climate reporting requirements under Article 173, finds that while investors have advanced in their acknowledgement of climate risks, they appear to be in the initial stages of implementing risk management measures, with only a few investors having assessed their exposure to climate risk. Indeed only 22% of companies surveyed assessed their exposure to physical climate risks (infrastructure and real estate assets only), while 9% assessed exposure to transition risks (EY, 2017b).

4.3.2. IORP II

The Institutions for Occupational Retirement Provision Directive II (IORP II) was issued by the European Commission in 2016. The Directive (2016/2341/EU) requires European occupational pension fund managers (or IORPs) to consider ESG factors, including climate risk, in their investment portfolios. Under the Directive, which replaces the 2003 IORP I Directive, EU member states shall require these fund managers to deliver risk assessments every three years or following any significant changes to the fund's risk profile. The risk assessment should include risks related to ESG, climate change, use of natural resources, and risks related to the depreciations of assets due to regulatory change (European Parliament and Council of the European Union, 2016). These assessments are expected to drive greater analysis of both physical and transitional climate risks among IORPs, thereby driving demand for climate services to perform these analyses. Alongside regulatory requirements, the long-term investment profile of pension funds (30 years) may further drive impact assessment as climate risks become more pronounced. This Directive applies to tens of thousands of registered EU pension funds, that manage a combined EURO 2.5 trillion in assets. Pension funds have until January 2019 to integrate IORP II into their national laws, a timeline that should fall before Brexit (Rust, 2016).

4.3.3. Mobilisation of Central Banks and Associated Regulatory Authorities

European central banks are concerned with the physical risk arising from extreme events, liability risks associated with climate-related losses, and transition risks stemming from the progression to a low carbon economy, as they can have profound impacts on the stability of financial systems (New Economics Foundation, 2017). The Network for Greening the Financial System (NGFS) is a consortium of bank governors, newly established in 2017. Spearheaded by the UK, France and the Netherlands, the NGFS brings together five other institutions from China, Germany, Mexico, Singapore and Sweden with the objective to share and identify best practice in the supervision of climate-related risks and encourage the role of finance to mobilise green investment (Banque de France, 2018). The clearest example pertains to the regulation of insurers. Central banks are concerned with the ability of insurance companies to develop models that capture the changing frequency and intensity of extreme events such as hurricanes and flooding, and price risk accordingly. If further supervision requiring, for example, greater transparency around climate risks could drive demand for more robust climate services (Giugliano, 2018). Other objectives of the NGFS, such as to promote green investment, could also drive demand for climate services in the near future, as investors may look to screen prospective investments on the basis of their resilience.

At the European level, the European Banking Authority (EBA)[7] monitors main risks and vulnerabilities in the EU banking sector and is one of the member institutions on the Commission´s technical expert group on sustainable finance. The EBA is currently at the early stages of considering how to integrate long term thinking into regulatory frameworks, which usually focus on shorter horizons. The EBA has expressed an interest in developing its understanding on the performance of different types of green assets and to explore what types of data are available to supervisors in order to perform short, medium and long-term climate risk analyses on different asset types. Proposed amendments to (EU) regulation No 575/2013[8] currently being considered by the Committee on Economic and Monetary Affairs of the European Parliament could mean climate and ESG-related risks become mandated, requiring the EBA to set out technical standards (see proposed articles 449a and 501da in European Parliament, 2018).

4.3.4. Non-Financial Reporting Directive

The Non-Financial Reporting Directive (2014/95/EU) was issued in 2014, to address the disclosure of non-financial and diversity information. The NFR Directive aims at improving the transparency of certain large EU companies' non-financial information, concerned with environmental, social, and employee-related policies, human rights and anti-corruption, and diversity policies. As a fundamental goal, the Directive enhances the consistency and comparability of non-financial information disclosed throughout the EU. Companies must align to recognised standards, including but not limited to:

- The UN Global Compact;
- The OECD Guidelines for Multinational Enterprises;
- ISO 26000; and
- The Global Reporting Initiative (GRI).

Companies with 500+ employees need to provide information on their business models, supplying details about the policies adopted with regards to non-financial aspects, including due-diligence procedures and performance indicators they use for monitoring purposes. Annual reporting is the principal mechanism by which non-financial and diversity information is provided to stakeholder in terms of the impact of an organisation's operations on the environment, as well as the extended value chain. Furthermore, environmental, social and work-related risks are identified, assessed and monitored, improving the company's resilience. The information provided is checked by auditor companies hired by disclosing businesses. Countries may additionally require (with the adoption of the Directive in the national law) non-financial information to be verified by an independent provider of auditing services, such as in Italy.

By linking science and policy, climate services may effectively enhance the inclusion of climate information into corporate decision-making processes. The NFR Directive prescribes to a predefined set of companies to disclose information about policies, targets and outcomes in relation to core matters. Strategies to respond to risks and opportunities are also considered. Climate services may support their identification, making them explicit at medium-range and long-term timescales. The reporting exercise provides firms with

[7] The EBA is an independent EU Authority working to ensure effective and consistent prudential regulation and supervision across the European banking sector. It is one of three European Supervisory Authorities introduced under The European system of financial supervision (ESFS) in 2010.

[8] (EU) regulation No 575/2013 of the European Parliament and of the Council – known as the Capital Requirements Regulation (CRR)

the opportunity to apply a systemic approach to their strategic planning: by highlighting current and future risks, the NFR Directive supports an accurate business model.

4.3.5. HLEG on Sustainable Finance and the EC Action Plan for Sustainable Finance

The High Level Expert Group (HLEG) on Sustainable Finance was convened by the European Commission in 2016[9], as part of its efforts to reform the Capital Markets Union. 20 experts from academia, civil society, and the finance sector, coupled with observers from European and international institutions comprised the HLEG. The Commission tasked the Group with providing recommendations aiming to help deliver an EU strategy on sustainable finance. The HLEG released its final recommendations to the Commission on 31st January 2018, which has now informed the European Commission's strategy on sustainable finance and its wider efforts to create enabling conditions for the EU to meet its targets under the Paris Agreement and goals of the 2030 Agenda for Sustainable Development (see HLEG on Sustainable Finance, 2018).

The HLEG's recommendations stop short of prescribing the use of climate data and information, and do not include an explicit focus on physical climate risks. A member of the HLEG confirmed that the Group's emphasis was addressing the urgency of climate change (Kivisaari pers comm 2018). This focus is, for example, reflected in the HLEG's focus on expanding the flow of capital for low-carbon investments. Indeed, the rising interest in the financial sector is so far mainly concerned with the mitigation side of climate change (e.g. 'green investment'), and much less with physical climate risks, with the exception of key segments of the sector such as certain types of insurers. A further stakeholder involved in the HLEG process explained that 'discourse has developed toward risk awareness of climate change impacts. There is better understanding of climate risks as a financial risk', which is a crucial step in managing those risks via climate services (Kamppi pers. comm. 2018).

The recommendations have the potential to continue to influence how the financial services sector perceives physical climate change risks, first and foremost by encouraging a longer-term view than is typically considered. Furthermore, the recommendation on climate risk disclosure (recommendation 3) builds on the voluntary TCFD recommendations, highlighting the momentum being gained by analysis and disclosure of climate risks in the finance sector (European Commission, 2016). The analysis and disclosure of climate risks – both physical and transition – will be a keystone of the climate services market in Europe. Finally, as the HLEG recommendations become codified into the Commission's strategy and potentially incorporated into legislation aimed at ensuring a more sustainable finance system in Europe, the demand for climate data and information to underpin these requirements will certainly grow.

The European Commission is committed to taking the HLEG recommendations forward. To that end, just under two months after the HLEG recommendations were released, the Commission proposed its EU strategy on sustainable finance, or its so called 'Action Plan'. Published in March 2018, the Action Plan on Financing Sustainable Growth sets out a roadmap for further work and upcoming actions for the financial system.

The actions set out in the Action Plan mirror the HLEG recommendations and include (European Commission, 2018):

- Establishing a common language for sustainable finance, i.e. a unified EU classification system – or taxonomy – to define what is sustainable and identify areas where sustainable investment can make the biggest impact.

[9] This group is referred to as the Technical Expert Group on Sustainable Finance (TEG) as of June 2018.

- Creating EU labels for green financial products on the basis of this EU classification system: this will allow investors to easily identify investments that comply with green or low-carbon criteria.
- Clarifying the duty of asset managers and institutional investors to take sustainability into account in the investment process and enhance disclosure requirements.
- Requiring insurance and investment firms to advise clients on the basis of their preferences on sustainability.
- Incorporating sustainability in prudential requirements: banks and insurance companies are an important source of external finance for the European economy. The Commission will explore the feasibility of recalibrating capital requirements for banks (the so-called green supporting factor) for sustainable investments, when it is justified from a risk perspective, while ensuring that financial stability is safeguarded.
- Enhancing transparency in corporate reporting: we propose to revise the guidelines on non-financial information to further align them with the recommendations of TCFD.

In June 2018, the European Parliament's Committee on Economic and Monetary Affairs proposed amendments to EU Legislation 575/2013[10] reflecting the Commission's Action Plan. At the time of writing, these amendments have been agreed by the committee and will now be debated in the plenary of the European Parliament in 2019(European Parliament, 2018) .

4.3.6. UK's Environmental Audit Committee

In 2018, the EAC of the UK House of Commons conducted the Green Finance Inquiry, which reviewed the ways in which sustainability and climate can be embedded in financial decision making. The Inquiry investigated the current state of climate risks analysis and disclosure by the UK's 25 largest pension funds. The EAC's report, which summarises the Inquiry finds that while seven schemes have committed to report in line with the TCFD recommendations, most have no current plans to do so (EAC, 2018, p. 22).

4.4. TCFD recommendations: a landmark voluntary climate risk disclosure scheme

Where the regulatory interest in Europe is a top-down interest in climate risk disclosure, The TCFD is a hybrid development, involving direction from high level actors such as G20 members. Development of the scheme, however, was completed by, and for, members of the financial and corporate sectors.

Recognising the risks of stranded assets and potentially disruptive economic impacts of a shift to a low carbon economy, the G20 finance ministers and central bank governors asked the Financial Stability Board (FSB) to review how the financial services sector can take account of climate related issues. Apart from identifying that there are opportunities associated with climate change, the FSB TCFD broke climate risk down further into (energy) transition risks and physical risks. Box 4 describes these risks in further detail.

The Task Force importantly identified the need for better information to support informed investment, insurance underwriting, and lending decisions to improve the analysis of climate related risks and opportunities. The TCFD's final report includes recommendations that climate-related financial disclosures are mainstreamed with other annual financial disclosures and made publicly available, to ensure that financial institutions can more effectively measure and evaluate risk. The recommendations provided by the TCFD to mainstream climate risk disclosures centre around four thematic areas; governance, strategy, risk

[10] EU) regulation No 575/2013 of the European Parliament and of the Council – known as the Capital Requirements Regulation (CRR)

management, metrics and targets (TCFD, 2017). See Annex 5 for further description of the TCFD recommendations. While financial institutions could in theory rely on the TCFD disclosures of their clients to analyse climate risk in their portfolios, many are interested to take action now and respond to the recommendations themselves (stakeholder interviews, 2017; 2018). The Task Force recognised this potential, and included specific guidance relating to financial service providers who are looking to respond to the TCFD recommendations. Large financial service providers AXA have, for example, recently published their climate related financial disclosures (see AXA Group, 2018).

Box 4: Climate risks as characterised by the TCFD (TCFD, 2017)

Transition Risks	**Physical Risks**

• Policy and legal
  ○ Increased pricing of GHG emissions
  ○ Enhanced emissions-reporting obligations
  ○ Mandates on and regulation of existing products and services
  ○ Exposure to litigation
• Technology Risk
  ○ Substitution of existing products and services with lower emissions options
  ○ Unsuccessful investment in new technologies
  ○ Upfront costs to transition to lower emissions technology
• Market Risk
  ○ Changing customer behavior
  ○ Uncertainty in market signals
  ○ Increased cost of raw materials
• Reputation Risk
  ○ Shift in consumer preferences
  ○ Stigmatisation of sector
  ○ Increased stakeholder concern or negative stakeholder feedback
	• Acute Risk
	  ○ Increased severity of extreme weather events such as cyclones and floods
	• Chronic Risk
	  ○ Changes in precipitation patterns and extreme weather variability
	  ○ Rising mean temperatures
	  ○ Rising sea levels

Nearly all stakeholders engaged in this study described the TCFD recommendations as a watershed moment for climate risk reporting - in the financial services sector and beyond. The initiative should be seen as a watershed moment for the climate services market by extension. TCFD is already spurring demand for climate services as these disclosures, particularly relating to physical climate risk and opportunities, are predicated on access and use of climate-related data and information. Apart from driving major corporates and finance actors to analyse and disclose their physical (*inter alia*) climate risks, the TCFD recommendations have been an important catalyst of further initiatives which will drive the use of climate services. Examples at the time of publication include UNEP FI's working group of commercial banks, who are piloting their responses to the TCFD recommendations. A further example is the EBRD GCECA[11] joint

[11] As it was known at the time of the project; the GCECA is currently known as the Global Center for Adaptation GCA).

initiative to designed to develop metrics specifically for corporates seeking to analyse and physical climate risk and opportunities (see section 6.2 for further description). And in June 2018 the Finnish umbrella organisation for the finance sector published a guidance report for financial sector companies on how to adopt and implement climate risk disclosure reporting principles (Finance Finland, 2018).

Apart from inspiring spin-off initiatives in the financial services sector, the TCFD recommendations are influencing other areas which may drive the climate services market. Namely, several existing voluntary disclosure frameworks, which are now expanding their requests for climate risk information (SASB, 2017). In April 2018, for example, the CDP, a leading not-for-profit disseminating voluntary climate disclosure surveys, revised its questionnaire in line with the TCFD recommendations. This alignment was introduced to encourage the adoption of TCFD recommendations, streamline reporting efforts for companies, and speed up the generation of decision-support information for data users (CDP, 2018). Similarly, the Principles for Responsible Investment (PRI) have also revised their 2018 reporting framework to integrate new climate-related indicators to align the TCFD recommendations (see PRI, 2017).

4.5. Sustainable Development Goals

In 2017, the 193 Member States of the United Nations (UN) committed to a global agenda to end poverty by 2030 by adopting 17 Sustainable Development Goals (SDGs). The SDGs are considered to be an attractive entry point for new investors, not yet engaged in impact investing, to build a portfolio that drives private capital towards poverty reduction (GIIN, 2016). While impact investors already have strategies aligned with ESG goals, the SDGs can help investors demonstrate how investee funds can generate impact by aligning investments with one or more of the goals which include zero hunger, gender equity, and climate action (GIIN, 2016). For example, UBS alone have publicly committed to investing $5 billion over 5 years to impact investments related to the SDGs (Price, n.d.).

As SDGs pertain to 17 different topic areas, with climate action accounting explicitly for only 1 category, it is difficult to ascertain whether the SDGs will drive greater climate services uptake. As a part of a due-diligence process of assessing potential or prospective investments, presumably an investor would consult relevant data and information pertaining to the investment. While impact investments are often cross-cutting, the SDGs encompass a range of goals beyond climate impacts. As such, climate services may not be entirely relevant to SDG investment analysis.

4.6. Evolution of drivers in the finance sector

A plethora of other background drivers and initiatives exist, all of which cannot be listed here primarily due to space constraints. Further, this is a rapidly evolving landscape. Over the period it took to write this report alone, numerous initiatives, technologies, policies, studies, etc. from governments, corporates, and sector associations, etc. have emerged all contributing to the interest in physical climate risks and therefore climate services. Important background drivers not discussed here, for example, could include the growing field of climate finance, the unfolding role of development finance institutions as both a user and provider of CS, and ongoing engagement of the UK's PRA with the insurance and banking sector to understand potential climate impacts on these segments.

5. BASELINE OF CLIMATE SERVICE UPTAKE IN THE EUROPEAN FINANCIAL SECTOR

5.1. Introduction

This chapter provides the results of our literature reviews and interviews with the financial services-related stakeholders, with regard to *current* climate service *use*. It is presented for each sector segment and sets out current climate services (CS) demand. Supply is set out in the following chapter. This chapter and chapter 6 set the scene for latter chapters which characterise obstacles related to the supply and demand of CS in the financial services sector.

This chapter and the next utilise the Constructive Technology Assessment (CTA) climate service scenario, here termed *product matrix*, as a means to present and discuss user demand and provider supply. See chapter 2 for a further description on how the CTA exercise was interpreted for WP2. EU-MACS Deliverable 1.4 also provides in-depth information on the CTA approach and how it has been appropriated for EU-MACS in general (Stegmaier & Visscher, 2017). The product matrix groups CS into four main types: *Maps and Apps, Sharing Practices, Expert Analysis, and Climate-Inclusive Consulting* (which can be used as point of departure of product scenarios). See Annex 4 for further description of these CS categories. It is important to note that not all CS fit neatly into one category - some services can be found at the boundary between two or more of these profiles. In these instances, we indicate where along the continuums the services sit: (1) generic to specific, and (2) focused (on climate) to integrated, as illustrated in Figure 4. See EU-MACS Deliverable 5.2, chapter 3 for further discussion on the fluidity of these products in relation to these categories and the potential implications for CS providers.

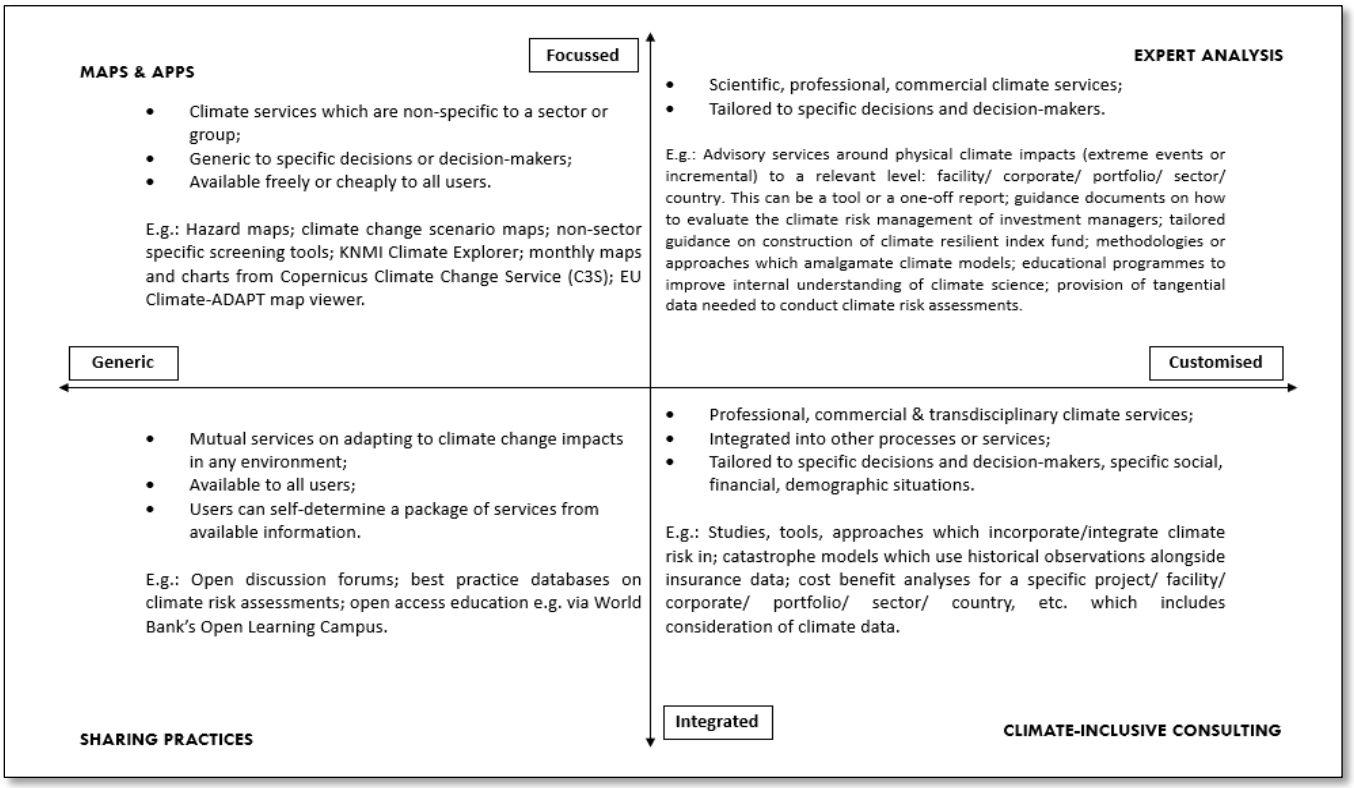

Figure 4: Climate services product matrix (scenarios) as interpreted for the financial services sector

5.2. Insurance and Reinsurance

The widespread use of catastrophe models highlight demand for CS relating to Climate-Inclusive Consulting in the insurance segment. Insurers and reinsurers have long since been interested in climate change and vulnerability, having expressed concerns around growing losses due to climate change as far back as the 1970s (PRA, 2015). Yet it was the record US $15 billion loss from Florida's Hurricane Andrew in 1992, and the resulting insolvency of 11 insurers which helped create strong demand for climate data and information amongst this segment. Hurricane Andrew is widely cited in the insurance sector as the catalyst of the widespread use of catastrophe modelling ('cat modelling') as a means to better predict catastrophe risk losses (AIR, 2002; Kenealy, 2012; Toumi & Restell, 2014). Cat models are mathematical models which help estimate potential losses from a variety of hazards such as flood, hurricane (wind damage and storm surge), earthquake, tornado, hail, wildfire and winter storm. The models simulate these hazardous events which allow insurers to analyse their potential losses, assess their solvency and price premiums – in a typical year (Dlugolecki, Bermingham, & Crerar, 2009; Maddox, 2014). There are four primary modules that govern cat model development; event, hazard, exposure and vulnerability, and financial (ERG, 2014). The first two modules: event and hazard, rely on meteorological inputs such as historical records on the incidence and magnitude of floods or forest fires, when creating 'event sets', or sets of scenarios around different peril events which might occur.

It is important to note that most primary insurers and reinsurers are often removed from the direct procurement of climate related data and information. Most insurance companies lack the internal capacity to develop probabilistic risk models (cat models) in house, so they typically license cat models from cat modelling companies - or cat model 'vendors' and have internal teams run them (stakeholder interviews, 2017). When they do not have these teams in-house, they may instruct brokers to do their modelling for them as part of their broking remuneration (Dixon pers. comm. 2018). While insurers themselves create the demand for upstream climate data and information (e.g. Maps and Apps), their actual climate service demand is for Climate-Inclusive Consulting. Important exceptions include the few very large reinsurance agencies e.g. Swiss Re, Munich RE, and brokers such as Aon Benfield (NOAA & NCEI, 2016) as these firms develop cat models in house. Further research in this segment to also understand the obstacles around climate data and information for cat modelling vendors such as RMS, Core Logic, and AIR, may therefore be important.

Meteorological information used in cat models can include 'global tropical cyclone track data, severe convective storm data (for tornado and hail), as well as temperature and precipitation data' (NOAA & NCEI, 2016). A further example of climate data used by modellers is information on climatic patterns such as the Atlantic Multi-decadal Oscillation (AMO) or the El Niño Southern Oscillation (ENSO), which is used by hurricane modellers (Dlugolecki et al., 2009). Although in the past the incorporation of climate related data into cat models was limited to that of historical observational data around essential climate variables (ECVs) (see WMO, 2018) there is a growing potential opportunity to incorporate future climate projections from General Circulation Models (GCMs) into cat models (Dixon pers. comm. 2018). Dlugolecki et al. confirm the potential for climate modelling in the cat modelling space: 'the use of dynamical, high resolution GCMs, to complement and substitute inadequate historical observational data, could provide a powerful means to tackle some of the key challenges to climate variability and extreme event modelling' facing cat modellers and insurers (2009, 16). Several large reinsurers are pursuing this with inhouse research teams, including Munich RE and Partner Re, according to one stakeholder. One potential outcome could be improved seasonal forecasts, or improved windstorm modelling (see discussion on WISC in the next section).

Important barriers to this development remain such as issues around GCM resolution, touched on in chapter 7.

Important to note is that insurance companies are also interested in physical hazard data, whereas other actors in the financial sector tend to prefer translations into financial risks. This was evidenced from the Norwegian Insurance Association initiative regarding the sharing of anonymised damage (claim) data combined with meteorological and hydrological observation data. Responses in the questionnaire also indicated this.

Insurance actors are interested in CS relating to the Maps and Apps category, which they can use themselves. Stakeholders noted they are beginning to use alternative services to avoid the high cost of using cat model vendors. For example, insurance stakeholders mentioned the use of open source cat model platform such as the Oasis Loss Modelling Framework (LMF). The Oasis LMF is not necessarily a climate service itself, though it is a tool which would help facilitate the further use of climate data and information, as developers of cat models can utilise it to 'plug and play' into their models, which use observational data as an input (Hayes and Whitaker pers. comm. 2018). The LMF may be considered closer to Expert Analysis than Maps and Apps, as it is an application more tailored to a specific context (insurance).

The Windstorm Information Service (WISC) was identified by stakeholders as a further Map and App type of CS in use. WISC is the result of a collaborative effort between specialist organisations, researcher, meteorological offices and Swiss Re[12], and produced an event set of 7,660 physically realistic windstorm events. The WISC portal offers data resources to enhance insurers' understanding of the nature of windstorms over the European continent. The event set can be plugged into the Oasis LMF and is based on the outputs of climate simulations running under the conditions of 1985 to 2011 (IEA, 2016). Datasets offered in WISC include historic storm tracks, historic storm footprints as well as a number of tiered indicators incorporating wind speed, windstorms and storm severity among others (Copernicus Climate Change Service, n.d.).

Stakeholders in the insurance segment also listed the OASIS Hub as a growing source of climate data and information. Similar to the OASIS LMF, the Hub is not necessarily a climate service itself, but is more of a marketplace or window front with which to view climate service offerings. The Hub offers access to data, tools and consulting services, acting as a 'one stop shop', aimed at signposting both free data and commercially available datasets on different environmental risks. The Hub is geared primarily for specialist users including catastrophe modellers and risk managers in financial and insurance services firms among others (Irvine pers. comm. 2017; see Oasis Hub 2018).

Other instances where insurance actors use Maps and Apps include cat model validation. Some insurance firms have modest teams of scientists who can use upstream climate data (Maps and Apps) directly in their analysis of vendor models. Cat model validation is typically carried out by large firms who wish to challenge licensed cat models to be able to assess their assumptions and the risk associated with those (stakeholder interviews, 2017). Cat model validation or research teams in insurance or reinsurance firms can also be responsible for creating their own view of the risk that a cat model may provide should they not agree with the cat model output.' (Dixon pers. comm. 2018). Although model validation is not currently common practice, it may be in the future - one stakeholder from a reinsurance firm indicated several large

[12] WISC was led by CGI IT, who partnered with Telespazio Vega, the UK Met Office, KNMI, IVM, OASIS and Swiss Re.

firms have model validation teams and noted many more firms may be trying to build such in-house expertise (stakeholder interviews, 2017).

Additionally, those involved in parametric and catastrophe bonds, as described in chapter 3 will use climate data and information directly themselves as well. Types of information needed for parametric insurance development include precise data on floods, temperatures, event occurrences (Navarro-Martin, 2017). Majors such as Swiss Re, Munich RE, AXA, Willis Towers Watson provide parametric insurance products so will be spearheading this demand (stakeholder interviews 2018).

Finally, based on experiences of Joanneum Research and FMI EU-MACS partners, there are signs that also 'ordinary' indemnity insurance companies, depending on their product portfolio and recent experiences with natural hazard related claims, demonstrate increasing interest to analyse realised and claimable damages in conjunction with meteorological observation data and other relevant background data.

Large insurance actors are at times able to satisfy their climate service demands themselves and some venture into climate service provision, typically relating to Climate-Inclusive Consulting. Swiss Re, for example provide the CatNet® services, on complimentary basis to their clients, and on a commercial basis to external actors (including banks and other financial services actors). The service provides a range of 'geo risk tools specifically designed to provide swift overviews and assessments of natural hazard exposure worldwide' (Swiss Re, n.d.). Munich RE has a similar tool titled NatCatSERVICE (Munich RE, n.d.) These mapping tools are closer to Climate-Inclusive Consulting than Maps and Apps as they are commercial and integrate other information alongside climate data. Other examples include Aon, a large reinsurance broker, who develop their own cat models for their clients to use when assessing the reinsurance market, and Munich RE who offer cat models on a commercial basis (NOAA and NCEI 2016; stakeholder interviews, 2018).

Figure 5 presents a map of CS demand encountered in this study. Sharing Practices was not encountered in stakeholder interviews, though an example is provided in Figure 5, namely the Insurance Development Forum (IDF), led by Geneva Institute. The IDF is a public/private partnership which aims to optimise and extend the use of insurance and its related risk management capabilities to build greater resilience and protection for people, communities, businesses, and public institutions that are vulnerable to disasters and their associated economic shocks (IDF, 2018). The Forum supports support the delivery of international initiatives such as the InsuResilience Climate Risk Insurance Target, by developing shared priorities, coordination of activities among members, mobilisation of resources, and cultivation of relationships between governments, industry and international institutions (Actuarial Post, n.d.; see InsuResilience Global Partnership, 2017). Perhaps this is a forum where climate data and information or best practices are shared and cultivated.

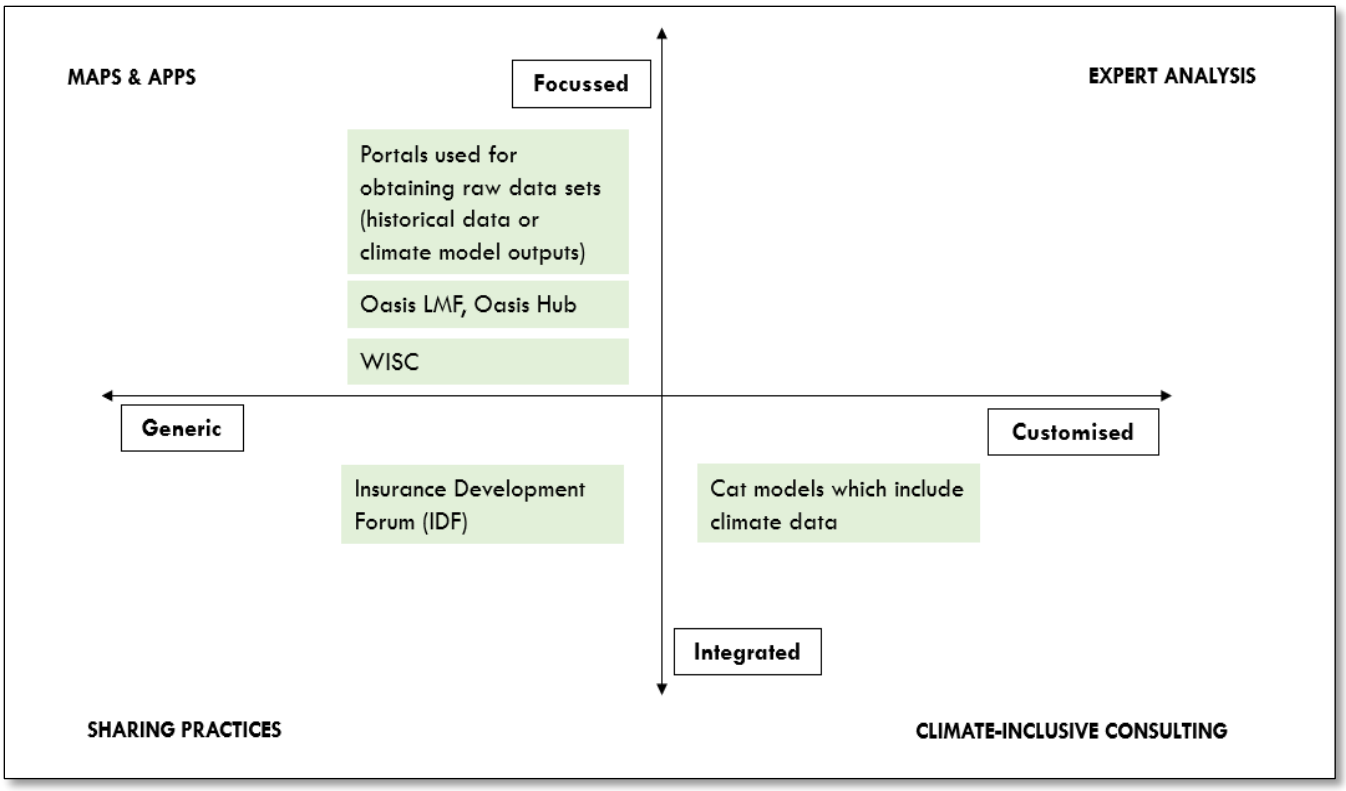

Figure 5: Encountered CS demand in the insurance / reinsurance segment

5.3. Development-Finance Institutions

To screen individual projects and investments, DFIs use portals relating to the Maps and Apps category, including those developed internally. The World Bank's Climate Change Knowledge Portal (CCKP) is a prime example of an internally developed Map and App CS. Developed by and for the World Bank, the portal is now also publicly available (see World Bank Group, 2018b). The CCKP allows World Bank staff to access global, regional and country level data on observed records of climate variables. The portal provides historical data along with climate change projections based on emissions scenarios from the Intergovernmental Panel on Climate Change (IPCC). It also offers numerous other features including country-based adaptation profiles, sector specific information, and information relating to climate mitigation (stakeholder interviews, 2017). The CCKP is used by staff within the bank as they work to gather climate risk information during the development of projects, and it allows staff to populate the Bank's internal climate risk screening tools. These World Bank Climate and Disaster Risk Screening tools developed for World Bank staff, are publicly available, and target a range of sectors where investment is concentrated, such as agriculture, water, energy, roads, coastal flood protection, health and include a multi-menu 'general' tool (see World Bank Group, 2018a). These tools are constantly evolving, and recently a set of rapid assessment tools based on the original tools was developed, for example (Rigaud pers. comm. 2018).

DFIs also use risk screening tools, built by external consultants, in their project development processes. The European Investment Bank (EIB) and Asian Development Bank (ADB) utilise Acclimatise's climate risk screening tool, Acclimatise's *Aware for Projects*, for example, to screen potential and current investment projects for climate risks and geological hazards. This climate service sits in between Maps and Apps, and

Expert Analysis as it is more narrowly tailored to a certain context than the CCKP and is offered on a commercial basis.

Apart from portals and tools, Maps and Apps CS demand from DFIs includes climate data and information. Data needs include IPCC emissions scenarios, output from GCMs and downscaled data when available, information on extreme or climate-related events (e.g. peak temperatures, storms, floods), through to projections of mean climate conditions, e.g. mean temperatures (EUFIWACC, 2016). These Maps and Apps services are at times used by DFIs in their development of climate risk screening tools. Vladimir Stenek, a senior climate change specialist with the IFC, explains that raw climate data and information is used as one input to the organisation's development of sector-specific climate risk screening tools (pers comm 2018). The tools are then elaborated in-house with external help (discussed below under Expert Analysis).

The screening of climate risks at project / investment level also creates demand for a wide range of Expert Analysis. Commonly procured advisory services include those which guide the integration of considerations of climate risks and disaster management from the outset of a project or investment, and Climate Vulnerability and Risk Assessments (CVRA) on projects or investments (see Acclimatise, 2017; ADB, 2016). Services such as climate impact modelling (e.g. using hydrological models) are used by DFIs in project finance decisions as well (Losenno pers. comm. 2018). Detailed analysis on varying types of adaptation measures, including cost benefit analysis, and effective monitoring and evaluation measures are further examples of Expert Analysis demanded by DFIs (EUFIWACC, 2016).

DFIs also procure tailored CS (Expert Analysis) which helps them develop further products such as new lines of credit. Several DFIs have, or are, currently procuring advisory services to aid in the selection and prioritisation of bankable adaptation projects with the intention to create a 'climate line of credit' (see CAF, 2012). For this work, DFIs outside of Europe often procure expertise from European consultants, in collaboration with other European institutions. ICare, for instance, is currently leading on one such project involving Acclimatise, on behalf of the French Development Agency (AFD). Acclimatise's role in the project will involve selection and evaluation of adaptation projects (Hernandez pers. comm. 2018).

Expert Analysis involving Earth Observation (EO) data could be important for DFIs moving forward. Several of the 12 projects carried out in the ADB and the European Space Agency's (ESA) initiative 'Earth Observation for a Transforming Asia and Pacific' (EOTAP) indicate the advantages of combining Maps and Apps with Expert Analysis. In the 'Climate-Resilient Rural Livelihoods in Mongolia' project, for example, EO data such as the baseline land use and land cover (LULC) maps, provided for higher-resolution data with which to monitor vegetation productivity and conditions in the Bayankhongor province. The Maps and Apps (LULC maps) effectively allowed for enhanced drought monitoring (Expert Analysis) (ESA & ADB, 2016).

DFIs' efforts to develop and provide CS themselves highlight their evolving Expert Analysis needs. In their efforts to create and provide Expert Analysis, Maps and Apps, and Shared Practices themselves, DFIs have evolving demands for the Expert Analysis they require. That is, this segment will need advisory services to aid the development of their own climate services in addition to current demand for Expert Analysis at the project or investment level. IFC, for example, have recently developed a first set of tools for sectors that span forestry, pulp and paper, transport subsectors, and insurance. These tools analyse climate impacts on the financial, environmental, social performance of a project. Together, the tools have formed a toolkit with global geographical coverage, to be used internally at IFC, though could be publicly available in the future. Input from advisory firms and governmental institutions (Expert Analysis) has been required to

complement internal expertise in order to develop the toolkit, e.g. to format existing climate indices (Stenek pers. comm. 2017).

Other examples where Expert Analysis has been procured to aid the development of DFI-led production of CS include: EBRD's work with the GCECA[13] to create and provide guidance documents around physical climate risk analysis, the World Bank's provision of climate data and information portals (in addition to the CCKP), and the ADB's facilitation of Sharing Practices such as the Regional Climate Consortium for Asia and the Pacific (RCCAP)[14]. In the EBRD GCECA project, for example, tailored expertise around climate information and metrics was provided by specialist advisory firms Acclimatise and Four Twenty Seven, who formed part of the project's technical secretariat[15]. As DFIs move toward collaborative efforts to provide publicly available CS, climate service providers will need to be able to continue to provide relevant Expert Analysis to this segment of the financial services sector. This includes, for example, high-level expertise and advisory services around emerging best practices in physical climate risk and opportunity analysis at varying levels, either at project, corporate, or portfolio level. This Expert Analysis demand has features of Climate-Inclusive Consulting, so are shown as closer to that area of the CS product matrix (Figure 6). These services, for example, may involve advice on a wide range of other data and information apart from solely climate data and information. This example also indicates the fluid nature of the matrix, highlighting why it is not meant to be over prescriptive in terms of categorising services.

Demand for Expert Analysis may evolve into (semi)automated services. While current demand in this segment is primarily in Expert Analysis, there are indications this will progress to demand for services which are semi-automated, such as subscription-based services. Climate risk advisory firms such as Acclimatise and FourTwentySeven, providers of Expert Analysis, have developed subscription-based products. In the case of Acclimatise, this has been in part due to demand from finance actors including DFIs. This could also be the case for other segments of the sector, as the sector may prefer the potential cost efficiencies subscription-based services provide.

[13] As it was known at the time of the project; the GCECA is currently known as the GCA.

[14] These offerings are discussed in further detail in chapter 6 which summarises the baseline of climate service supply in the sector.

[15] This project was aided by input from a number of working groups composed of representatives of businesses, commercial financial institutions and financial regulators, as detailed in chapter 2 (methodology).

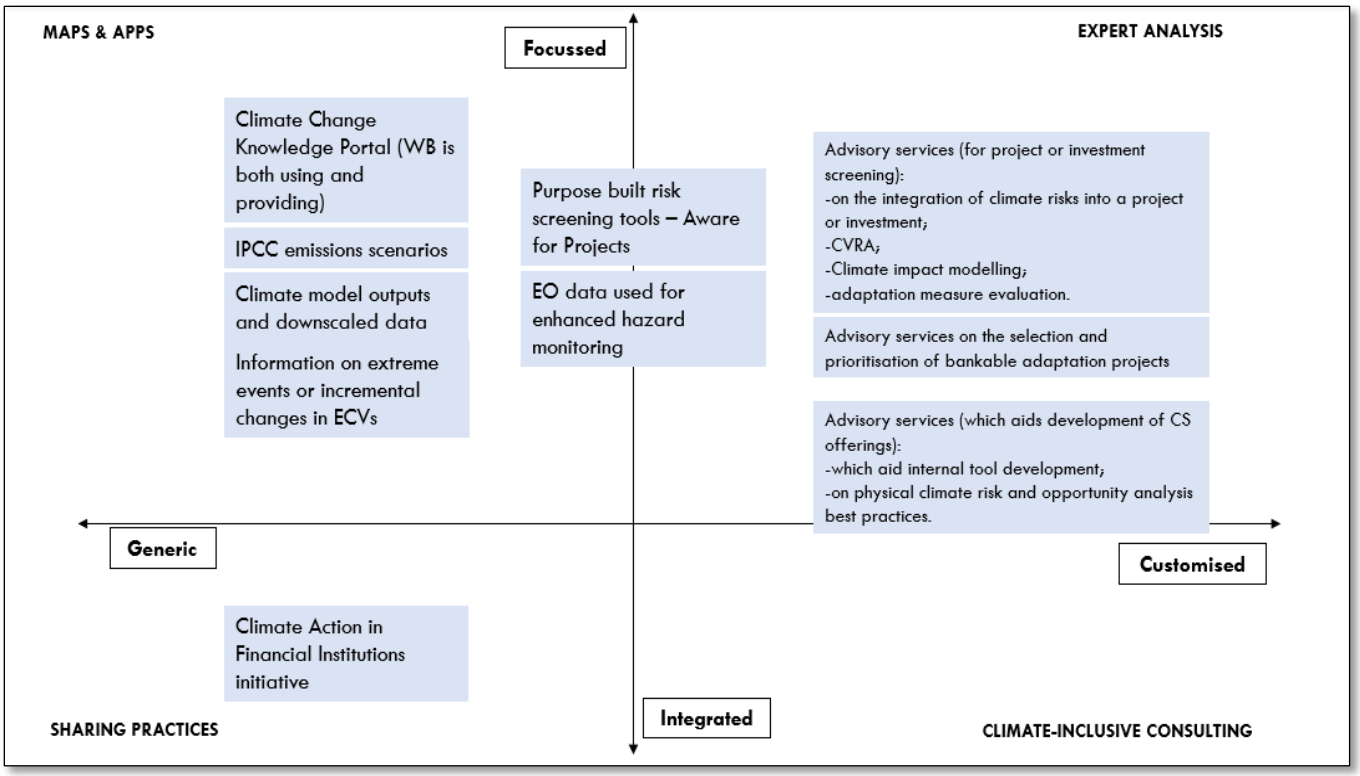

Figure **6 presents the encountered DFI segment's CS demands.** Stakeholder engagement did not reveal demand for Sharing Practices though an example of Sharing Practices is included here, namely the Climate Action in Financial Institutions initiative. This is an international coalition of public (e.g. DFIs) and private financial institutions which aims to encourage the integration of climate change considerations across their strategies, programs and operations. The initiative operates database which shares climate mainstreaming best practices, and is discussed further in chapter 6.

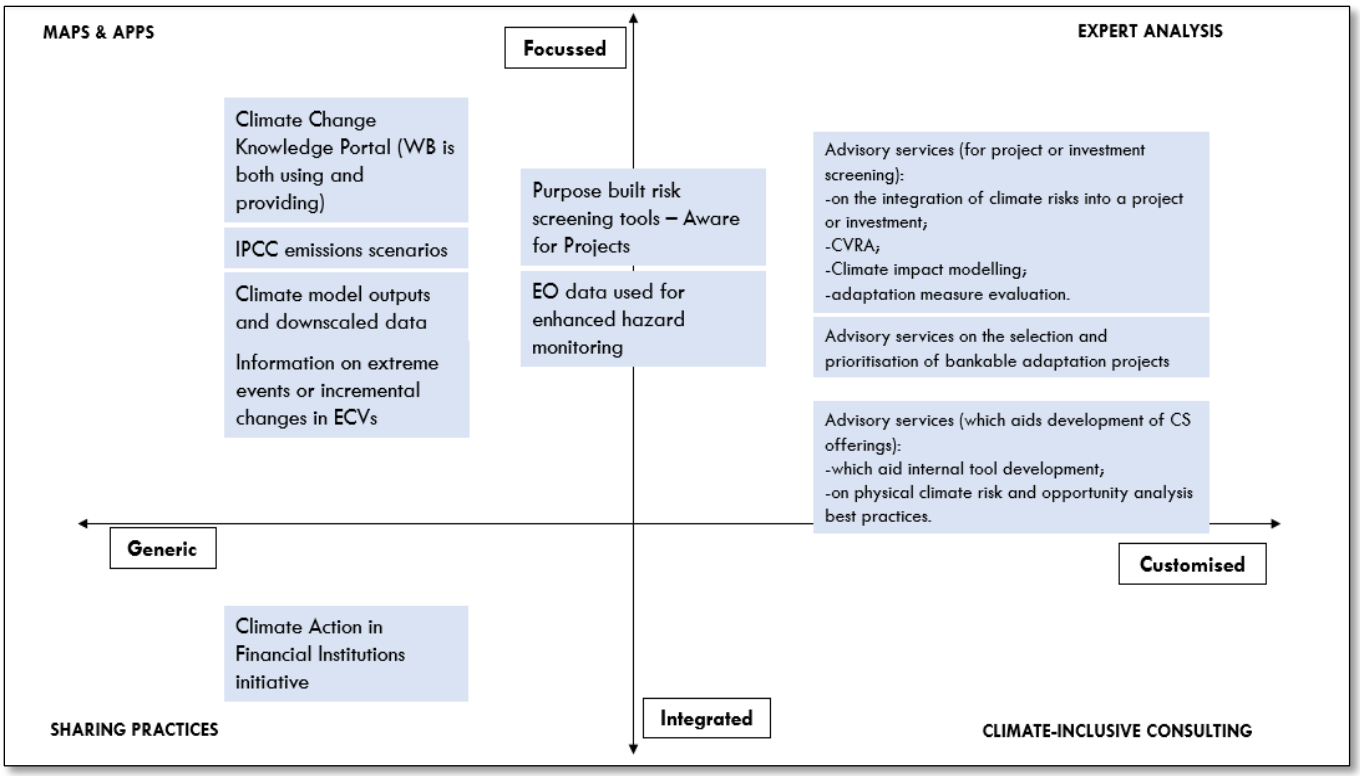

Figure 6: Encountered CS demand in the development finance institution segment

5.4. Commercial Banks

Several banks have made early individual forays into the use of Maps and Apps related CS. Barclays has previously carried out a bottom-up analysis to analyse an area of its loan portfolio in the UK. The aim was to assess the risk of expected loss due to flooding for properties, specifically for those without insurance. The exercise was ultimately conducted to inform the bank's decision making around insurance procurement – the bank sought to determine whether it ought to seek an insurance policy to cover for the eventuality of high levels of defaults in mortgage payments from high-risk borrowers in the event of a major flood. To achieve this, the bank's mortgages were plotted, with the aid of a geotagging consultant (Expert Analysis), which was overlaid with national flood maps generated by the UK Environment Agency based on historical flood risk record (Maps and Apps). The firm was able to determine their risk by identifying the number of properties in at 1 in 75, 1 in 200, and 1 in 1000-year flood zones. This exercise allowed the bank to determine there were not significant risks at the time of analysis, and that an insurance policy against this risk was not necessary. Barclays have continued to engage in efforts to analyse physical climate risks alongside transition climate risks. For instance, they have participated in the UNEP FI working group of banks piloting the TCFD recommendations.

The Royal Bank of Scotland Group also conducted a robust flood risk assessment of all its real estate ownership in the UK to identify the level of risk for each location. These findings were integrated into the Bank's long-term planning process and informed the disaster recovery process (Finley & Schuchard, 2010). Similarly, Rabobank have screened the exposure to flood risk of their mortgage portfolio in The Netherlands. The outcome was that there were no risk levels requiring additional measures in the short run.

Nevertheless, Rabobank have apparently found monitoring of the mortgage portfolio is useful (Dumitru pers. comm 2018).

UBS, a multinational investment bank, carried out a top-down balance sheet stress test along with a bottom-up analysis on several key sectors, in 2015. These exercises relied on a combination of internal expertise, and external climate-related data and information. In the top-down test, the bank used an in-house team of experts to develop a climate change scenario. The bank used data drawn from some of the most reliable publicly available sources (CISL & UNEP, 2016) which can be considered Maps and Apps. This allowed for modelling of transition risks such as changes in carbon pricing mechanisms, as well as of physical risks such as severe weather events. A bottom-up analysis was carried out as a complement to the top-down analysis. For the physical risk aspect of this analysis, the bank's loan portfolio secured by real estate was assessed for vulnerability to physical risks using Swiss Re's CatNet® tool. This tool allowed mapping of key parts of their real estate portfolio overlaid with various hazards (CISL and UNEP 2016, 56–58; stakeholder interviews, 2018). As noted in the insurance segment, CatNet can be seen as Climate-Inclusive Consulting rather than Maps and Apps as it is a proprietary tool and combines climate-related data (e.g. data on observed natural hazards such as wildfire, river and pluvial flooding and tropical cyclones) with other information (e.g. location of properties).

Collaborative efforts between banks and external actors are creating demand for Expert Analysis and resulting in both the co-production and demand of further CS. Alongside the efforts of several trailblasing banks, collaborative initiatives are emerging in the banking segment, in order to tackle the complexity of climate risk analysis within lending portfolios. These initiatives are unique as the demand for CS cannot be categorised as just one area of the CS product matrix. Rather, they involve aspects of all four areas of the CS product matrix (see **Figure 4**). For example, these initiatives require the procurement of advisory services providing Expert Analysis to be able to utilise climate data and information relating to Maps and Apps, which then guides the co-production of further climate service tools and methods. The produced methods / tools can be considered Maps and Apps, as they are often open source tools, though may verge on Expert Analysis as they are tailored to commercial banks in particular. And in some instances they lead to methods which allow for to integrate climate risk considerations within existing risk analysis mechanisms and systems such as stress testing, thereby moving closer to Climate-Inclusive Consulting. Further, these projects are effectively developing and documenting best practices for physical climate risk analysis, and therefore have characteristics of Sharing Practices.

One such initiative is the Drought Stress Testing tool, developed by GIZ, NCFA, RMS, GCP and UNEP FI in conjunction with nine banks[16]. Based on a catastrophe modelling framework[17], the tool attempts to assess the impact of different drought scenarios, by calculating the impact on cost and revenue generated by changes in the performance of economic sectors when they are affected by water scarcity and drought. The initiative was a first attempt to develop a tool which allows to banks to assess how drought impacts can affect corporate lending portfolios (Carter & Moss, 2017; CISL & UNEP, 2016).

[16] Including Industrial and Commercial Bank of China (ICBC) Ltd, Caixa Econômica Federal, Itaú, Santander, Citi-Banamex, Banorte, Trust Funds for Rural Development (FIRA), Citigroup, and UBS.

[17] See section 5.1 or 3.1.1 for further description.

Another initiative in this vein is the Working Group of 16 commercial and international banks[18], brought together by UNEP FI, who piloted Task Force on Climate-Related Financial Disclosures (TCFD) recommendations. The group worked to co-develop methodologies allowing them to analyse both transition and physical climate risk impacts on their portfolios[19]. The Working Group pooled resources to procure Expert Analysis, e.g. guidance from advisory firm Acclimatise on developing the physical climate risk methodology. The physical climate risk methodology was developed and piloted across selected climate-sensitive sectors: agriculture, energy and real estate, is built upon a variety of Maps and Apps CS. The methodology for agriculture and energy focusses on analysing the impacts of incremental climate change and extreme events on borrower revenues and cost of goods sold and estimating changes in probability of default. For real estate, the methodology assesses potential changes in property values and loan-to-value ratios due to extreme weather events. As such, the result of this initiative has produced a prototype methodology for climate risk screening in banks' loan portfolios, which can be used by banks themselves and others as it is publicly available. The methodology, as described in Connell et al. (2018) is a type of climate service itself, with elements of Sharing Practices (as it is publicly available guidance), and Expert Analysis (as it is complex and targeted to a specific set of end-users, i.e. banks).

Maps and Apps are needed to drive portfolio level analysis though, importantly, in conjunction with Expert Analysis and non-climate data. As banks look to respond to various climate risk disclosure frameworks, including TCFD recommendations, climate service demand in this segment in the coming years will stem from interest in portfolio-level analysis[20]. Or if not portfolio-wide, at least in parts of banks' portfolios deemed to be climate-sensitive. The propagation patterns of climate change hazards are not yet sufficiently understood for generation of reliable dedicated sensitivity indicators, so at this early stage, banks use recent experience with climate hazards and impacts, or perception of potential risk, to determine sensitivity. As hinted in the discussion on the TCFD pilot working group of 16 banks and in the Drought Stress Testing tool, CS in the Maps and Apps category are needed to feed into portfolio-level analysis.

In the TCFD pilot working group's physical risk methodology, Maps and Apps CS are used to assess incremental climate change impacts such as outputs of sector-specific climate change impact models and studies. For example, in the energy and agriculture sectors, published climate change impact studies are used to help determine how incremental climate changes (e.g. for temperature and precipitation) could affect sector productivity in the future (e.g. agricultural yield or power plant output). The impacts of extreme events (e.g. cyclone, flood, wildfire, drought and extreme heat) are assessed using online data portals (also Maps and Apps), where relevant[21]. Recommended web-based portals providing maps and data include Princeton Climate Analytics' drought risk product, UNEP Global Risk Data Platform and ThinkHazard![22] and commercial tools such as Swiss Re CatNet® (Connell et al., 2018).

These methods, and portfolio level analysis in general, rely on a wide range of climate data and information in the Maps and Apps category, though demands for Expert Analysis associated with these methods should not be underestimated. Despite clear methodologies such as that developed in Connell et

[18] Including ANZ, BBVA, BNP Paribas, Barclays, Bradesco, Citi, DNB, Itaú, National Australia Bank, Rabobank, Royal Bank of Canada, Santander, Standard Chartered, Société Générale, TD Bank Group and UBS.

[19] This group also worked to analyse climate-related opportunities. Opportunity analysis typically relies less on climate data and information, and as such is not detailed here.

[20] as opposed to project-level screening as is the case in DFIs.

[21] For instance, drought and extreme heat would not considered for real estate.

[22] Developed by GFDRR.

al. (2018), physical climate risk is a new area for banks to assess, and they are likely still building up internal knowledge and capacity to be able to comfortably access and manipulate the climate data involved in these sorts of analyses. The climate data and information which these initiatives are built upon are often studies which were not designed to be a climate service product. The rigor around their production is important to banks and other financial services actors, but these types of studies require interpretation to be able to be used by banks. There will likely be demand for Expert Analysis in the form of tailored advisory services to guide portfolio level physical risk screening analyses further.

The boundary conditions involved in the production of publicly available methodologies may also create demand for further Expert Analysis. In the TCFD pilot working group, for instance, one such boundary condition was that the datasets should be universally applicable but should also reflect national and local realities and variations. This led to the use of climate-related datasets which provide global coverage at the highest available spatial resolution (Connell et al., 2018). While this method is a very good first step toward portfolio-level physical climate risk analysis, banks may need to seek out further analysis and guidance to access other datasets for countries in which they operate which were not able to be covered in the current iteration of the methodology.

Finally, advisory services relating to non-climate data are needed in the banking segment as well. While not CS per se, this information is essential for the uptake of climate data and information, and Expert Analysis climate service providers such as advisory service firms may be tasked with helping to procure, manage and manipulate it, due in part to the sheer volume of data required. For instance, banks interested in portfolio level analysis will need large quantities of location or asset-level data, information around their clients' levels of insurance coverage and the extent to which adaptation measures are in place.[23] Stakeholders in the TCFD pilot project indicated that location data is not often held in an easily accessible manner and that currently, banks do not typically have staff skilled in spatial analysis (e.g. in GIS programmes) which can combine climate and non-climate data together to determine climate risks. As such, banks may need assistance determining how best to combine this information with the climate-related information in order to assess the impacts.

Many banks are interested in receiving CS on existing information channels. Those who do not yet have internal capacities built up around spatial analysis, for instance, have shown a keen interest in the potential to use platforms which they already use for data analysis. These border on Expert Analysis and Climate-Inclusive Consulting as they will often have climate data and information already embedded along with a range of other data and information. Examples include functions on the Bloomberg terminal such as Bloomberg MAPS which allows for some extreme event data to be coupled with location data, to help visualise potential physical climate risk (Connell et al., 2018). This demand could evovle as banks develop in-house capacities for spatial analysis - the Royal Bank of Canada (RBC) is forging ahead in this respect. The bank has established a new team of experts allowing them to conduct tailored spatial analysis internally (ibid pg. 63). Though banks will likely increase their internal capabilities to manipulate datasets in a GIS environment, the interest in including CS in existing channels of information will not likely wane. This may be due to the commitment and investment these organisations have already made to existing financial data systems. This demand likely applies to most segments of the financial services sector.

[23] Note that not all of this information is currently available to banks, particularly around insurance coverage. Data gaps are discussed in further detail in chapter 8.

Figure 7 depicts the CS demands of commercial banks as encountered in this study. Sharing practices were not discussed explicitly by stakeholders in the banking segment, though one such example is the UNEP FI banking group. UNEP FI have various specialist groups for their members, including banking, investment, and insurance. These specialised groups hold general assemblies and roundtables where approaches and advances are shared among members. The forum also organises collaborative efforts as described here, all of which helps drive CS uptake in this segment.

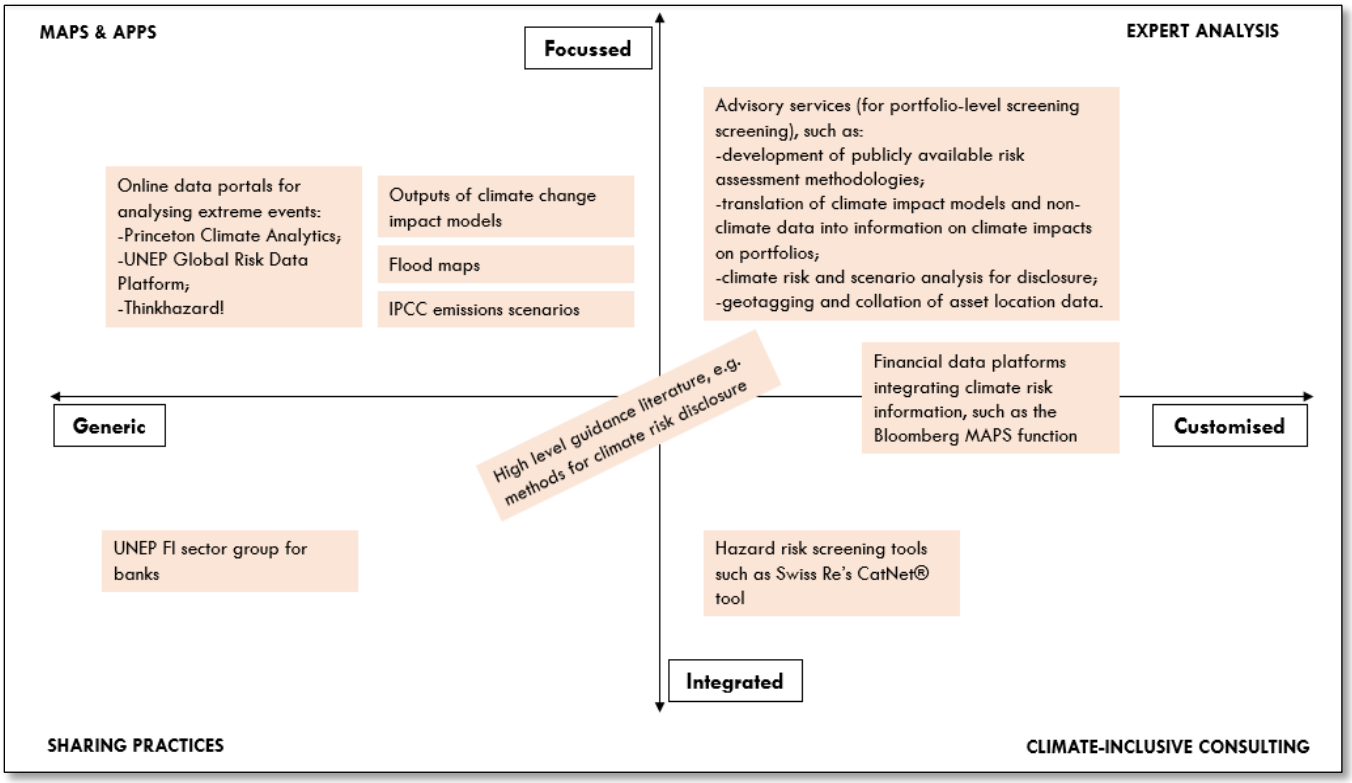

Figure 7: Encountered CS demand in the commercial banking segment

5.5. Other Finance Actors

Insurers, DFIs and commercial banks are far enough along on their journey to be creating observable demand for CS. Other actors in the financial services sector are less advanced in articulating and creating demand. These include rating agencies, those involved in the investment chain, and sector associations. Another particular group are banks or financing institutions for local public authorities and closely related actors (public or private with a public service assignment). The role of these specific financial actors links also to the urban planning focus of WP4. Even though the point of departure of these public sector banks is market aligned interest rates, their assessments of risks and benefits may attribute more weight to societal benefits and hence this makes them a small but potentially interesting category for versatile adaptation orientated CS (see section 1.2.3 for discussion on adaptation orientated CS). A truly important exception among the 'other finance actors' are various large institutional investors, a small number of which appear to be committed to climate risk analysis. This section presents the climate service demand encountered by these other groups, however early or nascent it may be.

Rating agencies may demand Climate-Inclusive Consulting, though demand is indirect and limited. The interest of rating agencies in climate data and information is relatively latent – these actors procure little climate data and information directly. Rather, they primarily rely on the sponsor (those who they are rating) to provide climate data and information which will inform their rating. For instance, when assessing an insurance company for capital adequacy, they assess the company's exposure to weather related risks, among others, using the outputs of catastrophe models which are provided by insurers or their brokers.

A representative of S&P Global confirmed that another, although nascent, area where CS could be used is in understanding the resilience benefit (e.g. reduction in damages) of adaptation projects. To do this, one stakeholder from a rating agency suggested the agency could use appraisals of the physical climate risks, and the resilience benefits, which would potentially be found as part of the feasibility study or the environmental and social impact assessment (ESIA) for the project. Important to note, however, is these impact assessments may not often incorporate climate change considerations adequately. This type of climate service would be Climate-Inclusive Consulting since climate data and information is integrated in with other services.

Rating agencies directly demand Expert Analysis and Maps and Apps in small quantities. Climate service demand is, however, directly driven by rating agencies in a few instances. One such example is in their one-off assessments, which includes reviews of how climate change will impact financial services actors, sovereigns or corporates. For instance, S&P Global reviewed how climate change will affect extreme weather and how that would then affect insurers' balance sheets. In that instance, they used Expert Analysis such as views from RMS (see Petkov, 2015). Many other one-off assessment examples exist, including a 2015 review of the climate change risks to sovereign ratings conducted by S&P Global and Swiss Re (see Mrsnik, Kraemer, Petrov, & Glass, 2015). That work involved the open-source Climada natural catastrophe damage modelling tool developed by David Bresch[24]. As this tool is open source, it is located between Maps and Apps, and Climate-Inclusive Consulting. Other Maps and Apps include impact models for flood and tropical cyclones (ibid pg. 20)

Moody's have also suggested they may be using CS, in their production of research pieces similar to S&P Global. For example, in 2015, Moody's created a 'heat map' sensitivity matrix that highlighted the most and the least exposed sectors from climate related-risks[25]. The work involved an assessment of various environmental risks, including physical climate risk, across 86 sectors. It is not, however, transparent which climate data and information were used to create this piece and the firm were not available for comment. Moody's have also developed a methodology to assess the physical effects of climate change on sovereign bond issuers. The analysis used Maps and Apps CS such as the IPCC Fifth Assessment Report as well as more detailed Expert Analysis such as country-level assessments of climate impacts (Moody's, 2016).

Asset owners and investment managers are, in the majority, only recently starting to recognise the potential materiality of physical climate risks in their portfolios. Sporadic evidence of demand for Climate-Inclusive Consulting and Expert Analysis exists in this segment. Stakeholders involved along the investment chain indicated that for them to play closer attention to physical climate risks and to devote time and resources to physical climate risk considerations, the climate exposure and the potential financial losses generated by a changing climate would need to be more evident (stakeholder interviews, 2018). A

[24] of the Swiss Federal Institute of Technology ETH Zurich, and MeteoSwiss.

[25] As discussed by Rahul Ghosh, VP-Sr Credit Officer, Moody's ESG team, at the EBRD-GCECA Advancing TCFD Guidance on Physical Climate Risks and Opportunities conference, 31st May 2018.

large magnitude of change or a large financial impact in an investment portfolio would, for instance, be required for asset / investment managers to believe that physical climate risks ought to be taken into consideration on a regular basis. Currently, the perception in many of these organisations appears to be that the financial consequences of physical climate risk for an investor are relatively modest and may stretch beyond typical investment horizons. The investment segment is therefore at the early stages of climate service use and demand is generally low, with a few examples of exceptions discussed below.

In terms of Climate-Inclusive Consulting, large firms such as AXA, for example, utilise cat modelling to assess climate related physical risks in their portfolios (AXA Group, 2018). This is to be expected as they are a major insurer as well as an investment manager; other asset management firms not linked to insurers might not have this potential demand. Stakeholders in this segment also expressed interested in adding functionalities around climate risk to existing platforms such as the Bloomberg terminal, such that financial data and climate data could be easily collated (stakeholder interviews, 2017). Some investors have made use of methodologies put forth in Mercer's Investing in a time of Climate Change[26], e.g. the UK Environment Agency Pension Fund (Mercer & Environment Agency Pension Fund, 2015). Stakeholders from one investment management firm who utilised Mercer's method, however, did not necessarily agree this service should be considered Climate-Inclusive Consulting. The stakeholders regarded the service as more generic (i.e. closer to the more generic areas of the CS product matrix) as it was not tailored to their specific portfolio enough to prove useful (stakeholder interviews, 2017).

With regards to Expert Analysis demand, stakeholders from investment manager PGMM explained, 'investors might need help – initially – in translating climate change into implication for investment policy and portfolio management' though suggested there would come a point where external analysis would not be needed (pers. comm., 2017). The stakeholders felt it is the duty of the firm to internalise this – at which point firms would no longer need Expert Analysis services and could need Maps and Apps. Other stakeholders in this segment indicated a more differentiated viewpoint, however. During the Finance session at the Finnish Climate Summit (13.06.2018; Helsinki) several chief asset managers of both pension funds and commercial banks, from across France, Sweden, and Finland, suggested that they may consider to do more in-house risk analysis pertaining to climate change and climate policy – at least temporarily – , as a means to learn this new risk area better, rather than outsourcing it right from the start (without proper knowledge of the specific features). In the long run, when this particular field of expertise and resulting CS products get more established, a substantial part of the work may get outsourced, this growing the CS market. These varied viewpoints highlight that the investment segment has a wide range of actors and that there is not yet consensus on how best to react to climate data and information.

Expert Analysis demand appears to be stemming from action on TCFD reporting and physical climate risk analysis by both asset managers and owners. AXA has completed TCFD aligned reporting, for example, using Expert Analysis to do so (AXA Group, 2018). MN in the Netherlands has recently completed TCFD-aligned reporting as well, though it is not clear if the firm used external support for this (MN, 2018)[27]. In its 2017 Annual Report, the [UK] West Midlands Pension Fund has included analysis of climate risks and opportunities, in line with the TCFD recommendations (EAC, 2018). Other asset owners in Europe who conduct physical climate analysis include First State Super in Australia, the Environment Agency Pension Fund in the UK, and AP7 in Sweden (ShareAction & AODP, 2018). It is not clear which CS these analyses

[26] This can be considered Climate-Inclusive Consulting in that it is provided by financial consultant Mercer, who often will have established relationships with investors, and as such may provide this analysis alongside other services they provide.
[27] Currently only available in Dutch.

demand, though demand could potentially be Expert Analysis and Maps and Apps, depending on the level of internal capacity[28].

Investment managers also reported on their use of advisory firms for the development of climate scenarios, though the exercise was focussed on climate scenarios for transition risks and therefore did not technically demand CS (if they developed scenarios for analysing on physical risks, this would be considered CS procurement). Along these lines, stakeholders also indicated the investment segment largely mistakes *climate* risk to mean carbon-related risks, or transition risks. The focus on carbon rather than climate means interest and uptake of carbon data has been steadily on the rise in this segment, though information around physical climate impacts has only just started to gather momentum.

Similar to commercial banks, collaborative efforts are important in the investment segment in these early stages of climate service uptake. In mid-2018, UNEP FI convened a working group of investors which will work to pilot the TCFD recommendations, similar to the working group of 16 commercial banks. The group has also procured technical guidance (Expert Analysis) from a mix of private firms and research organisations and will produce an open source methodology for physical risk analysis of equities and bonds in 2018-2019. A further example is Deutsche Asset Management's[29] collaborative effort with climate advisory firms Four Twenty Seven and Trucost. In late 2017, the group worked to produce a preliminary assessment tool which score public equities' exposure to climate change impacts (Four Twenty Seven, 2017).

There might be more scope for regular use of dedicated CS products from banks for non-state public sector organisations, such as municipalities, water boards, etc. in the future. These organisations are often already involved in urban and infrastructure development projects in which sustainability criteria are ambitious, or which are directly addressing mitigation through investments in energy savings and renewable energy. In this respect the interviewed actors (Kuntarahoitus (Finland) and Bank Nederlandse Gemeenten BNG (Netherlands)) mentioned involvement in and further interest in green bonds. Resilience bonds have not been explored yet. There is also a raised awareness to ensure that real estate and infrastructure projects are accounting for climate change impacts relevant for intended location(s). Next to this ex-ante assessment, both organisations mentioned also possible relevance of risk monitoring of such projects. BNG also mentioned that the activities of the Dutch Central Bank (DNB) could be expected to give some guidance for further development of risk and opportunity monitoring in this theme area. Both organisations emphasised that sustainability, greening, climate proofing, etc. have become important themes and criteria in urban and infrastructural development plans. Although each in their own way, both organisations indicated that clearer (harmonised) decision and requirement frameworks for non-state public sector organisations regarding climate change would help these banks to more effectively develop or mobilise relevant expertise. The organisations will probably strengthen their expertise in this thematic area as well as intensify acquisition of expertise services. Yet, so far no regular acquisition of CS has taken place, beyond retrieval of public information. From the answers can be inferred that, if the applicability and choice of CS get clearer, there might be more scope for regular use of dedicated CS products.

Sharing Practices instruments incorporating climate change risks, often involve sector associations and are an important channel for the development and uptake of CS among investors. Stakeholders from PGGM as well as from French asset manager firms indicated there are many platforms, networks, and informal contacts which exist for sharing climate knowledge and information (PGGM pers. com. 2017;

[28] These firms were not available to participate in this study.

[29] As the firm were known at the time of the project. The firm is currently known as DWS.

stakeholder interviews, 2018). The Institutional Investors Group on Climate Change (IIGCC) in Europe, the Investor Group on Climate Change (IGCC) in Australia, and the Dutch Association of Investors for Sustainable Development (VBDO) have all recently produced (or are currently in the process of) guidance for their membership on the use of climate data, tools, scenarios and other information, to manage physical climate risks. The focus of various investment sector associations indicates the current growing awareness of physical climate risks and could point to eventual growing demand for CS in the investment segment. Despite a preference for existing networks such as the IIGCC (rather than new), there are several important emerging Sharing Practices which stakeholders indicated could potentially prove useful (stakeholder interviews, 2018). This includes the Climate Disclosure Standards Board and TCFD's Knowledge Hub where preparers of TCFD-aligned reports can learn from others (see section 6.2 for further discussion.

Research from other sector bodies, such as the Resource and Environment Board of the Institute and Faculty of Actuaries (IFoA) also points to the potential demand for actuaries working in the investment and other segments of the financial services sector, i.e. guidance on climate risks. The Resource and Environment Board and its sub-committees have recently published guides for actuaries, providing practical guidance on how to consider climate change (Hails et al., 2017; Trust, Jones, Jones, & Aspinall, 2018). These guides indicate a growing need for this type of guidance information among actuaries in the investment and other segments of the finance sector, following the 2017 release of a risk alert on climate risk to actuarial professionals (See chapter 4; IFoA 2017). The guidance documents are also a provision of CS in a sense, falling under the Expert Analysis category, though border on Sharing Practices in that they are open source and relevant to actuaries working in different areas of the sectors (See chapter 6). **Figure 8** provides a map of encountered CS demand among actuaries, investors, and rating agencies.

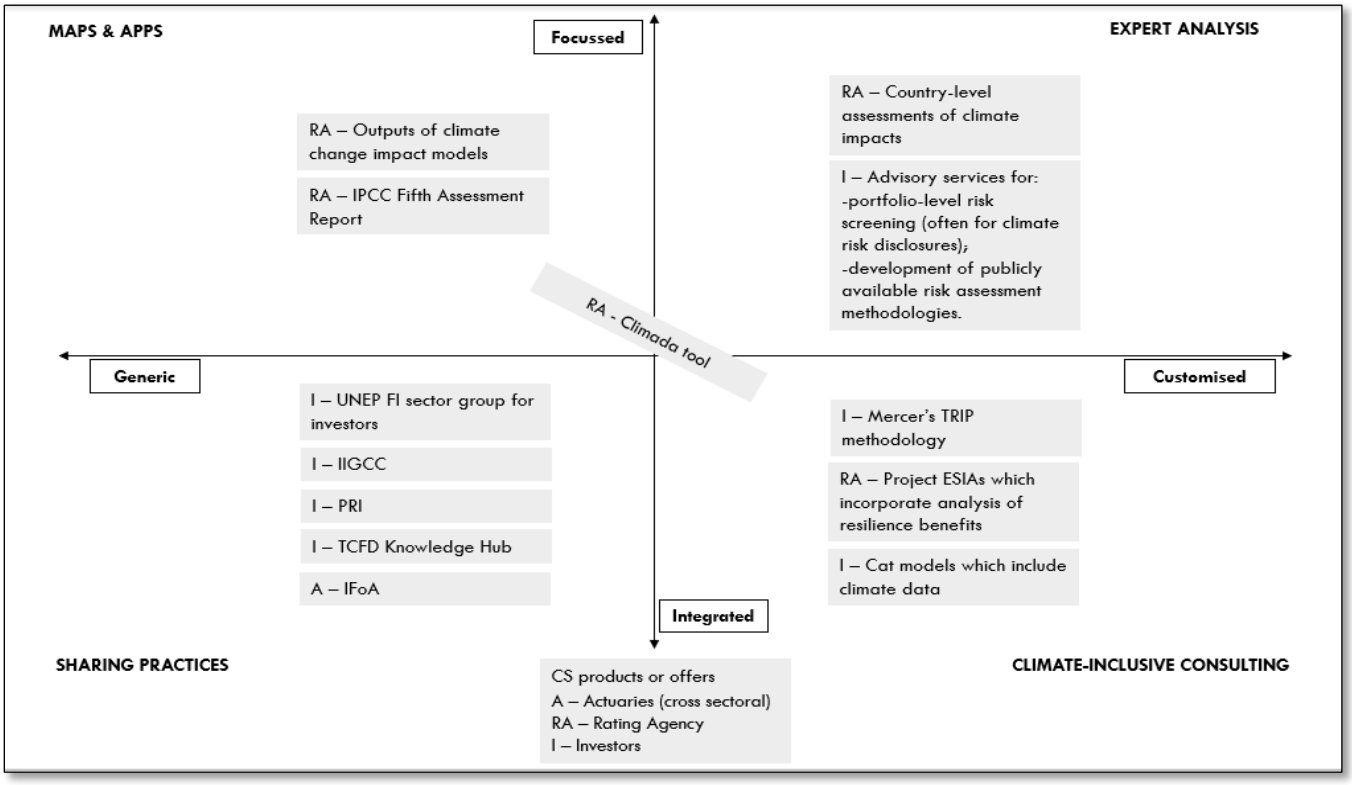

Figure 8: Encountered CS demand in other areas of the finance sector

6. Baseline of Climate Service Supply in the European Financial Sector

This chapter provides the results of literature reviews and interviews with the financial services sector, with regard to current climate service supply. This summary of current supply is presented by area of the climate services product matrix (i.e. Maps and Apps, Sharing Practices, Expert Analysis, and Climate-Inclusive Consulting; see Figure 4, pg. 43). It is important to note that this matrix is a useful way to describe the current market, though providers or products may not sit neatly into one category of the matrix. Figure 9 summarises main types of encountered CS provision, with more detail provided in and discussed in this chapter. This and chapter 5 set the scene for latter chapters which characterise obstacles related to the supply, demand, and matching of climate services (CS) in the financial services sector.

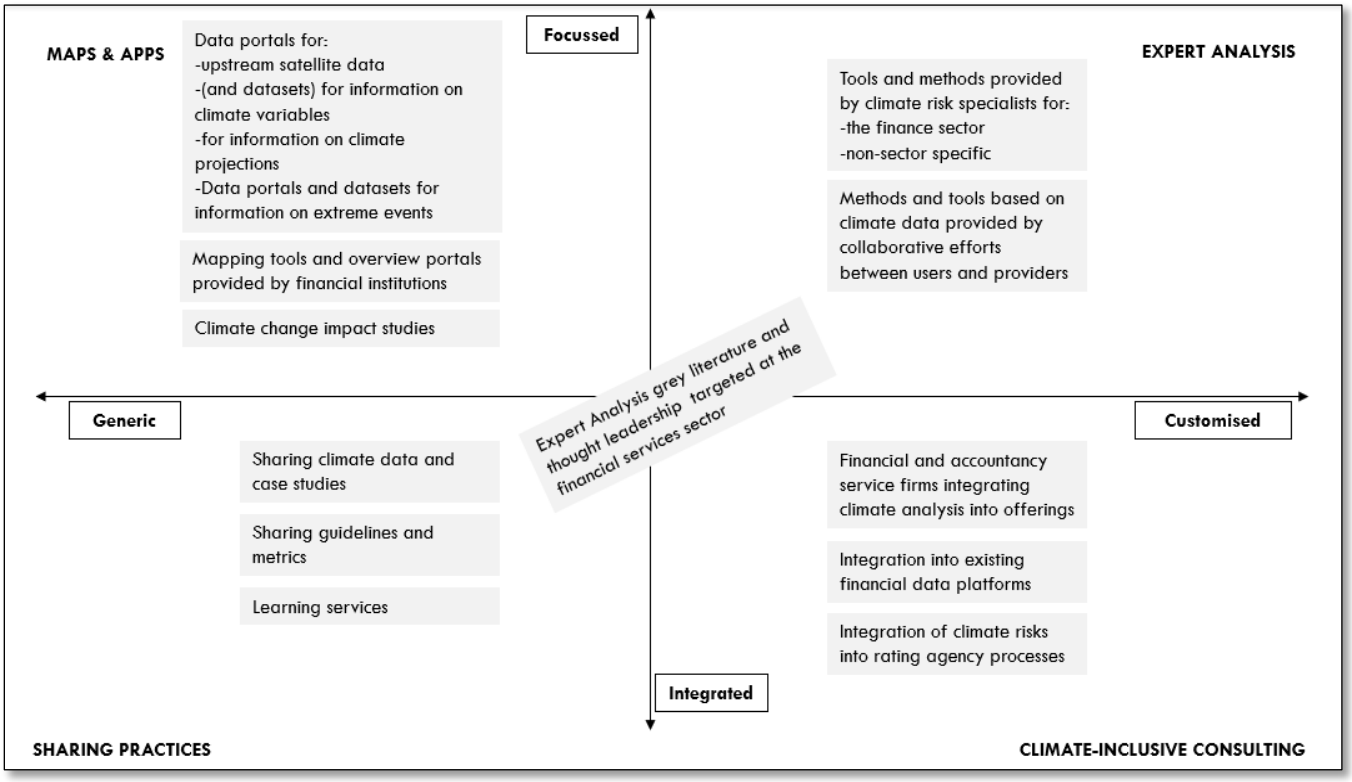

Figure 9: Summary of encountered CS provision

6.1. Maps and Apps

There is a healthy supply of climate and climate-related data provided via data portals and websites. These range from portals and websites which provide access to upstream satellite data, data on essential climate variables (ECVs), climate model outputs, and information on certain extreme events. These are mostly provided on an open and free basis by governmental agencies though some require registration. Some providers charge for datasets, e.g. meteorological offices. The proliferation of this type of CS is also documented in EU-MACS deliverable 1.4. The large number of Maps and Apps services available to users should not be mistaken to mean all climate data needs are fulfilled. Gaps are discussed further in chapter 8.

Climate change impact studies provided as either academic or grey literature are increasing in supply, though are not always useful for financial actors. These types of studies produce analysis targeted at

actors within certain sectors, e.g. agriculture, in order to advance the understanding of physical climate impacts on production (crops in the case of agriculture). Often, impact studies stop short of analysing the climate change impact on variables of interest to financial actors, however, such as price, which would additional steps of analysis. It is important to note that not all sectors and geographies have impact studies; the literature in the agriculture sector is far more advanced than most other sectors. Sectoral climate impact studies are often open access and not tailored to finance actors, so have more characteristics of Maps and Apps. More macro-level analyses are also problematic. There are a range of approaches to analyse the macro-economic impacts of climate change including computable general equilibrium (CGE) models, integrated assessment models, and those based on econometric techniques. These differing types of analysis often present widely diverging results, however. This uncertainty means these studies are not yet helpful or useful to banks (Vivid Economics in Connell et al. 2018). It is worth mentioning that macro-economic analyses will have features of Expert Analysis as they may be more tailored to a specific context or decision-makers.

Climate change impact studies highlight how the CS product matrix can have more fluid than solid boundaries for its CS categories. These studies do not sit neatly in the Maps and Apps category. When used for understanding climate impacts by those within the sector they analyse (e.g. agriculture), they are more in the Expert Analysis category as they provide specific information tailored to those users. But when these studies get used for a larger analysis such as a bank's portfolio analysis, they are closer to the Maps and Apps category as they provide information not tailored to the FS sector. The studies also have characteristics of Maps and Apps because they are often open source, or available for very little cost.

Maps and Apps are sometimes provided by advanced CS users within the finance sector including DFIs and reinsurance firms. The World Bank's Climate Change Knowledge Portal (CCKP) is one such example of the supply of Maps and Apps by finance actors themselves. This open access data portal is unique in that it serves more as a library of other portals, and is a source for both World Bank staff as well as the wider public. One stakeholder from a flood risk modelling company confirmed the CCKP is one of the first places they look to access climate model and precipitation data from other sites (Smith pers. comm. 2017). The World Bank has also partnered with other organisations to develop other Maps and Apps type service, e.g. the Climate-Smart Planning Platform (CSPP) which was designed specifically for those in a developing country context. Other finance actors providing CS products include reinsurance firms. For example, Swiss Re offer their CatNet® services which allows users to investigate exposure of their assets or portfolios to physical climate risks (see chapter 5 for further discussion). Zurich Insurance Group and Munich RE have similar tools.

Table 9 in *Annex 6* summarises main categories of the supply of Maps and Apps encountered in this study.

6.2. Sharing Practices

Web-based platforms which allow sharing of a range of information, including climate-related data to case studies are common. Although outside of Europe, the ADB's Regional Climate Consortium for Asia and the Pacific (RCCAP) is a prime example of a web-based Sharing Practice. Similar to the World Bank's CCKP, the RCCAP is categorised as a Sharing Practice as it has case studies and a forum element, a common feature of Sharing Practices. The Oasis Hub, another web-based platform, has elements of a forum in that allows users to add comments and feedback on the services they bought / accessed, which other users can use to guide their choices. Web-based knowledge hubs and databases of case studies have recently emerged as well, e.g. the TCFD Knowledge Hub and the Climate Mainstreaming Practices Database. These platforms allow users to review others' experiences with integrating climate considerations with climate risk

disclosure.

Less commonly provided Sharing Practices include best practice guidance documents. These types of sharing practices also allow for users to better understand and use climate data and information, and provide clear direction on how to do so. They are often web-based platforms. A prime example includes EBRD's partnership with GCECA[30] which sought to engage with members from the finance, corporate and regulatory sectors in an initiative titled 'Advancing TCFD guidance on physical climate risks and opportunities'[31]. Together, the group produced a set of guidelines for corporations to use when analysing and disclosing their physical climate risks and opportunities, which are set out in a report bearing the same name as the initiative. The guidelines build on current reporting frameworks such as the TCFD, PRI, and CDP, providing a more detailed set of metrics to report against. While the aim of this initiative was to inform and support early efforts of corporates to adopt the TCFD recommendations, the guidelines can also be used by asset managers and banks as an engagement tool with their corporate borrowers (stakeholder interviews, 2018). These guidelines border on Expert Analysis as the guidance is quite technical in nature, despite being publicly available to a wide audience. Other evidence of these Sharing Practices includes guidance documents on how to consider climate change provided to actuaries across the sector by the IFoA (see section 5.4). Guidance documents in general (i.e. not necessarily on metrics) are very commonly provided, though these have been included under Expert Analysis because they typically focus on one segment of the finance sector (e.g. asset owners). Guidance documents, then, are another instance when then CS product matrix has fluidity rather than solid borders.

DFIs frequently work in partnerships and amongst themselves to produce Sharing Practices which can be used by other sectors. DFIs consulted in this study have participated in a range of collaborative efforts, resulting in both types of Sharing Practices: best practices and guidelines, as well as platforms for sharing climate-related information. Five of the seven examples listed in Table 10, *Annex 6* involve DFIs, for example. Importantly, these resources can be used by finance actors in other segments of the sector, as well as by other sectors.

Sharing practices also include provision of open access or online learning courses. Both the World Bank and UNEP FI currently offer such courses. World Bank's e-course on climate services is a free self-paced open access course. Kanta Kumari Rigaud, who was involved in the development of this course at World Bank, explained this new offering aims to advance understanding, awareness and uptake of climate services among policy and decision-makers in a developing country context (pers. comm. 2018). This course provides important background information on climate data and information and is a means to share knowledge and understanding around climate data and information. Box 5 provides more information on the course content.

[30] Currently known as the Global Center on Adaptation (GCA).
[31] see chapter 2 for list of participants.

Box 5: Course content of the World Bank's open access course on weather and climate services

Course: E-Platform on Weather and Climate Services for Resilient Development: A Guide for Practitioners and Policy Makers

Modules include:

1) Introduction to the benefits of weather and climate services. Includes the basics of how hydro met data can be derived into services and includes examples and economic rationales;
2) Exploration of the CS value chain. This module provides information on how water and weather data is collected and managed, through to the delivery of climate information to end-users, as well as the institutional actors involved along the way. The module covers how to transform this data into information and discusses a range of climate services in agriculture, urban planning, other sectors. It also covers how to address the short (daily)/medium (seasonal)/long term (longer range) data needs;
3) Investigation of a range of investment options. This is reviewed in the context of a real project. Information on how CS can be embedded into the design of a project;
4) (Special module) Use of Earth Observations. Covers potential areas of use for EO data in the context of climate risk management.

(Rigaud pers. comm. 2018, World Bank Group, 2018c)

UNEP FI's course is tailored to personnel at banks in particular, as they look to understand physical climate risks and conduct TCFD-style reporting.

6.3. Expert Analysis

Conventional expert advisory services are in steady supply, though the market is still fragmented with many diverse providers. Specialist climate risk firms offer highly relevant tailored Expert Analysis for the financial services sector, for example, with many now offering climate risk disclosure services, in line with the emerging disclosure schemes such as Article 173 in France and the TCFD recommendations (see chapter 4 for further discussion on these initiatives). Further, these firms are often involved in advising the collaborative efforts between sector groups and finance actors, effectively guiding the production of further Expert Analysis tools, e.g. the methods produced under UNEP FI TCFD projects (as discussed in chapter 5) or the tool which will be produced in the ClimINVEST project, as detailed below and in Table 11.

Yet there are many other actors providing Expert Analysis, including research organisations, non-governmental organisations, meteorological offices and finance actors themselves. Some providers focus on offering services to the finance sector more than others, e.g. CICERO who are working as part of a consortium of European researchers and advisory firms under then ClimINVEST project to develop a tool for investors to analyse physical climate risk. Meteorological offices also work with advanced users of CS such as development banks and insurers. Stakeholders from met offices also indicated the need and interest to work with other segments of the sector in the future (see UK Met Office 2016; stakeholder interviews, 2018).

Some providers of expert analysis provide services in a more general sense which could eventually be of use to finance actors. Research organisations as the German Potsdam Institute for Climate Impact Research (PIK) are a well-established provider of integrated assessment models, and have a spin-off consulting

service, for example (see "Climate & Environment Consulting Potsdam GmbH," n.d.). NGOs in North America may also make up part of the provision of Expert Analysis advisory services, e.g. Climate Analytics, who specialise in climate impacts and risk assessment (see Climate Analytics, n.d.).

Finally, Expert Analysis is provided by some actors in the financial services sector themselves. Swiss Re, for example have carried out analysis for New York City following Hurricane Sandy (see Swiss Re, 2013; The City of New York, 2013) and Lloyd's who have partnered with UK Met Office to deliver methodologies on analysing the potential links between weather events globally (Lloyd's & UK Met Office, 2016).

Expert Analysis is increasingly moving beyond conventional provision of expertise via consulting, to involve tools, models and methods with a range of business models. A handful of tools and methods aimed at analysing physical climate risk for various financial institutions are now available. These are primarily provided by advisory firms specialised in climate risk analysis. Acclimatise's *Aware for Projects*, for instance, is provided under licence, and allows for the screening of potential and current project finance investment for a suite of climate risks and geological hazards. Similarly, Acclimatise' *Aware for Investments* tool can be used to screen for climate risks related for investments in individual companies (i.e. equity investments). Carbon Delta's Climate Value-at-Risk (Climate VaR™) model, targets investment portfolios, aggregating calculated climate risk, e.g. that associated with extreme events. FourTwentySeven provide methodologies such as their climate risk scores for analysing physical risk within equity portfolios as well. See IGCC (2018) for further description of these and related tools. This is important as it also means there is an expansion from the downstream (end-use) part of the value chain to midstream products (both for some end-users and for expertise organisations, discussed further in EU-MACS deliverable 5.1 and 5.2.

Collaborative efforts between finance actors, sector associations and advisory firms are also producing publicly available tools and methodologies targeted at specific groups of the sector. These tools, methods, and platforms are also discussed in chapter 5. A prime example is the methodology developed under the UNEP FI TCFD pilot project with 16 commercial banks to analyse physical climate risk within banks' loan portfolios (Connell et al., 2018). At the time of publication of this study, UNEP FI were starting to work with expert advisors and other factions of their membership to produce similar methods for the investment and insurance segments of the sector, due out in 2018/2019. Sector assocaitions, NGOs, and development organisations have often been the catalyst of these efforts – e.g. a consortium of organisations including GIZ, The Natural Capital Finance Alliance (NCFA), RMS, The Global Canopy Programme and UNEP FI developed the Drought Stress Testing tool with banks in 2017.

There is evidence of numerous specialist climate risk firms which provide tailored climate data and information tools though do not yet appear to be targeting financial services actors. These firms are typically outside of the EU, e.g. ClimateRIsk in Australia and CLIMsystems in New Zealand.

These platforms are closer to Expert Analysis than Maps and Apps in that they are typically proprietary[32] rather than open access tools and platforms, involving information more closely tailored to the needs of actors in the financial services sector.

Collaborative open source efforts to provide Expert Analysis literature are currently very common in the sector. Numerous reports, analyses and guidance documents have emerged in recent years, providing varying degrees of high-level guidance around climate risk and disclosure to the finance sector. These types of reports typically target one segment of the broader sector (e.g. banks or asset owners). Providers of

[32] exceptions include collaborative open access efforts such as the UNEP FI sanctioned methods discussed.

these reports are also a diverse group, from sector associations and advisory firms, to financial regulators and financial institutions themselves. Stakeholders in EU-MACS have confirmed that in the early stages of understanding climate risk, these types of grey literature documents are helpful in expanding the sector's understanding of potential climate impacts[33]. Increasingly this body of grey literature has started to explicitly feature physical climate change impacts and risks, progressing from a previous focus on transition risk or carbon-related risks (e.g. a shift in focus from an investment's carbon intensity and carbon policy-related risks to inclusion of impacts of extreme events on an investment's performance). In this way, these documents help build the climate service market by creating and maintaining momentum around perception of climate risk in the sector.

A non-exhaustive sample of this literature is shown in Table 12, *Annex 6*. These guidance documents are listed under Expert Analysis as they are usually targeted and specific. Some are a preamble to further consulting services, e.g. Mercer's Investing in a Time of Climate Change.[34] Yet these documents also have features of Sharing Practices in that they are open source and help share best practices or cutting-edge methods for climate risk assessment and are not narrowly targeted to the context of just one organisation.

6.4. Climate-Inclusive Consulting

Climate-Inclusive Consulting appears to be less common in provision, though this type of climate service could be more difficult to detect as it is embedded with other services.

Conventional financial and accountancy service firms are starting to offer and incorporate climate analysis relating to physical climate risks into their offerings. Consulting firm Mercer, for example developed and is refining its TRIP[35] Climate Change Modelling Framework. Large consulting firms such as PwC also offer sustainability and climate change services, with specialised services around scenario analysis. Further evidence is seen in the Netherlands, as financial consulting firm Ortec Finance has established a Climate Solutions division in early 2018. Much of the service provision by these actors appears to be in anticipation of the increase in demand for climate risk disclosure services in general and the need for financial institutions to respond to TCFD recommendations specifically. Important to note is that the fact that a consultancy firm is offering CS does not automatically imply all its CS belong to the Climate-Inclusive Consulting category, as some may have features of Expert Analysis.

Apart from consulting services, Climate-Inclusive Consulting provision also currently involves platforms and modelling. Financial information provider Bloomberg, for example, has recently started to provide a service which is directly integrated into its terminal, for example. Titled Bloomberg MAPS, this function allows for the impacts of some climate-related events to be analysed for select sectors and geographies. Catastrophe models (cat models) are another example of Climate-Inclusive Consulting. chapter 5 discusses the types of climate data cat models typically incorporate. The vast majority of cat models are produced by several firms, (or vendors) including AIR, RMS, CoreLogic. Otherwise these are provided by brokerage firms and at times specialist consultants such as Marsh.

[33] Note, the content in these reports should not be taken to convey financial advice and should be used for general information purposes only.

[34] Mercer's climate related services are classified as Climate-Inclusive Consulting services, though this publicly available report / framework is considered an example of Expert Analysis grey literature.

[35] TRIP factors in the framework include: Technology, Resource Availability, Impact, and Policy.

As with most other types of CS, financial services firms are also involved in the provision of Climate-Inclusive Consulting CS. Major reinsurance firms, for example, provide cat modelling services, as discussed in chapter 5. A novel example, however, is the new credit rating offering from financial services firm Beyond Ratings. The firm's rating methodology aims to be the first of its kind to systematically include ESG factors into financial ratings and gives equal weighting to economic & financial and sustainability profiles. The methods should allow for physical impacts of climate change to be factored into ratings of public bond issuers and eventually, ratings of infrastructure bonds and utilities (Beyond Ratings, 2018). Additionally, recent analysis from the PRI has indicated more conventional rating agencies are also increasingly considering ESG factors (PRI, 2018b). Moody's, for example, downgraded Californian utility company Pacific Gas & Electric (PG&E) to A3, and PG&E Corp to Baa1, negative outlooks in 2018. The rating agency justified this by considering California's public policy goals and an elevated level of political risk, especially given the company's history of safety and governance issues as well as potential substantial exposure to rising climate change-related liabilities such as wildfires (ibid pg. 36). The integration of ESG factors by credit rating agencies, on either an ad hoc or systematic basis, may not be explicit provision of CS. There is potential, however, to use and integrate climate data an information in this process, which can be considered Climate-Inclusive Consulting.

7. Encountered Barriers to the Uptake of Climate Services

This chapter describes encountered barriers to the uptake of climate data and information, which are framed in terms of:

- Demand side barriers – factors that hinder users from articulating their climate service (CS) needs;
- Supply side barriers – factors that prevent providers from developing portfolios of CS products further; and
- Matching barriers. – factors that delay, prevent, or distort matches of arisen CS needs and climate service offering.

7.1. Demand side barriers

Lack of awareness is a key barrier to CS uptake in much of the sector, particularly amongst banks and investors. Expert stakeholders[36] provided insight into the wider banking and investor segments, regarding awareness and perception of climate risk and climate data. In larger organisations, including many of the stakeholders we engaged with, awareness and understanding of climate impacts, types of climate risk, and how climate data and information can be incorporated into decision making is more advanced. Indeed, in the year it took to complete this study, awareness around climate risks had certainly developed. However, this is not the case across the board. One CS provider confirmed that much of their early engagement with end users in the finance sector is spent reviewing basic information around climate change and climate data, stating often there is 'tepid realisation of climate risk' (stakeholder interviews, 2018).

There is a lack of applied knowledge of the impacts of climate change on portfolios. Across the sector, stakeholders typically had a well-developed understanding of potential climate risks in a general sense, though most had only just started to come to terms with what these might be in their own portfolios. Many are still developing a nuanced understanding of types of climate risk (e.g. physical, transition) and the types of data and information needed for their analysis. Stakeholders in the insurance and development finance segments are notable exceptions as they have frontline experience with and mandates to consider physical climate risks, respectively.

Misconception that climate change is only a long-term issue. Many stakeholders view physical climate risks as a longer-term issue and not happening now. This view is incorrect; the consensus amongst the scientific community is clear – man-made climate change is already underway.

There is greater understanding of the impacts associated with extreme weather, compared to longer-term incremental climate change. Several banks indicated they are starting to suspect correlations between losses and extreme events such as wildfires, floods, and droughts. Connell et al. found that commercial banks had started to conduct bottom-up granular analysis that assesses the impacts of weather and climate on their clients (2018, p. 57) and therefore their portfolios. As highlighted in chapter 5 of this study, banks have carried out similar analysis around floods and real estate loans. Although there is concern around the impact of extreme events on their borrowers or investments, there appears to be limited awareness of the impact of incremental changes in temperature and precipitation.

Lack of awareness around climate impacts is not necessarily homogenous within financial organisations. Stakeholders indicated that often there is some lack of coordination between the various

[36] Stakeholder groups in this study included: experts, users, and providers (see methodology, chapter 2).

teams within their organisations that would use CSs. For example, bank teams with a remit covering environmental, sustainability, social, or engagement affairs tend to have a growing awareness of the changing governance landscape around analysis and disclosure of climate risks. These teams tend to have, therefore, the strongest motivation in a bank to engage with climate data and information. Yet technical engagement with the climate data and information would sit with other teams in a bank, e.g. credit risk or stress testing teams, as they would need to incorporate this data into their risk modelling activities. Stakeholders indicated there has not historically been extensive coordination and interaction between these types of groups and that risk assessment teams may be less exposed to concerns around physical climate risks. Therefore, even though there may be growing awareness of climate risks in financial institutions, a barrier to CS demand articulation can be the silos within the institutions themselves, and lack of awareness of both the data and climate impacts themselves amongst the teams who need to use climate data. Stakeholders in the investment segment indicated they experience similar issues, though this was mentioned less frequently.

Perception amongst investor stakeholders that physical climate risk is not material. Some investor stakeholders felt that the lack of proof of materiality of physical climate risks meant that time and resources to regularly assess for these was not warranted. Most investors had not yet screened their portfolios for physical climate risks, however. This misconception could be preventing progress by keeping them trapped in a cycle of not perceiving climate risks, and therefore not procuring data and analysis, which leads to the continued cycle of not perception of low levels of risk. Worth noting, however, is the increase in demand for consideration of environmental social and governance (ESG) factors in the investment cycle, which has grown steadily. French asset manager firms in particular appeared to actively use ESG factors, though when pressed on how well physical climate risk factors are integrated as a part of ESG considerations, they were not sure. It became clear that better metrics on physical climate risk are needed (stakeholder interviews, 2018) (also see chapter 8).

Financial institutions may have limited bandwidth to take on additional risk analysis. Stakeholder engagement revealed a tendency of banks and investors to focus on climate risks associated with transition risks more than physical climate risks. This is due in part to their perception that the transition risks are more immediate, and physical risks are longer-term. Transition risk analysis involves large amounts of data, though does not typically include climate data or CS (e.g. information on ECVs, climate model projections, or climate risk assessments). Transition risks have historically received more attention than physical risks, and the methodologies and metrics to analyse these are more established (EBRD & GCECA, 2018). Both investors and commercial banks engaged with in this project had more experience with analysing them (stakeholder interviews, 2017; 2018). Stakeholders also indicated lack of awareness around physical climate risks could also stem from pressing matters, such as keeping up with regulatory stress testing, and planning around the UK's departure from the European Union (Brexit). Further, important changes facing the sector are being brought by the advent of fintech, which some financial institutions may see as a threat to their core operations. Focussing on these other concerns takes up analytical bandwidth within these organisations and can work to suppress awareness and demand.

There is a lack of demand from the top of the investment chain. Asset / investment managers and consultants both named lack of demand from their clients (asset owners) around physical climate risk (or opportunity) analysis as a key reason why they are not yet using climate data further. They indicated their clients are not yet demanding this information, and that their priorities are generally set by their clients. As a stakeholder from an asset management firm explained, 'clients are focussed on CO_2 and transition risk,

[and we are], focussed on clients' needs' (stakeholder interviews, 2018). One expert stakeholder affiliated with asset owners and managers suggested that pension trustees may have limited capacity at present to develop a deep understanding of physical climate risks (stakeholder interviews, 2018).

The financial services sector typically has a short-term outlook, which presents a notable structural barrier to the consideration of climate risks and use of climate data. Planning time horizons in various segments of the financial services sector are very short; typically around 1-3 years and with 5 years as a maximum. For instance, most stakeholders from the banking segment suggested that stress testing activities usually have around a 1-3 year time horizon. One stakeholder explained 'the way our models work mirror the way the business cycle works: they go out to three years. Going beyond that, given how quick the books are churning, five years is the absolute maximum. We don't model with any sort of confidence longer than 5 years. The models would flatten' (stakeholder interviews, 2018). Recent analysis finds that while 'investors with long-term liabilities, such as pension funds and insurers, are supposed to optimise their return on a 15-30 year horizon' in the investment segment, portfolio holding periods are just 21 months on average (2Dii & The Generation Foundation, 2017, p. 5). Further analysis explains, 'the high liquidity of public markets enables investors to trade frequently and capture profits from short-term price movements. Naturally this trading pattern leads many investors to be more interested in what a stock price will be tomorrow than in 10 years' (The Generation Foundation, Mercer, & 2Dii, 2017, p. 6). Aviva confirmed the fee and incentive structures of investment consultants 'too often drive a short-term outlook that overlooks long term sustainability considerations' (Avivia in EAC, 2018, p. 13).

Box **6** presents evidence from the 2018 Green Finance Inquiry in the UK, which highlights how deeply ingrained short termism is in the UK finance sector, which is likely to case elsewhere in Europe and globally.

Box 6: Evidence of misaligned incentives at each stage of the investment chain (EAC, 2018)

In the 2018 Green Finance Inquiry, the Environmental Audit Committee (EAC) of the UK House of Commons heard evidence from actors across the UK finance sector regarding the structural focus on short term returns in the country. The evidence collected throughout the inquiry is summarised below:

- The 'fiduciary duty' of pension scheme trustees is misinterpreted as a duty to maximise short-term returns (Aldersgate Group, 2017; Aviva, 2018; UKSIF, 2017);
- The quarterly earnings cycle and structure of remuneration for investment consultants and fund managers encourages a pursuit of short-term returns rather than long-term value creation (Aldersgate Group, 2017; Aviva, 2018; ClientEarth, 2017; ShareAction, 2018);
- There can be a tendency to underinvest in physical assets, technology innovation, and employees' skills in preference for nearer term gains from financial mergers, acquisitions or restructuring (PRI, 2018c);
- Investment banks are incentivised to increase short term market activity. Sell-side analysts rarely produce long-term sustainability-orientated research due to commercial conflicts of interest and pressure from company management/investor relations (Aviva, 2018);
- Credit ratings agencies do not sufficiently incorporate long term considerations into their credit analysis, despite sustainability risks often being of material importance to a company's performance and credit worthiness (Aviva, 2018; WWF, 2018);
- Stock exchanges are themselves listed companies and are thus incentivised to increase trading volumes to improve their own share price. As a consequence, holding periods are getting shorter and listed companies are pressured to focus on short term returns (Aviva, 2018).

There are a number of notable information gaps around non-climate data. Conducting physical climate risk assessments requires non-climate related data, such as location of the physical asset, and production characteristics. Engagement with banks and investors revealed that this information is not typically held in an easily accessible format in-house, and in some cases, is not held at all. Connell et al., found:

> *Access to borrower-level data can be restricted due to privacy rules, particularly for retail mortgages. Banks may also lack data on the locations and production characteristics for commercial borrowers. For instance, agricultural borrowers may have mixed farms, and banks are unlikely to know the contributions of crops, livestock, etc., to farm revenues. Banks can also lack facility-level data on commercial clients with multiple fixed assets* (2018, p. 62).

Investor stakeholders indicated they feel even further removed from the physical location of the underlying facilities and companies they invest in as they effectively invest in a small sliver of a company (stakeholder interviews, 2017; 2018). This is an important barrier to the use of climate data and information in that firms might not have a good grasp on where and which geographical scale to start their physical risk analysis. Gathering and manipulating this data across whole portfolios and loan books can be an arduous task[37]. Gaps in non-climate data would not stop actors from using CS outright, though could slow the process, and may be pushing them toward use of more expensive Expert Analysis type services where advisory firms or specialist platforms can bring together climate and non-climate data for them.

7.2. Supply side barriers

Climate data and information is not always packaged as a service. Climate impact studies and research are not typically created for the purposes of financial risk assessment. Rather, these studies are created by research organisations or academics seeking to further the understanding of climate impacts in a given geography or sector. For example, agricultural studies about climate impact may be designed to assess climate change impacts on food security, not for plugging into a bank's credit risk model. Researchers and organisations who produce this work are likely to have very little awareness that finance actors are potentially interested in using their studies. This disconnect means providers may not know to engage with this sector to further develop their studies and offerings.

There are many Maps and Apps, though these do not target a clear end user. A myriad of portals and terminals exist that provide information on climate variables or hazards (as described in chapter 6). However, providers of these do not typically target actors in the finance sector. Rather the services and data are provided in a general sense. Lack of awareness of end users or low engagement with end users in the finance sector might hinder further product development.

Climate service providers are still learning the language of the financial services sector. Expert Analysis providers specialised in climate risk analysis have developed tools and processes (see chapter 6) for various parts of the finance sector and are making progress in understanding existing systems and processes used by various financial services actors to analyse risk. Yet conventional CS providers and financial service actors have distant knowledge bases. CS providers need to learn the existing risk management processes / systems / structures within financial institutions, which may prove to be a steep learning curve that could slow the entry of further CS providers in the market. Progress is being made to develop quantitative

[37] An appropriate alternative advocated in Connell et al. is for organisations to start by analysing a representative sample of their portfolio.

methodologies for climate risk assessment in these organisations, making this barrier less important. For instance, some providers have been able to bring financial expertise in-house, and the development of publicly available methods under UNEP FI's projects help shine light on metrics important to finance actors.

Expertise and knowledge of some established providers of non-climate and climate data to the financial services sector is still developing. Financial institutions sometimes approach existing service providers, typically of non-climate data, to provide CS, such as risk assessments. Furthermore, providers of financial data and information are starting to add functionalities to their platforms which allow for spatial analysis, enabling climate risk analysis (e.g. Bloomberg MAPS, see section 5.4 and 6.4). Existing service providers have tended to focus on providing analysis on transition or carbon risks, as these methods are better established, and physical climate risk analysis is still relatively new for many. These existing service providers may still be developing their understanding of existing climate data and information and may need guidance themselves on the best sources of data and their appropriateness for climate change risk assessments. Connell et al. (2018) found platforms provided by existing service providers, for example, could be improved to support more sophisticated analysis such as physical risks the supply and demand side of borrower's value chains, and that more geographies and datasets on extreme events could be included. Some methodologies by these providers have tended to focus on the impact of extreme events to characterise physical climate risks, leaving out incremental climate change impacts. Finally, some methods rely on the use of Integrated Assessment Models (IAMs) as part of their analysis, and as such, may also have levels of uncertainty embedded within them which are not palatable to finance actors, or may be unable to capture physical impacts comprehensively. Existing service providers will potentially be able to increase their offerings as their awareness and understanding of climate data and information deepens.

Gaps in climate data and information hinder the development of additional and more advanced CS. Gaps in CS and climate data are summarised in detail in chapter 8. Some of these data gaps slow the ability of CS providers to further develop offerings for the finance sector, and more broadly. One such gap is around climate model outputs for the short – medium term, particularly inter-annual and decadal projections. Other gaps that hinder the ability of CS providers to develop further products and services include: lack of climate modelling data in catastrophe models, poor data resolution and quality, particularly in certain developing country contexts, adaptation indicators for evaluating cost and effectiveness, and spatial data on future changes in incremental climate change and extreme climate-related events.

Lack of open access data. One stakeholder from an insurance brokerage firm highlighted that the lack of open access information around essential climate variables may be holding back the European market. The stakeholder indicated that at present, there is more demand for climate information in Europe, however, the fact that various European meteorological offices charge for certain data sets mean their analysts revert back to open source data from US sources. While the stakeholder's firm develops cat models in Europe, US-based companies are hired to carry out the model development, as a consequence of having more easily accessible data (stakeholder interviews; 2018). Restrictions to raw data access in Europe are a remaining barrier for further development of downstream tools and analysis in the insurance segment and others (Golnaraghi, 2018; Golnaraghi, Surminski, & Schanz, 2016).

7.3. Barriers for matching

Internal capacities around climate data and information are still developing. Engagement revealed that users do not always have appropriate skillsets in-house to be able to use climate data in a sophisticated way. Many of the outputs from sectoral studies that financial service actors then use to assess physical climate risks in their loans books or equity portfolios are represented and stored in geographical formats (e.g. using grid georeferenced data). This poses a challenge for financial institutions as they generally lack in-house capabilities for spatial analysis and the software to handle and analyse geo-referenced information. This means even when the demand and articulation for climate data and information has arisen, and climate data is available, organisations cannot use it. This is not a complete barrier to the use of CS, as the demand for value-add downstream services would increase, turning to existing service providers or specialist CS providers for analysis. This barrier, could, however, also be working to keep awareness of climate risks low, and by extension demand for CS low.

Users may not know how best to navigate the wealth of climate data and information available. Stakeholders from the provider side suggested that users may be overwhelmed with the amount of data and information available to them. One stakeholder suggested that users could do with more guidance on how to gauge the quality of the data and information, including levels of uncertainty associated with individual climate parameters.

8. INNOVATION POTENTIAL: UNMET NEEDS AND PERSISTENT GAPS

This chapter provides information on unmet climate service needs and remaining gaps in climate data and information, as highlighted through stakeholder engagement and literature review. The information is presented by segment of the wider finance sector, though a number of data gaps identified in individual segments are cross cutting and are summarised at the end of this chapter. Wherever possible, the identified needs and gaps have been linked back to the climate services product matrix (see Figure 4).

8.1. Insurance

Further incorporation of climate modelling data and expansion of catastrophe models. A common request from stakeholders in the insurance segment was for probabilistic catastrophe models (cat models) to consider climate change in an improved way. There is a growing interest in the better inclusion of dynamic inputs from climate models in cat modelling, for example. Some cat modelling firms are indeed using climate models to help generate synthetic event sets, though the inclusion of forward-looking climate projections in cat models are not yet fully materialised across the board. Richard Dixon of cat modelling consultancy CatInsight explains that this is primarily because climate models do not have output that are user-friendly for insurers; climate model data is frequently presented spatially (i.e. on a grid), whereas insurance data is often not. Further, climate models have not always been able to generate data with sufficiently high spatial resolution and may not properly be representing events such as hurricanes (Dixon pers. comm. 2018). To better model such perils would require improvements in computing power and reductions in the costs associated with processing the large amounts of data involved (Ibid).

Additional data and information needs include attribution studies and information on storms (wind, hails, etc.) and event teleconnections. Although attribution studies are increasingly carried out (Faust 2017) stakeholders indicated a need for further information on the potential link between extreme events and climate change. For instance, participants in a recent study conducted under the Lighthill Risk Network indicated a strong interest in understanding if windstorm activity over the last 10-20 years in Europe was driven by natural variability or is an early indicator of future climate change (Dixon, 2018).

With expansion of cat models there is continuous growing demand for data in the insurance segment (Golnaraghi et al. 2018, forthcoming). Furthermore, according to Golnaraghi, et al., advancements in climate research and modelling (e.g. seamless forecasting from minutes to decades, Earth System Simulations, and Nested models within Global Climate Models) as well as latest research on climatic regimes and interconnectivities in the global weather patterns, are providing unprecedented opportunities to innovate and develop the next generation of cat risk models.

The Copernicus Climate Change Service (C3S) project, SECTEUR, also provides detailed insight into the climate-related data demands of the insurance segment. The project found that additional (climate) information and impact indicators not currently in use but requested by the insurance sector include wind / precipitation measurements, with associated uncertainty information (Alexander, Bruno Soares, & Dessai, 2016).

8.2. Development Finance Institutions

Climate risk screening tools for the analysis of portfolios. In recent years, progress has been made in the development and use of project-level climate risk screening tools, however, stakeholders indicated interest in their wider use to assess risks across investment portfolios. As mentioned in chapter 5, the IFC have develop sector-specific tools that will allow for the screening of climate risks across their portfolio (Stenek pers. comm 2018). Others in the DFI segment may not yet be as advanced (see chapter 5 for further discussion). Stenek highlighted a set of key requirements for such tools, namely:

1) Flexibility and efficiency - the tools should not be too demanding of user inputs or time consuming;
2) Precision and representation on the level of confidence in their results;
3) Any limitations of the tool need to be clearly highlighted, with guidance for the users on how to interpret the results; and
4) They are fit for purpose.

In the longer term, the development of standards and regulations for climate resilient assets will negate the need for climate risk screening tools. Stenek explained that climate risk screening of individual projects, such as of individual infrastructure investment decisions, or portfolios would eventually not be necessary in the form that it is done now once the idea of climate resilient assets is further developed and explored (pers. comm. 2017). The logic is that eventually, standards and even regulation for incorporating resilience considerations within infrastructure projects will be developed and enforced. For instance, buildings are no longer assessed for earthquake readiness, as these considerations are incorporated into building regulations. The development of such standards and regulations around climate resilient assets would certainly still require Expert Analysis services.

Further provision of educational guidance and tools will build the capacity of users to effectively use climate data and information. Stakeholders indicated that despite the provision of CS by DFIs themselves (e.g. portals and toolkits), there remains a need for guidance for internal users on the interpretation of outputs, including the limitations of different datasets and of tools, and treatment of uncertainty (Stenek pers. comm., 2017; stakeholder interviews, 2017). This was further elaborated by Craig Davies, Head of Climate Resilience Investments at EBRD who suggested that there is emerging need in the financial services sector for analysis and tools that support decision-making in the face of uncertainty. Businesses want certainty, and the FIs that serve them need to be able to give robust advice to be able to help businesses to make sound decisions. One example is the effective use of scenarios, for both carbon transition and physical climate, in strategic planning, as recommended by the TCFD. Dr Davies also highlighted the potential need amongst DFIs and in the wider financial services sector for internal training for staff. This would allow financial institutions to more comprehensively integrate climate information into investment operations. EBRD and other DFIs are considering this option, to be able to best make use out of climate data and information such as emissions scenarios, GCMs, downscaled data. There could be multiple training levels, for example, a basic level for bankers and a more advanced level for e.g. specialised climate experts, sustainable finance experts and engineering teams. Dr Davies also noted EBRD are increasingly interested in understanding how best to facilitate market facing climate services. They need analysis on what capacity and technical skills are needed to use climate information. This should help to identify potential service providers, as well as the business needs of clients. These capacity building services would be provided via Expert Analysis.

Improving data resolution and quality, particularly in certain developing country contexts. Data gaps in certain developing countries is a notable gap for DFIs and others in the sector. In some cases, there is concern amongst users in this segment over the lack of good available data to quantify climate impacts, especially for projects in developing countries where appropriate CS do not currently exist or are in early stages of development (stakeholder interviews, 2018). Globally, across different development contexts, accurate data and information on weather / climate extremes is also limited. One stakeholder highlighted this concern, stating information on future changes in extremes that may be material to the design of key components of some assets, such as frequency of frost / snow, behaviour of wind storms, wildfires, etc., are missing or not sufficiently detailed for many climate indices (Stenek pers. comm. 2017).

Further development of adaptation indicators would be valuable to enable decision makers to better evaluate different options, including cost, and facilitate tracking of adaptation progress. A number of stakeholders from major DFIs indicated interest in improving indicators for adaptation measures, including metrics that allow for the quantification of adaptation costs. This would support decision-makers to rank and prioritise measures (stakeholder interviews, 2017). Indicators linked to the adaptation measures would also allow for the tracking of adaptation progress over time. These services would be provided via Expert Analysis.

8.3. Commercial Banks

Improved spatial data are needed on future changes in incremental climate change and extreme climate-related events. Upstream data needs include datasets that allow for more accurate analysis of floods, cyclones and droughts, both today and into the future. Additional spatial data are needed which include future changes in the frequency and distribution of extreme events. This currently unmet data needs aligns with the Maps and Apps category of the CS spectrum.

Climate change impact studies that are tailored or created specifically for banks' purposes. There is an identified gap in the provision of studies which move beyond current impact models and allow for the quantification of physical climate impacts on the price of commodities or affect changes in revenue. Ideally, these impact studies should cover all 'productive' economic sectors and geographies. For instance, research studies in the agriculture sector are far more advanced than most other sectors. Studies on how physical climate change will impact macro-economic indicators, such as inflation and interest rates, are another notable gap (Connell et al., 2018). Macro-economic studies on the impacts of climate change on GDP, though abundant, often present widely diverging results and that uncertainty means these studies are not yet helpful or useful to banks (Vivid Economics in Connell et al., 2018). As such, there is work to be done to narrow the bounds of uncertainty around the scale of potential economic impacts of climate change. These studies would be aligned with the Maps and Apps and Expert Analysis categories, and could be provided by academia, or specialised research institutes, ideally through a co-production process with financial institutions.

Sensitivity indicators which capture the effects of climate risks are needed. Stakeholder interviews (2018) indicated there is still scope for thorough analysis the proliferation of climate change risks, and how these might impact various assets. In the future, sets of sensitivity indicators could be developed which capture these effects. The development of such indicators would need to be based on the outcomes of more

fundamental climate impact studies, and should be representative and simple (stakeholder interviews, 2018).

Guidance and tools relating to borrower level data are needed. Banks have recognised the need to become more familiar with the risks faced by companies in the sectors they lend to, and to increase their understanding of their clients' geographic climatic exposures (Connell et al., 2018). While there is some data collation around geographic locations of real assets such as real estate or in some sectors such as agriculture, information on locations of physical assets covered corporate loans is sparse or not centrally collected (Caldecott & Kuirtwagen, 2016). Technologies and platforms which help to access, collate and manage asset level data and information are needed within this segment, as well as in the investment space as well. Guidance from advisory firms (Expert Analysis) is likely needed, such as how best to navigate existing platforms and databases holding asset level data, as well as how best to combine that information with climate data for the purposes of climate risk screening.

Information around adaptation investment needs for sectors and countries. For banks, adaptation investment needs represent commercial opportunities 'to support clients by financing their adaptation investments' (Connell et al., 2018, p. 68). Until borrowers or corporates are assessing and disclosing climate risks and opportunities more regularly, this information could be provided to banks by Expert Analysis services, such as market assessments.

Understanding of the future development of government adaptation responses and the future behaviour of insurance companies. Expert Analysis informed by National Determined Contribution statements and other legislative frameworks could help banks navigate uncertainty stemming from future policy and help inform credit risk teams with information on borrower level adaptation measures. Supporting the development of either studies or knowledge sharing and dialogue platforms between the insurance sector and the banks could also help overcome the current knowledge gap that banks face pertaining future changes in the insurance sector.

8.4. Investment

Stakeholders in this group were generally less experienced in their use of climate data and information, and therefore less able to express highly specific data gaps and unmet needs. However, they did provide general feedback on various categories of the climate services product matrix (see Figure 4).

Climate risk screening tools to assess entire portfolios and funds. Asset / investment managers highlighted their interest in combining of asset-level data and tools / functions with different climate-related datasets, to assess current and future climate risks in their portfolios. Stakeholders suggested these data should be brought together in tailored risk assessments and suggested providers would be advisory firms and academia. While there is some provision of this type of Expert Analysis, it remains an unmet need as there is not currently mainstream provision of this service.

Guidelines for asset managers on how investment decisions could be impacted by climate change. Investment management consultants suggested the development of standards on the criteria and considerations that asset managers should take into account in their investment decisions would be useful.

These guidelines could be expanded to allow for the evaluation of asset managers' performance in relation to management of climate risks, for instance, methods to assess their understanding of climate risks and the incorporation of climate considerations in their portfolio management decisions.

Instruments that could facilitate better integration of ESG principles in the provision of investment advice, attributing physical climate risks to the category of environmental risks. Following on from the point above regarding guidelines, investment management consultant stakeholders felt that ESG principles provided the most obvious link to climate risks. The development of appropriate metrics would be in the form of Expert Analysis or potentially Maps and Apps to help process information to arrive at a score for an equity or other asset.

Information sharing platforms and other forums. To facilitate the understanding on the advantages and disadvantages of using different types of climate services in an investor context, stakeholders indicated there is need for further development of platforms and other methods of information exchange. Although sharing practices were of interest in the investment segment, it was viewed as comparatively less important compared to other segments.

Additional data and information needs include short to medium term climate projections. These projections are particularly important for the investment segment because of the overlap with typical investment time horizons. It is worth noting that banks also expressed similar time horizons relating to their lending activities.

8.5. Rating agencies

Information on the effectiveness and co-benefits of adaptation investment. A representative of S&P Global highlighted that they would like to see further development in understanding the benefits from adaptation investments for the reduction of physical climate risks. However, the limited availability of relevant data and appropriate tools remains a constraining factor. Since rating agencies rely on the sponsors' appraisals, there is a need for further development in publicly available case studies focussed on adaptation cost benefit analysis. Furthermore, mechanisms to account for adaptation investments in internal probabilistic models are needed. These climate services are likely to be a combination of Expert Analysis and Maps and Apps, as the integration of adaptation investments in existing models is likely to require a specialised tool or portal.

Additional data and information needs include attribution studies and more comprehensive inclusion of other risk drivers, such as wider socio-economic factors. One stakeholder in this segment highlighted the uncertainty regarding the link (attribution) between extreme events and climate change (Petkov, pers. comm., 2017). A further need discussed was the inclusion of non-climate data, to complement climate data, in risk assessments. One area specifically mentioned was uncertainty in growth / development scenarios, which affect exposure to climate hazards and impacts; 'if there are more assets in harm's way, how a house will be affected by the hazard, and what damage will occur?' (Petkov, pers. comm., 2017).

Standardisation of climate-related disclosure from companies. Stakeholders in this segment noted that standardisation of climate-related disclosure from companies should be promoted. Furthermore, this should be developed with the support of disclosure-information users (such as the rating agencies themselves) to

ensure the disclosures can be quickly and easily incorporated into decision-making. A potential barrier to further climate risk analysis in the sector could stem from incompatibility of climate risk disclosures and the users of these.

8.6. Summary of climate data and information gaps across the sector

A number of the information and data gaps identified by stakeholders in different segments are cross-cutting, with wider relevance for the finance sector more broadly. These are summarised as follows:

- Improved access to data, which is fairly priced;
- Improved spatial resolution and quality of data, particularly extreme events and in developing country contexts;
- More clarity on the potential attribution of extreme events to climate change, and teleconnections between different hazards and impacts;
- More explanation on the uncertainty associated with different climate datasets, and guidance on how users should interpret and use such data;
- Further development of adaptation indicators to enable decision-makers to better evaluate different options, including cost, and facilitate tracking of adaptation progress;
- Inclusion of other drivers / factors within climate risk assessments and resilience planning, such as the macroeconomic impacts of climate change and the responses of governments and insurance to the evolving risks;
- Further development of climate risk screening tools, at the project, sector and portfolio-level;
- Educational tools, capacity building programmes and knowledge sharing platforms, covering topics such as available information portals, interpreting climate data, including levels of uncertainty, and combining climate and non-climate data;
- Development of guidelines, standards and regulation, as required, for integrating climate resilience into project design and sector operations / procedures; and
- Development of a standardised format and content for climate-related disclosure, which should be used across all sectors.

9. A Macro Level Assessment of Climate Information

This chapter considers the uptake of CS in the financial sector from a macro level point of view, looking at typical sector features which lead wide spread attitudes towards CS and general accepted practices and inclinations regarding this kind of new requirements and opportunities originating from outside the financial sector. It is also considers the overall economic and societal significance of the uptake in the financial sector.

Last but not least considering the high level of rationalised decision making the chapter explores a formalised assessment of the uptake sensitivity for various market obstacles and features as identified in earlier chapters and WPs. These sensitivities of outcomes can subsequently linked to the few recent explorations on global asset value at risk due to climate change (Dietz, Bowen, Dixon, & Gradwell, 2016; Dietz, Gollier, & Kessler, 2018).

9.1. Sketching the boundary conditions for climate service uptake

Compared to tourism and even to urban planning the financial sector is a very intensive data and information user. Furthermore, the financial sector has already a large risk management and monitoring system in place to which the information from climate services should fit and also sufficiently make a difference to justify the extra information handling effort. Admittedly, the financial sector should also have the capability to accommodate completely new kind of information and extend its risk management system to include new domains of risk.

Compared to the other two sectors the financial sector can be expected to apply more economically rationalised decision making regarding the use of CS. This not necessarily means that CS have to be cheap, but rather that credibly assessed benefits of CS should clearly outstrip the expected cost of acquiring and using CS.

Another criterion which counts heavily for the financial sector is a level playing field with respect to practical implementation of climate risk disclosure in several types of financial reporting, as well as regarding the quality standards of the data used for the disclosure. This means that at country level as well as at international level a consensus has to be reached before wide spread application can start in earnest. Some actors can start earlier, for example to influence the discourse by setting examples and/or to explore whether early movers can reap other benefits (e.g. via reputation and new niche products). It is however unlikely that a large organisation would implement a solid and complete climate change risk monitoring system, before sectoral consensus is reached.

As indicated in chapter 4 both regulation and self-imposed guidelines regarding climate change risk disclosure may be expected to create demand for CS. However, as indicated above it will depend on the kind of consensus and on the expected net benefits whether demand for climate services will remain more superficial, or instead both volume and especially sophistication grow really substantially. This breadth and depth of the use of climate services in the financial sector will be important for uptake of climate services by many other sectors, since owners of financial assets and providers of loans will require transparency about climate change risks in the underlying physical assets and activities of their clients.

The above mentioned elements would imply that significant volume growth in the use of CS by the financial sector can go through a fairly long take-off period, i.e. in the order of seven years from now. Yet, at the same time for specific CS take-up can occur earlier (see also chapter 6). For example, scenario studies fit into an approach of first scanning the new risk domain. Also for explorative purposes financial actors may

want to try out various climate services. Both the scenarios and explorations suggest one-time delivery services rather than regular replication, even though from a CS provider perspective similar projects may be built on common approaches and tools. Also some user segments, notably insurance, are ahead of the sector in general, thereby allowing for own CS market segments. This is most obviously happening for damage risk projection products, i.e. cat modelling, often in relation to seasonal CS.

Next to the above sketched uptake moderating factors following from market conditions (competitive caution), there are also technical and data logistics related factors affecting uptake (see also EU-MACS deliverable 1.3). Technical factors will be less crucial for one-off scenario studies and purely exploratory CS endeavors, but for CS meant for regular use at larger scale they will be. Data formats and the ability to use GIS data will play a role for some time, but these obstacles should be surmountable for the financial sector. Also, formalised, standardised and systematic quality assurance is important for CS meant for regular use at larger scale. EU-MACS explored whether block chain applications or approximations thereof may become a solution for quality assurance of CS. This may happen for upstream (climate data focussed) CS products, but it seems less likely to happen for downstream CS products, which include many non-climate data and/or qualitative information. On the other hand, quality assurance can be organised in layered systems, in which for example higher (meta) level information is integrated in block chains. DNV-GL applies such an approach for the issuing and tracking of risk classifications of large investment objects (certificates in blockchain) which is directly relevant for the insurance sector and other parts of the financial sector (DNV GL, n.d.).

In the next section we assess the identified factors in a more formalised setting, with the aim to get an appreciation of the most significant factors for the progress in uptake.

9.2. Towards a formalised description of climate service uptake

Compared to tourism and even to urban planning the financial sector is a very intensive data and information user. Furthermore, the financial sector has already large risk management and monitoring systems. This means that by and large this sector par excellence may be expected to apply quite rational assessment approaches when judging the usefulness of CS. In this respect should be emphasised that an assessment structure, which is overall primarily rational, can still contain information and traits of which the rationality can be challenged. For example, loyalty and peer pressure may make actors decide differently as compared to entirely independent decision making.

Given the largely rational decision frameworks this sector lends itself for exploring a formalisation of the propensity to start using a CS. In essence we assume that the uptake of a CS by an actor from the financial sector gets highly likely if the expected benefits of using the CS are well above the expected cost of acquiring and using the CS. Generally spoken this is a valid assumption for any sector, yet only a part of them can be expected to apply formalised versions of such cost-benefit criteria, whereas it is more likely to be applied to seasonal CS than adaptation orientated CS thanks to better verification possibilities of the former CS type.

In formalised terms, if the benefit-cost ratio rises beyond a certain threshold level uptake gets ever more likely. Since the uptake of CS may partly happen via exploratory processes, this formalisation doesn't imply that actors from the financial sector are explicitly applying specified threshold levels for adoption of CS. Instead, at least in initial stages it is more likely that the involved finance and insurance experts have at best some notion about what seems a fair benefit for a certain effort level.

The formalised assessment of the likelihood of uptake starts with recognising that the use of CS can generate benefits and the subsequent specification of these benefits. The following main types of benefits can be generated or enhanced thanks to the use of CS:

1. **better pricing of risk**
   a. leading to better coverage of expected damage from premium revenues --> less damage (re) financing cost
   b. more competitive (sharper) pricing for existing products --> more turnover and/or market share
   c. better matching of asset revenue with asset price
   d. new options to make a competitive difference by pricing risks better than competitors (see also no.3)
2. **avoidance of seriously underestimated risks**
   a. no excess losses on assets
   b. no excess insurance cost
3. **opportunities for CS enriched financial & insurance services**
   a. more revenues from new products
   b. less claims & losses among better informed clients

The second main type of benefit, avoided costs, is the classic example, which usually comes to mind first. This type of benefit is easier – yet as such not easy – to quantify than the other ones. For the financial sector as a whole the first main type of benefit seems however more significant, as it is eventually about improving efficiency and hence productivity within the sector. Over time, if more performance data are available the approximate quantification of this effect may become feasible. Lastly, the exploitation of opportunities for new financial products could be important, at least for some actors, but the quantification will be even harder than of the first benefit. We nevertheless assume that the concrete uptake of a particular (set of) climate service(s) by financial actors will be based on some notion of the order of magnitude of the benefits. As long as such a notion cannot be specified financial actors are assumed to use at best only some free CS and/or explore to some extent CS options.

Also indirect benefits can be identified (see Box 7), but these stay outside the formalisation approach discussed in this section.

Box 7: The indirect bonus of CS – the induced macro-economic effect of wide spread use

The direct benefits specified under points 1-3 in the main text of section 9.2 are the direct benefits for the financial sector, as well as its clients. There is however also an indirect benefit, which is hard to assess quantitatively. The overall effect of CS use in connection with points 1-3 implies a slightly higher factor productivity in the economy, normally leading to a slightly higher economic growth rate; this latter induced effect (of which the significance is as yet largely unknown) provides a valid foundation for some degree of generic as well as specific promotion of CS by public programmes, at least for a period during which uptake of climate services is significantly below the societal optimum; on the other hand, given the expected large effects of climate services use and related climate risk reporting by the financial sector on the entire economy the financial sector can also justify some degree of extra and/or early effort on the basis of ESG considerations, next to the benefits it can reap from extra economic growth.

From studies on the economic benefits of weather services we can infer that these cause in aggregate direct benefits in the order of magnitude of 0.1% - 0.3% of GDP in western countries (Anderson, Kootval, & Kull, 2015; Nurmi, Perrels, & Nurmi, 2013). In Perrels et al., 2014 informational effects on adaptation efficiency and effectiveness are discussed showing significant volatility of the resulting benefits, but by and large indicating similar or somewhat smaller fractions of GDP. Furthermore, one could refer to older literature on multiplier effects (of direct benefits), indicating that for wealthy countries the net extra effect is about $1/5$ to ½ of the direct benefits. The market value of CS in turn can only be a fraction of the 0.1% - 0.3% of GDP, inter alia due to the uncertainty of its effectiveness for the individual users, i.e. 0.5 to 0.1 of those fractions. With a current GDP of around 15 000 billion Euro (of EU 28 in 2016) the total value would roughly vary between 3 billion Euro and 20 billion Euro. Moreover this assumes all CS is delivered under market conditions. On the other hand CS are a much broader package of services as compared to weather services and also have more dynamic effects via investment behaviour, which could raise the total economic significance and value of CS.

The Value at Risk approach applied by Dietz et al. (2016, 2018) to climate change induced risks to global financial assets would suggest a CS market value of around 0.1% of these assets at risk, which could amount to approx. 2.5 billion US$ to 25 billion US$, depending on the use of average or tail risks. Yet, in this case the market value may concern a multi-year period instead of one year as in the GDP based indication above. This means that the annual *potential* global market CS value would be much lower, i.e. between 0.5 billion US$ and 5 billion US$ - yet this would concern mainly CS for the financial sector, globally.

The resulting benefit of the use of a CS is postulated to depend on three factors:

- the perceived **benefit potential** which is addressed by the use of the CS, denoted as $E_{it}(B_t)$
- the **fit for purpose** of the CS (and of its mode of provision), denoted as α_{it}
- the **information sharing and exclusivity** factors, denoted as κ_{ist}

where *i* refers to CS product type, *t* to time (of existence) or maturity stage of the CS product.

These elements can be influenced by several factors. We list a few for each of them below:

Fit for purpose factor α_{it} :

- Offered CS is (perceived as) not fitting enough for the risk analysis needed (can be both over- and under-sophisticated)
- Ability to infer damage risks or financial service opportunities yet to developed
- Interface, guidance, etc. not sufficient
- Variation in CS offered reduces confidence

Benefits (perceived)) $E_{it}(B_t)$:

- Lack of awareness that benefits could be generated from CS
- Current risk management system & data are unable to generate good / meaningful estimate
- Available risk alleviation & sharing instruments are believed to suffice (i.e. the tentative expected *additional* benefit of CS is perceived as small compared to the efforts needed)

$$E_{it}(B_i) = f_i\,[E(R_{csi}) - E(R_{ncsi})]$$

Information sharing and exclusivity factors κ_{ist} :

Availability of same information for other financial sector actors is either positive (benefits of sharing / level playing field) or negative (benefit generation requires exclusivity). This is summarised in the table below. As value added from financial service provision for a particular provider can inter alia depend on – at least temporarily – unique knowledge, sharing of input information may be too risky in terms of losing a competitive advantage. If the knowledge differential is the defining factor of the business model, information sharing is unlikely to occur. This is represented in column 1. Information sharing may also help to raise the credibility of a product, as wide spread use is an endorsement of its quality, whereas wide spread use may also help to improve the quality if social learning properly exploited. This is reflected in the options of column 2. Joint disposition of information improves alignment and ensures relevance of this particular information over nearby alternatives. At the same time joint acquisition cannot only lead to lower information costs but also better tailoring of the demanded data, due the more impactful demand volume. This notion is represented by column 3. In relation to value chains (see also D1.1, D1.2, D5.1, D5.2) column 1 refers to downstream and some midstream CS, columns 2 and 3 to upstream and some downstream CS.

Table 2: Distinguishing effects of sharing or shielding information under information functionality regimes

	1. If information is common competitive advantage diminishes	**2. If information is (more) common, credibility and hence value rises**	**3. If information is common more options for joint benefits**
Information is not shared, but can be acquired by others	In case of public source information copying will emerge soon; Private (tailored) CS may lengthen period with advantage	Even if eventual products have also competitive elements, equally accessible basic layers would help uptake; coordination problem due to reluctant single movers	Separate acquisition leads to higher aggregate acquisition cost and risks for mismatches; only relevant if coordination cost are high
Information is shared already in acquisition	Irrational strategy, unless there are other benefits in sharing	As above but may need more time to realise; may also lead to shake out at CS provision side as uniformity is a benefit	Usually most beneficial, unless coordination cost high

Inferring from the above table we distinguish a shared and non-shared information option, i.e. κ_s and κ_{ns}

If shared information reduces the benefit potential: $0 < \kappa_s \leq 1$, while $0 > \kappa_{ns} \geq 1$.

If the benefit of shared information rises with more participants the opposite process ensues:

$0 < \kappa_s \leq 1$ for early adopters, while $0 > \kappa_s \geq 1$ for followers, and vice versa for κ_{ns}.

Costs

Users can also expect to make costs when acquiring and using CS. According to the WP1 survey results use costs are often even much more significant than acquisition cost, and this does not only apply to public (free-of-charge) CS. We distinguish fixed search cost C_{ss}, effort related variable search cost V_{ss}, unit price of the CS p_{cs}, fixed cost of in-house processing Cip, and variable cost of in-house processing Vip. Fixed search cost C_{ss}, and effort related variable search cost V_{ss} are especially relevant for smaller actors, where specialisation and outsourcing may be more difficult to realise, and hence the opportunity cost of search cost can be high.

This can be summarised in the following simple equation: $g(C) = C_{ss} + V_{ss} + p_{cs} + C_{ip} + V_{ip}$

However, for the constituent variables further assumptions can be made:

$V_{ip} = f(p_{cs}, C_{ip}, S)$ where S denotes relevant skill, and

$\frac{dV_{ip}}{dp_{cs}} < 0$ and $\frac{dV_{ip}}{dC_{ip}} \geq 0$, meaning that a higher (unit) price is often related to adding features particularly

important for the user and thereby making (variable) use cost lower, while fixed cost of CS use can be associated with investments in facilities that make the use of CS more effective, but also will require more labour and expertise (skill) input to exploit all these capabilities.

The benefit-cost ratio as uptake threshold indicator

The probability that a prospective user will actually acquire CS is tied to a certain state of that user, indicated as A. A can assume two values, being 0 and 1. The former indicates a state of the user which makes uptake of the CS unlikely and the latter a state in which uptake is more likely than not. The quality of the state is determined by the benefit-cost ratio (BCR) of a climate service (package), which should exceed a certain level to change the state from no use (A=0) to use (A=1).

$$A = \begin{cases} 0, & BCR < 1 + \delta \\ 1, & BCR \geq 1 + \delta \end{cases}$$

Admittedly, it is more likely that the uptake has a smoother shape, e.g. like a logistic or Gompertz curve, but owing to lack of data we use the present approach as a first approximation.

The BCR consists of a benefit function and a cost function, both of which were explained above.

$$BCR = \frac{f(B)}{g(C)} = \frac{\alpha.B.\kappa}{C_{ss}+V_{ss}+p_{cs}+C_{ip}+V_{ip}}$$

We first explore how for several levels of the key variables the threshold BCR level is surpassed or not. The table below gives the results, which are further summarised in figure … on the next page.

Assumptions regarding exploratory numbers inserted

As regards the benefits generated it should be realised that CS are often one element of a wider set of measures or actions taken so as to realise the benefits. The entire avoided damage potential can be large, e.g. tenths of millions. The annual *expected* value of the avoided damage is already much smaller, whereas on the other hand non-use of CS may be partly compensated by insurance and/or by less well informed and – therefore – oversised prevention measures. In other words quite often the attributable benefits of a CS will be *a fraction of the expected value* of the avoided damage (or of the efficiency gains). On the other hand, when using CS, the users and their stakeholders will learn to better exploit CS, among others through introduction of other innovations, and hence the benefit potential can grow. So, in the example calculation the attributed benefit of 0.5 million in the early phase could well be associated with an original (underlying) damage avoidance potential of e.g. 50 million.

The example assumes that a semi-standard CS is acquired annually, and it requires both some quantitative work and some tailoring and modest consultancy packaging from the CS provider, whereas also the user has to perform post-processing in terms of combining with other data, own analysis and interpretation / clarification for internal use. In relation to the CS product matrix used in chapter 6, this example represents the Expert Analysis type of products. This group, together with the group of Climate-Inclusive Consulting type of products, consists primarily of charged CS, usually from private sector providers. In the early market situation it is assumed that the (prospective) user has itself very limited experience with CS. In developed and mature markets it is assumed that the user has (somewhat) more prior experience, and there are other experienced providers and users.

Table 3: Estimation of benefit cost ratios (BCR) of hypothetical CS at different stages of market maturity

		early	developed	mature
α		0.15	0.3	0.6
B		500 000	1 000 000	2 000 000
some benefits in commonality	K_s	0.1	1	1.5
	K_{ns}	1	0.65	0.27
no benefits in commonality	K_s	0	0	0
	K_{ns}	2	1.5	1
E(B) in case of commonality	K_s (=0.1 / 1 / 1.5)	7 500	300 000	1 800 000
	K_{ns} (= 1 / 0.65 / 0.27)	75 000	195 000	324 000
E(B) in case of no sharing of benefits	K_s (=0 / 0 / 0)	0	0	0
	K_{ns} (= 2 / 1.5 / 1)	150 000	450 000	1 200 000
C_{ss}		2000	2000	2000
V_{ss}		10000	7000	5000
P_{cs}		15000	12000	10000
C_{ip}		1000	1000	1000
V_{ip}		10000	6000	4000
BCR some sharing benefits	sharing strategy	0.197	10.714	81.818
	non-sharing strategy	1.974	6.964	14.727
BCR no sharing benefits	sharing strategy	0.000	0.000	0.000
	non-sharing strategy	3.947	16.071	54.545
Hypothesised BCR Threshold		~5	~3	~2.5

A first indication of this exercise is that the costs are important in the beginning, but once the use of the CS starts to mature market growth seems to be more driven by the extent to which the benefit potential can be addressed (α), the evolution of the benefit potential thanks to learning processes and innovation (B), and the right approach to the market as being essentially cooperative or not (κ). This exercise is not meant to correctly predict benefit-cost levels, but it does show the significance of the main mechanisms. Figure 10 summarises the messages of the exercise.

At early stages of the market it is hard to achieve satisfying BCR levels. This means that early movers could be inclined not to share information, as this seems to promise better BCR levels in the short run. Yet, so far the encountered stakeholders from the financial sector in EU-MACS seem very often to prefer public or shared data approaches, inter alia for reasons of trust building, quality assurance, and possible synergies later on. In the longer run sharing strategies could generate higher benefits. Yet, one should never forget that at some point more downstream in the CS value chain competing firms cannot anymore share (all) information. Furthermore, wide spread CS information sharing may also lead to a notable reduction in CS suppliers, as it will be harder to devise viable business models – even if some degree of public support is available.

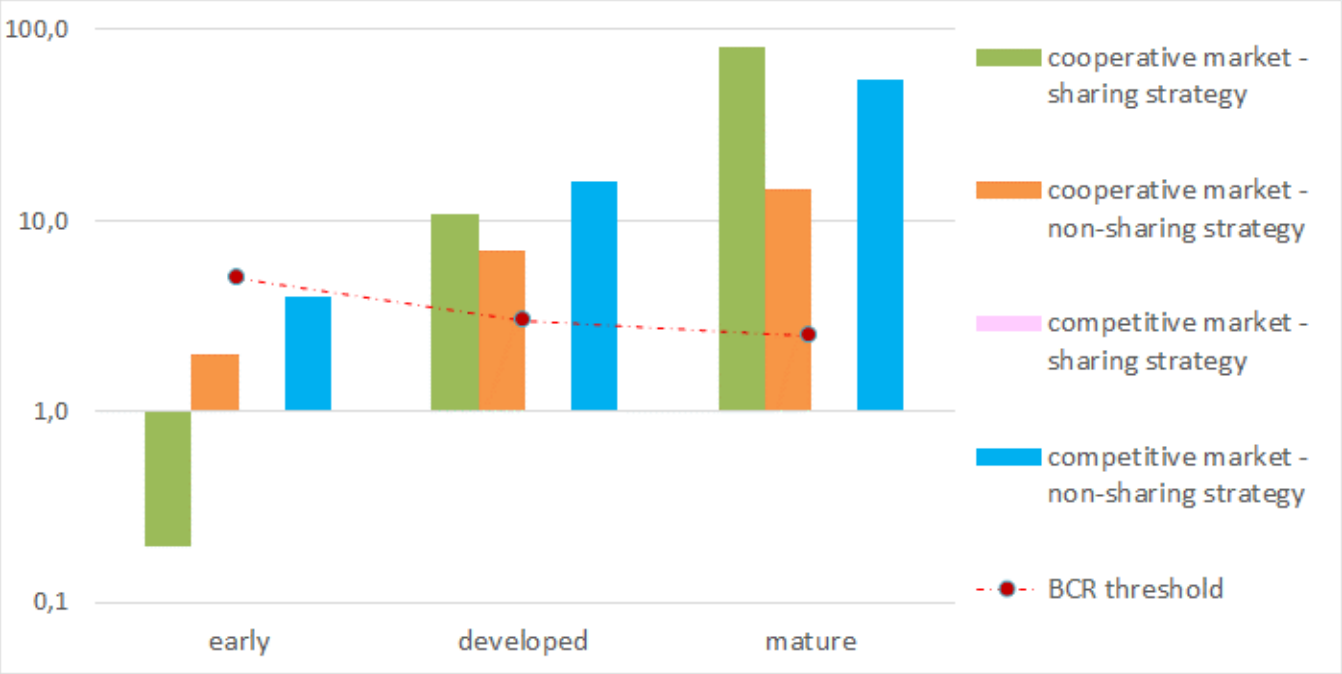

Figure 10: Benefit-Cost Ratios (BCR) of a single CS for the different stages of market maturity differentiated by information strategies and information market properties

(BCR=1 means breakeven; the dotted line indicates how decision makers may judge the (tentative) BCR)

Considering effects of multiple CS and multiple users

For CS can be expected that economies of scope are relevant both at the provider *and* at the user side. This means at the provider side that unit-cost of provision go down, if several related CS can be provided in one package. Yet, lowering of prices in response to lower unit cost does not affect uptake too much as the adoption seems to depend really more on the benefits of use. Based on the responses from interviews and the survey that seems often the case in the financial sector. Economies of scope are likely to often apply also at the user side, implying that it could boost benefits of the newly considered additional CS as well as of already adopted CS. As shown above improvement of expected benefits is likely to have stronger impacts on uptake than service cost reduction. This can be attributed to more effective access to benefit potential(s) and/or extension of that potential, and/or quicker build-up of commonality benefits. This means several things for promoting effective uptake of CS for the financial sector, such as promotion of learning within and across user organisations, better attention of the CS provider for user perceived fitness for purpose and creation of excellent linking options to other (non-climate) data (in addition to translating impacts to user relevant variables).

At the user side it means especially that information sharing strategies have to be carefully considered. For a range of genuine end-use CS products one may expect that competition forces will call for non-sharing strategies. So, here the financial market conditions in which the users operate meet with the CS market and alternative business models for providing CS. On the other hand for midstream CS, which feed into the (individualised) end-use CS, information sharing – also across a range of related midstream CS – could be beneficial, as it improves transparency on adequacy of underlying methods and basic input data and can help to support credibility of both the input information and the resulting downstream CS. A hybrid solution,

which combines a sufficient scale of data sharing with limitation of competition risks of openness, is the creation of a *club* of complementary users and CS providers. By 'club' is meant a group of cooperating organisations (CS users and provides) for the purpose of creating shared benefits for the club members through climate service development, provision and use by the club members. By 'complementary users' is meant financial organisations which are not (much) competing with each other, i.e. due to different sub-markets and/or clientele, but for which their information input to the club works mutually reinforcing regarding the quality of the resulting CS. In that case the CS can extend more downstream and still incorporate information sharing.

In the model based numerical illustration presented on the previous pages a single CS adoption was considered, while assuming that the concurrent use of the CS by competitors does not entail interaction between benefit potentials of these competing CS users. The potential benefits of providing and using related CS were discussed above, and also included concerns about sharing information at the input side. Yet, depending on how the CS outcomes are used in managerial decisions the use of CS by competing firms can also invoke actions that would reduce the benefit potential of CS use of a competing user. As was indicated on page 81 the use of CS may enable a more competitive pricing of risk in financial products, which may attract new customers as well as customers of competitors. Dramatic customer switching is unlikely, but, especially when more competitors start to use CS, its character may gradually transform from a creative to defensive activity and consequently the development of the benefit potential per user levels off (or may even reduce somewhat), even though the total benefit volume may still have grown (almost) commensurate with the increase of the number of users. The benefit reduction effect due to the use of CS in competitive behaviour is illustrated in figure 11, which is otherwise the same as figure 10. From figure 11 can be inferred that for financial sector actors in very competitive sub-markets the choice between extensive information sharing and minimal information sharing approaches is a dilemma. The actors have to assess in advance whether this additional information from CS can notably affect market shares or not.

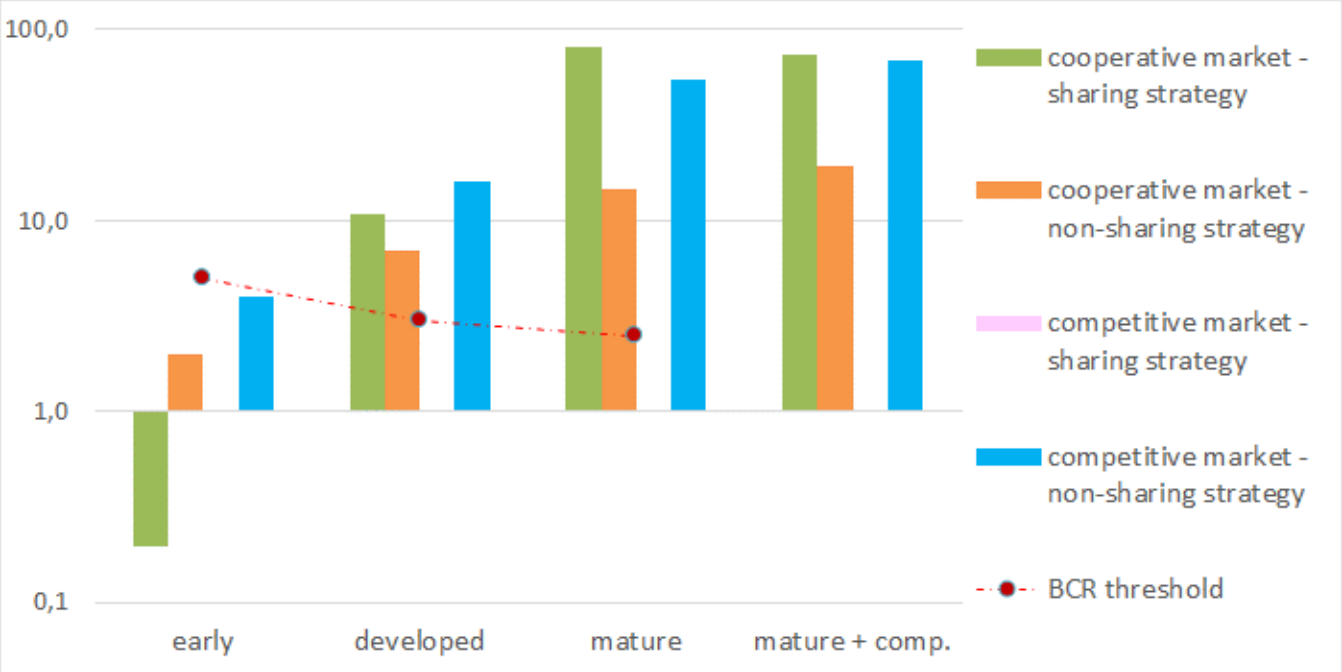

Figure 11: BCRs of a single CS for the different stages of market maturity differentiated by information strategies and information market properties – with added option for mature market with competition effects at the user side

The message of this assessment for a single CS is that not sharing (which seems a logic initial premise) could have drawbacks in the medium to long term future (say 7 years and beyond). When accounting for the possibility that both providers and users are interested in clusters of (closely related) CS the complexity of the market development and risks of starting at the wrong footing get further emphasised. On the one hand provision and use of multiple (related) CS can bring benefits in terms of lower unit-costs and more importantly of enhanced benefit potentials. For prospective users it is important to consider and monitor possible ramifications for competitive positions on which the use and sharing of CS may have some effect. As a rule of thumb it usually beneficial to choose a sharing strategy for upstream and midstream CS, whereas for downstream CS either bilateral contracts or some kind of club seems preferable.

9.3. Summarising the outlook

Of the five main types of actors from the financial sector, two types show already a longer history of activity, have a high awareness level, and use already a portfolio of CS. They even generate already some CS themselves. These are the insurance sector and the international development banks / DFIs. These are probably also the only two user types that use both seasonal and long-term CS. Within the segment of support services there are pockets of higher awareness and use of CS, such as some risk expertise & intelligence services. Overall the table suggests that there is *scope for very significant growth* as many product-market segments are barely developed. A point of caution is that the capability of the financial sector to evolve towards very efficient information solutions may mean that a limited number of intermediate actors processes a significant amount of CS, and integrates that into their products for banks, asset managers, etc. In conjunction with quality assurance demands this may lead to concentration at the

supply side of the CS market, with a limited number of favoured versatile (international) CS providers or conversely with financial support services actors that diversify upward in the CS value chain by acquiring CS providers.

Table 5. Detailed overview of approximate CS uptake status by type of user per CS product market segment

		(re) insurers	Internat. Develop. Banks	Central banks; Other financial authorities	Support services*	Commercial banks	Asset managers (long term)
Seasonal CS							
Hazard risk scans (near term)	**pub**	**M&A | SP**	**M&A | SP**	**M&A | SP**	**M&A | SP**	**M&A | SP**	**M&A | SP**
	priv	**EA | CIC**	**EA | CIC**	**EA | CIC**	**EA | CIC**	**EA | CIC**	**EA | CIC**
Damage risk modelling (intra-annual)	**pub**	**M&A | SP**	**M&A | SP**	**M&A | SP**	**M&A | SP**	**M&A | SP**	**M&A | SP**
	pri	**EA | CIC**	**EA | CIC**	**EA | CIC**	pub/ppp/pri often charged both providers and users	**EA | CIC**	**EA | CIC**
Long term (adaptation orientated)							
Basic data & long term projections	**pub**						
(longer term) Scenarios	**pub**	generic	Both pub. & priv. + own	occasionally	generic	Not yet syste-matically	Not yet syste-matically
	pri	specific		?	specific		
Hazard risk scans (long term)	**pub**						
	pri						
Damage risk modelling (long term)	**pri** **pub**	Scarce; So far mainly pub.		not yet	both providers and users; so far mainly pub		
Specific products							
Project risk assessments	**pri**				both providers and users		
Portfolio risk indicators	**pri**					Not yet syste-matically	Not yet syste-matically

*) rating agencies; risk analytical services; accounting services; financial intelligence; legal counsel

M&A: maps and apps; **EA**: Expert Analysis; **SP**: Shared Practices; **CIC**: Climate Inclusive Consulting; **pri**: private; **pub**: public	
	No or negligible use; unknown use
	Occasional use; scope for growth
	Use got more common / repeated; but scope for growth
	Intensive (deep & broad) use
	Both provider and user positions in this p-m segment
	Some exploratory use, but otherwise little, yet scope for growth
	No products available yet, large development challenges; large significance if taken up

10. CONCLUSIONS AND RECOMMENDATIONS

10.1. A diverse sector with a wide range of background drivers for CS use

The finance sector is comprised of a wide range of actors in numerous segments. This study's look at CS uptake in the broad financial services sector found that the context of these different segments strongly influences the scale and characteristics of CS demand. The (re)insurance, banking, and investment segments have varying activities, timescales and regulatory environments that they operate in. Insurance companies are interested in understanding the changing frequency and severity of extreme events under climate change, in order to price insurance premiums and products accordingly. Banks with investments in climate sensitive industries including agriculture have a vested interest in understanding seasonal drought impacts on crop production. Investors, including pension funds with long-term investments, may be more concerned with stranded assets and the transition risk this poses to their portfolio. CS providers may use chapter 3, where these subtleties are described in more detail, to orient themselves to the various motivations to offer CS to these segments.

It is important for CS providers to grasp the scale of changes in the regulatory landscape facing the finance sector regarding environmental and climate risks. The UN Environment Inquiry into the design of a sustainable financial system, which has been documenting the evolution of policy and regulatory action in the financial sector, calls the move to align financial systems with sustainable development a 'quiet revolution'. Financial regulators, central banks and governments around the world are increasingly interested in understanding climate risk as a risk to global financial stability. While this 'quiet revolution' is indeed global, European actors are leading the way: France has established the first mandatory climate risk disclosure legislation and financial regulators in European Member States (e.g. UK, Netherlands, Finland) are actively investigating, discussing, and publishing guidance around climate risk in their jurisdictions. Further, the European Commission itself has developed an 'Action Plan on Financing Sustainable Growth' which includes efforts to align existing reporting frameworks with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations. Perhaps indicative of the momentum of these background drivers of the CS market is the fact that much of this action has occurred within the two-year timeframe it took to conduct the wider EU-MACS study.

Climate risks typically belong to the Environmental Social and Governance (ESG) realm, but increasingly are seen as a material / financial risks. The teams within financial institutions which are handling climate risks are therefore evolving. Credit risk and stress testing teams are now involved in the analysis of climate risk, and CS providers should orient themselves with existing risk analysis methods, processes, and platforms to align with these as much as possible.

A decisive factor for interest and uptake of CS are the concerns in the sector around having a level playing field. This has led to the establishment of voluntary risk disclosure frameworks / self-regulation, including the TCFD recommendations. Climate risk disclosure frameworks, mandated or otherwise, can directly encourage the use of CS and can be considered to be a primary driver for demand in Europe and beyond. Other important developments in the governance landscape indirectly encourage the CS market by creating increased awareness of climate risk and climate action more generally. Despite the presence of these fundamental drivers behind the CS market, their true impact on CS demand is still unfolding. The wider finance sector appears to currently be evaluating the merits of complying with voluntary climate risk and opportunity disclosure frameworks. Mandatory regulation on climate risk disclosure may be needed to

really drive uptake of CS further. Quality assurance and minimum standards may play an important role in the future (e.g. around TCFD disclosures).

10.2. Engaging with financial services sector

Even though in principle the well-developed understanding of risk in the finance sector offers a good platform for introducing CS, in practice the sector appeared difficult to engage with on this topic. Confidentiality and competition concerns tend to make actors from the financial sector reluctant to participate in group exercises. Notable exceptions were international development finance institutions and – to some extent – (re)insurance. These traits affected this study but will also affect CS providers at least during early stages of market development. Individual relationships will be important for further engagement.

This study has shown that when financial services actors are in the early stages of searching and selecting CS, simplified representations of main choices are useful to aid discovery of the range of products and services available. In EU-MACS, the CS product matrix was developed for these purposes. The matrix groups CS into four main types (scenarios): Maps and Apps, Sharing Practices, Expert Analysis, and Climate-Inclusive Consulting (see chapters 2 and 5, **Figure 4**, and Annex 4 for further description of these CS product segment categories). Many stakeholders were only marginally aware of climate data and information. In those cases, the matrix served as a map showing the range of offerings and acted as an invaluable starting point during stakeholder engagement. In cases where users were more familiar, the matrix served as a means to raise awareness of additional categories of services. The matrix provided thus enabled fruitful discussions with users, both potential and current.

10.3. Baseline demand and supply of CS in the finance sector

This study documents the current baseline of CS use and supply in the sector, which could be useful for both potential users and providers. These are detailed in chapter 5 and 6. Potential users of CS can use this report to understand how their peers have engaged with climate data and information. CS providers can orient themselves toward emerging opportunities in provision to the sector by reviewing current demand and gaps in provision. Demand will not be static, and providers will benefit from staying informed on the potential for CS demand to evolve. Current Expert Analysis needs around climate impacts to an investment or asset class may, for example, evolve into demand for more automated, subscription-based services.

CS demand is differentiated in each segment of the sector, which is documented in chapter 5. Insurers and Development Finance Institutions (DFI) are more mature in their CS use than most other segments. The insurance segment was seen to primarily use upstream CS (Maps and Apps) and services which are integrated into wider services, such as catastrophe modelling (Climate-Inclusive Consulting). DFIs encountered in the study showed a strong demand for advisory services, though these tend to be on the project or investment level as opposed to the portfolio or loan book level. Demand for analysis around selection and prioritisation of investments based on their resilience benefits was also noted. As some leading DFIs are now starting to provide CS themselves, for their own and external use, there is also demand for Expert Analysis to develop these further.

In commercial banking, demand for CS is present for all four categories of the CS matrix though for the moment Expert Analysis has the largest apparent demand. Portfolio level analysis is currently important to commercial banks, mostly driven by interest in disclosure frameworks such as TCFD. Collaborative efforts through sector associations or groups such as UNEP FI have been popular over the last few years and could

continue so, in the short term. In commercial banking there are leaders who are already using CS, though the leaders tend to move together rather than on their own. This collective approach is creating demand for Expert Analysis which helps develop publicly available methods and resources for the wider segment to use. Banks appear to be in the early stages of their CS use, so while there are some examples of direct use of maps and apps, such as flood maps and climate data portals, there is a strong demand for the translation of that data into information which can be integrated in stress testing and risk assessments.

Other actors have more nascent demand. Rating agencies have potential to increase CS use as they try to better incorporate climate risk into ratings. There is not yet consensus in the investment space on whether upstream CS or more translated, downstream, CS are preferable. While there are some early moving asset owners and managers, demand in this segment is lagging behind commercial banks and others.

There is now a steady supply of CS, both in general and increasingly for the financial services in particular. There is a healthy supply of climate and climate-related data provided via data portals and websites. Similarly, there is a growing body of climate change impact studies provided as either academic or grey literature. Both these types of CS typically lack utility for financial actors, as translation into meaningful information for financial institutions is needed.

Advanced CS users within the finance sector including DFIs and reinsurance firms work in partnerships and amongst themselves to produce CS which can be used by other segments in the wide finance sector. Web-based platforms which allow sharing of a range of information, including climate-related data to case studies are common and best practice guidance documents are emerging frequently, around the importance of climate risk analysis. Further, some financial institutions are providing open access or online learning courses around the use of climate data and information.

Conventional advisory services around climate impacts are in steady supply, though the market is still fragmented with diverse providers. Expert Analysis is increasingly moving beyond conventional provision of expertise via consulting, to involve tools, models and methods with a range of business models. Collaborative open source efforts to provide Expert Analysis literature are currently very common in the sector. Apart from dedicated CS providers, conventional financial and accountancy service firms are starting to offer and incorporate climate analysis relating to physical climate risks into their offerings.

10.4. Barriers to use and unmet demands

A full description of barriers, organised by barriers to demand, supply, or matching, is covered in chapter 7. Chapter 8 covers the innovation potential by discussing gaps and unmet needs. Both are summarised below.

Factors which slow demand are wide ranging. Lack of awareness is a key barrier to CS uptake in much of the sector, including within financial institutions. Climate data and services is still often presumed to include carbon risks (transition risks) and carbon-related data. Some institutions have teams which are aware of physical climate risks, as well as how climate change may impact portfolios. Even so, there are common misconceptions that climate change is only a long-term issue, and that climate impacts are mostly associated with extreme weather, rather than incremental changes in climate variables. While this is evolving, there is still a strong perception amongst investor stakeholders that physical climate risk is not material.

Importantly, financial institutions may have limited bandwidth to take on additional risk analysis, such as climate risk, especially when they do not yet see a strong demand for this from the top of the investment chain and feel removed from the physical location of the underlying facilities and companies, they invest

in. The ever-present short-term outlook in most segments of the sector presents a notable structural barrier to the consideration of climate risks and use of climate data. The lack of collated data on asset location and features hinders further demand for CS. Finally, several other background changes facing the wider sector may be diverting time and resources away from CS, namely Brexit or more pressing short-term priorities including developments in fintech.

This study noted a range of factors hindering the supply of CS to the sector. Climate data and information is not always packaged as a service or targeted toward the finance sector. Research studies are not typically created for the purposes of financial risk assessment. Rather, these studies are created by research organisations or academics seeking to further the understanding of climate impacts in a given geography or sector. Important data gaps remain, such as climate model outputs for the short – medium term, particularly inter-annual and decadal projections, which hinders further product development.

A number of the information and data gaps identified by stakeholders in different segments are cross-cutting, with wider relevance for the finance sector more broadly. These are summarised as follows:

- Improved access to data, which is fairly priced;
- Improved spatial resolution and quality of data, particularly extreme events and in developing country contexts;
- More clarity on the potential attribution of extreme events to climate change, and teleconnections between different hazards and impacts;
- More explanation on the uncertainty associated with different climate datasets, and guidance on how users should interpret and use such data;
- Further development of adaptation indicators to enable decision-makers to better evaluate different options, including cost, and facilitate tracking of adaptation progress;
- Inclusion of other drivers / factors within climate risk assessments and resilience planning, such as the macroeconomic impacts of climate change and the responses of governments and insurance to the evolving risks;
- Further development of climate risk screening tools, at the project, sector and portfolio-level;
- Educational tools, capacity building programmes and knowledge sharing platforms, covering topics such as available information portals, interpreting climate data, including levels of uncertainty, and combining climate and non-climate data;
- Development of guidelines, standards and regulation, as required, for integrating climate resilience into project design and sector operations / procedures; and
- Development of a standardised format and content for climate-related disclosure, which should be used across all sectors.

10.5. Benefits and costs of CS

Apart from the initial stages of new CS products the unit-costs (prices) of these services are likely to be much less crucial for broader uptake of CS products than the benefits that their use can engender. Nevertheless, during early stages when trust has to be built up and hence *expected* value of these product is low, whereas initial cost can be higher in the absence of learning benefits, pricing can be a more decisive factor in early stage exploratory use. For non-routine CS products, such as occasional scenario studies such generalisations are harder to make.

The benefits from the use of CS in the financial sector are often severely influenced by the extent that input (and possibly output) information is shared. The delivery model of the CS may create a situation where there is no, or very limited information sharing, even though it seems that with maturing markets at least some degree of sharing seems attractive.

The uptake of CS by the financial sector has far reaching consequences for climate risk management in practically all other economic sectors. It also means that the broad uptake of CS in the financial sector will have some (moderate) induced macro-economic growth effect on national economies due to the induced efficiency gains in risk management and risk pricing.

The economic benefit of CS is based on beneficial differences in informedness of decision makers leading to (improvements in) avoided cost and (improvements in) extra revenue opportunities. As it is mostly about differential effects on effectiveness of measures, this a third order benefit, possibly further reduced by uncertainties. As a consequence, the expected value of a CS can be often only a small fraction (i.e. a few promilles[38]) of the original value at risk.

10.6. Recommendations

The benefits from the broad uptake of CS in the finance sector are likely to permeate to wider society. The potential for these benefits warrants public policy promoting the uptake of CS in this sector. This may involve (self-imposed) risk reporting obligations on one hand. On the other hand, public policy could include a well-developed publicly financed climate data and modelling infrastructure, and to some extent initial support for sector specific platforms. Considering the significant benefit potentials when the CS markets mature, public support could evolve to focus on keeping upstream and, to some extent, midstream data facilities up-to-date and high quality. Both national and EU level climate risk reporting in the finance sector is preferably guided, monitored and supported by financial authorities (e.g. central banks and associated financial market authorities, etc.).

Seasonal CS can be used to anticipate and thereby reduce or hedge against damages. Hence, for verified seasonal CS the expected net benefits of the use of CS can be estimated. For this reason, many seasonal CS products lend themselves well for provision on a commercial basis. If impacts and their prevention relate to societal or human peril, seasonal CS products could be public. This means seasonal products, not the least for the finance sector, could (should) be privately provided in most cases. Tasked with the oversight of societal protection and with ensuring good basic conditions for an efficient and reliable society, the state has some interest in ensuring that the finance sector sufficiently recognises the benefits of using seasonal CS. In this respect public institutions should consider raising general awareness regarding seasonal CS, emphasise private sector responsibilities for societal resilience (inter alia as part of the Sendai Framework and EU critical infrastructure guidelines), and support open pilots.

In the case of adaptation-related CS, commercial interests are mixed with public good interests. Availability of good quality upstream data is important to allow for development of downstream services. For some downstream services affordability and quality needs to be ensured by public actors. This implies that for this type of CS, states and the EU could assume a larger role especially regarding resourcing and regulation that promote continuity in the upstream (and to some extent midstream) CS, which are usually open. These actors could also consider quality assurance and standardisation practices. For example, the EU initiative

[38] Thousandths.

to develop policies for Sustainable Finance in conjunction with EU Climate Adaptation policy may offer a suitable basis for this.

In all segments of the sector, there is an interest in receiving CS through existing information channels, be that existing risk assessment processes or hazard models, or platforms and technology already in use. CS providers should consider aligning with these platforms and processes where possible, though development of new tools and applications should not be ruled out. Providers should also consider lingering information gaps in the development of new products and services. Financial institutions, who are well established users of CS should consider collaborating with providers to share their learning and success stories to encourage additional growth in the CS market. It is important for potential users to see demonstrated benefits and would demonstrate leadership. Established channels such as sector associations and networks could be used for dissemination. CS users who are at the early stages of regular CS use could benefit from addressing any internal silos and assessing the extent to which climate risks have been brought to high level decision makers in their organisation. Assessing this existing internal capacity to utilise CS, will be the crucial next step. Both users and providers need to pay close attention to the unfolding advances in the climate science and regulatory landscape, as climate risks and their regulation are now firmly established centre stage.

REFERENCES

2Dii, & The Generation Foundation. (2017). *All swans are black in the dark: How the short term focus of financial analysis does not shed light on long term risks*.

Acclimatise. (2017). Guayaquil adapts to climate change. Retrieved September 18, 2018, from http://www.acclimatise.uk.com/2017/03/20/guayaquil-adapts-to-climate-change/

Actuarial Post. (n.d.). ICMIF applauds creation of the Insurance Development Forum. Retrieved September 20, 2018, from http://www.actuarialpost.co.uk/article/icmif-applauds-creation-of-the-insurance-development-forum-9384.htm

ADB. (2016). *Climate Risk and Vulnerability Assessment: Tuvalu Outer Island Maritime Infrastructure Project*. Retrieved from https://www.adb.org/sites/default/files/linked-documents/48484-002-sd-01.pdf

AIR. (2002). *Ten Years after Andrew: What Should We Be Preparing for Now? Technical Document_HASR_0208*. Retrieved from http://www.air-worldwide.com/_public/NewsData/000258/Andrew_Plus_10.pdf

Aldersgate Group. (2017). *Written evidence submitted to the EAC by the Aldersgate Group*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/75999.html

Alexander, M., Bruno Soares, M., & Dessai, S. (2016). *Multi-sector requirements of climate information and impact indicators across Europe: Findings from the SECTEUR survey – Part 1*.

Allianz. (2017). The complex and changing world of fiduciary duty. London. Retrieved from http://www.sri-connect.com/index.php?option=com_docman&task=doc_view&gid=290&Itemid=428

Anderson, G., Kootval, H., & Kull, D. (Eds.). (2015). *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*. Geneva: World Meteorological Organization. Retrieved from www.wmo.int

Arjaliès, D.-L., Grant, P., Hardie, I., MacKenzie, D., & Svetlova, E. (2017). *Chains of Finance*. Oxford University Press.

Athukorala, W., Martin, W., Neelawala, P., Rajapaksa, D., & Wilson, C. (2016). Impact of Wildfires and Floods on Property Values: a Before and After Analysis. *The Singapore Economic Review*, *61*(01), 1640002. https://doi.org/10.1142/S0217590816400026

Aviva. (2015). *Aviva's strategic response to climate change*.

Aviva. (2016). *Aviva's strategic response to climate change: 2016 update*.

Aviva. (2018). *Written evidence submitted to the EAC by Aviva*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/76414.html

AXA Group. (2018). *Climate-related investment and insurance report*.

Bank of England. (2018). Stress Testing. Retrieved July 9, 2018, from https://www.bankofengland.co.uk/stress-testing

Banque de France. (2018). Network for Greening the Financial System. Retrieved April 23, 2018, from https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system

Barker, S., & Girgis, M. (2017). Bank of England eyeballs the financial sector on climate risk, (June), 1–4.

Beyond Ratings. (2018). BR Agency. Retrieved September 14, 2018, from https://www.beyond-ratings.com/agency

BlackRock. (2016). *Adapting portfolios to climate change: Implications and strategies for all investors*.

BlackRock. (2017). Guidelines, reports and position papers. Retrieved September 19, 2018, from https://www.blackrock.com/corporate/about-us/investment-stewardship/voting-guidelines-reports-position-papers#2018-priorities

Brigandi, T., & Ortel, S. (2018). The Seven Kinds of Asset Owner Institutions.

https://doi.org/10.2470/rf.v1983.n2.4716

CAF. (2012). Environmental impact reduction through "green" credit lines. Retrieved June 1, 2018, from https://www.caf.com/en/currently/news/2012/05/environmental-impact-reduction-through-green-credit-lines/

Caldecott, B., & Kuirtwagen, L. (2016). How Asset level Data Can Improve The Assesment Of Environmental Risk In Credit Analyses. *S&P Global Market Intelligence*, *October*, 1–10.

Carter, L., & Moss, S. (2017). *Drought Stress Testing: Making Financial Institutions More Resilient to Environmental Risks*.

CDP. (2018). *CDP Technical Note on the TCFD: Disclosing in line with the TCFD's Recommendations*. Retrieved from www.cdp.net

CDSB, & TCFD. (n.d.). TCFD Knowledge Hub. Retrieved September 19, 2018, from https://www.tcfdhub.org/

CFA Institute. (2017). *Environmental, Social and Governance (ESG) Survey*. Retrieved from https://www.cfainstitute.org/en/research/survey-reports/esg-survey-2017

CISL. (2016). *Investing for resilience*. Cambridge, U.K. Retrieved from http://www.cisl.cam.ac.uk/publications/publication-pdfs/Investing-for-resilience.pdf

CISL, & UNEP. (2016). *Environmental risk analysis by financial institutions – a review of global practice*.

Clapp, C. S., Lund, H. F., Borgar, A., & Lannoo, E. (2017). *Shades of Climate Risk: Categorizing climate risk for investors*. *CICERO Report*.

ClientEarth. (2017). *Written evidence submitted to the EAC by ClientEarth*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/76268.html

Climate & Environment Consulting Potsdam GmbH. (n.d.). Retrieved July 9, 2018, from www.cec-potsdam.com

Climate Action in Financial Institutions. (2017). Climate Mainstreaming Practices Database. Retrieved July 9, 2018, from https://www.mainstreamingclimate.org/climate-mainstreaming-practices-database/

Climate Analytics. (n.d.). Climate impacts and risk assessment. Retrieved July 9, 2018, from https://climateanalytics.org/what-we-do/climate-impacts-and-risk-assessment/

Connell, R., Firth, J., Baglee, A., Haworth, A., Steeves, J., Fouvet, C., & Hamaker-Taylor, R. (2018). *Navigating a New Climate. Assessing credit risk and opportunity in a changing climate: Outputs of a working group of 16 banks piloting the TCFD Recommendations*.

Copernicus. (2018). Copernicus Climate Change Service. Retrieved September 3, 2018, from https://climate.copernicus.eu/

Copernicus Climate Change Service. (n.d.). WISC - Windstorm Information Service. Retrieved July 25, 2018, from https://climate.copernicus.eu/wisc-windstorm-information-service

Cortekar, J., Lamich, K., Otto, J., & Pawelek, P. (2017). *EU-MACS Deliverable 1.1: Review and analysis of climate service market conditions*.

De Haan, J., Oosterloo, S., & Schoenmaker, D. (2009). *European Financial Markets and Institutions*. Cambridge University Press.

Dent, K., Westwood, B., & Segoviano, M. (2016). Stress testing of banks: an introduction. Bank of England. Retrieved from http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2016/q3/a1.pdf

Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). "Climate value at risk" of global financial assets. *Nature Climate Change*. https://doi.org/10.1038/NCLIMATE2972

Dietz, S., Gollier, C., & Kessler, L. (2018). The climate beta, *Journal of Environmental Economics and Management,* Vol.87, pp.258-274, http://dx.doi.org/10.1016/j.jeem.2017.07.005.

Dixon, R. (2018). Understanding cat risk: Every little helps. Retrieved September 14, 2018, from https://www.simplitium.com/modex/blog/understanding-catastrophe-risk-modelling-every-little-helps

Dlugolecki, A., Bermingham, K., & Crerar, C. (2009). Climate change and its implications for catastrophe modelling. In *Coping with climate change: risks and opportuntiies for insurers*. London: Chartered Insurance Institute.

DNV GL. (n.d.). Certificates in the blockchain: Immutable, instant and assured. Retrieved August 20, 2018, from https://www.dnvgl.com/assurance/certificates-in-the-blockchain.html

EAC. (2018). *Greening Finance: embedding sustainability in financial decision making*. London. Retrieved from https://publications.parliament.uk/pa/cm201719/cmselect/cmenvaud/1063/1063.pdf

EBRD, & GCECA. (2018). *Advancing TCFD Guidance on Physical Climate Risks and Opportunities*. Retrieved from www.physicalclimaterisk.com

EIB. (2015). *EIB Climate Strategy: Mobilising finance for the transition to a low-carbon and climate-resilient economy*. Retrieved from http://www.eib.org/attachments/strategies/eib_climate_strategy_en.pdf

ERG. (2014). Literature Review: Reinsurance Industry Catastrophe Modeling and Risk Assessment Dad Needs and Interests. Eastern Research Group.

ESA, & ADB. (2016). *Earth observation for a transforming Asia and Pacific*. Retrieved from http://esamultimedia.esa.int/multimedia/publications/EOTAP/offline/download.pdf

EUFIWACC. (2016). *Integrating Climate Change Information and Adaptation in Project Development: Emerging Experience from Practitioners* (Vol. 0).

European Commission. (2015). *A European Research and Innovation Roadmap for Climate Services*.

European Commission. (2016). European Commission appoints members of the High-Level Expert Group on sustainable finance. Retrieved from http://europa.eu/rapid/press-release_IP-16-4502_en.htm

European Commission. (2018). Action Plan: Financing Sustainable Growth. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0097

European Parliament. (2018). *Report on the proposal for a regulation of the European Parliament and of the Council amending Regulation (EU) No 575/2013 as regards the leverage ratio, the net stable funding ratio, requirements for own funds and eligible liabilities, counterparty credi*. Brussels.

European Parliament and Council of the European Union. Directive 2016/2341/EU (2016). European Parliament and Council of the European Union. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016L2341

EY. (2017a). *2017 European insurance outlook*. Retrieved from http://www.ey.com/Publication/vwLUAssets/ey-2017-european-insurance-outlook/$FILE/EY-2017-european-insurance-outlook.pdf

EY. (2017b). *How have investors met their ESG and climate reporting requirements under Article 173-VI?*

EY. (2018). *Global banking outlook 2018*. Retrieved from http://www.ey.com/Publication/vwLUAssets/ey-global-banking-outlook-2018/$File/ey-global-banking-outlook-2018.pdf

Faust, E. (2017, May). Rapid attribution: Is climate change involved in an extreme weather event? Munich RE. Retrieved from https://www.munichre.com/topics-online/en/2017/topics-geo/rapid-attribution

Federal Reserve. (2014). What is the difference between a bank's liquidity and its capital? Retrieved March 31, 2018, from https://www.federalreserve.gov/faqs/cat_21427.htm

Finance Finland. (2018). *Financial sector increases transparency in its climate work*. Retrieved from http://www.finanssiala.fi/en/material/FFI-2018-Climate_work.pdf

Finley, T., & Schuchard, R. (2010). Adapting to Climate Change: A Guide for the Financial Services Industry. BSR. Retrieved from https://www.bsr.org/reports/BSR_Climate_Adaptation_Issue_Brief_Financial_Services.pdf

Firth, J., Swann, S., Kerr, L., & Kim, Y. (2018). Lenders ' Guide for Considering Climate Risk in Infrastructure, 1–42.

Four Twenty Seven. (2017). *Measuring Physical Climate Risk in Equity Portfolios*.

G20. (n.d.). What is the G20? Retrieved September 14, 2018, from https://www.g20.org/en/g20/what-is-the-g20

GIIN. (2016). *Achieving the Sustainable Development Goals: the Role of Impact Investing*. Retrieved from https://thegiin.org/assets/GIIN_Impact InvestingSDGs_Finalprofiles_webfile.pdf

Giugliano, F. (2018). Global Warming Is a Central Bank Issue - Bloomberg. Retrieved April 16, 2018, from https://www.bloomberg.com/view/articles/2018-04-13/global-warming-is-a-central-bank-issue

Global Investor Coalition on Climate Change. (2015). *Climate Change Investment Solutions: A guide for asset owners*.

GlobalAgRisk. (2012). *A Comparison of Indemnity and Index Insurances* (No. Technical Note 4). Lima, Peru. Retrieved from http://seguros.riesgoycambioclimatico.org/publicaciones/Nota-Tecnica4-eng.pdf

Golnaraghi, M. (2018). *Climate Change and the Insurance Industry: Taking Action as Risk Managers and Investors*. Retrieved from https://www.genevaassociation.org/sites/default/files/research-topics-document-type/pdf_public//climate_change_and_the_insurance_industry_-_taking_action_as_risk_managers_and_investors.pdf

Golnaraghi, M., Nunn, P., Muir-Wood, R., Guin, J., Whitaker, D., Slingo, J., … Beck, M. (2018). *Managing Physical Risks of Climate: Leveraging Innovations in Catastrophe Risk Modelling*.

Golnaraghi, M., Surminski, S., & Schanz, K.-U. (2016). *An Integrated Approach to Managing Extreme Events and Climate Risks: Towards a concerted public-private approach*. Zurich. https://doi.org/10.13140/RG.2.2.20750.36166

Grossi, P., & Kunreuther, H. (2005). *Catastrophe Modeling: A New Approach to Managing Risk*. Boston, Massachusetts: Springer Science & Business Media. Retrieved from http://fulviofrisone.com/attachments/article/466/Springer-Verlag Catastrophe Modeling A New Approach to Managing Risk.pdf

Hails, R., Attfield, J., Calcutt, E., Campbell, R., Claringbold, A., Duckering, L., … Spencer, N. (2017). Resource and Environment Issues: A Practical Guide for Pensions Actuaries. IFoA.

Hamaker, R., Jiménez Alonso, E., Rycerz, A., Baglee, A., & Stegmaier, P. (2017). *EU-MACS Deliverable 1.3: Analysis of existing data infrastructure for climate services*.

HLEG on Sustainable Finance. (2018). *Financing a Sustainable European Economy*. Retrieved from https://ec.europa.eu/info/sites/info/files/180131-sustainable-finance-final-report_en.pdf

IAIS, & SIF. (2018). *Issues paper on climate change risks to the insurance sector. Issues Paper*. Retrieved from http://www.unepfi.org/psi/wp-content/uploads/2018/08/IAIS_SIF_-Issues-Paper-on-Climate-Change-Risks-to-the-Insurance-Sector.pdf

IDF. (2018). Understanding risk to create resilient platforms for sustainable growth and human dignity. Retrieved July 9, 2018, from http://theidf.org/

IEA. (2016). Windstorm Climate Service (WISC). Retrieved July 25, 2018, from http://www.the-iea.org/projects/windstorm-climate-service-wisc/

IFoA. (2017). RISK ALERT: Climate-Related Risks.

IGCC. (2018). *Investing in Resilience: Tools and frameworks for managing physical climate risk*. Retrieved from https://igcc.org.au/wp-content/uploads/2018/07/IGCC-Investing-in-Resilience-report_FINAL.pdf

Insurance Europe. (2016). European Insurance - Key Facts. Retrieved from https://www.insuranceeurope.eu/sites/default/files/attachments/European Insurance - Key Facts - August 2016.pdf

InsuResilience Global Partnership. (2017). About – InsuResilience. Retrieved July 9, 2018, from https://www.insuresilience.org/about/

IPCC. (2013). Summary for Policymakers. In T. Stocker, D. Qin, G. Plattner, M. Tignor, S. Allen, J. Boschung, … P. Midgley (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf

Kenealy, B. (2012). Hurricane Andrew impacted how industry models catastrophe risks. *Business Insurance*. Retrieved from http://www.businessinsurance.com/article/20120819/NEWS06/308199984/Hurricane-Andrew-impacted-how-industry-models-catastrophe-risks

Larosa, F., & Perrels, A. (2017). *EU-MACS Deliverable 1.2: Assessment of the existing resourcing and quality assurance of current climate services*. Retrieved from http://eu-macs.eu/wp-

content/uploads/2017/07/EUMACS_D12_EXISTING-RESOURCING-AND-QUALITY-ASSURANCE-OF-CURRENT-CLIMATE-SERVICES.pdf

Larsen, K. (2017). What index provider FTSE Russell has learned about ESG investing. *GreenBiz*. Retrieved from https://www.greenbiz.com/article/ftse-russell-esg-investing

Law Commission. (2014). *Fiduciary Duties of Investment Intermediaries*. London. Retrieved from https://www.lawcom.gov.uk/project/fiduciary-duties-of-investment-intermediaries/

Lloyd's, & UK Met Office. (2016). *The risk of global weather connections: Are atmospheric hazards independent? Emerging Risk Report*.

Maddox, I. (2014). What is a cat model? Retrieved from http://www.intermap.com/risks-of-hazard-blog/what-is-a-cat-model

Mason, A., Martindale, W., Heath, A., & Chatterjee, S. (2016). *French Energy Transition Law: Global investor briefing*. Retrieved from www.unepfi.org/fileadmin/documents/PRI-FrenchEnergyTransitionLaw.pdf

Mercer. (2015). *Investing in a time of climate change*. Retrieved from https://www.mercer.com/content/dam/mercer/attachments/global/investments/mercer-climate-change-report-2015.pdf

Mercer, & Environment Agency Pension Fund. (2015). *Investing in a time of climate change: Environment Agency Pension Fund*. Retrieved from http://www.mercer.com/services/investments/investment-opportunities/responsible-investment/investing-in-a-time-of-climate-change-report-2015.html%5Cnwww.mercer.com/ri/climate-change-study

MN. (2018). *Jaarverslag MN 2017 [2017 Annual Report]*. Retrieved from https://www.mn.nl/media/1884/jaarverslag-mn-2017.pdf

Moody's. (2016). How Moody's Assesses the Physical Effects of Climate Change on Sovereign Issuers. *Moody's Investors Service*, (November).

Mrsnik, M., Kraemer, M., Petrov, A., & Glass, B. (2015). The Heat Is On: How Climate Change Can Impact Sovereign Ratings. *RatingsDirect*, (34), 1–23.

Munich RE. (n.d.). NatCatSERVICE. Retrieved June 1, 2018, from https://www.munichre.com/en/reinsurance/business/non-life/natcatservice/index.html

Navarro-Martin, M. (2017). Parametric Risk Insurance. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=5&cad=rja&uact=8&ved=0ahUKEwiCwJW__KDbAhVFWsAKHdutDUEQFgheMAQ&url=https%3A%2F%2Fec.europa.eu%2Feuropeaid%2Fsites%2Fdevco%2Ffiles%2Fnavarro_parametric_risk_insurance_final.pptx&usg=AOvVaw0vPnjnz

Nelson, G. C., Valin, H., Sands, R. D., Havlík, P., Ahammad, H., Deryng, D., … Willenbockel, D. (2014). Climate change effects on agriculture: Economic responses to biophysical shocks. *Proceedings of the National Academy of Sciences*, *111*(9), 3274–3279. https://doi.org/10.1073/pnas.1222465110

New Economics Foundation. (2017). *Central banks, climate change, and the transition to a low carbon economy*. Retrieved from https://neweconomics.org/2017/09/central-banks-climate-change

NOAA, & NCEI. (2016). *Success Stories on User Engagement*. Retrieved from https://www.ncei.noaa.gov/sites/default/files/ncei-reinsurance-report-2016.pdf

Nurmi, P., Perrels, A., & Nurmi, V. (2013). Expected impacts and value of improvements in weather forecasting ontheroad transport sector. *Meteorological Applications*, *20*(2), 217–223. https://doi.org/10.1002/met.1399

Oasis Hub. (2018). Retrieved September 4, 2018, from https://oasishub.co/

Petkov, M. (2015). Insurers anticipate a smooth road ahead on climate change, but their view may be restricted. *Standard & Poor's Ratings Services Insights*, (December), 37–40.

PRA, B. (2015). *The impact of climate change on the UK insurance sector A Climate Change Adaptation Report by the Prudential Regulation Authority*. London.

PRI. (2016). *How Asset Owners Can Drive Responsbile Investment: Beliefs, strategies, and mandates*.

PRI. (2017). *PRI reporting framework 2018: Strategy and Governance (Climate-related indicators only)* (Vol. 44).

PRI. (2018a). *Implementing the Task Force on Climate-Related Financial Disclosures (TCFD) Recommendations*.

PRI. (2018b). *Shifting Perceptions: ESG, credit risk and ratings. Part 2: Exploring the disconnects*.

PRI. (2018c). *Written evidence submitted to the EAC by the Principles for Responsible Investment*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/76878.html

Price, D. (n.d.). UBS to invest $5 billion to meet the 2030 Sustainable Development Goals. Retrieved April 23, 2018, from https://impactalpha.com/ubs-to-invest-5-billion-to-meet-the-2030-sustainable-development-goals-699c96464556/

RCCAP. (n.d.). Data, Guidance and Resources. Retrieved July 9, 2018, from http://www.rccap.org/

re:focus partners. (2017). *A Guide for Public-Sector Resilience Bond Sponsorship*.

Rigaud, K. K., Sherbinin, A. De, Jones, B., Bergmann, J., Clement, V., Ober, K., … Midgley, A. (2018). *Groundswell: Preparing for internal climate migration*. https://doi.org/doi.org/10.7916/D8Z33FNS

Rissik, D. (2015). *Investing Through an Adaptation Lens: a practical guide for investors*.

Rust, S. (2016, November). European Parliament passes revised IORP Directive. *Investment and Pensions Europe*. Retrieved from https://www.ipe.com/countries/eu/european-parliament-passes-revised-iorp-directive/10016370.fullarticle

SASB. (2017). *Converging on Climate Risk: CDSB, the SASB, and the TCFD*.

ShareAction. (2018). *Written evidence submitted to the EAC by ShareAction*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/76271.html

ShareAction, & AODP. (2018). *Winning Climate Strategies*. Retrieved from https://shareaction.org/resources/winning-climate-strategies-summary-report/

Stegmaier, P., & Visscher, K. (2017). *EU-MACS Deliverable 1.4: A multi-layer exploration on innovations for climate services markets*.

Stenek, V., Amado, J. C., & Connell, R. (2010). *Climate Risk and Financial Institutions: Challenges and Opportunities*.

Sullivan, R. (2014). *Climate Change: Implications for Investors and Financial Institutions*. https://doi.org/10.2139/ssrn.2469894

Sullivan, R., Martindale, W., Feller, E., & Bordon, A. (2015). *Fiduciary Duty in the 21st Century*. *Benefits Quarterly*. https://doi.org/10.2139/ssrn.2724866

Swiss Re. (n.d.). CatNet® services. Retrieved June 1, 2018, from http://www.swissre.com/clients/client_tools/about_catnet.html

Swiss Re. (2013). Climate Analysis. In *Special Initiative for Rebuilding and Resiliency [Report]* (pp. 20–36). New York. Retrieved from https://www1.nyc.gov/assets/sirr/downloads/pdf/Ch_2_ClimateAnalysis_FINAL_singles.pdf

TCFD. (2017). *Final Report: Recommendations of the Task Force on Climate Related Financial Disclosures*.

The City of New York. (2013). *Special Initiative for Rebuilding and Resiliency report*. Retrieved from https://www1.nyc.gov/site/sirr/report/report.page

The Generation Foundation, Mercer, & 2Dii. (2017). *The long and winding road: How long-only equity managers turn over their portfolios every 1.7 years*. Retrieved from http://www.tragedyofthehorizon.com/The-Long-And-Winding-Road.pdf

Toumi, R., & Restell, L. (2014). *Catastrophe Modelling and Climate Change*. Retrieved from https://www.lloyds.com/~/media/lloyds/reports/emerging risk reports/cc and modelling template v6.pdf

Trust, S., Jones, C., Jones, S., & Aspinall, N. (2018). Climate Risk: A Practical Guide for Actuaries working in Defined Contribution Pensions. IFoA.

UK Met Office. (2016). Insurance and capital markets. Retrieved July 9, 2018, from https://www.metoffice.gov.uk/research/applied/insurance-capital-markets

UKSIF. (2017). *Written evidence submitted to the EAC by the UK Sustainable Investment and Finance Association*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/75983.html

UNE. (2018). *Greening the rules of the game: How Sustainability Factors Are Being Incorporated Into Financial Policy and Regulation*.

UNEP FI. (2005). *A legal framework for the integration of nvironmental, social and governance issues into institutional investment. United Nations Environment Programme Finance Initiative*. Retrieved from http://www.unepfi.org/fileadmin/documents/freshfields_legal_resp_20051123.pdf

University of Twente. (2018). CTA Toolbox project. Retrieved September 3, 2018, from https://cta-toolbox.nl/

van de Kieft, R., Verdegaal, W., Mulder, A., Ligthart, D., Molenaar, M., Wintzen, H., … van Waveren-Severs, S. (2018). *DNB Sustainable Finance Platform's Working Group on Climate Risk: Reflections on integrating TCFD-style information into risk/return decision-making from the Dutch financial sector*. Retrieved from https://www.dnb.nl/binaries/rapport_tcm46-374715.pdf?2018041418

van Vliet, M. T. H., Wiberg, D., Leduc, S., & Riahi, K. (2016). Power-generation system vulnerability and adaptation to changes in climate and water resources. *Nature Climate Change*, *6*(4), 375–380. https://doi.org/10.1038/nclimate2903

WMO. (2018). Essential Climate Variables. Retrieved September 4, 2018, from https://public.wmo.int/en/programmes/global-climate-observing-system/essential-climate-variables

World Bank Group. (2018a). Climate and Disaster Risk Screening Tools. Retrieved September 4, 2018, from https://climatescreeningtools.worldbank.org/

World Bank Group. (2018b). Climate Change Knowledge Portal 2.0. Retrieved September 4, 2018, from http://sdwebx.worldbank.org/climateportal/

World Bank Group. (2018c). E-Platform on Weather and Climate Services for Resilient Development: A Guide for Practitioners and Policy Makers (Self-Paced). Retrieved September 4, 2018, from https://olc.worldbank.org/content/e-platform-weather-and-climate-services-resilient-development-guide-practitioners-and-policy

World Economic Forum. (2017). *The Global Risks Report 2017 12th Edition. Insight Report*. https://doi.org/10.1017/CBO9781107415324.004

WWF. (2018). *Written evidence submitted to the EAC by WWF*. Retrieved from http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/environmental-audit-committee/green-finance/written/76335.html

ANNEXES

Annex 1: Stakeholder details

Stakeholder details are provided in more detail in the following tables[39].

Table 4: CS users engaged in EU-MACS WP2

Users	Number of organisations	Name of organisation	Geography
Asset owner	2	Varma, Anonymous AO-A	Finland, UK
Asset manager	7	ABN-AMRO, Brunel Pension Partnership, BNP Paribas, PGGM, Sycomore, Russell Investments, Anonymous AM-A	France, Netherlands, UK
Commercial bank [as part of UNEP FI TCFD Working Group] Commercial banks with approved additional interviews	16 total 3	ANZ, Barclays, BBVA, BNP Paribas, Bradesco, Citi, DNB, Itaú Unibanco, National Australia Bank, Rabobank, Royal Bank of Canada, Santander, Société Générale, Standard Chartered, TD Bank Group, and UBS Barclays, Rabobank, UBS	Australia, Brazil, Canada, France, Norway, Spain, Switzerland, UK, USA
Development Finance Institution	4	EBRD, EIB, IFC, World Bank	International, Pan-Europe
Local authority banks	2	Kuntarahoitus (Fi); Bank Nederlandse Gemeenten (BNG)	Finland, Netherlands
Insurance and reinsurance	5	Direct Line Group, LähiTapiola, Swiss Re, Anonymous I-A, Anonymous I-B	Finland, Switzerland, UK
Insurance broker	1	Anonymous	USA
Investment consultant	1	Anonymous	UK
Ratings agency	1	S&P Global	International, UK
TOTAL	39		

Table 5: CS providers engaged in EU-MACS WP2

Providers	Number of organisations	Name of organisation(s)	Geography
Catastrophe / hazard modellers	2	CatInsight (Richard Dixon); SSBN	UK
Consultants and advisors	5	Acclimatise; Carbon Delta; Carbone 4; Four Twenty Seven; Vivid Economics	France, Switzerland, USA, UK
ESG data provider	1	Sustainalytics	Netherlands
General	1	Oasis Hub (Tracy Irvine)	UK

[39] Stakeholders were anonymised upon request. Anonymised stakeholders were coded based on their segment, e.g. first anonymous asset owner was assigned 'Anonymous AO-A', asset manager was assigned 'AM-x' etc.

National meteorological offices	1	UK Met Office	UK
Research organisation	1	CICERO	Norway
Providers who are also users (DFIs, reinsurers)	*counted under users*	-	-
TOTAL	11		

Table 6: Experts and other groups engaged in EU-MACS WP2

Experts	Number of organisations	Name of organisation(s)	Geography
Affiliated with investors	2	Chris Sier; Ario Advisory (Mike Clark)	UK
Affiliated with insurance	1	OASIS LMF (Ben Hayes, Dickie Whitaker)	UK
Central banks (including regulatory divisions)	3	Bank of England, De Nederlandsche Bank (Dutch central bank), Suomen Pankki (Bank of Finland)	Finland, Netherlands, UK
EU-level regulation authority	1	European Banking Authority (EBA)	HQ in UK
General experts	4	Climate Finance Advisors (Stacy Swann); Minter Ellison (Sarah Barker); CPI (Bella Tonkonogy); Rory Sullivan	Australia, UK, USA
Sector associations / groups	3	IFoA; Finance Finland; VBDO	Finland, Netherlands, UK
NGOs	1	UNEP FI (Banking segment group)	International
TOTAL	15		

Annex 2: Stakeholder interview guidelines

WP2 - Interview guideline – stakeholders (end-users)

This interview is conducted as part of the EU-MACS project. EU-MACS is a project funded by the European Commission. The project's purpose is to analyse how the supply of and demand for climate services can be better matched.

The interview is conducted by phone, computer based virtual meeting facility or face-to-face. In conjunction with the interview you should have received an informed consent form, which clarifies the rights of the interviewee.

The questions below are meant to guide the interview but should not effect as a straightjacket. Some questions could be further elaborated, others may be irrelevant or answerable in only very general terms.

The operational environment of the organisaation

1. Summary of the organisation:
   Public, private or not-for-profit organisation?
   What main types of services is your organisation providing?

2. How many employees does your organisation have

(1 - 10 / 11 - 50 / 51 - 200 / 201 - 500 /> 500)

Is decision making and risk management organised by division / unit?

If yes, does this mean there are multiple separate acquisition centres for climate services (and for other risk management related information needs)

3. What are key cooperating (public / private / not-for-profit) organisations for your organisation (with respect to risk management)?

Has climate change been a topic for which you are or have been conducting cooperation with the aforementioned organisations?

If, so, what kind of cooperation does or did it entail?

Is this mode and cluster of cooperation sufficient to satisfy your needs?

What would merit improvement?

4. What is / are typical planning horizon(s) in your organisation?

Risk perception

5. Does your organization perceive climate / climate change mainly as a policy driven risk (e.g. related to the transformation of energy supply and international differentiation in the pace of change) or also as a natural hazard related risk (with possible effects on capital stocks and productivity)

6. Could you please describe how **current climate variability** affects your business and the finance sector in general?

- Indications of effects of seasonal variations (relatively dry or wet) and of effects of projections of such conditions?
- Indications of effects of extreme weather events and of effects of projections on future severity or prevalence of such events?
- How do you deal with these impacts?
- How vulnerable do you perceive your business and/or the finance sector with respect to climate variability?

7. How do you think **climate change is** going to affect your business / the finance sector?

- Are you already experiencing these impacts?
- What are your strategies to deal with these impacts?
- **How vulnerable** do you perceive your business / the finance sector with respect to climate change?

8. Do you **feel well informed** about climate change and climate change impacts on tourism?

9. Do you have the impression that your current risk management system is tuned to the inclusion of risk relevant climate information?

Current use of climate information and climate services

10. **Which climate information** or services do you use (a) in your **daily operational business** and (b) in your **strategic business planning**? – these climate services can encompass either *seasonal projections* (related to risks of climate variability e.g. expected drought and harvest volumes; expected winter temperature anomalies and energy sales) and/or long term climate change projections (e.g. related to evolving flood risks or to future biomass availability)
(basic climate data / processed physical information (e.g. hydrological/snow models) / early-warning systems / economic impacts (e.g. regarding production volumes, prices, expected losess, etc) – vulnerability analysis / cost-benefit analysis / macroeconomic impacts / weather insurances / consumer behavior studies / mitigation strategies / adaptation strategies / other – please specify)

11. **If your organization implicitly or explicitly uses any:**

Is it used/processed inside the organization or is there a (strong) tendency to outsource such assessments and concentrate on the outcomes?

12. **Why** do you use the climate information/ service (or the outcome of its assessment) ? Which kind of decision is taken based on this information/service? (… or do you use CS also for monitoring purposes?)

Do you regard your organisation as an experienced user? (i.e. using more than 2 years)?

Do you use **tailored climate information**?

Tailoring of otherwise standard (quantitative) product?

Tailoring in terms of dedicated commissioned (one time) CS?

Does tailoring entail consultancy and/or training?

Do you combine – in a formal sense – CS information (data) with other information (data)?

If so, does the amount and features of the other information (data) affect the CS choices and formats?

Do you experience limitations in the use of CS owing to difficulties in merging the data?

Do you **pay** for the climate information/ services?

If no. - Would you pay for (tailored) climate services?

What is the **spatial scale** of the service?
(Local / Regional / National / Transnational / Continental / Global)

What is the **temporal scale** of the service?
(Past / Present / daily forecasts / Seasonal projections / Future - until 2040, 2070, 2100)

In which format do you **receive** the climate information/ service?
(Print material - reports / Digital data / Graphics, maps / Online platform (general – or client access) / (Online) Tool / Workshop / Face-to-face advice / Presentation of results / Media / Others – please specify)

What kind of CS provider(s) do you use? Do you share CS with allied organisations?

How did it come to the use of the climate service / information?
(Own initiative / Contacted by climate service providers / Involved in research projects / Other – please specify)

Is the information easily **understandable**?

What is your experience regarding the effectiveness of using climate information or services?
(any cost savings, optimization of planning etc.)

Does the use of the CS in your organization cause notable costs?

Owing to CS acquisition cost

Owing to the necessity to invest in equipment or software to use the CS (one time cost)

Owing to the necessity to recruit or hire expertise labour (continuous or recurrent cost)

If none:

Why not? *(risk awareness, uncertainties, suitability of available information/services (e.g. temporal or spatial scale), lack of knowledge regarding the interpretation of data/results, lack of knowledge regarding information sources/ providers, lack of access to climate data/information, budgetary constraints, etc.)*

Are you planning to ?

Identifying users' needs/perspective

Already users:

Apart from the climate information / services you already use, which of your activities or services could be improved with greater knowledge/understanding of climate variability and change – briefly explain why and how? (What kind of weather/climate information or service would be important for your activity?)

Non- users:

Which of your activities or services could be improved with greater knowledge/understanding of climate variability and change – briefly explain why and how? (What kind of weather/climate information or service would be important for your activity?)

Quality assurance

How do you / would **you assess the quality** of climate information and services?
(e.g. regarding the suitability of available information and services / transparency (meta-information) / provision of uncertainty information / matching spatial and temporal resilience / user-friendliness / selection of providers (reputation, publication record etc.)

Has QA been an issue in the choice of CS provider(s)?

According to your experience/opinion, could you describe some **limits/drawbacks** of the current interaction network **hampering the process of climate change adaptation**?
(e.g. lack of information sharing)

NB: Interviews with PGGM and Varma followed this guideline more strictly, for others this was the starting point for a semi-structured interview.

Questionnaire for BNG and Kuntarahoitus

This interview is conducted as part of the EU-MACS project. EU-MACS is a project funded by the European Commission. The project's purpose is to analyse how the supply of and demand for climate services* can be better matched.

Climate services can be summarized as: *the transformation of climate related data – often together with other relevant information - into customized information products, offered as such or embedded in consultancy and/or education* [condensed version of European Roadmap definition]

The interview is conducted by phone, computer based virtual meeting facility or face-to-face. In conjunction with the interview you should have received an informed consent form, which clarifies the rights of the interviewee.

The questions below are meant to guide the interview, but should not effect as a straightjacket. Some questions could be further elaborated, others may be irrelevant or answerable in only very general terms.

The operational environment of the organisation

1. Summary of the organisation:
    a. *Public, private or not-for-profit organisation?*
    b. *What main types of services is your organisation providing?*

2. How many employees does your organisation have

    (1 - 10 / 11 - 50 / 51 - 200 / 201 - 500 /> 500)

3. Is decision making and risk management organised by division / unit? –

    a. If yes, does this mean that these distributed risk management centres acquire external risk information (mainly) separately?

4. What are key cooperating (public / private / not-for-profit) organisations for your organisation (with respect to risk management and climate change)?

5. What is / are typical planning horizon(s) related to the service products of your organisation?)

Risk perception

6. Does your organization perceive climate change mainly as a *policy driven risk* (e.g. related to the transformation of energy supply, transport fuels and energy efficiency and energy use in buildings) or also as a *natural hazard related risk* or *opportunity* (with possible effects on capital stocks, productivity, and innovations)

7. How do you think **climate change is** going to affect your business / the finance sector?
    a. Are you already experiencing these impacts?
    b. What are your strategies to deal with these impacts?
    c. **How vulnerable** do you perceive your business / the finance sector with respect to climate change?

8. Do you **feel well informed** about climate change and climate change impacts on public sector investments, public sector financing needs, and public services?

9. Do you have the impression that your current risk management system is tuned to the inclusion of risk relevant climate information?

Current use of climate information and climate services

10. Is your organisation using climate services (as defined above)?
    a. If so, what kind of climate services, and for what purpose?
    b. Are all these services from domestic (national) sources or also international?

11. If you acquire climate services, are these:
    a. Provided by a commercial expert organization?
    b. Provided by a public expert organization
        (a) Charged
        (b) Free of charge

12. If your organization is not using climate services proper, is it perhaps using information in which such information is integrated (i.e. risk indicators accounting for climate change related risks)?

13. What kind of climate services, which are not (yet) available, would your organization be interested in?

14. Are you planning to develop climate services as part of your own service package?

Annex 3: Interactive questionnaire and interviews with local public sector banks

Interactive questionnaire addressed to finance sector

The questionnaire as presented here is adapted for representation in A4 formatted report rather than web-page. The questionnaire was filled in in February – March 2018. The questionnaire appeared very challenging, implying that of the 12 approached stakeholders, who had indicated their preparedness to fill in the questionnaire, only 3 managed to do so. Most of the approached stakeholders had contributed to earlier surveys or interviews. Number of responses per answer and open answers are in **red font.**

1. **What type of activity do you represent:**
   - Asset management
   - Risk management (within finance organisation)
   - Property Insurance (and/or other damage insurance)
     - **1**
   - Risk information services (modelling, indicators)
   - Market supervision / research
     - **2 (Central Bank; Commercial Bank)**
   - Other: …….

2. **Are you interested in** (more than one option possible, but topics of marginal interest may be left out):
   - Climate services related to climate **mitigation** efforts and policies (carbon intensities; clean-tech) **2**
   - Climate services related to climate **adaptation** efforts and policies (protecting against direct risks of changing climate) **3**
   - Climate services related to the cross-roads of climate **mitigation and adaptation**, e.g. effects of climate change on the productivity of renewable energy **2**
   - Climate services not per se related to adaptation or mitigation, but rather dealing with **current levels of hazard preparedness** and climate investment or business **opportunities** (hurricanes, droughts, etc.; seasonal variations affecting hydropower, tourism, etc.) **2**
   - Other:
     - Impact on Financial services companies

3. **Are you interested in** (*more than one option possible*, but topics of marginal interest may be left out):
   - Regular information services, i.e. recurrently updated risk indicators? **1**
   - Project specific information services, i.e. occasional specific information on a region and/or sector for the purpose of assessing (investment) project risks?
   - Scenario exercises:
     - Short term (1 – 4 years) **1**
     - medium term (i.e. 10 ~ 15 years) and/or - **2**
     - long term (i.e. 25 ~ 50 years (and beyond) **1**
   - Consultancy services 1, e.g. generic and specific education & training, mainstreaming climate change and variability in decision making,
   - Consultancy services 2, e.g. co-designed information products or scenarios, risk analysis, etc. **1**

Deeper digging questions (exploring fitness for purpose, quality notions and trade-offs / breaking points)

4. **If you wish to acquire climate change related risk indicators, do you want:**
   - risks expressed in physical terms, i.e. changes in expected frequencies of hazards of a certain severity class by area / region **No 1 ; Yes 1**
     - if yes, do you want such data
       - for current circumstances **1**
       - for the medium term (~ 15 years ahead) – NB! the signal may be hard to distinguish from noise **1**
       - for the long term **1**
   - risks expressed in economically meaningful terms, **Yes 3**
     - if yes, do you want such data:
       - for current circumstances **2**
       - for the medium term (~ 15 years ahead) – NB! the signal may be hard to distinguish from noise **2**
       - for the long term **2**
     - if yes, do you want:
       - a 'pure' climate effect (assuming other variables, such as value of potentially affected assets, as unchanged) **1**
       - estimates in the context of broader scenarios?

5. **In case of recurrent risk monitoring needs, would you:**
   a. Outsource the climate risk information to an expert organisation which assesses the entire portfolio of risks (political, technical, natural hazards (incl. climate), …)
      i. Why …
   b. Acquire specific climate risk information and further process internally **1**
      i. Why: "we do all risk assessment internally and have expertise on that. we just need the impact in a way that we can integrate it in the models …"
   c. Hedge against such risks in another way, and not use efforts to acquire hazard risk assessments
      i. why

6. **In case of project specific information, would you:**
   a. Outsource the climate risk information to an expert organisation which assesses the entire portfolio of risks (political, technical, natural hazards (incl. climate), …)
      i. Why …
   b. Acquire specific climate risk information and further process internally **1**
      i. Why: "we do all risk assessment internally and have expertise on that. we just need the impact in a way that we can integrate it in the models …"
   c. Hedge against such risks in another way, and not use efforts to acquire hazard risk assessments
      i. why

7. **Suppose that a climate (information)service is able to provide projections for frequencies of severe droughts** (i.e. significant enough to affect yields for staple food at a large scale) for *the next 4 years*, under what conditions would you be interested to acquire this information? Please put a cross in the options that you would seriously consider and 2 crosses in the most preferred options (max. 2)

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global	1			
Selected areas (countries; country groupings)				1
As public service				
Club good*				
Commercial product				

*) A club good is freely available or easy accessible for club members, and not available or only available at disadvantageous conditions for non-members; club members pay a significant entrance fee and/or annual fee (e.g. for information system upkeep), whereas club members can specify eligibility conditions for candidate club members (in as far as compatible with competition legislation)

8. **Same climate (information)service as in Q.6, but in this case as projection for at least a decade ahead (10 – 20 years ahead)**

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global	1			
Selected areas (countries; country groupings)				1
As public service				
Club good				
Commercial product				

9. **Same climate (information)service as in Q.6, but in this case as long term projection 25 – 50 years ahead: NO INTEREST BY ANY**

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global				
Selected areas (countries; country groupings)				
As public service				
Club good				
Commercial product				

Can you give a motivation for your answers to questions 6 – 8, what has guided your choices the most?

The information service proposed in this questionnaire is not easily translated into monetary effects for financial assets / financial companies. In order for this service to be useful it would need to de developed several steps further: i.e. we are not interested in the increased frequency of floods, but in how large percentage of real estate in a country / area is in danger of becoming flooded. This can then be translated into losses for insurers and banks.

Data should add something to existing data (either free like IPCC and such or paid like Bloomberg)

10. **Suppose that a climate (information)service is able to provide projections for frequencies and severity of hurricanes in the Mexican gulf and along the North-American Atlantic coast** for *the upcoming hurricane season (usually June – November)*, under what conditions would you be interested to acquire this information? Please put a cross in the options that you would seriously consider and 2 crosses in the most preferred options (max. 2)

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Whole area	1			
Selected areas (states; cities)				1
As public service				
Club good				
Commercial product				

11. **Same climate (information)service as in Q.9, but in this case as projection giving *an indication of the expected change in* frequencies and severity for at least a decade ahead (10 – 20 years ahead)**

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global	1			
Selected areas (countries; country groupings)				1
As public service				
Club good				
Commercial product				

12. **Same climate (information)service as in Q.10, but in this case as long term projection 25 – 50 years ahead: NO INTEREST BY ANY**

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global				
Selected areas (countries; country groupings)				
As public service				
Club good				
Commercial product				

Can you give a motivation for your answers to questions 9 – 11, what has guided your choices the most?

not sure if purchase would be interesting. depends on available data and what this service would add to that

13. **Suppose that a climate (information)service is able to provide projections of impacts on labour productivity and employability effects resulting from adverse ambient conditions** (related to temperatures, humidity, extreme events, vector borne diseases, etc.) **for at least a decade ahead (10 – 20 years ahead)** under what conditions would you be interested to acquire this information? Please put a cross in the options that you would seriously consider and 2 crosses in the most preferred options (max. 3)

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global	1			
Selected areas (countries; country groupings)				1
Selected sectors				1
Selected professions				1
As public service				
Club good				
Commercial product				

14. **Same question as for Q12, but in this case as long term projection 25 – 50 years ahead:** under what conditions would you be interested to acquire this information? Please put a cross in the options that you would seriously consider and 2 crosses in the most preferred options (max. 3)

	Large uncertainties allowed		Large uncertainties not desired	
	Free data	Priced data	Free data	Priced data
Global	1			
Selected areas (countries; country groupings)				1
Selected sectors				1
Selected professions				1
As public service				
Club good				
Commercial product				

Can you give a motivation for your answers to questions 12 and 13, what has guided your choices the most?

interesting data currently unavailable (i believe). should be available for wide research though.

15. **If the provision of a climate service is *not* free of charge, how do you relate to uncertainty of the service-product benefit?** (options a and b are mutually exclusive, otherwise more answers possible)
    a. The service fee should be clearly smaller than the expected value generated in the application of the climate service information with an added safety margin
    b. The service fee should be just a fraction of the expected value generated in the application of the climate service information (possibly further corrected with a safety margin)
    c. The service fee should fit in the typical tariff range for comparable risk information services
    d. The willingness to pay (WTP) for these services will develop in accordance with the track record and range of applicability of the offered services, at least initially the WTP is probably quite low (ALL)

16. **If you consider the entire transaction chain for the acquisition and meaningful use of a particular climate service (or a coherent service package)** (involving search, selection and possibly post-processing and training cost, and an acquisition price being zero or positive) **and this is this the first time you acquire the service, what would be typically your required (ballpark) benefit-cost ratio for this service?**
    a. Just somewhat above 1
    b. ≥ 3
    c. ≥ 10
    d. ≥ 100
    e. Cannot define

17. **What would be typically your (ballpark) benefit-cost ratio for a climate service which you are using already for some time?**
    a. Just somewhat above 1
    b. ≥ 3
    c. ≥ 10
    d. ≥ 100
    e. Cannot define

18. Are you interested to discuss the outcomes (overall) of this questionnaire

Annex 4: Climate services scenarios or product types

Table 7: Climate services - further descriptions of product typologies and their underlying philosophy

Maps and Apps (M&A)	Expert Analysis (EA)
In the Maps & Apps product type value can be created by providing climate data on a national or regional level, which can be considered by a large group of policy makers, managers, entrepreneurs and citizens when they make decisions on infrastructure, investment portfolios, policy measures, etc. The value proposition is related to having quick and cheap access to relevant projections, which can make individual and collective decision processes more robust and objective. Central in the provision of 'maps & apps' are meteorological and research institutes. As revenue streams from users are limited – due to free availability of the service and restrictions for institutes to commercialize – public funding from regional, national, and international bodies is the major source of funding.	Compared to the Shared Practices (SP) the Expert Analysis product type tends to have a clearer cut distinction between user and provider, even though the design or at least fine tuning of the product can be a joint effort of provider(s) and user(s). Indeed, the provision context can still have collaborative features as in SP, but the whole product environment is more oriented towards service delivery (and consequent decision support) rather than mutual learning, unless knowledge transfer and training (e.g. to use a new model) is part of the package. These services will often be based on models, tools or methodologies and tend to be charged, also when provided by public sector expert organisations, but in case of public duty activities EA may be free of charge. EA services will often draw on M&A or the underlying data, and may also be liaised to or born out of SP. In some cases EA can be embedded in a much broader consultancy endeavor and thereby be part of CIC (see below). Next to public expert organisations, such as meteorological and academic research institutes, private sector expert organisations, such as risk analysis consultancies, are the main providers of EA. Commercial EA provision is likely to increase significantly.
Sharing Practices (SP)	**Climate-Inclusive Consulting (CIC)**
In this case users of climate services are also producers of (elements of) climate services. So all are contributors. The identification of best practices and the sharing of experiences among peers – for instance local governments (from the same region), or companies (from the same sector or region) – is central to the value creation. The exchange within these communities is facilitated by databases, platforms and events, which may be resourced by the contributors together, possibly subsidized from a public programme, or conversely	Climate Inclusive Consulting is typically about absorption of climate service elements into broader based consultancy services. Typically, commercial, multidisciplinary consultants – such as engineering, urban planning, finance, policy or specialised adaptation consultants – take climate change into account when advising decision makers on infrastructure, investments or adaptation measures. The climate service contribution can be the lead element in the overall consultancy package, but doesn't need to be.

the shared facility is offered by commercial platform providers. A part of the contributions to SP comes from or draws on M&A and the underlying datasets. Critical issue in this scenario is the willingness of users to develop sufficient knowledge on climate change analysis, adaptation and mitigation, and to share this knowledge with others, especially in competitive situations or when users have limited resources to spend on this issue.	Value for users is created by more robust designs and more prudent decisions customised for their situation, made possible by consultancies with a strong user orientation. As for the Expert Analysis product type, this type of climate services is provided on a commercial basis, predominantly by private expert organisations. The initiative to integrate the climate service with other consultancy comes from the consultant, but can be based on previous project experience and customer feedback. Within a large scale CIC context specific climate analyses may be subcontracted to specialised agencies or departments of the consultancy firm itself or sometimes be based on a contextualised interpretation of publicly available maps and apps.

Annex 5: TCFD Recommendations

Table 8 provides detailed information on the Task Force on Climate-related Financial Disclosures recommendations.

Table 8: TCFD recommendations (TCFD, 2017)

Recommendations and Supporting Recommended Disclosures

Governance	Strategy	Risk Management	Metrics and Targets
Disclose the organization's governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	Disclose how the organization identifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
Recommended Disclosures	**Recommended Disclosures**	**Recommended Disclosures**	**Recommended Disclosures**
a) Describe the board's oversight of climate-related risks and opportunities.	a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.	a) Describe the organization's processes for identifying and assessing climate-related risks.	a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.
b) Describe management's role in assessing and managing climate-related risks and opportunities.	b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.	b) Describe the organization's processes for managing climate-related risks.	b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.
	c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.	c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.	c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.

Annex 6: Climate Service provision - summary tables

Tables 9-12 provide detailed information on available climate services, based on which category of the CS product matrix they are associated with. These tables are not exhaustive, rather they provide an overview of services available in each category encountered in literature reviews and stakeholder engagement.

Table 9: Encountered provision of Maps and Apps (non-exhaustive)

Name	Provider	Type of provider	Summary	Open access	Link
Data portals for upstream satellite data					
Giovanni Portal	NASA	Governmental agency, USA	Visualisation and comparison system for satellite data. Numerous variables covered at a range of spatial and temporal resolutions.	Yes	https://giovanni.gsfc.nasa.gov/giovanni/
Open Access Hub	Copernicus; ESA; European Commission	Governmental agencies, Europe	Provides access to Copernicus satellites (Sentinel-1, Sentinel-2 and Sentinel-3) user products.	Yes	https://scihub.copernicus.eu/
Data portals and datasets for information on climate variables					
NCEI website	NCEI	Governmental agencies, USA	Website linking to datasets and portals, providing an extensive geophysical data archive. Datasets include land-based, marine, model, radar, weather balloon, satellite, and paleoclimatic, among others.	Yes	https://www.ncei.noaa.gov/
Climate Data Guide	NCAR	Governmental agencies, USA	Website 'guide' with 201 data sets covering the Atmosphere, Ocean, Land, etc. User can access climate indices, reanalyses and satellite data and understand their application to climate model metrics.	Yes	https://climatedataguide.ucar.edu/
Climate Change Initiative Open Data Portal and Toolbox	ESA	Governmental agencies, Europe	Provides access to fourteen parallel projects geared to ECV data production, plus a dedicated climate modelling user project for assessment of the products. Provides access to a toolbox to facilitate the combining and analysis of the products, and visualisation.	Yes	Portal: http://cci.esa.iii/; Toolbox: http://climatetoolbox.io/

Climate Data Store	C3S	Governmental agency, Europe	Provides information about the past, present and future climate ECVs and derived climate indicators.	Yes, registration required	https://cds.climate.copernicus.eu/#!/home
Meteo-rological office datasets	Varies: e.g. UK Met Office; Finnish Meteorological Institute	Governmental agencies, Europe	Met offices provide a range of local datasets which can include precipitation, temperature, wind speeds, humidity among others. NB: some datasets are open source, some are chargeable; some are open access for research and personal use only; not all agencies charge.	Varies	E.g. https://www.metoffice.gov.uk/hadobs/ Or http://en.ilmatieteenlaitos.fi/download-observations#!/
Public datasets	ECMWF	Research institute	Provides global reanalyses, regional reanalysis, multi-model, and atmospheric composition datasets. NB: ECMWF provide other additional chargeable data.	Yes	http://apps.ecmwf.int/datasets/
Data portals for information on climate projections					
Climate Explorer	KNMI	Governmental agency, NL	Web application to analyse climate data. Includes range of climate model outputs, from CMIP3, CMIP5. NB: KNMI Climate Explorer also provides observational data and climate indices.	Yes, some features require mandatory registration	https://climexp.knmi.nl/
Data portals and datasets for information on extreme events					
Drought and flood risk products	Princeton Climate Analytics	Private company	Drought and flood risk products produced as a result of the company's proprietary Princeton Hydrological Engine (PHE).	Yes	http://princetonclimate.com/
GRID Global Risk Data Platform	UNE	NGO	Platform which allows the sharing and visualisation of spatial data information on global risk from natural hazards. Climate-related hazards covered include tropical cyclones and related storm surges, drought, biomass fires, floods, and landslides.	Yes	http://preview.grid.unep.ch/
Aqueduct Global	WRI With consortium of Deltares, University	Research institutes, NGOs,	Platform which measures river flood impacts by urban damage, affected GDP, and affected population at the country, state, and	Yes	https://floods.wri.org/#/

Flood Analyzer	Utrecht, VU, IVM, Netherlands Environmental Assessment Agency	governmental agency	river basin scale across the globe, as well as 120 cities. Includes the following types of data: Global hydrological and hydraulic modelling, extreme value statistics, inundation modelling, impact modelling (population exposed to flooding, GDP exposed to flooding, and urban damage in USD from flooding, estimation of annual expected impacts, future flood risk projections using GCM data, socio-economic data (socio-economic change). Only simulates large-scale river flooding, not coastal flooding, flash flooding, or pluvial flooding.		
ThinkHazard!	GFDRR with consortium of others	NGO	Provides a general view of hazards, for a given location, that should be considered in project design and implementation to promote disaster and climate resilience. Highlights the likelihood of different natural hazards affecting project areas (very low, low, medium and high), provides guidance on how to reduce the impact of these hazards, and where to find more information. Climate-related hazards covered include flood, landslide, cyclone, water scarcity, extreme heat, wildfire.	Yes	http://thinkhazard.org/en/
Climate change impact studies (examples)					
-	Nelson et al. 2014	Academic literature	Study: Climate change effects on agriculture: Economic responses to biophysical shocks. The study was coordinated by the Agricultural Model Intercomparison and Improvement Project (AgMIP). It assessed climate change impacts on four crop aggregates (coarse grains, oil seeds, wheat and rice) and provides estimates of projected changes in yield and price under a 4°C scenario in 2050.	Yes	http://www.pnas.org/content/pnas/111/9/3274.full.pdf
-	van Vliet et al. 2016	Academic literature	Study: Power-generation system vulnerability and adaptation to changes in climate and water resources. This study suggests incremental climate change will reduce the productivity of many thermal and hydropower plants worldwide.	Purchase of article required	https://www.nature.com/articles/nclimate2903?WT.feed_name=subjects_climate-change-adaptation
-	Athukorala et al. 2016	Academic literature	Study: Impact of wildfires and floods on property values: A before and after analysis. This study suggests the value of affected homes declines in the aftermath of wildfires compared to average market prices.	Purchase of article required	https://www.worldscientific.com/doi/pdf/10.1142/S0217590816400026

Macro-economic studies	-	Academic literature	Based on one of three types: CGE, IAM, econometric techniques	varies	-
	Rigaud et al. 2018	DFI literature	World Bank flagship study: a pioneering scenario-based approach that combined climate impacts (crop productivity, water stress (ISIMIP data), sea level rise); demographic data (GPW, v4), and emissions pathways (SSP2, SSP4) indicated that there could be more than 143 million climate migrants by 2050 under the pessimistic scenario for just three regions: Sub-Saharan Africa, South Asia and Latin America.	Yes	https://openknowledge.worldbank.org/handle/10986/29461
Mapping tools and overview portals provided by financial institutions					
CCKP	World Bank	DFI/NGO	Provides spatially referenced data visualised on a Google Maps interface. Users are able to evaluate climate-related vulnerabilities, risks, and actions for a particular location on the globe by interpreting climate and climate-related data at different levels of details. Contains environmental, disaster risk, and socio-economic datasets, and synthesis products, such as the Climate Risk and Adaptation Country Profiles, The CCKP also provides links to other resources and tools.	Yes	http://sdwebx.worldbank.org/climateportal/
CSPP	World Bank and consortium of 60 organisations	DFI	Built for those in a developing country context, incorporates data and knowledge from the WB's CCKP, and provides users with access to climate-related information and data at the global, regional, and country-level, as well as access tools for resilience planning at different levels of detail. Offers users access to a number of climatic variables over different future time horizons and according to different RCPs incorporating results from past two CMIP datasets (CMIP3 and CMIP5).	Yes	https://www.climatesmartplanning.org/
CatNet® services	Swiss Re	Reinsurance company	Mapping tool box enables users to carry out risk assessments on individual locations or entire portfolios by mapping locations against hazard, loss, exposure and insurance data. Uses hazard maps and satellite imagery. Historic climate related hazard data available in the tool includes: river and coastal flooding; wind speed; tropical cyclones; hail storms; tornadoes; and wildfires.	No, unless users are clients of Swiss Re	http://www.swissre.com/clients/client_tools/about_catnet.html

NATHAN	Munich RE	Reinsurance company	Mapping tools. Includes datasets for tropical cyclones, extratropical storms, flooding, storm surge, wildfire.	No	https://www.munichre.com/en/reinsurance/business/non-life/nathan/index.html

Table 10: Encountered provision of Sharing Practices (non-exhaustive)

Name	Provider	Type of provider	Summary	Reference / link (for portals or online services)
Sharing climate data and case studies				
RCCAP	ADB	DFI	Web-based portal which allows members to access climate data, case studies, and guidance, as well as a forum to promote regional sharing and learning.	(RCCAP, n.d.) Or http://www.rccap.org/
CCKP	World Bank	DFI	*Included under Maps and Apps*	
Climate Mainstreaming Practices Database	Climate Action in Financial Institutions Initiative	Join initiative of development banks, and commercial financial institutions	This database aims to facilitate knowledge sharing between financial institutions. Provides case studies written and submitted by supporting institutions, which share how they are integrating climate change in their operations.	(Climate Action in Financial Institutions, 2017) Or https://www.mainstreamingclimate.org/climate-mainstreaming-practices-database/
TCFD Knowledge Hub	TCFD and CSDB	International organisation task force and NGO	This web-based platform is a repository of useful information for those who are preparing their climate-related disclosures in line with the recommendations of the TCFD. The Knowledge Hub houses hundreds of resources.	(CDSB & TCFD, n.d.) Or https://www.tcfdhub.org/
Oasis Hub	EIT Climate-KIC, Oasis LMF and the Oasis+ Consortium	Joint initiative	Meta climate service offering. This portal allows users to browse climate service offerings, such as catastrophe or flood models, ranging from open source to commercial. Also allows users to provide feedback on services to other users. (See chapter 5 for further discussion).	("Oasis Hub," 2018) Or https://oasishub.co/

Sharing guidelines and metrics				
Integrating Climate Change Information and Adaptation in Project Development	EUFIWACC	Joint initiative between DFIs	Guidelines which aimed at helping financing institutions assess climate risks and integrate adaptation measures into project planning, design, and implementation.	(EUFIWACC, 2016)
Advancing TCFD guidance on physical climate risks and oppor-tunities	EBRD and GCECA with advisory forms Acclimatise and Four Twenty Seven	Joint initiative between DFI, global initiative and advisory firms	Presents a set of recommendations for corporates to follow to inform and support early efforts to adopt the TCFD recommendations. Areas covered include metrics for physical climate risk management and disclosures, metrics for climate resilience opportunities, and metrics for climate intelligence for business strategy and financial planning.	(EBRD & GCECA, 2018)
Learning services				
E-Platform on Weather and Climate Services for Resilient Development: A Guide for Practitioners and Policy Makers	World Bank	DFI	Provides a basic introduction to weather and climate services and seeks to demystify how weather and climate information systems function with a rich set of resources and case studies.	https://olc.worldbank.org/content/e-platform-weather-and-climate-services-resilient-development-guide-practitioners-and-policy
Climate Change & the TCFD: Risks & Opportunities for the Banking Industry	UNEP FI	NGO	Provides executives and middle management staff of banks, from both developed and developing regions information on the financial risks and opportunities from climate change, and about the required forward-looking assessment methods. Fee based; to run in November 2018.	http://www.unepfi.org/training/training/climate-change-training/online-course/

Table 11: Encountered provision of Expert Analysis tools, platforms, and methods (non-exhaustive)

Name	Provider	Type or specialty of provider	Summary	Open Access	Reference
Tools and methods provided by climate risk specialists for the finance sector					

Aware for projects	Acclimatise	Advisory and analytics firm specialising in climate change risk assessment, adaptation, and resilience building.	Aware platform provides an easy three-step process to screen a company or project for climate risks.	No	http://www.acclimatise.uk.com/analytics/applications/
Climate Value-at-Risk	Carbon Delta	Analytics firm specialising in analysis of climate risks in financial markets.	Forward-looking risk measure for analysing climate-related risks and opportunities of companies for the purposes of investors seeking to analyse their investment portfolios.	No	https://www.carbon-delta.com/
Climate Risk Impact Screening	Carbone 4	Consulting firm specialised in low carbon strategy and adaptation.	Forthcoming method which allows for physical climate risk analysis in investment portfolios.	No	http://crisforfinance.com/en/our-solution/
Climate risk scores in equity portfolios	FourTwenty Seven	Market intelligence and research firm specialised in services on the economic risks of climate change.	Method for analysing climate risk exposure of companies and activities and sectors they are involved in.	No	http://427mt.com/our-solutions/

Flood-Score, Heat-Score, Climate-Score	Jupiter Intel	Analytics firm	Provides services for predicting specific hazards, including the probability of extreme temperatures and flooding. Services available as interactive maps, reports, through an API or via custom consulting engagements. Currently covering the US Atlantic Coast, with plans to offer further coverage in the future.	No	https://jupiterintel.com/
Methods and tools based on climate data provided by collaborative efforts					
Drought Stress Testing Tool	UNEP FI-led consortium	Collaborative effort	Tool which looks at five drought scenarios in four countries – Brazil, China, Mexico and the US models the impact of drought on 19 different industry sectors, the companies in those sectors and the likelihood that they will default on their loans.	Yes	http://www.unepfi.org/ecosystems/ncfa/drought-stress-testing-tool/
Methodology for assessing commercial banks' physical climate risks and opportunities	Acclimatise - UNEP FI TCFD pilot working group of commercial banks	Collaborative effort	Scenario-based approach for estimating the impact of climate change on their corporate lending portfolios as recommended by the Recommendations of the TCFD.	Yes	http://www.unepfi.org/publications/banking-publications/navigating-a-new-climate-assessing-credit-risk-and-opportunity-in-a-changing-climate/
Methodologies for assessing investors' and for insurers' physical climate risks and opportunities	UNEP FI TCFD pilot	Collaborative effort	*Forthcoming 3Q 2018/2019*.	Yes	-
ClimINVEST tool	JPI climate ERA4CS research project	Collaborative effort	*Forthcoming 2019-2020*. The project aims to develop tailored information tools on physical climate risk for financial decision makers.	Yes	https://www.cicero.oslo.no/en/climinvest
Methods / platforms / tools provided by climate risk experts (finance sector and beyond)					
XDI dashboard	XDI	Advisory firm	Platform provides governments and business with risk analytics to optimise investments and assure climate resilience.	No	http://xdi.systems/

Table 12: Expert Analysis grey literature targeted at the financial services sector (non-exhaustive)

Name	Provider	Type of provider	Scope	Summary	Reference
Insurance					
Climate Change and the Insurance Industry: Taking Action as Risk Managers and Investors	Geneva Association	Sector organisation	Insurance	Offers insights into the role of the insurance industry in addressing climate change adaptation and mitigation. Perspectives from C-level executives in the insurance industry.	(Golnaraghi, 2018)
Issues paper on climate change risks to the insurance sector	International Association of Insurance Supervisors and the Sustainable Insurance Forum	Sector organisation	Insurance	Offers an overview of how climate change is currently affecting and may affect the insurance sector now and in the future, examples of current material risks and impacts across underwriting and investment activities, and describes how these risks and impacts may be of relevance for the supervision and regulation of the sector. The report explores potential and contemplated supervisory responses and reviews observed practices in different jurisdictions.	(IAIS & SIF, 2018)
Investing for Resilience	CISL	Sector network (Climate Wise)	Insurance	Explores the relationship between insurance industry and investment. Reviews actions insurers can take to promote climate resilience.	(CISL, 2016)
The impact of climate change on the UK insurance sector, A Climate Change Adaptation Report	Bank of England's PRA	Regulator	Insurance	Provides a framework for considering the risks arising from climate change through the lens of the PRA's statutory objectives in relation to insurers – i.e. the safety and soundness of firms and appropriate protection of policyholders.	(PRA, 2015)
Catastrophe modelling and climate change	Lloyd's	Insurer	Insurance	Reviews climate science, background on catastrophe modelling, and discusses whether and how catastrophe models can account for climate change.	(Toumi & Restell, 2014)
Banking					
Lenders guide for considering	Acclimatise, FourTwentySeven,	Advisory firms	Banking and investment;	'Provides an introduction to weather- and climate-related risks and opportunities for loan and credit officers assessing potential lending	(Firth, Swann, Kerr, & Kim, 2018)

climate risk in infrastructure investments	Climate Finance Advisors		infrastructure	for infrastructure. The goals are to enhance understanding of these risks so as to structure lending that maximizes performance and minimizes risks.'	
Investment					
Investing in Resilience; Tools and frameworks for managing physical climate risk	IGCC	Sector association	Investment	Provides guidance for investors on the basic concepts of climate resilience and to signpost a number of tools and resources relating to its management.	(IGCC, 2018)
Advancing guidance on physical climate risks and opportunities	EBRD and GCECA with advisory forms Acclimatise and Four Twenty Seven	Joint initiative between DFI, global initiative and advisory firms		*Included under Sharing Practices*	See Table 10
Implementing the Task Force on Climate-Related Financial Disclosures Recommendations ; A guide for Asset Owners	Principles for Responsible Investment	Sector association / NGO	Investment; Asset owners	Presents a practical framework for asset owners to follow to support them in their efforts to implement the TCFD recommendations. Presents actions asset owners can take to align with the TCFD framework.	(PRI, 2018a)
Shades of climate risk: Categorizing climate risk for investors	CICERO	Research organisation	Investment; regional	Highlights climate risks that require the immediate attention of investors. Taking a starting point in the existing science, the report categorises climate change risk according to timeframe and probability by region, coupled with a gap analysis on available information for investors.	(Clapp, Lund, Borgar, & Lannoo, 2017)
All Swans are Black in the Dark	2Dii and the Generation Foundation	Think tank / NGO	Investment	Provides insight into how the current short-term focus of financial analysis is problematic for analysing long term risks. NB: Many other highly relevant publications are available from this organisation.	(2Dii & The Generation Foundation, 2017)
Adapting portfolios to climate change:	BlackRock	Institutional investor	Investment	Details how climate change presents market risks and opportunities for investors.	(BlackRock, 2016)

Implications and strategies for all investors, 2016					
Investing in a Time of Climate Change	Mercer	Financial Advisory firm	Investment	Presents a high level overview of the TRIP Climate Change Modelling Framework.for analysing climate impacts on investment portfolios. The report itself is Expert Analysis though the services themselves are Climate-Inclusive Consulting.	(Mercer, 2015)
Climate Change Investment Solutions: A Guide for Asset Owners	GIC	Sector organisation	Investment; Asset owners, asset managers	Provides asset owners with a range of investment strategies and solutions to address the risks and opportunities associated with climate change. The guide is targeted at asset owners and more specifically at trustee boards and investment committees, but also contains insights for asset managers.	(Global Investor Coalition on Climate Change, 2015)
Investing Through and Adaptation Lens: A Practical Guide for Investors	IIGCC, NCCARF, ANU	Collaborative effort	Investment	This guide provides insights into the investment implications of adapting to climate change. It is the product of a workshop with participants across a range of industry sectors, aims to capture investor feedback from the discussion and provide practical insights on how investors can and should be investing through an adaptation lens.	(Rissik, 2015)
Climate Change: Implications for Investors and Financial Institutions	IIGCC, CISL, UNEP FI with consultant Rory Sullivan	Collaborative effort	Investment	Synthesises the most pertinent findings from IPCC 5th Assessment Report finance and investment sectors with the aim of helping translate the science into more usable format for this sector.	(Sullivan, 2014)