CLIMATE RESILIENCE DIALOGUE

Final report

July 2024

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- Final Report -

DISCLAIMER

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Acronyms

AAE	=	Actuarial Association of Europe
AFPCNT	=	Association Française pour la Prevention des Catastrophes Naturelles et Technologiques
AFM	=	Autoriteit Financiële Markten
AI	=	Artificial Intelligence
AZN	=	Insurance Supervision Agency of Slovenia
CAGR	=	Compound Annual Growth Rate
CCA	=	Climate Change Adaptation
CCR	=	Caisse Central de Reassurance
CCRIF	=	Caribbean Catastrophe Risk Insurance Facility
CEMS	=	Copernicus Emergency Management Service
CRC	=	Climate Resilience Certificate
CRESTA	=	Catastrophe Risk Evaluation and Standardising Target Accumulations
DRR	=	Disaster Risk Reduction
DSB	=	Norwegian Directorate for Civil Protection
EC	=	European Commission
ECB	=	European Central Bank
EDO	=	European Drought Observatory
EEA	=	European Environment Agency
EFAS	=	European Flood Awareness System
EFFIS	=	European Forest Fire Information System
EIOPA	=	European Insurance and Occupational Pensions Authority
EM-DAT	=	Emergency Events Database
ERCC	=	Emergency Response Coordination Centre
ESS	=	European Statistical System
EU	=	European Union
GEM	=	Global Earthquake Model
GHG	=	Greenhouse Gasses
GIS	=	Geographic Information System
GRA	=	Global Risk Alliance
GRI	=	Global Resilience Index
GRMA	=	Global Risk Modelling Alliance
IAIS	=	International Association of Insurance Supervisors
IPCC	=	International Panel on Climate Change
JRC	=	Joint Research Centre
KB	=	Norwegian Knowledge Bank
KTM	=	Key Types of Measures
ML	=	Machine Learning
NatCat	=	Natural Catastrophe
NGFS	=	Network for Greening the Financial System
NLP	=	Natural Language Processing
NUTS	=	Nomenclature of Territorial Units for Statistics

OECD	=	Organisation for Economic Co-operation and Development
PPP	=	Public-Private Partnership
RCP	=	Representative Concentration Pathways
RDH	=	Risk Data Hub
RMSG	=	Risk Modelling Steering Group
SFDRR	=	Sendai Framework for Disaster Risk Reduction
SME	=	Small and Medium size Enterprises
UK	=	United Kingdom
UNDP	=	United Nations Development Programme
UNDRR	=	UN Office for Disaster Risk Reduction
USA	=	United States of America
USD	=	United States Dollar
WEF	=	World Economic Forum
WHO	=	World Health Organisation
ZRS	=	Zurich Resilience Solutions

Executive summary

Average global temperatures continue to rise - 2023 was the warmest year on record. Europe is the fastest-warming continent and since the 1980s it has been warming about twice the global rate. The frequency, duration, and severity of weather events, as well as the long-term effects of climate change, are increasingly causing damage and economic losses that impact people, businesses, economies, and infrastructures at large. This trend is expected to continue for years to come. The increase of economic losses due to the materialisation of climate-related events, if not accompanied at the same time by an increase in climate resilience, can further widen the already relatively large climate protection gap in Europe.

The Climate Resilience Dialogue is a temporary group of stakeholders set up at the initiative of the European Commission (EC) to discuss ways to narrow the climate protection gap and increase the resilience of the economies and societies to the effects of climate change. This report brings together insights and learnings from these discussions and puts forward actions, highlights good practices, and explores possible solutions that are conducive to building climate resilience and narrowing the climate protection gap.

The analysis of the drivers of the climate protection gap has shown that one of its contributing factors is (low) risk awareness. This is often related to insufficient access to relevant information on risks and on risk prevention measures. Developing accessible tools that provide consumers with first-hand, clear, and easily understandable information on the risks they are facing, as well as on the risk reduction measures they could implement, can be helpful in increasing risk awareness levels and climate resilience and preparedness. As climate risks differ greatly depending on the geographic location, any risk awareness campaign on climate risks should be tailor-made, must address stakeholders' varying perceptions of risk, their knowledge about risk reduction and adaptation, levels of motivation, and response capacity. Any such campaign must provide information on the respective rights and obligations and what can be expected from other actors, such as local/national governments and/or the insurer.

To evaluate how severely (in terms of economic losses) a geographic area might be impacted by the different climate-related events, risk assessments need to be conducted. Data availability is crucial to perform proper risk assessments and to measure historical, current, and future climate protection gaps. Risk assessments based on robust, easily available, and accessible data can help identify hazards, evaluate risks, support the pricing of insurance products, and inform the most suitable risk reduction measures to take.

Climate risks are long-term in nature, non-linear and systemic, making them harder to hedge or diversify and challenging to estimate solely based on historical data. Hence, forward-looking risk assessments that consider plausible long-term climate scenarios are needed to assess how the risks are changing and to pinpoint solutions to mitigate these risks.

Insurance is considered one of the key elements of the 'coping capacity dimension' of climate risks. The fact that extreme weather events are becoming more severe and frequent may affect the availability and affordability of insurance cover across all perils and hazards. There is a variety of measures that both public and private actors can take to support the affordability of cover and increase insurance penetration for climate-related risks. One of such measures is the implementation of adaptation measures by policyholders and their reflection in the insurance premium, using risk-based pricing as a key tool to send risk signals and promote resilience.

Insurance is an intangible product and its purchase relies heavily on trust that insurers will fulfil potential claims. Insurance contracts can be worded in a way that make the coverage, deductibles and limits included in the product difficult to understand and to compare among products. These factors may result in customers not being fully aware of what is covered in these products or able to assess whether they fit their needs. Product simplicity and clarity in contractual language regarding climate-related risks can help overcome some of the demand-side barriers to the uptake of insurance.

It is important to point out that 100% insurance coverage (or a 0% climate -insurance- protection gap) is neither necessarily a desirable objective, nor one that can be achieved in all cases. In practice, citizens, businesses, and public authorities may choose to not seek financial protection through insurance solutions and sometimes opt to self-insure. While insurance is pivotal in securing resilience and coping capacity, it is also important to look at other factors, such as climate adaptation, since the ability of insurers to cover for damages caused by climate-related events will increasingly depend on strong and effective adaptation measures that can improve insurability. Investments in climate resilience and adaptation and the implementation of risk reduction measures are a pre-condition of insurability.

At the moment, the vast majority of the climate resilience investment comes from public sources. However, it needs to be recognised that building resilience is a shared responsibility, and to be effective it needs to involve a wide range of stakeholders. Adaptation projects may be perceived as riskier due to the uncertainty and complexity of climate impacts, and often result in public benefits rather than direct financial returns. According to World Research Institute every dollar invested in climate resilience saves between 2 and 10 dollars in avoided losses in the future, which needs to be recognised as return both in a business and wider economic sense.

Effective and efficient risk reduction will almost always consist of a combination of different types of measures and will require cooperation of different stakeholders. For climate change adaptation, the focus is on reducing exposure and/or vulnerability, both under actual and future climatic conditions. While all stakeholders have a shared responsibility in managing and reducing risks, they have different roles and involvement in the decision making. The roles might vary for different types of risk, for the same risk in different regions and countries or for groups of stakeholders with different cultural and behavioural preferences and possibilities.

Whether insured or not, climate risk does not go away and the related economic losses will have to be addressed. Initially, these damages will be borne by the impacted individuals and businesses, and potentially through direct emergency state intervention as a last resort (with eventual tax consequences). Therefore, public authorities have a role to play not just in preserving insurability and promoting adaptation, but also in helping to cover risks that are deemed uninsurable. Addressing the twin challenges of affordability and insurability may require higher levels of mutualization, of risk sharing across economic actors (e.g., through public-private partnerships), and/or subsidisation, either as direct subsidies or fiscal incentives. These are inherently political decisions, which should be informed by sound technical analysis from relevant experts and key stakeholders. However, without smart and well-planned coordination and collaboration between private insurance markets, policyholders and public authorities, the consequences of climate risks can increasingly unfold in a disorderly and inefficient way from a social, economic and fiscal point of view.

Collaboration between public and private actors is therefore key for reducing the lack of protection and lowering the costs for a single actor. One of the most effective tools to reduce vulnerability and ensure greater risk sharing are public-private partnerships (PPP) in insurance. PPPs present several potential advantages, such as centralised expertise and data regarding climate change and natural catastrophes. There are many different sorts of PPPs and the examples of PPPs in Europe and abroad vary enormously. The design of PPPs should ensure that the risks, costs and responsibilities are clearly shared between the public and private sectors. Schemes should also encompass suitable safeguards and incentives to avoid adverse risk selection and promote risk mitigation and climate adaptation measures.

The Climate Resilience Dialogue analysed other insurance-based solutions, such as mandatory insurance coverage against climate risks and mandatory offer of climate-related insurance, which could potentially improve the affordability of insurance and mitigate adverse risk selection, thus tackling some of the (demand and supply-side) drivers of low insurance penetration. Bundled insurance against multiple climate perils offers several benefits, such as increased simplicity for the consumer, but its successful implementation depends on the generation of sufficient revenues and sound risk management by insurers, to make it an economically viable proposition. Artificial intelligence, parametric insurance and multi-year insurance are tools and products that are still evolving in the market and require further analysis to determine whether they will materially contribute or not to narrowing the current climate protection gap in Europe. Nevertheless, it is important that the insurance market continues to innovate and develop effective solutions.

Based on the analysis of the factors contributing to the climate protection gap which were identified during the discussions, the Climate Resilience Dialogue put forward a summary of actions, presented in chapter 5 of this report. The actions can be implemented by different stakeholders (public authorities, including supervisors, consumers, and the insurance industry) and aim to address the climate protection gap and increase climate resilience by their collective contribution to individual and community resilience against various hazards and in a variety of ways: by promoting risk awareness, preparedness, and proactive measures in the face of climate change. While the proposed actions are listed under the stakeholder groups with primary responsibility for leading the action, the buy-in and coordinated efforts of other stakeholder groups in the actions are essential. The participants see merit in building on the work of the Climate Resilience Dialogue to launch follow-up initiatives on the climate protection gap.

The importance of climate mitigation for risk reduction

There are two types of actions in climate change: **adaptation** and **mitigation**. Adaptation is used as a tool to tackle the negative effects of climate change, while mitigation tackles the root causes of climate change and is defined as lowering the release of heat-trapping greenhouse gases such as CO2 into the atmosphere.

During the last thirty years, the European Union (EU) has undertaken multiple measures to reduce emissions, such as shifting away from the use of fossil fuels and increasing the use of renewable energy. The European Climate Law writes into law the goal set out in the European Green Deal to achieve climate neutrality by 2050 and to cut the greenhouse gas emissions by at least 55% by 2030 compared to 1990s levels. To reach these binding targets, EU Member States have set in place tools to drastically reduce their emissions and find ways to compensate for remaining and unavoidable emissions. Other objectives set under the law are to create a system for monitoring progress and take further action if needed, provide predictability for investors and other economic actors, and to ensure that the transition to climate neutrality is irreversible.

Notwithstanding all the efforts made to reduce emissions, the impacts of the climatic conditions will not decline any time soon and there is a significant chance that the world will temporarily overshoot 1.5°C already before 2026. Even if emissions come down quickly, the physical impacts will continue to worsen for the foreseeable future, due to inertia in the climate system.

The Climate Resilience Dialogue has been set up to address the climate protection gap that is related to the physical risks of climate change, therefore the discussion and proposed action focus mainly on climate adaptation. However, the group recognises that without taking mitigation measures today, the future adaptation costs will increase. Adaptation and mitigation are complementary and should be both pursued with the same energy and commitment.

In Europe, which is the fastest warming continent globally, climate risks such as extreme heat, drought, wildfires, and flooding are threatening energy and food security, ecosystems, infrastructure, financial stability, and people's health. The losses from extreme weather events deriving from climate change will continue to occur in the future, potentially resulting in issues of affordability and availability of insurance cover. To reduce the climate protection gap and keep risk reduction and adaptation measures affordable in the future, taking mitigation measures is incredibly important.

Though this report primarily discusses adaptation as a tool for risk reduction, mitigation is equally important for risk reduction in the long-term.

Introduction

This report is the result of the work of the Climate Resilience Dialogue, a temporary group set up by the European Commission that gathered, since its launch in November 2022, representatives of a wide range of stakeholders to discuss climate protection gaps in Europe, good practices, and possible solutions to address them.

The main objective of the Climate Resilience Dialogue is to narrow this climate protection gap – the gulf between how much is lost and how much is insured - and to find ways to increase climate resilience, with a focus on adaptation. The primary task of the Climate Resilience Dialogue is to exchange views on how to address the losses incurred from climate-related disasters and to identify how the insurance industry in collaboration with other stakeholders can contribute more to climate resilience, from actions that increase the penetration of climate risk insurance, to making the conditions right for more investment in good adaptation solutions.

The Climate Resilience Dialogue is the result of one of the concrete actions included in the European Union Adaptation Strategy (European Commission, 2021) and in the 2021 Strategy for Financing the Transition to a Sustainable Economy (European Commission, 2021) to address the climate protection gap. Both strategies are part of the European Green Deal.

The special group produced an Interim Report, which was published in July 2023 (Climate Resilience Dialogue). In the Interim Report, the Dialogue defined the climate protection gap as the difference between economic losses and insured losses from the materialisation of climate-related risks. Moreover, the Interim Report included preliminary findings of the group on the identified climate protections gaps and the outlook for further work towards the final report.

The Final Report is **structured** as follows:

- First, it provides a brief overview of the main climate-related perils and hazards to which people, businesses, and assets are exposed and vulnerable to today in Europe (chapter 1).

- Then, an analysis of the key contributing factors of the climate protection gap is made, encompassing risk awareness, risk assessment and other supply and demand factors such affordability of the premiums, mistrust vis-à-vis insurance and limits to the insurability of risks (chapter 2).

- Subsequently, an analysis into the solution space is made focusing on risk reduction, risk sharing and risk transfer approaches, such as public-private partnerships and other insurance-based solutions, including evolving insurance-based approaches that have the potential to overcome some of the barriers of the climate protection gap (chapters 3 and 4).

- Finally, a deep-dive is made into the main climate-related perils in Europe, covering floods, wildfire, heatwave, drought and storms, including lessons, good practices, and potential solutions stemming from past events that could be implemented to increase climate resilience (chapter 6).

This report is an attempt to bring together existing insights, lessons, and learnings, with the aim to propose actions as well as integrated and/or collaborative approaches to the climate protection gap that help meet the needs of different types of stakeholders. These are summarised in chapter 5.

The members of the Climate Resilience Dialogue (Annex 3) appreciate the opportunity this initiative has provided for an open and constructive exchange of views and expertise, which is particularly important for such overarching, complex and multi-faceted topics as the climate protection gap and the impact of climate change on economies, society and the insurance sector. This stakeholder Dialogue allowed for an open and comprehensive discussion, as well as the formulation of proposed actions, possible solutions and good practices that increase climate resilience and contribute to the reduction of the climate protection gap, while considering different positions and stakeholder perspectives. The participants see merit in building on the work of the Climate Resilience Dialogue to launch follow-up initiatives on the climate protection gap.

1 Climate-related hazards in Europe

Average global temperatures continue to rise. Between June 2023 and May 2024, they exceeded pre-industrial levels by 1.63°C[1] (Copernicus). 2023 was recorded as being the warmest year on record, and Europe was identified as the fastest-warming continent. Since the 1980s, warming on the continent was about twice the global rate. This means that the frequency, duration, and severity of weather events, as well as long-term effects of climate change, are increasingly causing damage and related economic losses and impacting people and businesses, as well as societies, economies, ecosystems, and infrastructures at large, and this trend is expected to continue for years to come[2]. While the increased frequency and severity of climate-related events has a significant impact on the total economic losses, their increase is also driven by an increasing exposure at risk of losses driven by urbanisation, increase of prices and economic growth[3].

In this context, the most pertinent climate-related perils and hazards in Europe today are **floods, wildfire, heatwave, drought, hail, and storms**. All of them have immediate, as well as longer-term impacts, and there are interlinkages between different perils and hazards, which are further enhanced in line with the accelerating pace of climate change. The related economic losses from the materialisation of climate-related events, if not accompanied by the same pace of an increase of insurance coverage and investment in climate resilience, will further widen the climate protection gap.

This report will cover the above-mentioned perils and hazards (except for hail) but it will not cover other types of events for which protection gaps, sometimes significant, also exist and which are also important to address - such as earthquake, landslide, subsidence and rising groundwater, and hail, among others.

Floods are the most frequently occurring type of natural perils that can turn into disasters, and affect more people globally than any other natural hazard (European Commission). Floods can have various causes (e.g., pluvial, coastal, riverine) and can result in loss of life and distress, in forced relocation[4], and widespread physical losses, including damage to personal property and public infrastructures.

Wildfires are unwanted and uncontrolled fires that occur in nature, most commonly in a forest, vegetation or grassland (European Commission). Wildfires cause damage to the natural area, to properties, and to health when burning near a populated area. Houses can be burnt or severely damaged by the fire that catches on combustible materials on or near the property. Smoke from large-scale wildfires can also damage human health.

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[1] IPCC AR6: The occurrence of individual years with global surface temperature change above a certain level, for example 1.5°C or 2°C, relative to 1850–1900 does not imply that this global warming level has been reached. The Paris Agreement temperature goal is to be understood as human-made temperature change averaged over 20-30 years – in other words to climate change, not variability from year to year.
[2] European Climate Risk Assessment (EEA).
[3] See: "Changing climates: the heat is (still) on" (Swiss Re Institute).
[4] A recent study found that, in the United States, over 3 million citizens can be considered climate migrants as they have had to move away from their street or neighbourhood in the wake of flood risk.

Heatwaves are becoming more frequent in Europe. In 2023, Europe saw a record number of days with 'extreme heat stress' (Copernicus). Heatwaves are characterised by unusually high temperatures during the days and nights in the summer period. The impact of heatwaves on human health is a central issue of this peril. However, heatwaves can also damage agriculture, natural ecosystems, properties, infrastructure and have economic effects marked by a loss of productivity and an increased demand for energy from cooling appliances. The excess heat is further linked to the perils of drought and wildfire as the excess heat can be a trigger for wildfires of dry vegetation.

Drought is 'a climate extreme characterised by persistent unusual dry weather conditions affecting the hydrological balance' (EDO). The conditions are usually associated with lack of precipitation, deficit in soil moisture and water reservoir storage, leading to widespread impacts. Droughts can be exacerbated by heatwaves. Droughts can last for weeks or months, and often cannot be marked by a clear beginning and end point. They can lead to water scarcity and, as such, can have a severe effect on different economic activities and sectors, including tourism, transportation infrastructure, renewable electricity production (hydroelectric), agriculture, forestry, as well as water resources, and biodiversity. Droughts lower water levels in rivers and groundwater, inhibit the growth of trees and crops, and as a result they also intensify pest infestations, and contribute to the escalation of wildfires (European Commission). Prolonged droughts can also create favourable conditions for wildfires.

Storms are among the most frequent and most damaging natural catastrophes, as they can cause many types of damage to properties, including destruction from high winds (of roof tiles, solar panels, windows, objects dislodged or carried in the wind), electrical damage from lightning, damage to infrastructure (such as powerlines, roads, railways) and even severe health damage and death (Euronews; Politico). Swiss Re estimated that in the first half of 2023, severe thunderstorms accounted for up to 70% of all insured natural catastrophe losses – particularly driven by storms in the US. The effect of storms with heavy rainfall can also cause flooding. Moreover, while thunderstorms can start wildfires, wildfires can also cause convective storms due to the disruption in the weather (Insurance Information Institute).

A deep dive into floods, wildfire, heatwave, drought, and storms, with a focus on the hazards, exposure, and vulnerability challenges associated with these events can be found in chapter 6.

2 Factors contributing to the climate protection gap

The climate protection gap is defined in this report as the difference between economic losses and insured losses from the materialisation of climate-related risks. The European Environment Agency (EEA) estimates that only around 19.5% of economic losses from extreme weather- and climate-related events in Europe in the period 1980-2022 were insured, with large disparities across countries (EEA, 2023). This indicates that there is a relatively large climate protection gap at EU level. All EU countries are exposed to climate-related risks and, as shown in the dashboard of the European Insurance and Occupational Pensions Authority (EIOPA) on insurance protection gap for natural catastrophes, protection gaps exist in all countries even though the magnitude and specificities of the gaps vary from country to country (EIOPA, 2023).

To make informed decisions on how to narrow the climate protection gap in the European Union, it is important to understand first why these protection gaps exist, keeping in mind that the situation varies sometimes significantly across countries and that the drivers of protection gaps differ from one stakeholder to another.

This chapter analyses some of the contributing factors or drivers of the climate protection gap generally, and the uptake of insurance specifically, starting with risk awareness factors, followed by risk assessment factors, related data issues, and finally the key (demand and supply side) drivers of the climate protection gap: affordability, (mis)trust and insurability. At the end of each section, considerations to address these factors are made.

An overview of some of the drivers analysed in this chapter, and mentioned throughout the report, classified into supply and demand side factors, are summarised in Table 1.

Table 1: Summary of supply and demand side drivers of climate protection gaps

Supply	Demand
Difficulty to address information asymmetry/adverse selection (e.g., due to those who have experienced losses being more prone to buy insurance) and avoid moral hazard (e.g., due to expectation of government support)	Low levels of risk awareness, risk perception and risk knowledge - section 2.1.1
Legal and regulatory framework and environment	Reliance on the expectation of government support (i.e., 'charity' hazard) [section 2.1.1]
Lack of data availability or accessibility to price risks more accurately - section 2.2	Lack of awareness of available insurance solutions/products and incorrect assumptions of cover (i.e., 'insurance illusion') - section 2.1.1
Limits to insurability of risks - section 2.5	Cultural factors and behavioural biases - section 2.1.2
Decreasing level of capacity of the insurance market (including the [un]availability of reinsurance) - section 2.5	Complexity of insurance products leading to misunderstandings and lack of clarity of policy wordings (coverage and exclusions) - section 2.1.3
	Limited access to relevant information or data on risks - section 2.2
	Unaffordability of the premium - section 2.3
	Mistrust vis-à-vis the insurance industry - section 2.4

Notes: Supply in this context is the availability of affordable and prudentially sound insurance solutions to cover the damages stemming from climate events. Demand in this context is the demand of consumers to buy insurance solutions to cover the possible damages from climate events.

2.1 Risk awareness factors

The International Panel on Climate Change (IPCC) defines '**risk**' as a "*result of dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human* (both social and economic) *or ecological system to the hazards*" (IPCC AR6, 2023). For this report, the focus is narrowed down mostly to property and assets. The three components of risk are:

- **hazard**, i.e., physical variables that define the frequency and intensity of a certain event;
- **exposure**, i.e., characteristics and information of the buildings and respective content that might be hit by the event (e.g. number of floors, presence of basements, etc.); and,
- **vulnerability**, i.e., the conversion of the intensity of any event into the loss of value of building or content or both, taking into account the exposures' characteristics.

Risk awareness refers to the level of understanding and knowledge that individuals, communities, businesses, and policymakers have about potential risks. It involves recognising and acknowledging the existence of risks and their potential impact.

In the context of the climate protection gap, risk awareness is a pre-condition for preparedness, enhanced resilience, and provides the necessary information for decision-making and long-term planning.

This section explores the factors leading to risk awareness, the explanations for shortcomings in risk awareness as well as examples of good practices and possible actions to foster risk awareness, financial education, and preparedness.

2.1.1 Risk perception, risk knowledge and moral hazard

The key drivers of risk awareness are risk perception and risk knowledge.

Risk perception refers to how individuals or groups subjectively perceive, interpret, and evaluate risks. This involves the subjective assessment of the likelihood and severity of potential risks and can be influenced by various factors, such as personal beliefs, values, social influences, and media coverage. For instance, policyholders may have awareness about certain risks but underestimate their severity or likelihood[5].

There are four key features that are driving misalignment between risk perception and risk awareness: (i) perceived exposure; (ii) perceived severity; (iii) risk experience; and (iv) risk culture.

The perceived exposure to climate change-related risks is a good risk perception barometer. The decision to obtain insurance coverage for climate change-related risks is influenced by risk perception, even though it may not accurately represent an individual's actual risk. Frequently, both consumers and businesses fail to accurately assess their true level of exposure to climate-

[5] The UK Committee on Climate Change 2020 report explains how behavioural science approaches can influence risk understanding and how cognitive bias may impact risk action.

related risks. Often, they underestimate the potential losses or the likelihood of an event or disaster, leading them to perceive insurance protection as unnecessary. For example, an average of over 30% of respondents (from Belgium, Romania, Spain and Germany) to a survey conducted by EIOPA on natural catastrophe (hereinafter, NatCat) insurance uptake (EIOPA, 2024) stated that the main reason for not being insured was that they considered such NatCat events to be very unlikely, while in reality many of them could be affected by such events. A survey conducted by the Dutch homeowners' association on flood risks(VvE, 2024) found that only a quarter (24%) of the 1,038 homeowners surveyed stated they live in a flood risk area, while in reality more than half (54%) did.

The perception of risk severity is a widely recognised indicator of risk perception. In the '*2024 Global Risks Report'* of the World Economic Forum (WEF, 2024) two-thirds of respondents rank extreme weather events as the risk most likely to cause a material crisis on a global scale in 2024. It is also seen as the second-most severe risk over the two-year timeframe and nearly all environmental risks feature among the top 10 over the next 10 years.

Another factor playing a role in purchasing insurance is risk experience. When it comes to climate change-related insurance, the majority of people lack firsthand experience with catastrophic events and the associated losses, which may diminish risk perception and thus affect the uptake of coverage (EIOPA, 2024). According to EIOPA's consumer surveys, risk perception and uptake of insurance coverage were closely linked to consumers' previous experiences with NatCat events, and consumers who live in areas with greater NatCat risks declared themselves more likely to get insured against them. This is supported by findings in the '*White Paper on Climate-related Insurance Issue'* from Agéa (French National Federation of syndicates of insurance general agents), which highlights that coastal populations are more aware of natural hazards in coastal areas than other population categories.

Risk culture also plays an important role in risk awareness. A strong risk culture, with transparent and accessible information, prevents the creation of a false sense of security and complacency. Therefore, risk culture should be promoted and further encouraged in local communities by using tools such as modernising natural risk prevention plans and developing local protection plans. Furthermore, it needs to be supported by clearly defined roles and responsibilities: everyone who makes risk-relevant decisions is well informed and enabled to take responsibility for managing risks. In this sense, governments and regulators play a vital role in the coordination and initiation of risk management efforts (McLennan, 2023). At enterprise-level, a dedicated function of Risk Manager can help to permeate a risk management culture throughout – generally large – organisations.

Risk knowledge refers to the link between the way individuals or businesses perceive and understand their susceptibility to risks and their knowledge of local hazards. Having a comprehensive understanding of these risks can motivate consumers and businesses to take appropriate measures in response to potential disasters or local risks, and thus adapt to climate risks (Cong Ngo, 2021). However, sometimes the risk knowledge does not translate easily into appropriate actions. For example, the data clearly shows that 10% of new business premises built in England and Wales between 2008 and 2018 will be exposed to high or medium level flood risk by the 2050's under a 2°C warming scenario, and 15% under a 4°C warming scenario. However a survey by Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science (LSE) (LSE, 2021) found that while many businesses (45%) are concerned about possible climate risks, they have not yet assessed them. Half of the businesses which have been affected by flooding in the previous year expected the potential financial impact of climate risks to increase over the next three to five years, however only 13% could give a specific number for what it cost them.

Another factor that comes into play is the consumer's knowledge of available insurance products and their features. In its revised staff paper on '*Measures to address demand side aspects of the NatCat protection gap*' (EIOPA, 2024), EIOPA explains that the fact that insurance undertakings spend a minimal budget on advertising NatCat insurance products makes consumers less aware of their existence and benefits. According to this study, the third most reported reason by uninsured participants for not being covered is the lack of awareness of the existence of NatCat coverage.

Along with the risk awareness and risk perception, insurance uptake is also influenced by reliance on government support (Browne and Hoyt, 2000). One of the most important factors is the phenomenon of so-called '**charity hazards**' (Tesselaar et al, 2022), wherein the expectation of government compensation for uninsured damage diminishes the incentives for individuals to seek insurance coverage, particularly in regions where insurance is optional, as is the case in many EU countries. Therefore, a combination of low risk awareness, risk misperception and high expectations about state intervention drives down consumers' willingness to buy insurance against climate risks.

2.1.2 Cultural factors and behavioural biases

In the staff paper '*Policy options to reduce the climate protection gap*' (ECB-EIOPA, 2023), the European Central Bank (ECB) and EIOPA suggest that a lack of awareness regarding the risks faced by businesses, government entities, and individuals may stem from limited access to relevant information or data, and that cultural norms, attitudes and behaviours may also contribute to this gap in awareness.

Under the banner of cultural factors, the combination of risk perception and knowledge and 'charity hazard' as well as the absence of a widespread culture of purchasing insurance products and services in certain regions, could explain low demand for insurance. These factors can differ significantly across European countries, particularly in regions where insurance is optional. Other behavioural factors or biases that influence the demand for insurance, such as loss aversion and mental accounting (i.e., different values a person places on the same amount of money based on subjective criteria.

2.1.3 Contract design, policy wordings and exclusions

The fragmented nature of insurance coverage against natural catastrophes in many European countries is potentially a significant contributor to the climate protection gap, as standard household insurance products sometimes exclude the indemnification of damages linked to certain climate-related risks. A study conducted in Germany (Groß and Wagner, 2023) explains that 95% of homes in Germany buy home insurance against hail and storm but only 52% are insured against flooding, heavy rain, land subsidence, and other NatCat and climate-related risks.

For consumers, there is often considerable uncertainty or misconceptions about which natural disasters or climate-related events are covered or should be covered or not in their homeowner insurance policy. Policyholders may mistakenly believe that their contract includes coverage against (specific) climate perils, when in fact this coverage may only be purchased as a separate policy (or as an additional rider on the original contract). The aforementioned study (Groß and Wagner, 2023) shows that some consumers make incorrect assumptions about their insurance cover, believing they are insured against natural hazards when in fact they are not. This happens regularly (the effect explains roughly 12% of consumers underinsurance against climate-related perils in Germany, for example) and is known in the literature as the '**insurance illusion**' (Osberghaus and Philippi, 2016). In addition, the lack of risk knowledge, accompanied in some countries by the lack of homeowner contract standardisation covering climate or NatCat relevant perils, can explain low insurance penetration for some countries and perils.

When purchasing insurance consumers need to spend time and effort on understanding and evaluating various risk coverage options to see if they fit their needs and often have difficulties in comparing insurance products. As stated by the International Association of Insurance Supervisors (IAIS, 2023), the process of purchasing insurance and understanding the various risk coverage options available can be burdensome, which consequently may deter the uptake of natural catastrophe coverage.

In general, exclusions are common in the insurance business and allow a variety in the offer to customers. Although insurance contract law is not harmonised at EU-level, there are pre-contractual disclosure and insurance distribution requirements in place to enhance transparency and protect consumers (e.g., the Insurance Distribution Directive[6]). Nevertheless, exclusions can be worded in a way that make the coverage, deductibles and limits included in the product difficult to understand, which in turn may result in the situation where customer is not fully aware of what is covered or not by their policies or be able to assess whether they fit their needs. This, along with other factors, can ultimately discourage the purchase of the insurance product thus contributing further to underinsurance.

[6] Directive (EU) 2016/97 of the European Parliament and of the Council of 20 January 2016 on insurance distribution (recast).

2.1.4 Considerations to foster risk awareness and financial education

It must be noted that while risk awareness and financial education are crucial initial steps, they alone do not provide a complete solution and it is essential to implement cost-effective insurance solutions and incentives for risk mitigation and prevention in order to make significant strides towards enhancing community resilience (Guy Carpenter).

It is also important to improve, where necessary, simplicity and clarity in contractual language, for example by clearly setting out the definition of perils and what kind of damage is covered in the relevant policies (e.g., the parameters and timeframe included regarding damage from rain, flooding, wind, lightning, hail, etc.), as crucial coverage gaps may not be evident (Zurich PERC, 2021). Moreover, improving business conduct is as important as consumer education, therefore market conduct authorities should ensure that good practices take place.

While insurers, insurance intermediaries and stakeholder associations can help to disseminate information, or even provide training, it is crucial that public authorities strive to help communities and corporations by sharing either standards or information on climate and natural catastrophe risks and adaptation measures.

Examples of good practices to increase risk awareness through access to relevant information or data

Access to accurate information is key in increasing risk awareness. Developing accessible tools that provide consumers with first-hand and clear information on the risk they are facing can be helpful in increasing insurance uptakes and fostering climate resilience and preparedness. It is important that consumers are well informed about financial loss information (e.g., how much loss someone would experience due to a NatCat event), how to mitigate the risk, and/or how long it would take to pay back a specific prevention-related investment that can reduce or prevent a potential loss.

There are already tools available that help raise awareness about climate-related risks. Examples of such tools include:

- **EIOPA dashboard for natural catastrophes** (EIOPA, 2023), which shows in a graphic way the insurance protection gap for natural catastrophes in 30 European countries, including information on the national schemes in place.
- **Public or independent online risk zoning tools** (similar to Flood Risk Areas Viewer) that enable consumers to consult the level of risk of their regions and of their type of house, and they allow consumers to easily understand the risks their property is exposed to.
- **Specific risk awareness tools or advice**: more sophisticated tools using for example location and type of property, building on historical data, to determine the likelihood of experiencing different NatCat events. Inspiration could be taken from similar kinds of tools or advice provided from other sectors. For example, the Netherlands introduced energy performance labels to provide information on energy efficiency of homes to potential buyers (Dirk Brounen and Nils Kok, 2011). Also, in Germany, the Energy Caravan

campaign uses a neighbourhood approach in which municipalities offer citizens free energy advice at the homes and businesses on building-relevant topics; similar tools or advice showing the vulnerability of properties to NatCat risks could be considered.

- **Risk mapping for policyholders**: Public authorities, insurers and insurance intermediaries play a critical role in informing policyholders with regard to the risks to which they may be exposed (Agéa, 2024). In France, public authorities offer the Georisques tool, which allows citizens to map natural and industrial risks, to consult the decrees recognising the state of natural disaster in the municipality, or to identify the risk prevention plans implemented in the municipality. Some insurers offer natural risk mapping matrices or real-time information systems for policyholders. For example, a French mutual insurance company Maif relies on Geohazards data to feed its 'Environs' matrix, adding an inventory of local property prices and other information related to the risks that affect policyholders (power lines, underground cavities, etc.). Another example is Generali Climate Lab, a multidisciplinary team of high-level experts that carry out a detailed mapping of natural risks, alert policyholders in real time about so-called 'risky' climatic episodes, with advice on the right actions to limit potential damage.

- **Tools to assess real estate climate risks**: For example, the Swedish Property Federation developed some tools (guidance on climate proofing of properties, a web-based screening tool and an EU Taxonomy guide) targeted to commercial real estate operators to assess real estate climate risks in Sweden. Similar initiatives exist in the Netherlands, e.g., BlueLabel.

These tools can be helpful in raising awareness if used in the right moments (i.e., when consumers look for properties to buy or rent) as they provide specific information on the NatCat risks for the specific zoning area.

Supervisory and regulatory measures

Supervisory authorities can also play a role in raising awareness of climate-related risks and increasing financial education as highlighted by the IAIS in a paper on the role of insurance supervisors in addressing NatCat protection gaps (IAIS, 2023). Such measures can include:

- **Socialising useful and reliable sources of information on NatCat events or tools or portals to help consumers assess their risk** by, for example, providing science-based materials and governmental advice/data, which may aid consumers in understanding their own risk exposure. In France, the national authorities, the Caisse Centrale de Réassurance (CCR) and the insurance companies cooperate with communication and information associations to have an open exchange of information on insurance and adaptation measures.

- **Forming partnerships with other key stakeholders to develop an educational and risk awareness strategy to educate the public on NatCat risks and the role of insurance in building resilience and providing financial protection against such events.** For example, in response to severe flooding in Slovenia in 2023, the Insurance

Supervision Agency of Slovenia collaborated with insurance companies and the Ministry of Finance on analysing the scale and cause of underinsurance for such an event, developing resources to assist affected parties and recommendations on risk mitigation against future events.

- **Conducting research to better understand how consumers perceive and manage risks to identify potential barriers to taking out insurance coverage**.

  As highlighted in the IAIS's paper, initiatives to enhance consumer financial literacy and risk awareness can take the form of broad programs supported by the government, insurance industry associations, insurers, or a collaborative effort involving multiple stakeholders.

In addition to its work on the protection gap dashboard, EIOPA is working on developing a blueprint for climate risk sheets, to serve as a practical tool to enhance risk awareness and the understanding of related prevention measures among society and the industry, with the aim of reducing insured losses and supporting the take-up of insurance coverage. A similar idea is a diagnosis of vulnerability to natural hazards for each real estate property, based on the same model as the one for energy performance, which would influence the conditions of access to house and professional insurance policies (Agéa). The effectiveness of these tools in raising climate risk awareness could be further supported by introducing a requirement for sellers to provide information on climate hazards to prospective house buyers and renters.

Future risk awareness campaigns

Risk awareness campaigns can be helpful in mobilising households, businesses, policymakers, and other stakeholders. Targeted messages in a specific risk area prior to and/or following NatCat events may increase insurance uptake (ECB-EIOPA, 2023) and build climate resilience and preparedness.

Risk awareness campaigns should be tailor-made because climate risks differ greatly depending on the geographic location. Risk awareness pertains not only to the -differentiated- physical risk exposures, but also depends on the legal and general market context. Therefore, there should be information available on the institutional and market situation, along with the information on the rights and obligations and what you can expect from other actors, such as local/national government and/or insurer. It is important that awareness-raising campaigns take all these factors into account.

Effective communication on climate-related risks and possible risk mitigation measures must address stakeholders' varying perceptions of risk, knowledge about risk reduction and adaptation, levels of motivation, and response capacity. Therefore, stakeholder associations (e.g. consumer and SME organisations) should be involved in this process. Moreover, it would be important to conduct a study campaign by targeted segment, community, and geography to customise the campaign to the actual exposure of the community and the pre-existing level of risk perception.

In addition, it would be important to use impartial communication channels for those campaigns (like public institutions, government, relevant stakeholder associations and community forums) that are trusted and show an alignment of interest to the decisionmaker.

Finally, it is important to consider behavioural change frameworks that can incentivise autonomous adaptation. Allowing for cognitive biases is key when developing any communication plan or incentive strategy, and in some cases simple nudging tactics (e.g., opt-out versus opt-in) may be more effective than overt efforts to convince people to take a risk-reducing action.

2.2 Risk assessment factors

As discussed in the previous section, risk awareness is the first step towards addressing the climate protection gap. To be aware of the risks, it is necessary to assess them. **Risk assessments** help evaluate how severely (in terms of economic losses) a geographical area might be impacted by the different climate-related events, including the losses to any structures and contents of buildings regardless of the scope of use (residential, commercial, or industrial). It needs to be emphasized that risk assessments should be also included in land use and planning decisions (e.g., on new urbanisations, which need to take into account climate risk considerations). Understanding and assessing the climate protection gap is an important steppingstone toward pinpointing concrete actions to narrow it. Risk assessments are needed, inter alia, to:

- identify hazards and evaluate the existing risks;
- educate communities and the wider public on potential risks and to raise awareness;
- adopt the most appropriate adaptation measures, on small or large scale, at national/societal level; and
- support the proper pricing of insurance products, or support and advise customers on risk reduction measures potentially leading to lower insurance premiums.

This section first elaborates on issues and limitations regarding available data and the availability of modelling and risk analytics, then provides an overview of adaptation measure assessment and forward-looking risk assessment, and finally discusses actions that could lead to an improvement of climate risk assessments.

2.2.1 Data issues

Data availability is crucial to perform proper risk assessments and to measure the climate protection gap. Risk data should support the modelling of the three components of the risk deriving from climate-related losses: hazard, exposure, and vulnerability.

A good starting point for risk assessments are **historical loss data** as they are useful for assessing the development of the damages over time and for different events. They can help local, regional, and national governments, insurers and supervisors to monitor whether losses are increasing in specific regions and/or for specific perils. However, past data does not provide sufficient information on potential future losses for emerging climate-related risks and using historical data to assess the current and future risk would underestimate the potential impacts. Therefore, it is important that risk assessments adopt a forward-looking view of climate risks, notably based on climate-informed scenario analysis, and not only rely on backward-looking statistical evidence. Nevertheless, starting from the available historical loss information (for a limited period) would provide an anchoring point for an assessment of the risk.

From the **exposure** perspective, it is important to access detailed information on buildings and contents inside a building that may suffer damages due to different climate events[7]. The data must be kept up to date to provide an updated view on infrastructures and necessary defence measures. In addition, it is also very critical to precisely geo-localise the exposures, i.e., by converting the location of buildings into latitude and longitude coordinates[8].

The **vulnerability**, expressed as the relationship between the hazard intensity and the potential losses caused to the identified exposures by this hazard, is based again on historical experience of losses and on specific modelling on how, for example, a certain material or building structure reacts to a certain hazard[9].

In addition, to measure and understand the insurance protection gap, it is necessary to have information on the insurance availability, such as:

- the type of natural or climate-related events included in the insurance policy;
- the degree of insurance coverages that are effective in a certain area, expressed as a percentage of the total insurable value (e.g., the value of building which is insured);
- geographical data related to the territory on which the building or the asset is located;
- the insurance premium;
- whether a national scheme is in place and to what extent part of the cost of insurance is subsidised or not;
- whether insurers and/or building owners respectively are obliged to either underwrite or take up insurance (i.e., mandatory offer of insurance coverage or compulsory insurance);
- the type of exclusions that are present in the insurance coverages; and

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[7] For example, the presence of basements or the distance from a river are very relevant information for the risk assessment of losses derived from flood events but not from hailstorm or cyclone events.

[8] It has to be noted that it is equally important to be accurate in case of multi-location, i.e. a large site or geographical area that contains multiple buildings, that have to be disaggregated properly to identify what exposures or values of buildings and contents might be hit by an event. For example, if a large site has three buildings, the first 1 km from a river, the second 3 km and the third 7 km, clearly the impacts on the three buildings in case of flood it will be different, and it would be less accurate to consider a single sited exposures or other kind of simplifications.

[9] Typically, these models are developed by academic researchers and specialised companies, for which the advent of new technology is a boost: for example, through artificial intelligence (AI) it is possible to simulate with more accuracy the impact of flooding on buildings and contents based on a set of variables, such as the distance from a river, the slope, water speed, etc.

- the level of deductibles (i.e., the % or fixed amount of the losses that is retained by the policyholder) and limits (i.e., the threshold above which the policyholder is not covered by the insurance policy) that are in place.

Assessing climate risks and the associated climate protection gaps requires accessing data and models. It also requires considering adaptation measures and conducting forward-looking assessments. For example, to assess the historical protection gap, historical loss data is needed. To assess the current protection gap models can be used, and to capture the future protection gap, models with a forward-looking perspective are needed.

However, there are several **issues and limitations regarding data**. While multiple loss data sources are available, they are not necessarily open-source and, when they are, they might not be complete with regard to (insured) loss data, like for example the open-source loss Emergency Events Database (EM-DAT), which has more of a humanitarian than economic focus. Moreover, it is also difficult to compare the data when the methodology and underlying assumptions are not fully transparent. Other challenges include issues of comparability of data sources in terms of methodologies and the assumptions applied, the fact that there is no common reference to one or more climate event (i.e., no common 'ID' or identifier related to a particular event), or that there is no common delineation of the affected areas (e.g., Catastrophe Risk Evaluation and Standardising Target Accumulations - CRESTA, Nomenclature of Territorial Units for Statistics - NUTS, or Local Administrative Units - LAU[10]).

Against this background, an open-source database capturing the **economic and insured losses** for EU events using a similar methodology would help policymakers and the industry to have access to a view of the insured losses versus uninsured losses (which is a common way not only to measure the historical insurance protection gap, but also to calibrate models and to design adaptation measures). This open-source data should provide data at an aggregated level (by regions or municipalities, for example).

When it comes to **data needed to model the risks**, a common challenge of hazard, vulnerability or exposure data is the spatial granularity and whether it is satisfactory or sufficient to meet the needs of the user. For example, a model developer would need very detailed data at asset level to be able to build or validate new models, while another type of user may need data that is less spatially granular (e.g., data aggregated at regional or country level). Moreover, there might also be more data available for perils/regions where the insurance protection gap is small (as usually well covered by models which help insurers to assess the risks).

Against this background, developing an open-source access to common European hazard, vulnerability and exposure data would be a good starting point to help policymakers, public

[10] CRESTA defines two types of zone for each of the countries which it covers: (1) low-resolution CRESTA Zones, and (2) high-resolution CRESTA Zones. Low-resolution CRESTA Zones generally follow administrative boundaries (e.g. province or county boundaries) or merged postal code areas (e.g. first-two-digit postal code areas). High-resolution CRESTA Zones generally follow the full postal code areas (e.g. 4- or 5-digit postal code areas). NUTS or 'Nomenclature of Territorial Units for Statistics' is a standard for referencing the administrative divisions of countries for statistical purposes. The standard is developed and regulated by the European Union. Finally, LAU or local administrative units are the building blocks of the NUTS and statistical regions, comprising the municipalities and communes of the European Statistical System (ESS).

sector, businesses, business associations, and others to have a complete and trusted view on the protection gap. Given the large coverage of the dataset (all EU countries), to offer first-hand open-source information to the public, the data could be provided at a certain level of aggregation (e.g. country, regional, local-level). However, it should be borne in mind that model developers, the insurance industry or local municipalities would need more detailed or granular data. For this, more work needs to be done by data owners such as governments, insurers and data providers (who collect/share data) to ensure that the level of detail of the data is adequate to meet the needs of the end-user, for each peril.

To perform risk assessment and to be able to deliver improved climate protection, both **modelling and analytical capabilities** are necessary. Such tools can help policymakers, financial markets and exposed communities better understand their climate risks and to make, communicate and implement better decisions. Annex 1 provides an overview of model and analytical capabilities availability and current initiatives in this area. However, most of the available models have their issues and limitations.

The catastrophe modelling market is dominated by a limited number of large players offering commercial catastrophe models. The business model and pricing structure of the commercial model providers result in a focus on the known risks and perils. As a result, perils and regions with high insurance penetration are modelled extensively, while others with low insurance penetration are modelled less, creating issues in understanding the protection gap in insurance. In this regard, a better coverage of perils and regions is needed to be able to perform risk assessments and ultimately take actions to address the corresponding protection gap. Moreover, for some stakeholders, such as small and medium-sized enterprises (SMEs), commercial models can be very expensive, and some models might lack transparency, because the intellectual property does not always allow access to the underlying assumptions (black box models).

Catastrophe models provide predictions based on the data used in their input, therefore predictions provided by different catastrophe models can vary significantly. It is possible for two different catastrophe models to give out two quite different predictions (e.g., due to different assumptions or climate projections, *inter alia*). These models are also geared toward annual repricing and not forward-looking risk management for longer time horizons, which could be an issue when it comes to climate change considerations.

Given all the above, open-source models might reduce the costs of running climate change analyses, but with different needs to be addressed like the maintenance and the evolution of these models. In addition, because of the importance of the catastrophe models used by the insurance sector, it would be important to work towards enhancing understanding of these models by supervisors to ensure a proper assessment of risk.

2.2.2 Adaptation measure assessment

Adaptation measures (such as for example, flood barriers or nature-based solutions) are essential for decreasing the impacts from climate change. Adapting and mitigating climate change are key elements necessary to address insurance protection gaps and without them, climate-related risks will only keep increasing and make insurance coverage unaffordable or unavailable.

For climate adaptation (climate resilience building) to be beneficial, it should not be solely reactionary (i.e., after a particular event), but rather proactive and anticipatory (Bouwer and Aerts, 2006). To take proactive measures, it is important to be able to assess the range of adaptation measures that could and should be implemented. This assessment is useful for a range of stakeholders: for all levels of governments, which have a key role in implementing adaptation measures, for homeowners wishing to better protect their properties and for (re)insurers, to ensure continuous and long-term insurability.

Adaptive measures should also be aligned with a 'just transition' that avoids isolating vulnerable populations living in high-risk areas. Preventative measures should also be taken to avoid development within highly vulnerable regions to minimise unnecessary risk.

It is important to mention the increasing (and necessary) trend of local and regional governments involving non-expert local stakeholders (citizens and entrepreneurs) in these assessment processes (Oliver et al., 2023). Adaptation measures should be part of the overall risk assessment process and the right conditions need to be in place for this to happen.

For Europe, a good starting point is the European Climate adaptation strategy (European Commission, 2021), according to which single countries have to define own adaptation plans describing the actions to be put in place for risk reductions in the most vulnerable areas. For example, Italy's *'Piano nazionale di adattamento ai cambiamenti climatici'* (MASE, 2023) provides a comprehensive analysis of vulnerabilities along with actions to be put in place, at national, regional or even more local levels, identified based on their effectiveness. These are classified as grey, green, or soft depending on their nature and subject to the type of hazard to be mitigated.

Moreover, Notre Dame University publishes an Adaptation index that combines a vulnerability assessment together with an evaluation of readiness to implement adaptation actions. The analysis is complemented also by an Urban Adaptation Assessment, with a focus on the urban level. Flopros (Scussolini et al., 2016) can be mentioned as a database that provides extensive assessment of effectiveness of existing flood risk adaptation measures in terms of risk reduction.

While several tools exist, there is currently no consensus and no single approach to measuring the effectiveness of adaptation measures, because of the lack of a standard methodology and the importance of local context. One of the suggested approaches (Swiss Re publication) follows a cost-to-benefit scorecard evaluation, stressing the need for a cost-benefit ratio and of pursuing a stronger comparability and effectiveness (in terms of costs and benefit) of adaptation measures, as already suggested also by the International Institute for Environment and Development.

In addition, assessing adaptation measures requires detailed information on building stocks, building construction types, flood defences availability etc., which are not readily available open source in Europe. Better quality and availability of these data will be critical to the implementation of appropriate adaptation measures across Europe.

2.2.3 Climate scenarios

For the adaptation measure to be proactive and anticipatory, it is important to take a forward-looking approach to risk assessment. Climate-related risks are expected to contribute to the increase of climate-related economic losses and are long-term in nature and systemic, making the risks harder to hedge or diversify. Therefore, climate change may challenge the affordability and insurability of climate-related risks and as a result further widen the existing protection gap. Hence, forward-looking risk assessment that considers climate scenarios is needed to assess how the risks are changing and to pinpoint solutions to mitigate these risks.

Given the high uncertainty around future policies and global climate mitigation efforts (such as carbon reduction pathways), several forward-looking scenarios must be explored to cover a sufficiently broad range of potential outcomes. It is important to keep in mind that while scenarios can be particularly useful tools to holistically explore the future climate risk landscape and its strategic consequences, they do not claim to be accurate predictions of the future and should not be taken as such. Conceptually, forward-looking climate risk scenarios represent plausible 'what if' projections trying to combine in a single coherent narrative the potential future impacts of a given physical and socio-economic climate pathway. Although they are of major help to support risk management, they are generally not directly linked to quantitative financial metrics.

Although the IPCC and the Network for Greening the Financial System (NGFS, an international group of central banks and financial supervisors) scenarios are widely used (either directly or as the basis for further analysis) by financial institutions, supervisors and standard setters for forward-looking risk assessments, these scenarios are not immune to blind spots and limitations. For instance, the physical phenomena underlying climate change are by nature non-stationary. They involve physical thresholds (planetary limits) and tipping points beyond which positive retroaction loops can trigger irreversible and non-linear change with global consequences[11]. Such physical tipping points and their consequences are still unaccounted for in most climate risk scenarios.

In addition, the exercise to estimate future protection gaps shows the difficulty of forecasting the evolution of the protection gap, as this requires taking account of a wide range of parameters, all of which will evolve depending on many decisions and actions being taken, having an influence on, for instance: the extent and speed with which the climate will continue to change and what, when and how efficient adaptation measures will be taken.

[11] Such tipping points includes for instance the melting of the Greenland icesheet, the thawing of the Siberian permafrost, the dieback of the Amazon rainforest, or the permanent disruption of existing oceanic circulation patterns.

2.2.4 Considerations to improve climate risk assessments

To address climate protection gaps, the first element is to be able to perform adequate risk assessments to understand and measure them. Therefore, actions should be taken to:

1. Continue to measure protection gaps.

- EIOPA has committed to have yearly updates of the natural catastrophe insurance protection gap dashboard (EIOPA, 2023). The dashboard currently considers a historical and current view of the protection gap. In addition, it would be relevant for EIOPA to build a view on *future protection gaps* in Europe (even if this would come with significant uncertainties). On the future protection gap it is important to consider macro-economic and demographic developments (i.e. spending capacity, infrastructure development, adaptation measures, etc.).

To perform adequate risk assessments, data and models are necessary. This is why the following actions consider improving the access to data and modelling and analytical capabilities:

2. Ensure that there is a central open-source database containing the list of economic and insured losses by NatCat event at NUTS granular level for all European countries.

a. Total economic losses:

- The European Environment Agency should be encouraged to continue publishing, at regular intervals, information per year, country and hazard type, to keep a long-term reference of historical events and economic losses from weather- and climate-related extremes in Europe (EEA, 2022). All data, whenever allowed by the contracts, will be made available by the EEA. In addition, the EEA collects questions and needs from users of aggregated data and discusses this with providers.

- Public authorities should consider collecting and sharing data on economic losses and data on the losses paid by governments. Ideally, this should be done with unique European event 'ids' (i.e., a common identifier) which could be used to compare how much the public and private sectors have paid for a given event.

- Other initiatives such as the Common European Data Spaces (European Commission) should also be considered to enable more data sharing of economic damages.

b. Insured losses:

- EIOPA to work towards improving the open access to catastrophe data by collecting and sharing insured losses and insured exposure data for natural catastrophes. Ideally, this should be done with unique European event identifiers which could be maintained in the long term and which would allow a comparison of how much the public and private sectors have paid for a given event (see pilot catastrophe data hub).

- (Re)insurers should consider the EU taxonomy[12] eligibility of insurance products to climate change adaptation for which data sharing with public authorities is one of the key elements underpinning sustainable premiums classifications[13].

3. Improve the modelling of the risks with better access to (open source) exposure, vulnerability, and hazard data.

a. Exposure data:

- EIOPA to work towards improving the open access of catastrophe data by collecting and sharing insured exposure data for natural catastrophes.

- At EU level, an EU wide database of economic exposure could be created and made available at a certain level of aggregation.

b. Hazard data:

- The Risk Data Hub (RDH) developed by the Joint Research Centre (JRC) from the European Commission could be further developed to become a source of reference to get access to hazard data in Europe. This tool should be maintained in the long-term.

- The EU Flood Directive[14] is promoting the access to better hazard data. Further work by public authorities should enable the reporting of these data in a uniform reporting map to have comparable data between countries.

c. Vulnerability data:

- At EU level, an open-source European vulnerability/adaptation database with a common set of vulnerability curves (to be used by model developers to improve risk assessment) could be created and made available.

- The EEA should continue to enhance the adaptation dashboard which aims to inform regions on climate risks and impacts as well as adaptation policies and measures.

4. Improve the modelling coverage especially for regions with high insurance protection gap.

- The Risk Data Hub developed by the JRC could be further developed to become a source of reference to understand natural catastrophe risks in Europe, covering perils and regions with both low and high insurance protection gaps. This tool would need to be maintained in the long-term.

[12] The EU taxonomy is a classification system that defines criteria for economic activities that are aligned with a net zero trajectory by 2050 and the broader environmental goals other than climate.
[13] As defined in the substantial contribution criteria for non-life insurance underwriting of climate-related perils.
[14] Under the Floods Directive (Directive 2007/60/EC on the assessment and management of flood risks), all EU countries are required to assess all areas where significant floods could take place, map the flood extent and assets and humans at risk in these areas and take adequate and coordinated measures to reduce this flood risk.

- EIOPA should continue to promote innovation and development of open-source models, building on and widening the list of open-source tools for the modelling and management of climate change risks, to help with obtaining better peril/region coverage.

5. Ensure that catastrophe models used by insurers properly assess the risk.

- Given the importance of NatCat models for the insurance industry (for example, for the pricing of risk or the estimation of capital requirements), supervisors should work towards enhancing the understanding of catastrophe models to ensure that undertakings properly assess the risk.

6. Improve forward looking assessments of climate-related risks.

- All stakeholders involved in risk assessment should adopt a forward-looking view of climate risks, notably based on climate-informed scenario analysis which considers the expected evolution of physical climate processes, rather than only rely on backward-looking statistical evidence. The typical time spans used to collect historical data for statistical modelling purposes (e.g., 10 years) are not appropriate to capture the latest trends in climate risk which could mean that risk assessments are based on outdated and non-representative data.
- All stakeholders involved in risk assessment should consider forward-looking climate scenarios that include an appropriate and plausible combination of physical risks and transition risks, for instance:
    - Business-as-usual or 'hothouse' scenarios (e.g., based on the IPCC's Representative Concentration Pathway 8.5[15]) may include limited transition risk but should include extreme long-term physical risks; and
    - Net-zero scenarios (e.g. based on the IPCC's Representative Concentration Pathways – RCP – 2.6[16]) may include less severe physical risks but should include very high transition risks. Such transition risks should further explore the distinction between an orderly climate transition, and a late and disorderly transition.

7. Enhance collaborations to understand the risks and further innovation.

- The activities mentioned above could be performed in a more efficient way by multiple stakeholders if an EU-wide platform is created to ensure the long-term availability of critical data such as historical loss or data to perform risk modelling in an open-source way as well as to ensure that models used to assess the risk in Europe are adequate.
- To improve the knowledge sharing between supervisors and model providers as well as public data sharing, EIOPA should continue its work to position itself as a centre of excellence for catastrophe modelling and data (EIOPA).
- Industry driven approaches for information sharing such as the Global Risk Modelling Alliance (GRMA) and the Global Risk Alliance (GRA) for developing tools and training

[15] A scenario of comparatively high greenhouse gas emissions.
[16] A "very stringent" pathway that requires that carbon dioxide (CO_2) emissions start declining by 2020 and go to zero by 2100.

programmes on risk identification and management should be continued and reinforced by the insurance sector.

2.3 Affordability

There is a number of barriers and drivers which from a demand-side perspective explain the existence of protection gaps. The affordability of the product (i.e., the relationship of the premium to total disposable income) is a strong factor for all types of buyers: from households to SMEs and large corporates.

Premium is the most key factor in the insurance purchase process, as customers may perceive the premiums as expensive and/or unaffordable. Income is often related to consumer's housing conditions with some housing types not being insurable, or only at a high cost (EIOPA, 2024). Furthermore, low demand for insurance can indirectly lead to higher premiums since, as a result, insurers are less able to spread risks effectively.

To overcome potential affordability issues, low-income individuals in disaster-prone areas will require special consideration from public authorities. Whilst unconditional premium subsidies may directly address affordability, they may also distort the price signal of risk and disincentivise risk prevention. An alternative could be to offer property owners who invest in risk reduction measures conditional premium discounts that reflect the lower annual expected risk of disaster loss. Since these investments may come with high upfront costs, low-interest risk reduction loans with public support might be offered to overcome homeowners' potential reluctance to implement measures. Other public measures, such as a preferential fiscal treatment of the corresponding premiums (a deduction from taxable income), might also be considered.

In addition, insurers can support the affordability of cover and the implementation and recognition of adaptation measures taken by insured parties, for example by promoting impact underwriting[17] as a risk-based approach to premium setting, as risk-based pricing is a key tool to send risk signals and promote resilience. However, it is important to ensure that risk reduction measures do not become conditions for coverage and/or payout for lower-income households which cannot afford such measures, as this can further increase the protection gap. In any case, the financing and implementation of risk reduction measures should not fall only on low-income households.

2.4 Mistrust

Trust is another demand-side factor of the climate protection gap. Insurance is an intangible product, and its purchase relies heavily on trust in insurers to fulfil potential claims. While trust can diverge quite broadly and is also culture-driven, distrust in the (re)insurance industry, stemming from policyholders' bad experiences, misunderstandings regarding the inclusions and exemptions of the insurance contracts offered, or other factors, negatively affects demand for

[17] Impact underwriting is a concept capturing the ability of insurance undertakings, consistent with actuarial risk-based principles, to contribute to the adaptation of the society and real economy to climate change by means of their underwriting practices in terms of data, risk assessment and expertise, thereby promoting and incentivizing policyholders to take up climate-related adaptation measures (EIOPA, 2021 and EIOPA, 2023).

insurance products and services. Another factor that may contribute to customer's mistrust are the difficulties in comparing insurance products.

The role of public authorities and the insurance industry is crucial to spread the 'culture' of insurance among consumers and fill the attractiveness gap insurance instruments still have in many European regions. However, it is important that market conduct authorities ensure good practices take place. Improving business conduct should be treated as equally important as consumer education. Fair, transparent, and swift referral processes to handle disputes between policyholders and insurers over claims settlements could also help strengthen trust.

To overcome mistrust, product simplicity, reliability and clarity of the language are at the core. In addition, the introduction of incentives to support private demand to make insurance more attractive to consumers in general could be considered. For example, the provision of tax exemptions on insurance premiums could be functional in overcoming consumers' distrust of insurance, which is often seen as an additional cost, rather than as an opportunity. Furthermore, this action could also produce positive effects with respect to risk awareness vis-à-vis climate risk and natural catastrophe risk and can tackle issues surrounding the affordability of insurance.

2.5 Limits to insurability of risks

As outlined in the Interim Report of the Climate Resilience Dialogue, insurance is considered one of the key elements of the 'coping capacity dimension' of climate risk. It is important to point out that 100% insurance coverage is neither necessarily a desirable objective, nor one that can be achieved in all cases since in practice, citizens, businesses, and public authorities may choose to not seek financial protection through insurance solutions and sometimes opt to self-insure their risks. While insurance is pivotal in securing resilience and coping capacity, it is also important to look at other factors, such as climate adaptation or innovation, since the ability of insurers to cover for damages caused by climate-related events will increasingly depend on strong and effective adaptation measures that can improve insurability and on the ability of the insurance market to innovate and develop effective solutions.

Across all perils and hazards, the fact that extreme weather events are becoming more frequent and severe is raising questions about how to best guarantee affordable cover while providing the right incentives to reduce risk exposure. From the insurance perspective, one concern is that the accelerating pace of climate change is likely to turn certain risks into certainties, which goes against the principle that insurers provide cover for specified but unpredictable events. Another is that climate change will increase the severity of some of the perils to such an extent that the insurance sector alone may not be able to cover them. Furthermore, past losses are becoming unreliable for estimating future losses. Climate change could also affect the randomness and correlation of events across regions or countries, reducing the potential to diversify underwriting portfolios (ECB-EIOPA, 2023). Finally, there is the need to reconcile the objective of covering as many people and businesses as possible with the goal of sending the right price signals, to encourage risk mitigation and reduce risk exposure.

Reducing risk exposure can take different forms. For instance, in the context of floods or wildfires, reducing risk exposure can be achieved by local authorities making the sometimes-difficult decision to limit building in high-hazard zones or in the case of wildfires by reducing overgrown vegetation and improving evacuation routes (see example in California). Other types of measures entail making sure that the real, current risks are duly reflected in insurance premiums and that full risks are well known and understood. Moreover, risk reduction and measures that contribute to increased resilience also include the type of measures that could be taken at the level of property owners, or policyholders, be they private persons or businesses. First and foremost, policyholders could contribute to the objective of insurability by increasing their understanding of the type of risks to which they are exposed. Policyholders could, subsequently, implement measures to reduce their exposures and vulnerabilities. Insurers, in turn, have a role to play in reflecting risk reduction measures in the premium, being more transparent about what is covered and what is not, and increasing the risk awareness of their policyholders, before and after an insurance contract is concluded.

Another element to insurability is the availability of reinsurance (or lack thereof), which plays a critical role in diversifying risks across geographies. Reinsurance, sometimes referred to as the insurer's insurance, enables the insurer to cede all or part of the insured risks to a reinsurer, in return for a premium. If insurers cannot obtain reinsurance at an attractive price, they will be less inclined to underwrite risk themselves. Hence, the reinsurance market dynamics has a large impact on primary insurance.

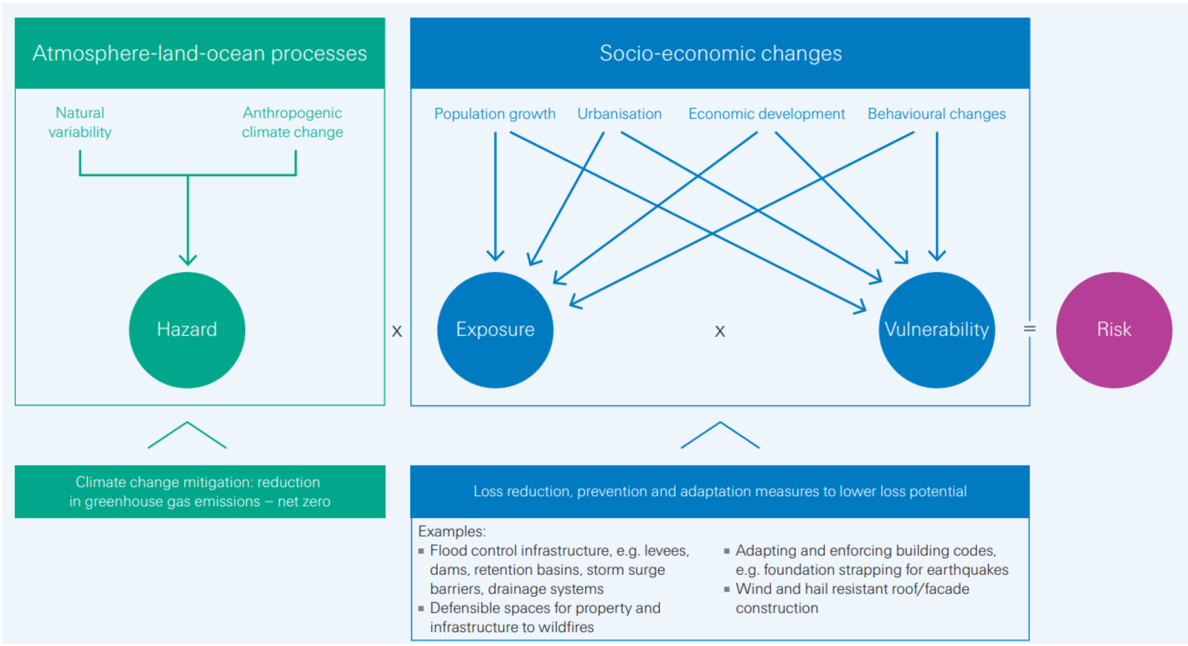
Finally, to improve insurability it is very important that there is a more standardised approach and information on adaptation to climate change, with a specific relevance for insurers. Public policies should continue to highlight the role of insurance in relation to adaptation to climate change, as done for example in the context of the EU's Strategy on Adaptation to Climate Change (European Commission, 2021).

3 Risk reduction measures

The European Commission states that '*we live in a new disaster risk management landscape'* (European Commission, 2024) . Besides other key factors, like the global security situation, they focus on the fast onset of climate change and extreme weather events as a risk driver. The Sendai Framework for disaster risk reduction (SFDRR) (UN, 2015) terminology defines disaster risk reduction as aiming to prevent new and reduce existing risks as well as managing the residual risks as key components as they strengthen resilience and therefore contribute to sustainable development. Risk reduction is a policy objective of risk management. While the SFDRR - at global and European implementation level - has a broader coverage of events than covered in this report, there is a lot of focus on the role of climatic drivers.

Risk reduction is one of the ways to address the climate protection gap and it can happen by influencing each of the elements: hazard, exposure and vulnerability. For climate change adaptation, the focus is on risk reduction by lowering exposure and/or vulnerability (Figure 1)[18], both under actual and future climatic conditions (Figure 2). Hazard reduction is addressed separately as part of climate mitigation efforts.

Figure 1:1 The three components and drivers of weather-related risk, and actions to reduce it



Source: Swiss Re Institute.

Figure 2 further below depicts the main interactions and trends related to climate change, human society, and ecosystems. In brief, human society causes climate change, which in turn, through hazards, exposure and vulnerability generates impacts and risks that can surpass limits to adaptation and result in losses and damages. Human society can (mal)adapt to and mitigate

[18] Risks can also be reduced by limiting the hazards (both in frequency and magnitude). This can be done by mitigating climate change (reducing greenhouse gas emissions). Both mitigation and adaptation are important to reduce future climate change impacts. As the focus of the Climate Resilience Dialogue is on climate change adaptation, so is the focus of this chapter (Figure 1).

climate change, while ecosystems can adapt and mitigate within limits. Ecosystems and their biodiversity provide livelihoods and ecosystem services. Human society impacts ecosystems and can restore and conserve them.

Meeting the objectives of climate resilient development supporting human, ecosystem and planetary health, as well as human well-being, requires society and ecosystems to move over (transition) to a more resilient state. The recognition of climate risks can strengthen adaptation and mitigation actions that reduce risks. The risk reduction actions need to be enabled by governance, finance, knowledge and capacity building, technology and catalysing conditions.

For this chapter, and as defined earlier, risk as determined by hazard, exposure and vulnerability is used for a general understanding. Without limiting its importance, Figure 2 does not recognise the ways in which responses modulate each of these three risk determinants. Likewise, it does not take into account the differential role of risk for impacts, adaptation and vulnerability versus risks related to mitigation (future directions with response risks related to adaptation and mitigation).

Figure 2: From climate risk to climate resilient development

Source: IPCC (2023, Summary for policy makers (a,b) and Chapter 1 (c)).

Box 1: Climate change adaptation versus disaster risk reduction

Climate change adaptation (CCA) and **disaster risk reduction** (DRR) are closely related concepts that **share a common objective**: both address the prevention and the reduction of risks of disasters by reducing the exposure and vulnerability and increasing the resilience of societies. In addition, risk and uncertainty are common to both CCA and DRR and both require the three components of risk (hazard, exposure, vulnerability) to be understood in order to design effective measures. To deal with the full spectrum of risk, the planned, implemented and contingency measures, and CCA and DRR measures need to be complementary (UNDRR, 2021).

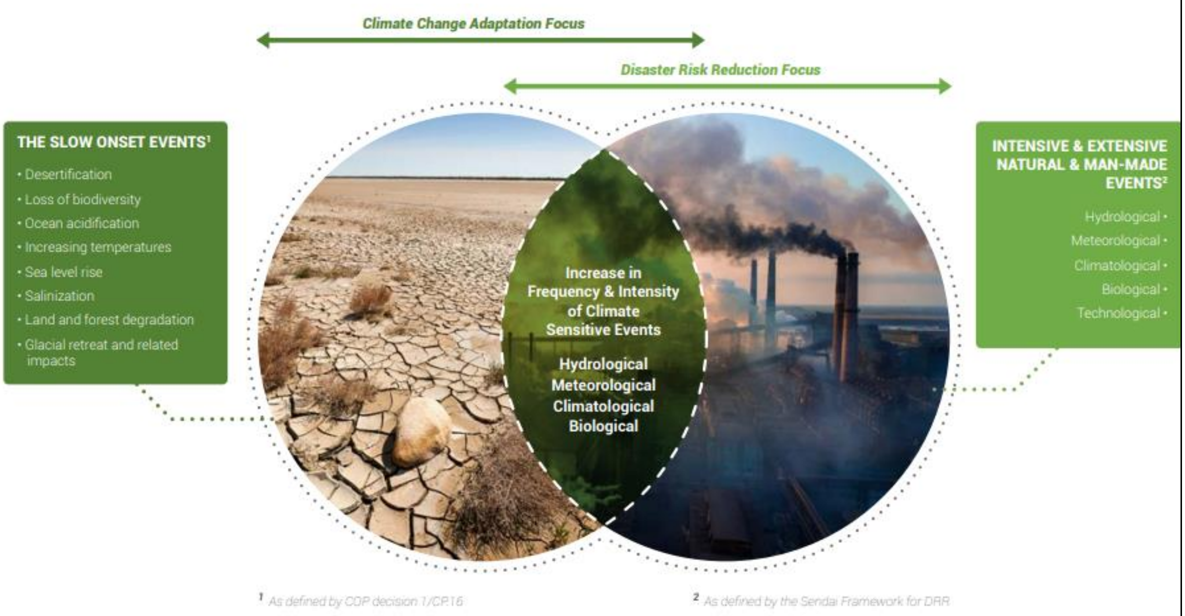
Notwithstanding this common objective, there are also differences between both concepts (Table2 and Figure 3).

Table 2: Differences between CCA and DRR

	CCA	DRR
Definition/objective	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.	Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development.
Focus	Mainly on future and addressing human development, societies' ability to thrive, taking a systems' perspective (including the positive effects) as well as related uncertainty and new risks.	On present and addressing existing risks.
Addressing	Mainly weather- and climate-related hazards. In addition, impacts of slow onset changes	All hazard types.
Origin and culture	In scientific theory.	In humanitarian assistance and civil protection.

Source: EEA, 2017; IPCC, 2014; UN, 2016.

Figure 3: Common and uncommon hazards that are the focus of CCA and DRR



Source: UNDRR, 2021.

Risk management is conceptually often presented as a **risk management cycle** and is used for example in the reporting about the Floods Directive (EU, 2007) distinguishing the following stages: prevention, protection, preparedness, response and recovery. In this logic, the focus is on prevention, protection and preparedness, as well as on the recovery, while the immediate response is civil protection and limiting acute damages rather than reducing the long-term risk (although there are blurred and overlapping zones, e.g., with slow onset (or chronic) events where the response and recovery phases overlap).

- Prevention: includes e.g., risk-based decision making in spatial planning (tools like where to live, where to build, etc.).
- Protection: includes all kind of nature-based solutions and physical interventions, both at individual and collective level.
- Preparedness: includes early warning systems and technological solutions Awareness raising and knowing what to do during an event can also be placed under this heading, although it's ideally an activity taking place in all stages of the risk management/risk reduction cycle.

Response, with the long-term solutions, happens in the aftermath of the previous event and before a future one and should focus on lessons learned and doing better than in the previous cycle (including the concept of building back better[19]). When it comes to types of measures taken during this phase (Table 3), there is an overlap with the pre-event stages.

[19] In this chapter, building back better is used as a term, covering also building back smarter and other related concepts.

Table 3: Key types of measures for adaptation

KEY TYPES OF MEASURES (KTMS)	SUB-KTM
A: Governance and Institutional	A1: Policy instruments
	A2: Management and planning
	A3: Coordination, cooperation and networks
B: Economic and Finance	B1: Financing and incentive instruments
	B2: Insurance and risk sharing instruments
C: Physical and Technological	C1: Grey options
	C2: Technological options
D: Nature Based Solutions and Ecosystem-based Approaches	D1: Green options
	D2: Blue options
E: Knowledge and Behavioural change	E1: Information and awareness raising
	E2: Capacity building, empowering and lifestyle practices

Source: adapted from ETC/CCA, 2021.

3.1 Stakeholder involvement in risk reduction

There is little structured knowledge available about the **role of different actors and stakeholders to reduce risks**. While generally stated that everyone (i.e. individual citizens and households, civil society groups, private companies of all sizes, professional risk managers, the finance and insurance sector, knowledge providers and academics, public authorities at all levels etc.) has a shared responsibility in managing and reducing risks, their roles and involvement in the decision making is very different. On top of this, these roles might be very different for different types of risk (e.g., related to different perils/hazards) or for the same risk in different regions and countries in Europe or for groups of stakeholders with different cultural and behavioural preferences and possibilities.

Not all stakeholders can use all types of measures (Table 3), and the level of involvement[20] is not the same for all stakeholders. When it comes to national adaptation planning there were two general tendencies[21]:

- When moving from national government (responsible for the development of the plan) to subnational governments, private sector interest groups and the general public, the level of involvement decreased towards gathering and giving information. If involved, researchers and scientists more often had an active involvement or consultation role.

- When moving throughout the policy cycle, from planning over implementation to evaluation, the level of engagement of all stakeholder groups in adaptation planning decreased.

The adaptation measures take place at multiple governance levels (national to local) and are undertaken by different groups (public and private actors, as well as individuals)[22]. Some measures are only possible in a coordinated context, with long-term planning and large budgets (e.g., a dyke to reduce flood risk management), while others can be taken by private and individual actors (e.g., making sure the environment around a house is free from burnable material to reduce wildfire risks). However, in most cases, there is a general awareness that climate change adaptation needs the involvement of diverse groups of actors, when adaptation is becoming more important and more urgent, there is an increased need to know '*who needs to do what and when (in which order) to unfold adaptation/risk reduction measures sufficiently fast*' to reach the envisaged policy objective of risk reduction (IPCC).

'Social contracts' for adaptation, as an agreement on the distribution of roles and responsibilities between different stakeholders, are increasingly debated at all geographical scales (Petzold et al., 2023). While adaptation is usually occurring in multi-actor settings, roles and responsibilities can differ as adaptation is context-based. If roles are unclear, the different actors will still appear to be self-organizing and allocating adaptation actions in a mutually beneficial and synergistic way, but this will nevertheless result in missed opportunities for deeper coordination that could result in more ambitious action compared to a situation where the roles were clearer (Hsu and Rauber, 2021)[23], e.g., in removing risk and adaptation blind spots in corporate adaptation strategies by private actors (Goldstein et al., 2019).

[20] From the highest to the lowest level of involvement, those were defined as: Empowerment, Partnerships, Active involvement, Consultation, Information gathered, Information given. The different stakeholder groups defined were Governmental stakeholders at from national level (e.g. policymakers, public administration, governmental agencies), Governmental stakeholders from subnational level (including local level), Private sector Interest groups (e.g. farmers' association, NGOs), Scientists and researchers, and General public.
[21] Based on a questionnaire in 2014.
[22] See Climate-ADAPT for examples, including in the national actions plans (see country profiles), the knowledge portal for the Mission on Adaptation or the examples in different EEA reports.
[23] A conclusion not unique for climate change adaptation and risk reduction, but e.g. also for climate change mitigation.

3.2 Examples of adaptation measures and stakeholder collaboration

The examples of collaborations between stakeholders presented in this section, show existing non-traditional ways of interaction that might have **upscaling potential** or contribute to a more coordinated approach to climate risks reduction and increasing adaptation measures.

Some of these examples can be found below:

1. Swiss example on flood barriers for communities most at risk (see Annex 2)
2. Trophée « bâtiments résilients » by the Association Française Pour la Prévention des Catastrophes Naturelles et Technologiques (AFPCNT) and partners
3. BNP Paribas Asset Management (Global Resilience Partnership, 2023)
4. Incorporating bioclimatic design in public spaces in Rethymno, Greece (see Annex 2)
5. Risk assessment and adaptation advice on heatwaves in Madrid by ZRS (see Annex 2)
6. Flood forecasting across Europe (see Annex 2)
7. Climate Resilience certificates (CRC) in Sweden (see Annex 2)
8. Insurance company supporting adaptation action in small and medium size enterprises in Turin, Italy (DERRIS project)

The examples above show a wide variety of types of risk reduction measures, with different actors and focusing on different perils. In none of them the risk was significantly reduced by one actor alone and almost all implied a need for interaction between:

- different public policies (and overlapping themes) and different levels of governance (from European to local level);
- the creation of market incentives to invest in risk management solutions; and,
- end users benefiting from an uptake of the measures.

Effective and efficient risk reduction will almost always consist of a combination of different types of measures (Table 3). While early climate change adaptation usually involved several actors working together in a local context, the increased need for climate change adaptation created a much more diverse landscape with more actors (with subnetworks, being permanent or temporary), dealing with more diverse risks. Consequently, the different actors and solutions were not always working in the same direction (and often caused maladaptation). As already stated by the need for a *faster, smarter and more systemic* adaptation (European Commission, 2021), there is a need for different actors (individually or via organisations that represent them) to work together in an organised and structured way.

The relationships between the different actors need to be of a long-lasting nature and with appropriate information flow between them to reduce the risk for maladaptation. Scaling up of initiatives that work in one place in another or scaling deep (e.g., covering multiple hazards, involving additional actors, etc.) should be promoted and the solutions should be adapted to the local context. For such solutions covering full range of relevant measures, a collective understanding on the efficiency and effectiveness of the measures is required.

For the **efficiency**, costs and benefits are defined, including co-benefits or ancillary impacts that are not always monetary or even quantitative. For many large-scale measures the ones bearing the costs are often not benefiting from the measures. Therefore, equity and justice aspects (EEA, 2021 and ETC/CCA 2021) have to be taken into account.

For the **effectiveness** of measures or groups of measures, risk reduction goals (reducing the exposure and/or the vulnerability) need to be defined. At the moment, there are no generally applicable goals on adaptation and no generally applicable (semi-) quantitative indicator frameworks to assess the effectiveness of measures towards these goals. The right level to define these goals needs to consider the following characteristics:

- Coherent in space (and time);
- Sufficiently location specific; and
- Starting from the different starting realities.

Coherence in space means that goals are defined for example for a catchment for fluvial flood risk, or a full slope when it comes to landslides and avalanches. Coherence in time deals with the relation between the short-, mid- and long-term goals. A group of measures with a lifetime of 20 years is only effective if these are in line with the 20-year goals. Location-specific goals do not only consider the physical and social geography but look also at administrative realities (and the related rules and regulations). The different starting points will define what is feasible for the different actors.

Monitoring, evaluation and learning aspects are still in early stages and need to be developed alongside the goals.

3.3 Considerations to improve risk reduction

Systemic solutions almost always come from a combination of key type of measures for adaptation, risk transfer and sharing mechanisms being one of them (see also EIOPA, 2020).

Specific attention to the upscaling potential / transferability of examples:

- Transboundary aspects[24]
- Different actors working together (see also section 4.1 on public private collaboration)

Risk reduction measures require enabling conditions to make them happen - many of these are covered throughout the report - for example:

[24] Transboundary is mostly used in the context of administrative (national) borders. As the regulatory and governance context across borders might differ, transferability of examples is not always possible without adaptations to the examples. In this case however, transboundary also refer to climate zoning, and e.g. in the context of nature-based solutions to the biogeographical regions in Europe as climate and environmental conditions might limit the transferability of risk reduction measures. Successful risk reduction measures in one place might be maladaptation elsewhere.

- Policy and governance frameworks, political leadership and momentum;
- Empowerment of communities (taking into account equity and justice);
- Investment in sustainable infrastructure, and the promotion of innovative investments and financing instruments;
- Capacity building to give stakeholders the necessary skills and capabilities to act;
- Data, information, knowledge and have effective communication;
- Scaling up disaster risk management, and dealing with the residual risk (for details see e.g. UNDRR, 2021).

Risk reduction is also important for SMEs and micro-businesses, where critical success factors are (UNDRR, 2020):

- Support and develop policy and legal frameworks that address SMEs for building resilience through prevention and training;
- Provide access to fiscal and financial products and instruments tailored to SMEs which support a prevention approach to business management, strategy and operations;
- Combine Enterprise Risk Management and Business Continuity Management mechanisms to better incorporate and increase the focus on prevention;
- Map and address interdependencies, complexities and inequities in supply and value chains related to disaster risks.

4 Risk transfer and insurance solutions to address the climate protection gap

This chapter analyses examples of risk transfer and insurance solutions that have the potential to address climate protection gaps in Europe. In particular, it examines public-private partnerships in insurance, mandatory insurance and multi-hazard insurance contracts. It also explores emerging or evolving tools in the insurance sector, such as the use of artificial intelligence (AI), parametric insurance, and muti-year insurance contracts.

It should be noted that risk transfer and insurance solutions can be implemented at household or corporate level (including at micro level) and at the city, national or even regional level.

4.1 Public-private collaboration

Whether insured or not, climate risk does not go away: the damage from weather catastrophes will have to be paid for anyway, initially by the impacted individuals and businesses themselves, and potentially through direct emergency state intervention as a last resort (with eventual tax consequences). Therefore, public authorities have a role to play not just in preserving insurability and promoting adaptation, but potentially also in helping to cover risks that are deemed uninsurable. Without smart and well-planned coordination and collaboration between private insurance markets, policyholders and public authorities, the consequences of climate risks will increasingly unfold in a disorderly and inefficient way from a social, economic, and fiscal point of view.

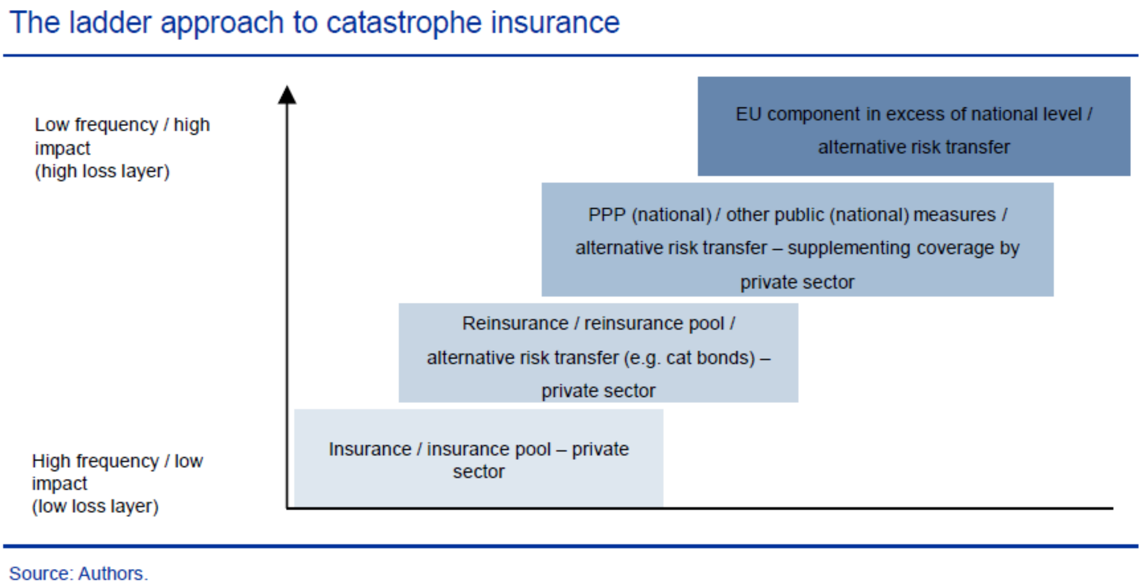
This unsatisfactory situation justifies possible intervention from public authorities in reducing the climate protection gap which, as explained in chapter 2, can be linked to a range of factors, such as insufficient adaptation measures or lack of customer demand for insurance etc. Public intervention can further be justified by the fact that insurance against climate disasters can be regarded by some stakeholders as meeting basic social needs, since it addresses the lower levels of the Maslow hierarchy of needs (helping to preserve or restore shelter, safety and security) (AAE, 2024). Furthermore, involvement from public authorities does not necessarily need to be permanent but can rather complement private insurance markets on a temporary basis (e.g., Flood Re scheme in the United Kingdom (UK), which is limited in time).

Climate risk is a systemic risk, and addressing the twin challenges of affordability and insurability may require higher levels of mutualization (e.g. between policyholders, through mandatory insurance for instance and/or the bundling of several hazards in a single insurance cover), of risk sharing across economic actors (e.g. through public-private partnerships) and/or subsidisation (either as direct subsidies or fiscal incentives for instance, see section 2.3). Such approaches can be organised and facilitated by public authorities and are examined in the rest of this section.

4.1.1 Public-private partnerships in insurance

As explained above, collaboration between public and private actors is key for reducing the lack of protection and for reducing the burden of costs on a single actor. One of the most effective tools to reduce vulnerability and ensure greater risk transfer are PPPs. PPPs can be mechanisms where losses from disasters are shared among various parties at different loss layers. This is illustrated in the ladder approach discussed in ECB-EIOPA discussion paper on policy options to reduce the climate insurance protection gap (ECB-EIOPA, 2023):

Figure 4: The ladder approach to catastrophe insurance



Source: ECB-EIOPA

The initial line of defence against climate change includes actions from policyholders themselves as individuals, enterprises, or organisations to protect themselves by doing what is in their power to reduce their exposure to natural catastrophes, as well as actions by public authorities in providing protection by investing in infrastructure to improve community resilience.

Once climate damage occurs and needs to be reimbursed, private (re)insurance should be the first layer of the ladder to cover losses from climate-related disasters. In addition, developing the use of cat bond markets in Europe to transfer risks may also support the (re)insurance of such risks. Some governments outside the EU have already taken concrete steps to attract issuers of cat bonds to their jurisdictions. Cat bond issuance by the public sector has been increasing globally over time, notably regarding climate risks, but there have been very few cat bonds by public pools in Europe (example of the Bosphorus bond in 2015 by the Turkish earthquake pool). PPPs notably may be able to pool residual risks at higher loss layers and to securitise part of this pool in the form of cat bonds.

However, as natural catastrophe risks are expected to grow and become more difficult to insure, policymakers need to consider putting in place more sophisticated frameworks to deal with extreme weather events and minimise future costs to taxpayers. This can take the form of public-private partnerships, together with suitable safeguards and incentives to avoid adverse risk selection, promoting risk mitigation and climate adaptation measures.

PPPs at the national level can support the overall functioning of the insurance market by providing additional coverage for higher layers of losses which exceed the deductibles and amounts insured, either via direct insurance or by indemnifying a private (re)insurer against extraordinary events. While the private insurance sector can provide expertise, prompt loss assessment and pay-outs, public authorities can improve the legal framework and could act as a reinsurer of last resort.

National PPPs to manage specific disaster risks already exist in various countries, and more is under discussion at the time of writing (such as a new state-backed reinsurance scheme in Italy following new legislation requiring Italian-registered businesses to purchase cover for climate-related perils (The Insurer, 2024). Table 4 below shows a selected list of examples of such relevant PPPs already in place around the world:

Table 4: list of global examples of relevant PPPs in place

Country/region	**PPP name**	**Perils covered**
Africa	African Risk Capacity	Drought, Tropical Cyclone, Flood
Australia	Cyclone Pool	Storm
Caribbean	CCRIF	Natural catastrophes
France	Régime catastrophes naturelles	Natural catastrophes
Morocco	Fonds de solidarité catastrophes	Natural catastrophes
New Zealand	Toka Tū Ake EQC	Earthquake
South-East Asia	SEADRIF	Natural catastrophes
Spain	Consorcio de Compensación de Seguros	Natcat + sociopolitical
Switzerland	Elementarschaden-Pool	Natural catastrophes
UK	Flood Re	Flood
USA	NFIP	Flood

There are many different sorts of PPPs, depending on how the risk is shared between the participants, their legal form, scope of coverage (in terms of perils, segments of the population, etc.) and financing mechanisms, *inter alia*.

Within a PPP, risk sharing can include stop-loss and quota-share types of arrangements or other combinations. In some cases, the government will only provide a backstop for the highest layers of losses, acting as an insurer of last resort. Typically, this is where the government takes on risks that others cannot take in order to provide a measure of financial protection to the population and provide stability when unforeseen catastrophic events occur (HM Treasury, 2020). At the other extreme, most of the risk could be carried by the government, and private insurers would remain mostly in a fronting role of collecting premiums, providing risk assessment, and handling claims. Many other arrangements exist between these two extremes. For example, governments can put limits on what schemes will cover, and then what is outside this limit is not insured or picked up by the private insurance market or alternative risk transfer solutions. Governments can also set a cap on the amount a policyholder can claim to mitigate accumulation risks. Various risk-sharing models for potential PPPs were notably debated during the Covid-19 pandemic in the context of the protection gap for business interruption, as documented by EIOPA in their 2021 staff paper (EIOPA, 2022).

In addition to the risk-sharing options, PPPs can also take various legal forms, ranging from the establishment of a dedicated state (re)insurer to government-sponsored pooling or co-insurance arrangements between private reinsurers.

In terms of funding the system of PPPs, there are choices to be made about pre-disaster funding for example by collecting premiums (or a proportion of premiums already collected) or through other means (e.g., taxes and similar levies), or post-disaster recuperation of the funding. Moreover, membership of the PPP can be optional or mandatory. Finally, there are considerations about how the premium is priced and collected, and the scope of coverage in terms of what perils the PPP will cover and who will be covered (for example, some PPPs only cover households, while others extend coverage also to businesses).

The design of PPPs should ensure that the risks, costs, and responsibilities associated with a resilient catastrophe insurance coverage programme are clearly shared between the public and private sectors. Synergies between all stages of the insurance ladder should be systematically explored to maximise the efficiency and economic viability of the scheme (IAIS, 2023). Successful PPPs should include mechanisms to limit moral hazard, for instance through deductibles or premium incentives to encourage risk reduction, to ensure that the scheme will remain sustainable over the long term. International PPPs which span across several countries provide greater potential for diversification of the risks. However, the increase in number of involved actors and geographies adds to the complexity of the administration of the PPP.

PPPs present several potential advantages to tackle the climate protection gap. They can help centralise expertise and data regarding climate change and weather catastrophes. They can also be naturally linked to publicly supported prevention measures (pre-disaster) and recovery measures (post-disaster) coordinated across the whole insurance sector, rather than fragmented and heterogenous risk mitigation measures initiated by individual (re)insurers. With the backing of the state, PPPs can also have access to financial and reinsurance markets on better financial terms than individual actors of the insurance market.

For less frequent, larger-scale climate catastrophes, an EU-wide public scheme for natural disaster insurance covering a broad range of weakly correlated hazards could potentially complement national schemes. Pooling risks at the EU level could help to reduce the capital costs of catastrophes and accelerate recovery and reconstruction efforts, and it should also be designed to incentivise and promote ex ante risk reduction via both mitigation and adaptation measures at the scale of the whole European Union. However, the proper design and implementation of such an EU-wide PPP presents numerous challenges of both political and technical nature. The macroeconomic effects of such an EU-wide public scheme on the insurance and reinsurance market need to be carefully considered in advance, e.g., through stakeholder consultations and impact assessments. For instance, there would need to be some thoughtful consideration given to the competences and how they are allocated between (in many cases) already existing national schemes and involvement from the EU. Cross-border losses would also complicate matters, and as with any EU-level scheme it would require a democratic administration to ensure to the extent possible that there is no perceived unfairness in matters pertaining to solidarity. The design of a potential EU-wide PPP should also take care to remain within the legal limitations of the EU Treaties, which restrict debt mutualisation between Member States[25]. At the time of writing, EIOPA is working together with the ECB to look at public-private partnerships that exist at national level and draw lessons that are relevant for the EU market (EIOPA, 2024).

4.2 Insurance-based solutions

4.2.1 Mandatory insurance

Mandatory coverage (i.e., a requirement for everyone or certain groups, such as households, corporates of a certain size, or operating in a certain industry, to insure against certain types of perils) and/or mandatory offers (i.e., a requirement for insurers to offer catastrophe cover alongside e.g. property insurance) have the potential to improve the affordability of insurance and mitigate adverse risk selection (Geneva Association, 2018).

In practice, mandatory insurance can encompass very diverse modalities:

- Mandatory for insurers to offer coverage against climate hazards.
- Mandatory for customers to purchase such coverage.
- Climate hazards in scope of the mandate and the minimum features of the mandatory insurance product.
- Potential subsidies available for customers and/or insurers.
- Potential additional controls on prices i.e., regulatory limitations to the level of premiums that can be set by insurers.
- Whether a public re/insurance option or PPP scheme exist to support the insurance mandate.
- How mandatory insurance coexists with private and competitive insurance markets.

[25] Article 125 of the Treaty on the Functioning of the European Union.

Mandatory or compulsory insurance can achieve a higher take-up of insurance coverage for catastrophe perils and lower levels of uninsured losses[26]. By facilitating the mutualization of risks through sharing among a broader base of policyholders, mandatory insurance makes coverage available for all and avoids anti-selection by ensuring a balanced risk pool. On the other hand, mandatory insurance may also increase moral hazard, disincentivise risk reduction and adaptation efforts, and may end up subsidising development in hazardous locations (ECB-EIOPA, 2023).

Indeed, insurance mandates can also have unwanted side effects (e.g., from a reserve adequacy and solvency perspective), especially if premium and terms and conditions are misaligned with the true price of risk. Mandatory insurance against climate perils should include adequate premium incentives and deductibles to lower costs, reduce moral hazard and incentivise risk prevention. Otherwise, the actual costs may soar and threaten the sustainability of the mandate over the longer term, like in the case of California, where implementation of mandatory features for insurance against wildfires have resulted in withdrawal of several insurers.

Any new compulsory insurance scheme should be structured in a way which addresses the root causes of the protection gap it seeks to reduce, is economically sustainable over the longer term and not vulnerable to political changes. Therefore, mandatory insurance must be understood and accepted by customers (demand-side), be financially viable for (re)insurers (supply-side), and properly encourage risk prevention for all parties involved.

EIOPA's dashboard on the insurance protection gap for natural catastrophes compiles the latest information on mandatory insurance schemes in the European Union (EIOPA, 2023), and points out that in Romania, for instance, home insurance is compulsory and covers earthquakes, floods, and landslides, but in practice this is not systematically enforced so the actual insurance penetration remains low (less than 25%) due to a lack of demand. In European countries with successful mandatory insurance against natural catastrophes and low protection gaps, like France or Spain (insurance penetration rates over 75% and 50% respectively – EIOPA, 2023) there is a carefully designed national PPP or risk pooling mechanism to support the mandatory cover, as well as accompanying risk prevention measures. Therefore, to be effective, mandatory insurance would need to be enforced and/or accompanied by a PPP or risk pooling mechanism.

4.2.2 Multi-hazard bundling

Certain insurers in the European market have opted to bundle multiple natural hazards into a single standardized insurance policy (i.e., multi-hazard bundling), which consists of including climate-related risks together with other hazards in a bundled insurance cover.

On the demand side, purchasing multi-hazard policies that cover the main risks to which the policyholder may be exposed can reduce the time and effort spent on understanding and evaluating various risk coverage options, thus reducing customer transaction costs. This could improve the cost/benefit ratio of purchasing insurance cover and thus make uptake more likely or appealing. Bundled insurance policies also have the potential to lower legal disputes over the

[26] As stated by the Organisation for Economic Co-operation and Development (OECD, 2021).

damages which are covered or not, compared to single-peril policies, and decrease the delays and the associated cost of damage assessments since multiple damage sources will be covered under the same policy. Reducing reimbursement delays and disputes over climate-related claims settlement is not only a cost-control issue, but it also makes for an improved customer experience and increases trust towards the insurance industry by making coverage more transparent and easier to understand, which can lead to the added benefit of higher renewal rates. It could therefore address two factors: transaction cost and mistrust issues.

On the supply side, there are also potential benefits for insurers themselves. Bundling covers for several natural catastrophes can lead to lower marketing and administrative costs for a single product, ultimately for the benefit of policyholders, versus having to sell and manage several policies and options for the same customer. Bundled insurance against multiple climate perils could also facilitate a broader spread of risk across hazards and geographic regions (where not all regions are exposed to the exact same perils). This may increase the potential for risk diversification (the core principle at the heart of insurance) and create more certainty about expected claims payments within a given year. As a result, insurers may be more likely to explore this option.

So far, the experience with the use of multi-hazard bundling is mixed. Some studies suggest that offering bundled insurance for natural disaster risks would increase insurance penetration rates compared to individual policies (Schade et al., 2012), and other research warn that it might be the opposite (Robinson/Botzen, 2023). Yet another study (Landry et al., 2021) finds that the higher premium costs of insuring multiple hazards at the same time, as well as a perceived lack of necessity for such insurance, are the main demand-side reasons why homeowners may be reluctant to purchase bundled insurance. However, surveyed individuals who showed interest in purchasing such insurance appreciate its convenience and simplicity.

Overall, this evidence suggests that there are important enabling preconditions determining whether offering bundled insurance will materially contribute or not to closing the current climate protection gap in Europe. Public authorities can support the development of bundled insurance policies, using means that range from direct regulation, to playing a convenor role and facilitating discussion among the insurance industry on the design of a standard bundled climate insurance product. Once enough suitable and reasonably simple insurance products are on offer, information campaigns supported by public authorities could disseminate knowledge about these products among the general public, in particular among homeowners.

The successful implementation of multi-hazard bundling for climate insurance will depend on the generation of sufficient revenues and sound risk management by insurers, to make it an economically viable proposition. It will also depend on whether premiums for such bundled insurance products properly reflect risk, and thereby serve their role as an adequate price signal of risk whilst encouraging risk reduction measures by policyholders. Finally, public reinsurance, risk pooling arrangements or other PPP schemes may be helpful to address the possibility that several positively correlated climate hazards occur in the same natural disaster event and are bundled together in the same insurance policy. Such PPPs or reinsurance offered by the public sector would enhance the capacity of insurers to reimburse claims, and therefore could support the financial sustainability of bundled climate risk insurance.

4.3 Evolving tools in the insurance market

This section explores emerging or evolving tools in the insurance sector that have the potential to address some of the drivers of the climate protection gap.

4.3.1 Artificial intelligence

The emergence and integration of Artificial Intelligence (AI) is a key development that is reshaping the contours of insurance. For the purposes of this analysis, AI is defined as a tool that synthesises the ability of machines to perform tasks that traditionally require human intelligence. This includes learning, reasoning, problem solving and natural language processing (NLP), all of which rely on the processing and analysis of large amounts of data for decision making and adaptive learning through pattern recognition (The Geneva Association, 2023).

The use of AI in the insurance industry presents clear opportunities, particularly in bridging the demand and supply side of climate insurance.

On the demand side, one of the first benefits is an improved customer experience, such as a more efficient buying process and more accessible customer service (e.g. chatbots for the management of customer claims). This also has implications for product development, with benefits ranging from accurate pricing to tailored insurance solutions (The Geneva Association, 2023). These benefits could provide a solution to the general lack of attractiveness of insurance solutions and product complexity, as well as the lack of customer centricity, which are often barriers to insurance uptake (The Geneva Association, 2018). In fact, a more personalised experience could have the effect of increasing the take-up of insurance, thereby reducing the protection gap.

Another important potential benefit for consumers is that by reducing the operational costs of the insurance value chain, AI has the potential to better differentiate the price of premiums, thanks to a more customised pricing of risk.

Turning to the supply side, one of the biggest benefits of using AI is cost efficiency and cost reduction. By automating many processes, such as claims management, underwriting and risk analysis, insurers can reduce transaction and operational costs, while improving the affordability of their products (The Geneva Association, 2023). There are already insurance companies on the market, such as for example Lemonade Inc, that have adopted an all-digital approach to reduce the cost of human interaction with customers.

AI can also expand the scope for risk pooling, since by improving the quality and speed of risk analysis, AI enables insurers to have a better understanding and a more comprehensive view of risk and risk assessment. Expanding the risk pool in this context can translate into the ability to reach segments of society and insure risks that were previously uninsurable, thereby addressing one of the key drivers of the protection gap, namely the limits of insurability (The Geneva Association, 2018).

Despite all the benefits, it is worth remembering that while AI solutions are quite transformative, they are certainly not without their concerns. Indeed, the rapid growth of AI across the insurance value chain has raised fear over the protection of citizens' and consumers' fundamental rights.

Firstly, the main risks associated with AI systems include transparency and explainability[27]. In particular, advanced AI models such as machine learning, which provide accurate risk assessment and loss probabilities, are described as *black boxes* (The Geneva Association, 2023), whose algorithms are difficult to communicate to consumers. The fact that it is complex for insurers to explain AI-based decisions on premiums, denials and claims reinforces the view that insurance products are inherently complex for consumers and raise trust issues, exacerbating the information asymmetries that already exist in the sector.

Secondly, risks with the use of AI in the insurance industry include bias, indirect discrimination, and fairness. Given that the innovative element of AI models is their ability to use data to identify stable patterns and make predictions, questions can be raised about the data training bias or accuracy, which could be reflected in the final output of the AI model[28]. Biased data training is an issue of concern, particularly around climate-related risks, where the historical data used for training may not be fully relevant for a forward-looking view, as is required given the increasing trend in climate impacts. In addition, if there is no experience of certain hazards there may be no training data at all. However, greater attention to the quality of the data and the way in which AI manages them (also considering recent European regulatory updates) could contribute to strengthening consumer confidence in better performing insurance products to reduce the protection gap. (Swiss Re, 2022).

Finally, AI can be a source of excessive price differentiation and exclusion. When allocating premiums, insurance companies create risk pools that include a large number of policyholders, and they do so based on the solidarity continuum. By allowing for more individualised risk assessment and losses (together with the increasing use of very granular geolocation data), AI could trigger a move away from solidarity-based risk pools and incentivise significantly higher premiums or exclusion by insurers of an ever-growing number of policyholders exposed to climate-risk. In this regard, various sources, such as the Dutch Financial Market Authority (AFM), have pointed out that even if some clients may experience an increase in their premiums or even become uninsurable, a more tailored risk assessment should be considered fair as it offers opportunities for risk reduction and mitigation (The Geneva Association, 2023).

As we delve deeper into the specific applications and implications of AI in insurance, it becomes clear that this technological evolution has the potential to offer a multi-faceted solution to reducing protection gaps. However, it also requires a balanced approach to harness its benefits while mitigating its risks, ensuring that the insurance industry evolves in a way that is both innovative and inclusive. This is where the **regulatory framework** comes in, seeking to address the risks associated with AI without hindering innovation in the sector.

[27] Explainability (also referred to as "interpretability") is the concept that a machine learning model and its output can be explained in a way that "makes sense" to a human being at an acceptable level.
[28] The Geneva Association, 2023.

Among the recent developments in AI legislation, the European Union has been at the forefront of this regulatory journey, demonstrating an ambitious approach to AI. In the proposal for a regulation on artificial intelligence (the AI Act, approved by European Parliament in March 2024) the European Commission included specific obligations for AI systems identified as high risk due to their considerable potential to impact health, safety, fundamental rights, the environment, and the very fabric of democracy and the rule of law. The new legislation is expected to directly influence the insurance sector, particularly concerning AI-based pricing and risk assessments in life and health insurance, categorizing them as high-risk applications that must adhere to the AI Act's specific requirements.

Against this background, it is important to align the current use of artificial intelligence and machine learning solutions with the principles and criteria of the European AI Act to ban the distorted use of these tools for discriminatory purposes or for purposes of distorting the insurance market. This is particularly relevant for instances of involuntary discrimination or distortion, due to the 'black box' nature of AI and hidden calibration biases.

4.3.2 Parametric insurance

Parametric (or index-based) solutions are a type of coverage of a pre-defined event happening instead of indemnifying the actual loss (Swiss Re, 2023). In this case, compensation - established a priori – is automatically activated in the event of a specific 'triggering' accident previously identified and measured by a third party. Both the risk assessment (which determines the pricing) and the activation (trigger) as well as the calculation of compensation are made on an objective basis: the calculation of losses and, therefore, the compensation depend on pre-established parameters (such as location and intensity of the event, exposure and vulnerability of the assets in the different areas, etc.) and not on the losses effectively suffered. This mechanism also means that there will always be some level of residual mismatch between the parametric payout and the exact losses incurred by the policyholder (this is known as the *basis risk* and can materialise both ways as either over- or under-payment compared to the actual economic losses).

Their predefined structure gives a rapid response to insured parties, guaranteeing a predefined level of compensation which, in the short term, may contribute to the swift restart of businesses activities and thus help strengthen the resilience of the economy during extreme uncertainty. This can be true not only for consumers or businesses, but especially for governments and municipalities or humanitarian organisations, where parametric insurance can serve as useful disaster risk finance tool to assist affected people after a natural catastrophe[29].

The effectiveness of parametric solutions to deal with climate risk has grown over the years, after its initial application to countries mostly exposed to meteorological phenomena of significant intensity (for example, the Caribbean area, African Risk Capacity or Southeast Asia) and where traditional insurance markets are not so developed compared to European countries. In the experience gained so far, parametric solutions have been used to cover damages caused by specific natural disasters (e.g., typhoons, hurricanes, floods, volcanic eruptions, earthquakes, etc.) or have been dedicated to covering catastrophe damages suffered by specific sectors[30]. According to the recent analysis, the volume of the global parametric insurance market was valued at USD 11.7 billion in 2021 and is expected to reach USD 29.3 billion in 2031, recording a Compound Annual Growth Rate (CAGR) of 9.9% (Allied Market Research).

Parametric solutions present characteristics that must be evaluated from both sides of the supply chain.

On the demand side, consumers have access to a rapid, streamlined, and efficient product, aimed at settling the compensation more quickly because it is not conditioned by formalities or burdensome investigations. In this sense, the predefined payment procedures represent an advantage in terms of deflation/elimination of possible disputes, as the policyholder will not have the burden of proving the damage suffered, with a further reduction in operating costs for the policyholder. These facilities reduce the level of total costs, with a possible positive impact on

[29] Since triggering is typically based on parameters directly related to the risk against which the protection buyer seeks to acquire coverage, such as hurricane wind speed, hurricane minimum central pressure, storm surge temperature of heat, total rainfall, the geographical position of a storm etc., it must be clear, from the moment of signing the contract, that the coverage is activated only when these parameters have actually occurred.

[30] Agriculture is still the main area of application of parametric insurance, but it extended also to fishing, construction, mining, manufacturing, energy sector, aerospace and defence.

premium. Despite this, parametric covers still present a variety of costs which could lead the customer to perceive an affordability problem. This critical issue could be overcome, in the future, by the greater diffusion of parametric insurances on the market and their better refinement.

In general, speed and certainty of payment make parametric cover more appealing for consumers who require immediate liquidity to recover from a disruptive event. Therefore, in the precontractual phase, and for each renewal, it is important that both the coverage and the evaluation are done in a transparent way and that the coverage and compensation levels included in the policies meet the needs of the customer. This process would contribute to strengthening consumer confidence in the insurance market.

On the supply side, insurance companies can offer on the market simple and effective solutions, with coverage in which the costs of managing the claim are drastically reduced thanks to the simplification of the settlement phase, made more agile due to the parametric automatisms established in the policy. This could determine a reduction of transaction costs for insurance companies, especially if the national context presents a regulatory framework that allows the effective simplification of the administrative and bureaucratic steps envisaged by the national rules on insurance contracts. The relative simplicity of the structure and the speed of compensation times could act as an attractive element to strengthen the presence of parametric solutions in the market. However, an adequate legal and regulatory framework could boost private demand, especially in case of insurance solutions oriented to specific categories such as SME's or households.

Parametric solutions represent, at that stage, a part of a more comprehensive and articulated path that the market is experiencing to structure itself to address climate risk more effectively. In this sense, parametric policies can be a complement to traditional coverage[31] and can be used more extensively as the insurance market develops more efficient products (i.e., for singular categories of subjects, just like SME's) to address the protection gap for climate risk in geographical areas less predisposed to the use of traditional forms of insurance.

Moreover, the use of parametric insurance is made easier today thanks to technological and digital innovations (e.g., AI, blockchain, Internet of Things), which should allow the formulation of more precise parametric policies in terms of protection, pricing, and claims management. The availability of advanced data analytics and risk models, and of data from weather stations, seismic sensors and financial markets, could help the further development of parametric policies in the medium term (AON; ONE INC).

Further development of parametric insurance has good starting points such as growing demand and the possibility of better refining the offer thanks to the advancement of technology. To have a more effective diffusion, parametric insurance needs to be able to involve larger and

[31] There are possibilities to bundle parametric and indemnity insurance, for example by covering the corresponding risk from a high deductible or exclusions of an indemnity insurance with a parametric contract (e.g. Best of Both: Bundling Parametric, Indemnity | Insurance Thought Leadership). Hybrid triggers are also used in Insurance-Linked Securities (i.e. catastrophe bonds).

homogeneous groups of recipients (for example, rural communities exposed to flood risk; condominiums present in an area at seismic risk; etc.). This approach could allow for greater penetration of insurance products in the residential sector.

Box 3: Examples of parametric-based solutions

Caribbean Catastrophe Risk Insurance Facility - Segregated Portfolio Company - CCRIF SP is a not-for-profit risk pooling facility, owned, operated and registered in the Caribbean for Caribbean governments. It offers parametric insurance elaborated to limit the financial impact of hurricanes, earthquakes, and excess rainfall events on Caribbean governments by quickly providing short-term liquidity when a policy is triggered. Operationally, it works as a mutual insurance in which the participating countries pay an annual premium calculated as a function of the risk transferred by purchasing coverage up to a maximum of approximately 100 million USD per insured risk. Risk pooling results in an estimated premium reduction of 50%. Thereby insurance provides the financial resources necessary to deal with catastrophic events in a cost-effective manner in the intermediate period between the emergency phase and the medium-long economic recovery term. Typically, insurance coverage covers about a quarter of the overall exposure of the Government to the risk of catastrophe. CCRIF was capitalised with a fund in which, in addition to Caricom (Caribbean Community), also participated Canada, EU, World Bank, UK, France, Ireland and Bermuda.

This is a well-known example of a parametric insurance system, based on a structured public-private partnership necessary to support the diffusion of parametric policies as tools for adapting to climate risk.

An example of parametric insurance dedicated to a specific sector is **Heat Stress Protect**, a parametric insurance dedicated to the most "typical" sector of parametric insurance, agriculture, and protects farmers from the damage that strong heat waves cause to the herds (lower milk production and reduced quality, higher production costs, and prolonged effects on animal health). The index calculation of economic losses is based on a certain level of temperature and humidity conditions unfavourable for the herd: in case of an exceptionally

To support the development of parametric policies in the market, the public sector should have a coordination role among the various actors involved in the insurance chain. In addition, public authorities can foster the further application and expansion of parametric insurance by ensuring that the applicable regulatory frameworks provide the necessary legal grounds to offer insurance and reinsurance covers on a parametric basis. However, it will be important to identify - in a coordinated and participatory manner with a range of stakeholders - the overall ways in which these products can be oriented, taking into account that massive involvement of the residential (property) sector would bring the best result for parametric insurance development. From this point of view, it would be appropriate to promote national and regional programmes as preliminary tests, aimed at collecting information or data useful for better defining strategies for the large-scale diffusion of parametric solutions.

4.3.3 Multi-year insurance

Multi-year insurance is a longer-term insurance contract than the traditional annual basis contract for non-life insurance, which provides a guaranteed premium (or guaranteed ceiling and floor price) over a term from 3 to as much as 25 years.

This type of insurance has very particular characteristics which present both risks and opportunities for insurers and policyholders. However, as these types of contracts are quite rare on the market, it is not possible to have a clear picture of their effectiveness in reducing protection gaps or addressing their drivers. Moreover, multi-year insurance policies must be analysed from a prudential perspective to understand the possible risks these multi-annual contracts entail in comparison to traditional annual non-life policies.

Notwithstanding the above, the potential of this kind of insurance contract deserves to be explored, together with the challenges associated to such an approach. Indeed, according to the Geneva Association (The Geneva Papers on Risk and Insurance, 2012)and EIOPA (EIOPA, 2021), a long-term contract presents positive characteristics and serious critical issues at the same time, both for insurance companies and for consumers.

The presence of a fixed premium should represent an attractive point on the demand side because it can protect against the volatility of prices on the market for the entire duration of the contract. On the other hand, multi-year insurance usually has higher prices compared to an annual policy, also because the fixed price can be set at higher values precisely to compensate for future volatility. This could imply a problem from the perspective of affordability. However, multi-year contracts have the potential to reduce administrative burden for those who have to publicly procure private insurance (e.g. a local authority that privately insures their assets). In addition, long-term contracts are less flexible than traditional one-year contracts because the policyholder cannot review or renegotiate the contract or decide to switch to another insurance provider in a short period. The limit of consumer choice embedded in this product represents a strong disincentive to taking out this type of policy.

On the supply side, insurers can benefit from the limitation of turnover in policyholders and reduced administrative costs connected to this activity. At the same time, they are penalised by the impossibility to review or renegotiate the contracts (or cancelling them, if necessary) or update the premiums according to any new information.

One important point is insurers' difficulty in managing premium prices in an efficient way: as in the case of climate risks, long-term risks can only be estimated, the consequence is a risk of a policy being underpriced, which exposes insurers to risks of insolvency. This explains the higher level of such premiums. Likewise, insurers could need larger capital to guarantee future possible coverage in the event that the accident occurs (in this case, a natural disaster) and they would not be able to use the turnover in policyholders to redistribute risk among a different and, if necessary, broader client portfolio. In addition, as future losses are expected to increase, this would require an adjustment of the cost over-time, which would cause the benefit of pre-fixed costs to be lost (unless adaptation measure are activated to 'neutralise' premium adjustments). According to the Organisation for Economic Co-operation and Development (OECD), insurers could have a positive advantage from multi-year contract by incentivising risk reduction through insurance, since the incentive would be tied to the duration of the contract, or linked to the 'loyalty' of the customer (OECD, 2023).

The complexities of the market for long-term contracts are clear and represent the reason why multi-year insurance contracts are not yet mature for a wider use in reducing the protection gap.

At present, the best lever to support the use of long-term contracts would be the implementation of adaptation and resilience measures by the insured accompanied by incentive tools linked to the policies (e.g., risk-based premium 'discounts', incentives linked to the longer duration of the contract). This option should allow insurers to use a more efficient commercial policy for offering this type of contract and consumers to implement their investments in risk prevention measures, when their cost-benefit return period exceeds the typical one-year horizon of property insurance contracts. To implement this solution, it may be necessary to define a regulatory framework that aims to incentivise adaptation solutions to make long-term contracts more attractive and to provide further incentives for SME's and citizens to consider purchasing climate-related insurance. In that sense, the first step should be to exploring the viability and feasibility of multi-year insurance contracts for climate risk in the European market.

5 Summary of proposed actions

This summary reflects the main actions that the Dialogue puts forward as possible solutions to address the climate protection gap and build climate resilience, and that can be implemented by different stakeholders: public authorities, including supervisors, consumers, and the insurance industry. These proposed actions aim to address the climate protection gap by their collective contribution to individual and community resilience against various hazards, by promoting risk awareness, preparedness, and proactive measures in the face of climate change. While the actions are listed under the stakeholder groups with primary responsibility for leading the action, the buy-in and coordinated efforts of other stakeholder groups in the actions are essential.

A. Public Authorities (local, regional, national and/or EU level authorities):

To note that the suitability of the actions depends on the competencies and responsibilities assigned to authorities across different levels, i.e., local, regional, national and EU level. Moreover, while the general common frameworks are agreed at EU level, the actual implementation approaches are often designed, decided, and implemented by the Member States at national, regional, and/or local levels.

1. **Further develop tailored approaches to resilience:**

   - Continue to **expand upon climate resilience building approaches (including building back better principle or standards for resilient rebuilding) when undertaking a project**. The approaches should make use of existing methodologies, and improve them where necessary, ensuring that the climate resilience measures are tailored to the geographical specificities and related climate risks. These approaches could draw upon the methodological framework of the EU Climate Risk Assessment (EUCRA), which in turn makes use of a risk management process based on widely recognised standards divided into phases of risk identification, risk analysis, and risk evaluation.
   - Work continually towards enhanced multi-level and cross sectoral **cooperation in designing and supporting climate risk reduction measures** both at local and cross-border levels, by analogy to the one provided in the EU Floods Directive (for other hazards).
   - When designing an adaptation measure, ensure the availability of solid scientific evidence underpinning the effect or impact the measure would have on risk mitigation or risk reduction and consult experts and insurers to assess the adaptation measures with the aim of **avoiding incidences of maladaptation.**
   - **Invest in disaster risk management** to:
     - avoid losses during disasters,
     - stimulate development by encouraging innovation and boosting economic activity (in light of reduced disaster-related investment risks), and,
     - realise social, environmental, and economic benefits from disaster risk management investments, even if no disaster occurs for many years.

- Consider introducing **climate resilience certificates and/or a requirement to provide information on climate hazards** to prospective house buyers and renters, for example in the context of the awareness initiatives described under item 4 below.

Examples

Floods:

- Implement flood-resistant infrastructure and drainage systems in flood-prone areas.
- Maintain dams diligently and conduct regular inspections: poor dam management or exceeding design capacities could worsen flooding.
- Implement proper land use planning strategies that prioritise the preservation of natural environments and aim to minimise soil sealing. Concretely this means:
- Review land use planning and permits to reflect flood risk and prevent development of private and public infrastructure exposed to high flood risk.
- *In urban settings*, expanding green areas, greening rooftops, introducing more porous soils (replacing asphalt with tiles, for instance), and implementing heavy rain multi-purpose storage solutions. Such solutions ensure that rainwater can be absorbed more easily (IPCC, 2023; and link to concrete examples).
- *In rural settings*, implementing extensive retention areas ("retention basins") to reduce the risk of water running off.
- *In agricultural settings*, implementing agroforestry to slow down rainwater from running off and to allow soil absorption (Climate-ADAPT, 2023). Besides limiting flood risks, this also has the advantage of contributing to restoring water cycles.

***Wildfire*:**

- Creating defensible space around properties by clearing vegetation and using fire-resistant materials.

Heatwave:

- Make use of public spaces to offer shelter from the heat – for example public pools/lakes that are made accessible to the public, or temporary shelters or 'cooling centres' equipped with essential supplies for the heat, as was set up e.g. in Barcelona with 'climate shelters'.
- Harness nature-based solutions to provide shade and protection from high temperatures in urban areas, such as planting additional trees to promote an urban tree canopy. This also includes transforming urban areas into 'cool islands'.

Drought/subsidence:

- Implement water conservation measures and using sustainable land management practices.
- Establish monitoring systems to detect changes in groundwater levels early, allowing for prompt intervention to prevent or minimise subsidence damage.
- Regularly inspect and ensure maintenance of infrastructure such as pipelines and underground utility networks to detect and address potential issues before they lead to subsidence.

2. **Regularly review and update hazard maps:**
   - Ensure a **legal framework**, similar to the EU Floods Directive, **for creating, reviewing and regularly updating hazard maps** for the various climate-related perils, e.g. torrential rain or heavy rain events.
   - **Make such hazard maps available to the general public, easily comparable on a cross-border basis, and free of charge, and communicate the maps** as well as the related hazard and risk information in a way that can be understood by non-experts.

> ***Examples***
>
> ***Floods:*** Review and revise pluvial flood statistics and, subsequently, existing flood maps, heavy rain hazard maps, and ensure these are known by key stakeholders. Such maps should reflect the evolving nature of pluvial flood risk.
>
> ***Wildfire***: Mapping high-risk areas prone to wildfires and updating maps based on historical fire data.
>
> ***Drought/subsidence:*** Monitoring groundwater levels and updating subsidence hazard maps accordingly.

3. **Continue to integrate hazard information [and hazard maps] into planning, zoning and permitting processes:**
   - Ensure the integration of hazard information and hazard maps in urban planning, zoning and permitting processes.

> ***Examples***
>
> ***Pluvial flood:***
>
> - Incorporating flood risk assessments into urban planning and development regulations.
> - Integrating (pluvial) flood maps in building permits within defined flood zones to ensure flood-adapted construction. This includes making the decision to only allow building once sufficient attention is paid to the risks involved and to building differently, in line with the exposure to the hazard in any given area.
> - Introducing a requirement to provide (flood) risk information to prospective house buyers and renters.
> - Enforce zoning regulations to limit or prohibit (re)construction in flood-prone areas.
>
> ***Wildfire:*** Implementing building codes and zoning regulations to limit construction in wildfire-prone areas.
>
> ***Drought/subsidence***: Issuing/requiring permits for groundwater extraction and implementing land use regulations to prevent subsidence, based on the updated subsidence risk maps.

4. **Enhance and promote public awareness, education and behavioural change vis-a-vis climate-related risks:**

   - **Promote tailor-made climate risk awareness campaigns** to improve prevention, adaptation, and risk management education, targeted by segment, community, and geography. Future risk awareness campaigns:
     - should include information on the institutional and market situation, along with information on the rights and obligation of relevant actors;
     - must effectively address stakeholders' varying perceptions of risk, knowledge about risk reduction and adaptation, levels of motivation, and response capacity;
     - should use impartial communication channels (e.g. institutions, government, relevant stakeholder associations, and community forums);
     - should include the participation of stakeholder associations (e.g. consumer, risk management and SME organisations) in their design; and
     - could be supported by EU-funded campaigns for cross-border perils.
   - **Promote awareness of climate risk insurance and other risk transfer measures**.

Examples

Pluvial flood:

- Conducting community workshops on flood preparedness and response.
- Promoting the disconnection of residential downspouts and, possibly, the use of downspout diverters, so as to mitigate the risk of basements overflowing and to capture rainwater in barrels.

Wildfire:

- Distributing educational materials on wildfire prevention and evacuation procedures.
- Make the data on risks and fire monitoring available to the public, to improve awareness and encourage risk prevention.

Drought/subsidence: Hosting informational sessions on water conservation and drought-resistant landscaping.

Heatwave: Consider introducing guidelines on ensuring workers safety during extreme heat. Inform the general public (especially the vulnerable and the elderly) about how to protect their health during heat waves.

5. **Ensure proper risk assessments:**

   - EIOPA to **continue to measure insurance protection gaps at national and EU level**. In addition, it is relevant to build a view on future protection gaps in Europe.
     - In order to improve the measurement of historical protection gaps, and also to calibrate models and help with the design of adaptation measures, EU level

authorities, in cooperation with Member States and the insurance industry, may wish to consider the creation of an **EU-wide public platform to ensure availability of economic and aggregated insured loss data** by NatCat event at NUTS granular level for all European countries. To do so, a unique European event identifiers should be used to compare how much the public and private sectors have paid for a given event. In particular:

    - EIOPA to consider collecting and sharing - anonymously and in an aggregated way - insured loss data for natural catastrophes.
    - The European Environmental Agency to continue its EU Climate Risk Assessment (EUCRA) on a periodic basis.

  - In order to improve the modelling of current and future protection gaps, both the availability and usability of risk modelling tools, as well as the modelling coverage especially for regions with a high protection gap, should be advanced. To do so, public authorities could consider creating an **EU wide database of economic exposure and vulnerability**, which would be easily accessible and understandable to individuals, households, companies and local authorities (e.g. with the use of visualisations and/or other digital tools). In particular:

    - EIOPA to consider collecting and sharing insured exposure data for natural catastrophes.

- Continue to **invest in multi-level governance collaborations to understand risks and foster innovation**. These efforts should capitalise on existing collaboration mechanisms and platforms such as the EU Covenant of Mayors, the Mission on Adaptation, ClimateAdapt, etc.

Examples

Pluvial flood: Providing real-time flood forecasts and warnings to local communities.

Wildfire:

- Share wildfire risk assessments and fire behaviour modelling with emergency responders.
- Invest in new technology to guide early monitoring and warning of wildfire risk.
- Support new research on approaches to reducing wildfire risk (ISET) as well as good forest management.

Drought/subsidence: Establishing groundwater monitoring networks to track changes in water levels over time.

6. Better coordinate emergency response and recovery efforts.

- Continue to work on the coordination of emergency response and recovery efforts in a way that reduce future risk and ensure that disasters will not repeat in a similar way.

Examples for pluvial and fluvial flood:

- Establishing a centralised command centre to coordinate flood response operations.
- Enhance stress testing procedures on a supra-regional level, paying attention to various phases, including hazard duration, recovery, and system behaviour.
- Post event:
- Ensure precise interpretation and contextualisation: translate forecasts and early warnings into local terms, such as understanding the practical implications of specific measurements like 150 mm or 200 mm of rain, or a gauge level of 6 m on-site, and decide on suitable preparation and response actions accordingly (Zurich PERC, 2021). This helps to ensure that alerts are well-understood and acted upon.
- Ensure that, following an event, there are robust communication channels and a coordinated handover process between outgoing and incoming forces, notably to prevent scenarios in which the same tasks are performed twice and ensure that action is taken where it is most needed.

Example for drought/subsidence: Providing financial assistance and support services to communities affected by subsidence-related damage.

7. Explore the potential for public-private partnerships:

- Actively engage, in cooperation with the insurance industry and other relevant stakeholders, in open discussions on the possibility of forming new **public-private collaborations schemes** also at EU level or enhancing existing ones at national level, where appropriate. These schemes should be embedded in ongoing efforts to enhance prevention and adaptation policies and investments. When designing public-private collaboration schemes, risk-based pricing should be maintained, and risks, costs, and responsibilities should be clearly shared between public and private players. Schemes should also encompass suitable safeguards and incentives to avoid adverse risk selection, promoting risk mitigation and climate adaptation measures.
- **Explore the appropriateness of making climate insurance compulsory, mandating hazard bundling** (to cover all or a subset of climate relevant perils) **or providing subsidies or tax exemptions to customers for climate insurance** at national level. These are inherently political decisions, which should be informed by sound technical analysis from relevant experts and key stakeholders.

A.1. Supervisory authorities (National and EU level)

- Hold a continuous dialogue with the insurance industry to **improve market conduct, contract/product design and consumer communication/information.**
- **Socialise useful and reliable sources of information on NatCat events** or tools to help consumers assess their risk.
- Consider forming partnerships with key stakeholders to **develop an educational and risk awareness strategy on NatCat risks** and the role of insurance in building resilience.
- **Continue conducting research and gathering information about the extent and causes of climate protection gaps** both at national and EU level.
- **Continue to exchange with other supervisors,** for example within the International Association of Insurance Supervisors, **to ensure convergence and to exploit best practices** worldwide for actions on reducing the NatCat and climate risk protection gaps.
- Continue to **work towards enhancing understanding of catastrophe models**.
- EIOPA to continue its work in positioning itself as a **Centre of excellence for catastrophe modelling and data**.
- **Continue to enhance forward looking assessments of climate-related risks in supervision**.

B. <u>SMEs, business and property owners, private individuals:</u>

1. **Stay informed and prepared:**
   - **Follow guidelines on how you protect yourself and your property** against flooding, warmer and drier climates, erosion, snowfall, storm and risk of fire.

Examples
• Keep track of weather forecasts and alerts.
• Act responsibly with flammable materials.
• Ensure drainage systems are clear and functioning.
• Store valuable assets above potential flood levels.

2. **Access information, seek guidance and, for the case of businesses, implement a robust risk management framework including a business continuity plan for the case of a climate-related or natural catastrophe:**
   - **Consult local, regional and national information and guidelines on prevention measures** against climate-related or NatCat events.
   - **Contact local municipalities and other affected property owners to discuss the need for preventive measures**.
   - **Consider using a risk management approach** with phases of risk identification, risk analysis and risk evaluation **in order to build enterprise-level knowledge** on hazards, exposures and vulnerabilities.
   - **Consult with insurers, intermediaries, and experts about the existing risk exposure and potential risk reduction and adaptation measures.**
   - **Engage in company-level and sectoral social dialogue and collective bargaining on climate change adaptation plans**, including flexible working time arrangements to effectively address climate risks.
   - **Factor climate hazards into financial decisions** (e.g., before acquiring new property)

Examples
• Seek authoritative flood maps and information.
• Consider expert guidance before significant construction projects.

3. **Explore financial support and protection:**
   - **Find out about local, regional, national and non-governmental loans or grants** for retrofitting properties or undertaking other actions to reduce risk to personal assets.
   - **Consider purchasing insurance and review policies for adequate coverage**.

C. <u>Insurance industry:</u>

1. **Develop tailored approaches to resilience:**
   - **Communicate regularly on prevention and on the role of insurance against climate-related perils** with the aim of raising consumer's awareness about the risks and about the existence of NatCat and climate-related insurance products.
   - **Translate forecasts and early warnings into local terms to facilitate understanding** of the practical implications of specific measurements.
   - **Enhance collaborations** with academic research **to further understand climate-related risks and foster innovation** in the insurance sector.
   - **Actively engage in open discussions** with public authorities and other key stakeholders **on** forming new **public-private collaborations schemes** or enhancing existing ones, where appropriate.
   - Explore the potential, challenges and opportunities of **multi-hazard bundling, parametric insurance solutions, the use of AI and multi-year insurance contracts** for climate risk to address demand and supply side factors of the climate protection gap.

2. **Promote risk awareness and financial education:**
   - **Cooperate with public authorities and other key stakeholders to increase awareness about climate risk** in general and more specifically about possible risk reduction and risk transfer measures. This includes joint initiatives to help consumers and businesses assess their risks and understand the role of insurance in climate change adaptation.
   - Develop accessible tools to provide customers with first-hand and clear information on the risk they are facing, including potential financial loss information from a NatCat event and how to mitigate the risks. In particular, make tools and references available to property owners such as hazard maps, infographics, manuals, and guidance documents.
   - Ensure **clarity in contractual language**, for example by clearly setting out the definition of perils and what kind of damage is covered in the relevant policies (e.g. the parameters and timeframe included regarding damage from rain, flooding, wind, lightning, hail, etc.).

3. **Enhance data sharing and data modelling:**
   - **Continue to enhance natural catastrophe risk modelling and risk assessment capabilities.**
   - **Engage with public authorities to support them in their own risk modelling capabilities.**

- **Enhance collaboration** with public authorities**, especially in terms of data sharing** (adhering to the proportionality principle, to data protection and data sharing regulations as well as regulation on commercially sensitive information).
- Gain a deeper understanding of **how different climate risks and hazards interact**.
- To **enhance forward looking assessments of climate-related risks**, by incorporating climate scenarios that account for the anticipated evolution of climate change.

4. **Promote customer support and consider risk-based incentives:**
   - Support customers in implementing prevention and risk reduction measures by **providing advice** based on their expertise in risk management. Specifically, contribute to loss and damage reduction, notably by sending advice/recommendations to policyholders following alerts that heavy rainfall and, subsequently, a pluvial flood might be imminent.
   - Provide assistance and advice to government and municipalities to secure an effective and efficient "resilience by design" and **build back better strategy**.
   - Support and incentivise the implementation and recognition of adaptation measures taken by insured parties, for example by promoting **impact underwriting** as a risk-based approach to premium setting, as risk-based pricing is a key tool to send risk signals and promote resilience.
   - **Diversify the types of insurance options and related costs** based on different categories of risks. In particular, further develop assistance to support the customer with any necessary build-back-better services post-event.
   - In the aftermath of an event, **prioritise support to customers** and ensure claims handling can continue as smoothly and quickly as possible and clarify how customers can submit a claim.

6 Deep-dives into specific climate-related perils

This chapter describes today's most pertinent perils and hazards in the European context, i.e. **floods, wildfire heatwave, drought, and storms**, and looks at the hazards, exposure, and vulnerability challenges associated with these events. Where possible, a distinction is made between their immediate and longer-term impacts, highlighting the interlinkage between different perils and hazards, which is enhanced in line with the accelerating pace of climate change.

To note that while there are other types of events for which protection gaps exist, sometimes significant, such as earthquake, landslide, rising groundwater, and hail, among others, which are also important to address, these are not discussed in this chapter.

6.1 Floods

In the EU Floods Directive[32], 'flood' and 'flood risk' are defined as follows:

- 'flood' means the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, and floods from the sea in coastal areas, and may exclude floods from sewerage systems;

- 'flood risk' means the combination of the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity associated with a flood event.

Floods are the most frequently occurring type of natural perils that can turn into disasters, affecting more people globally than any other natural hazard (European Commission, 2023). It is a very complex and multifaceted peril, frequently caused by storm (surge), heavy precipitation over several days, intense rainfall over a short period of time, or a dike or dam breaking, but, fundamentally, floods occur when there is more water than soils, drainage systems or rivers can process.

Three types of floods are typically distinguished: fluvial floods (river floods)[33], pluvial floods (flash floods), and coastal and estuarine floods (storm surge).[34] Each type is specific in terms of its

[32] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Floods Directive)

[33] More broadly known as river floods, fluvial floods occur "when the water level in a river, lake or stream rises and overflows onto the neighbouring land. The river's water level rise could be due to excessive rain or snowmelt. The damage from a river flood can be widespread as the overflow affects smaller rivers downstream, which can cause dams and dikes to break and swamp nearby areas" (Zurich). Referring to projections made on the basis of global hydrological models, the IPCC points out that river floods are more likely to occur in the future. Furthermore, the IPCC indicates that regional changes in river floods are more uncertain than changes in pluvial floods (IPCC).

[34] We speak of coastal or estuarine floods when land areas along the coast are inundated by seawater. This third type of flood is typically caused by intense windstorm events occurring at the same time as high tide (storm surge), and tsunamis. We speak of storm surge "when high winds from a windstorm force water onshore." As such, it is "the leading cause of coastal flooding and often the greatest threat associated with a hurricane or typhoon. The effects increase depending on the tide – windstorms that occur during high tide can result in devastating storm surge floods. In this type

causes, manifestation, and impact, which further implies differences in terms of exposure and vulnerability, and, thus, in terms of protection gaps (e.g. the occurrence of urban flooding, which is often sudden, creates immense risks to life). In this deep-dive, the focus will be on pluvial floods exclusively, notably because, of all flood types, pluvial floods are considered most widespread in Europe and because it is an area where many gaps exists in terms of risk management, even though strides have been made in this respect over recent years.

6.1.1 Hazard

Pluvial floods[35] occur due to extreme rainfall or heavy precipitation over several days, leading to surface water floods or flash floods/overland flow. Surface water floods happen when urban drainage systems cannot handle the water, causing streets and surrounding areas to flood gradually. This gives people time to relocate to safer areas, and the water level usually is not deep. While not immediately life-threatening, surface water floods can cause significant economic damage. In rural areas, pluvial floods occur when rain cannot infiltrate the soil due to sealing or compaction, especially after a dry period.

Flash floods or overland flow occur when intense rainfall exceeds the ground and soil's capacity to absorb water. Overland flow happens when water remains on the land instead of flowing into rivers or streams. These floods can emerge swiftly, often due to sudden heavy rain or discharge from upstream levees or dams. Even areas with low flood hazard can experience rapid flooding. Transparent hazard maps can identify high-hazard zones, prompting actions like avoiding construction in these areas, especially in urban settings.

A recent analysis (Ulpiani et al., 2024) by the Joint Research Centre found that precipitation is the second most frequently reported hazard in local authority Risk and Vulnerability Assessments, with an occurrence rate of 89%. The projected increase in heavy precipitation extremes moving forward is expected to result in increasingly frequent and large pluvial floods (IPCC, 2023).

Floods can result in loss of life and distress, in forced relocation[36], and widespread physical losses, including damage to personal property and public infrastructures. Floods can also severely impact businesses and business continuity, employment, sales, and labour.

6.1.2 Exposure

While data on the exposure to coastal and river floods in the EU is available, as well as hazard (and in some cases risk) maps identifying the areas most prone to flooding (an European example, and national examples from Austria and France, there is currently limited data available

of flood, water overwhelms low-lying land and often causes devastating loss of life and property" (Zurich). In the case of coastal flooding, the IPCC indicates that increased occurrence is expected, notably in low-lying areas. Also coastal erosion along most sandy coasts will increase, in line with the expectation of relative sea level rise (IPCC, Box TS.4).

[35] The definition of "pluvial floods" is based on the explanations and information provided by the European Court of Auditor's special report on the floods directive, the IPCC, and Zurich.

[36] A recent study found that, in the United States, over 3 million citizens can be considered climate migrants as they have had to move away from their street or neighbourhood in the wake of flood risk.

on exposure to pluvial flooding specifically[37]. One may also mention the unique experience caried out in Norway thanks to a concrete collaboration between the municipalities and the insurance industry (see Annex 1). According to researchers (Guerreiro et al., 2017; Grahn/Nyberg, 2017; and Hosseinzadehtalaei/Willems, 2020), this can be explained by lack of data and knowledge, as well as "the scarcity of sub-daily precipitation observations and model simulations, a limited availability of detailed and consistent data on future vulnerability components, and the computationally expensive continental flood modelling". This confirms that there are strides to be made in terms of securing the availability of the right level of data as well as in conducting large-scale and high-resolution pluvial flood hazard mapping (Mediero et al., 2022). The Floods directive has provided an interesting basis for normative approach to risk mapping (three levels of occurrence with precise or indicative return periods, etc), but there is still work to be done, as only some EU countries have opted to do so. The practice shows that this accomplishment cannot occur without a strong partnership between the national level authorities (or regional authorities according to the share of competences) and the insurance industry.

Analyses provide useful insights into the exposure of people and assets in relation to pluvial floods. Some studies (Skougaard Kaspersen et al., 2017; and Nicklin et al., 2019) have looked at pluvial flood risk in specific European cities, and confirmed a rise in (pluvial) flood vulnerability in Odense, Vienna, Strasbourg, and Nice (these cities were specifically studied, but can be seen as representing the average European city), correlating with a 7–12% expansion of impermeable surfaces from 1984 to 2014.

Other researchers have pointed out that the extent of urbanisation provides an indication of the extent to which people are exposed to pluvial flooding (Mediero, 2022): approximately 75% of the population in the EU lives in urban areas, and this is expected to rise to 82% by 2050 (Tapia et al., 2017). The studies thus confirm that urbanisation, and the fact that natural surfaces are increasingly covered by houses, roads and other infrastructure, is a key factor rendering communities vulnerable to pluvial flooding. However, it should be stressed that urbanisation really only is an indication of a phenomenon that cannot be measured directly. Indeed, even where 75% of people live in cities, many of them will not be directly affected by a flooding event.

Evaluation of the costs incurred from inaction against pluvial flood damages resulting from a single 60mm/1-h rainfall event in Rotterdam and Leicester reveals damages surpassing 10 million EUR in each city (Tapia et al., 2017), implying that there are steps that can be taken to reduce exposure and boost resilience. Figures on exposure in rural areas are not readily available, even though there are studies looking into pluvial flood risk assessment in (non-EU) rural settlements (Tiepolo, 2021).

6.1.3 Vulnerability: challenges to adequate protection

Given the strong relevance of the vulnerability dimension to protection gaps, understanding vulnerability challenges is key to identifying possible avenues that could be taken to address

[37] The Georisques website is run by the French Government, in order to provide to end users a multi risk exposure report at any house grid in the country. It covers all risk categories, in particular those covered by the NatCat insurance regime. Since 2005, there is a legal obligation in each real estate transaction to inform the candidate buyer about the risk exposure of the property, as well as the insurance loss experience from the 10 last years.

these challenges. This section outlines key factors rendering people, assets, and communities vulnerable to pluvial floods.

Urbanisation is particularly relevant as a vulnerability factor and a key area for risk reduction. However, a recent study (Rentschler, 2023) confirmed that, rather than reducing risk and vulnerability, and avoiding building in risk-prone zones, countries continue to amplify their risk exposure: between 1985 and 2015, building in flood-prone areas increased by 122% worldwide.

Another key factor is **old and inadequate** (water) infrastructure (Swiss Re, 2022; World Bank; KU Leuven, 2020). Researchers stress (Hosseinzadehtalaei/Willems, 2020) that the vulnerability of current water infrastructure systems must be addressed and that future designs of urban water systems and adaptation planning need to account for anticipated changes in precipitation patterns, including intensity, duration, and frequency. Hosseinzadehtalaei/Willems, 2020) that the vulnerability of current water infrastructure systems must be addressed and that future designs of urban water systems and adaptation planning need to account for anticipated changes in precipitation patterns, including intensity, duration, and frequency. In modernising water infrastructure, it is key to consider adaptable, nature-based approaches, rather than focus on pure grey-infrastructure (for instance in the United States of America - USA, the DC Environmental Impact Bond approach to improve infiltration as part of urban storm water management and “SuDs" sustainable urban drainage systems designed to manage surface water runoff).

In this context, two crucial aspects come into play. Firstly, building regulations evolve over time, leading to modern constructions adhering to updated codes that render them less susceptible to hazards, and older structures possibly not meeting contemporary standards. Secondly, ageing infrastructure faces degradation over time, thereby compromising protection levels and heightening vulnerability. It is important to note that neither aspect inherently implies superiority of new buildings over old ones, but it does point to the need for strategic decisions regarding infrastructure upgrades, retrofitting or renewal.

Agricultural practices could render rural and semi-urban communities vulnerable to pluvial flooding. In this regard, researchers (Alaoui et al., 2018) have established a direct link between increased flood risk and certain agricultural practices, as these can lead to soil compaction and land degradation, resulting in water runoff and, thus, possibly, (pluvial) flooding. Indeed, soil compaction is frequently associated with the heavy farm equipment and tractors needed to work the land. Such equipment is often so heavy because it needs to be able to withstand harsh conditions (European Commission).

Socio-economic status is a key determinant of vulnerability to (pluvial) flood risk. First, a lower socioeconomic status is frequently associated with increased vulnerability because individuals with limited financial means face challenges in mobility or lack resources for evacuation and preparedness. They also have limited capacity for recovery efforts (here).

Ageing is another vulnerability factor, as older individuals tend to experience physical frailty, impacting their ability to evacuate or relocate to safer areas (Clar, et al., 2023). In ageing populations, there also tends to be a higher prevalence of chronic diseases and social isolation, and people suffering from such conditions are more vulnerable to the impact of external events, such as the physical and mental health effects of flood events (European Climate and Health Observatory, 2021). Moreover, older adults may encounter difficulties with technology usage, potentially limiting their access to information sources such as early warning apps (here). At the same time, some studies (Clar, et al., 2023), looking at selected municipalities with ageing populations in the Gailtal (Austria), indicate that the risk awareness and coping capacity in rural settings tend to be relatively high, mostly due to the existence of social networks.

Looking at vulnerability post-disaster, there are important **differences between urban areas and rural areas**. In urban areas, access to essential services following a disaster is often more readily available compared to rural areas. Urban centres typically boast stronger and more resilient critical infrastructure, with greater capacity to swiftly restore services post-event. It is common for only certain parts of urban areas to be affected, particularly by flooding, leaving other areas untouched. In contrast, rural areas may face challenges in accessing services, often relying on less advanced infrastructure. Repairing infrastructure components can be slow and arduous. Moreover, medical services may be scarce and located at a distance from rural centres of population. Additionally, rural areas may have limited access points, such as two or three vulnerable routes that are susceptible to damage, relying on bridges or narrow mountain roads prone to blockages or erosion. At the same time, rural communities may benefit from stronger solidarity and mutual support networks. Residents tend to have closer relationships, enabling them to identify vulnerabilities and provide targeted support to those in need (here).

6.1.4 Lessons, good practices and potential solutions stemming from past flood events

From the review of floods as a peril, several good practices, potential solutions, and valuable lessons to the growing risk and future protection have been identified. These are outlined and organised by stakeholder group below.

All stakeholders

- **Become risk aware** and, in developing an approach to flood resilience, ensure it is tailored to the specific risk profile and exposure of the region, as well as to local conditions and practices.
    - The impact of low-pressure system Bernd (Zurich PERC, 2021), which could be considered a combination of a pluvial and fluvial flood was different across the various areas affected, notably due to geographic specificities of those areas. For instance:
        - Looking at the flooding of the Geul (Limburg, the Netherlands), the unique features of the landscape affected the manifestation and impact of the floods in this particular area. The "flooding occurred in a "relatively gradient" landscape, unusual for Dutch standards, which meant that water could flow quickly from the slopes towards the streams. While the streams have capacity to overflow, the villages were confronted with high discharges, and constituted bottlenecks and places where damage can occur" (Deltares, 2022).

- Discussions are on-going about the extent to which the vineyards on the slopes of the Ahr valley facilitated faster runoff of rainfall into the valley, thereby exacerbating the floods. This has raised questions with regard to vineyard organisation, grape row orientation, and the role of secondary vegetation (Zurich PERC, 2021).

Public authorities

- **Review and revise pluvial flood statistics** and, subsequently, **flood maps, heavy rain hazard maps** (examples of surface runoff risk map: Luxembourg; and Swiss), and ensure these are kept up to date (Zurich PERC, 2021) and known by key stakeholders. It will be important to ensure that such maps reflect the evolving nature of pluvial flood risk.
- **Integrate (pluvial, coastal and riverine) flood maps in building permits within defined flood zones** in order to ensure flood-adapted construction. This includes making the decision to only allow building once sufficient attention is paid to the risks involved and to building differently, in line with the exposure to the hazard in any given area.
- **Introduce a requirement to provide (flood) risk information** to prospective house buyers and renters.
- **Consider introducing climate resilience certificates for real estate.**
- **Launch public awareness and educational campaigns** to make people and businesses aware of what pluvial flooding is and how it could affect them, including possible measures which the public can undertake to mitigate or limit the possible damages following a climate event. Examples of useful infographics abound (example 1, example 2).
- **Implement proper land use planning strategies** that prioritise the preservation of natural environments and aim to minimise soil sealing. This means:
    - In urban settings, *expanding green areas, greening rooftops, introducing more porous soils (replacing asphalt with tiles, for instance), and implementing heavy rain multi-purpose storage solutions*. Such solutions ensure that rainwater can be absorbed more easily (IPCC, 2023, and concrete examples).
    - In rural settings, *implementing extensive retention areas ("retention basins")* to reduce the risk of water running off (Clar et al., 2023).
    - In agricultural settings, *implementing agroforestry to slow down rainwater* from running off and to allow soil absorption (Climate-ADAPT, 2023). Besides limiting flood risks, this also has the advantage of contributing to restoring water cycles.
- **Promote the disconnection of residential downspouts** and, possibly, the use of downspout diverters, so as to mitigate the risk of basements overflowing. This approach helps to effectively safeguard property and the environment.
- **Enhance stress testing procedures** on a supra-regional level, paying attention to various phases, including hazard duration, recovery, and system behaviour (Deltares, 2022).

- **Maintain dams diligently and conduct regular inspections**: poor dam management or exceeding design capacities could worsen flooding (Zurich PERC, 2021).
- **Ensure precise interpretation and contextualisation: translate forecasts and early warnings into local terms**, such as understanding the practical implications of specific measurements like 150 mm or 200 mm of rain, or a gauge level of 6 m on-site, and decide on suitable preparation and response actions accordingly (Zurich PERC, 2021). This helps to ensure that alerts are well-understood and acted upon.
- Ensure that, following an event, there are **robust communication channels and a coordinated handover process between outgoing and incoming forces**, notably to prevent scenarios in which the same tasks are performed twice and ensure that action is taken where it is most needed (Zurich PERC, 2021).

Insurers

- **Ensure clarity in contractual language**, for example by clearly setting out the definition of perils and what kind of damage is covered in the relevant policies (e.g. the parameters and timeframe included regarding damage from rain, flooding, wind, lightning, hail, etc.), particularly in older contracts, as crucial coverage gaps may not be evident (Zurich PERC, 2021).
- **Translate research findings into actionable guidelines** and share these publicly with homeowners, businesses, communities and governments (Geneva Association, 2020).
- **Increase their proactive engagement with public entities**, including governments and their customers (Geneva Association, 2020).
- Contribute to loss and damage reduction, notably by **sending alerts** to policyholders when heavy rainfall and, subsequently, a pluvial flood might be imminent.
- In the aftermath of an event, **prioritise support** to customers and **ensure claims handling** can continue as smoothly as possible and clarify how customers can submit a claim (Zurich PERC, 2021) and contribute after each major event to the lessons learned exercises conducted by State authorities, thanks to the insured loss data collected quickly.

SMEs, business and property owners

- **Keep track of weather forecasts and warnings** provided by meteorological services.
- **Seek out** authoritative, publicly available **flood-risk maps and information** (Geneva Association, 2020).
- Prospective buyers of property should **conduct risk assessments before investing** and add adaptation measures to the project.
- Property owners should **ensure that drainage systems are** clear of debris and **functioning properly**. This means ensuring that downpipes, draining pipes, gutters and wells are regularly cleaned in order to prevent blockages or leaks.
  - In checking the drainage, it should be ensured that the storm water is not connected to the wastewater, or house foundation drainage. The ground should

slope away from the property to allow for runoff. Any deficiencies in the runoff to the sewer network should be reported to the relevant authorities to mitigate additional risk.

   - Property and business owners could also ensure that valuable equipment, assets, documents, and materials are stored above potential flood levels or in waterproof storage units and do regular inspections to identify and address any vulnerabilities.
   - In a similar vein, property owners may consider creating local flood barriers. Converting hardened surfaces into reinforced green surfaces may also reduce the water load on the drainage system.

- Any openings such as windows, doors, roofs, or cracks in basement floors should be sealed. Property and business owners can install flood protection measures in the basement, for example installing a shut-off floor drain, backwater protection and checking the valves on drains.
- Find out if the local government provides **loans or grants for retrofitting** properties (Geneva Association, 2020).
- **Consider purchasing insurance and frequently review insurance policies** to ensure adequate coverage for flood-related damages (Geneva Association, 2020).
- Check with insurers and public institutions whether a **property inspection or risk assessment can be facilitated, subsidised, or financed**, to identify the key risks through professional services ("Climate Risk Assessment; Climate Resilience Services").
- In the case of flood risk, consider using **easy-to-install panels** to cover doorways, windows or ventilation and ensuring access to flood pumps, temporary flood barriers and backup power in case the supply is cut off.

6.2 Wildfire

Wildfires, otherwise known as 'forest fires' or 'bushfires', is a peril that is becoming increasingly relevant in the European context as climate change exacerbates the scale and scope of this event (EEA, 2021). Global losses due to wildfire are estimated at 69 bn USD between 2018-2022, with insurers covering 39 bn USD (MunichRe). For 2022 alone, the European Commission (2023) estimated the damage caused by wildfires in the EU to be at least 2 billon EUR.

Wildfires can cause significant loss to the environment, property, infrastructure, and personal health. They can also increase the risk of other perils through the damage caused, for example the increased risk of flooding after a wildfire or reduced protection capabilities of natural protection structures, such as protection of forests from avalanches or landslides. Wildfires release large amounts of greenhouse gasses (GHG) and can also damage biodiversity, cause soil erosion and affect water quality (EEA, 2021).

In the EU, wildfires currently affect mostly southern Europe, but increasingly also central and northern Europe (EEA, 2021).

Wildfires cause damage to the natural area, to properties, and to health, when burning near a populated area. Houses can be burnt or severely damaged by the fire that catches on combustible materials on or near the property. Insurance for wildfire damage is becoming increasingly problematic for some regions, especially as the hazard and severity of wildfires increases. This is the case for some areas of California in the USA, where several property insurers have withdrawn or cancelled renewals of property insurance for wildfires in the context of growing wildfire exposure and losses (Axios, 2023; San Francisco Chronicle; Munich Re, 2019), even though other aggravating factors, such as the regulatory inability to adapt premiums to the perils being covered, have also contributed to these decisions (Bloomberg).

Extreme heat, dryness and wind are the main drivers of wildfires, especially when combined. This links the peril of wildfires to the peril of heatwave and drought also analysed through this chapter.

6.2.1 Hazard

A wildfire is an unwanted and unplanned fire that occurs in nature, most commonly in a forest, vegetation or grassland (European Commission). It is estimated that since the 1980s, global wildfire season has lengthened by 27% (Doerr et al., 2022).

Human activity is the main trigger of wildfires in the EU (EEA, 2021; JRC, 2022), either intentionally or by accident (BBC, 2021). In certain cases it has also been linked to the friction of car tyres against a dry road, sparks from trainlines or powerlines (JRC, 2022; Bloomberg, 2024). The most common spark that is not caused by humans is lightning strikes.

6.2.2 Exposure

Europe has seen an unprecedented growth in wildfire events since 2020. In 2022 alone, almost 900 thousand hectares of land was burnt with over 40% belonging to Natura 2000 sites recognised as protected biodiversity area (JRC, 2022). Although many European countries face the risk of wildfires, the countries around the Mediterranean (Portugal, Greece, Spain, southern France and Italy) remain the most threatened by wildfires in terms of burnt areas (EEA, 2021).

The overall area burnt in the Mediterranean has decreased since the 1980s, which has been attributed to better fire control efforts and improved detection and monitoring capabilities. However, since then, areas in central and northern Europe are now being subject to fires, driven by an increase in droughts and heatwaves (EEA, 2021). In 2021, 22 out of the 27 EU member countries experienced forest fires, showing the wide-spread nature of this peril (European Commission).

As firefighting techniques evolve, regions can become more prepared for fires and mitigate the number of human casualties from the wildfires. However, as the fires season is prolonged and the frequency and intensity of wildfires increases, this is becoming a more difficult task (JRC, 2022).

The effects of wildfires also pose a threat to human health. The World Health Organisation (WHO) notes that wildfire smoke is hazardous, notably containing air pollutants such as PM2.5, NO2, ozone, aromatic hydrocarbons or lead. These pollutants can cause and exacerbate diseases of the respiratory system and other parts of the body, and can increase the risk of early death (NASA, 2020; Rongbin Xu et al., 2020). Most of the scientific literature focuses on the short-term effects of wildfire, however less is known about the long-term effects of exposure, especially in the context of recurring and increasing exposure (Grant/Runkle, 2022).

6.2.3 Vulnerability: challenges to adequate protection

Early intervention in wildfires is crucial to reduce the loss and mitigate the blaze spreading. Through monitoring the conditions and risk factors of the land at risk of wildfire, authorities can better detect a fire in its early stages. In Hawaii, new wildfire sensors are being put in place to mitigate the ignition potential or limit the early spread of wildfire, following the large fires in Maui in 2023. These 80 wildfire sensors and 16 wind sensors placed across the Hawaiian Islands act as a real-time identification of wildfire risk related to a series of indicators related to the risk. Their ability to detect gases and particulate levels is noted at about 1,000 times more sensitive than a home smoke alarm (US GOV, 2024).

At EU level, the EU Civil Protection Mechanisms is in place to support EU cross-border and international cooperation on wildfire risk, including the Early Warning and Information Systems and Emergency Response Coordination Centre and that liaises with national authorities from the Member States to exchange information on wildfire risk and preparedness throughout the wildfire season (European Commission).

Forest management is a major factor in limiting the risk of wildfire spreading, among other benefits such as managing storms, drought, invasive species, pests and disease in the forest. The EU has invested in researching such practices and calling on national entities to utilise these techniques and guidelines (European Commission, 2021; Climate-ADAPT, 2023). Sustainable forest management is an activity that involves multiple levels of public authorities (Mauri et al., 2023).

On an individual level, properties and communities, especially those located in the wildland-urban-interface, can protect themselves from the parks that are carried from wildfires and risk starting new fires. This includes specific measures on the immediate surrounding of the home (10 meters) to limit the amount of combustible material, for example regularly trimming vegetation, avoiding certain easily ignited vegetation, using non-combustible fencing and other (non-combustible) materials. If a wildfire breaks out, it is any combustible materials near the home that could catch fire and spread to the house itself. This task of property owners regularly checking for combustible materials and taking proactive measures to limit the accumulation of vegetation around the immediate home is imperative to control wildfire risk (ISET, 2020).

Besides the immediate vicinity of the home, there are also measures to be taken within 100 meters of the house. This stresses the importance of a community approach, as the actions of neighbouring houses can also increase the risk of wildfire. Preventative measures involve increasing spacing between combustible materials (trees, other vegetation) and regularly removing debris and excess vegetation to slow the speed and reduce the intensity of a spreading wildfire (Zurich, 2020; FireSmart Canada; III). These lessons were particularly noted in Zurich's assessment of 'Canada's costliest disaster,' the wildfire in Fort McMurray in 2016.

On a national level, there can also be regulations in place regarding the clearing of vegetation linked to wildfire risk. This is the case in France where it is mandatory for homeowners to cut the vegetation within 50m from their property (or 100m in some locations) in areas designated as high risk of wildfire. This applies to properties located within 200m of a forest or area of high vegetation, or in an area of known wildfire risk (FR GOV, 2023).

6.2.4 Lessons, good practices and potential solutions stemming from past wildfire events

From the review of wildfires, several good practices, potential solutions, and valuable lessons regarding the growing risk and future protection have been identified. These are outlined and organised by stakeholder group below.

All stakeholders

- **Study the risk of wildfire and its evolution** to better predict its future impact.
- **Share lessons** across borders in the EU and internationally **on wildfire risk reduction techniques**, as is commonly seen between the EU and its neighbours, and between the USA, Canada and the EU.

Public authorities

- **Launch public awareness and educational campaigns to increase risk awareness and promote risk-reducing behaviour**. Examples of such campaigns include the USA Insurance Institute for Business & Home Safety's guide, the French Government's campaign on wildfire protection (French Government, 2022), and the FireSmart Canada initiatives which promotes preventative measures for homeowners to reduce their risk.
- **Make the data on risks and fire monitoring available to the public, to improve awareness and encourage risk prevention**. At EU level, the European Forest Fire Information System (EFFIS) tracks the fire season across the continent. National authorities also have their tracking, such as the Dutch Klimaateffectatlas, the French Georisques portal for individuals to assess their risk, and Promethee portal on wildfires available to the public.
- In high-hazard areas, **enforce the regular clearing of vegetation between forest areas and urban areas** to create a natural separation in case of fire.
- **Land-use planning: avoid or limit granting permits to build in areas prone to wildfire** based on predefined conditions (e.g. distance between buildings and forests) and avoid uncontrolled sprawl of individual properties into the wildland-urban-interface. . In high-hazard areas, enforce the regular clearing of vegetation between forest areas and urban areas to create a natural separation in case of fire.
- **Invest in new technology** to guide **early monitoring and warning of wildfire risk**, such as new fire-tracking systems developed through the EU AF3 project, real time satellite-based forest fire detection system in Sweden (UNDRR) or the sensors in Hawaii.

- Ensure there is a **central crisis centre that can communicate and coordinate emergency actions** in case of a wildfire.
- Encourage a **community approach to wildfire resilience** through community engagement programmes (ISET, 2020).
- Support **new research on approaches to reducing wildfire risk** (ISET, 2020) as well as **good forest management**.

Insurers

- **Make tools and references available** to property owners on how they can **reduce their risk of wildfire** through appropriate actions. For example, what building modifications can be made or standards buildings can be adapted to.
- **Encourage the policyholder to take measures to limit their risk**. In the case of adaptive measures by the prospective policyholder, take these into account in the risk calculation for the policy (MunichRe, 2019).
- **Invest in renewed catastrophe and risk modelling** to reflect the evolving risk, as was noted in the USA, where the industry is investing in better understanding wildfires (SciAm, 2024)
- **Notify policyholders of the growing risk** in their area and explain any changes to the policy and renewal clearly.

SMEs, business and property owners

- **Check personal risk levels** and act accordingly to reduce the risk to your property and yourself. This includes regularly clearing vegetation and combustible materials near your property and having an emergency plan.
- During wildfire season, **follow the alerts and guidance** of the authorities.
- **Adapt the property** to reinforce resilience to wildfires. This can include for example ensuring the airways into the house are protected from embers and smoke entering the properties (Quarles et al., 2010).
- **Act in a responsible way with flammable materials**, particularly if near vegetation. For example, ensure your campfire or barbecue are fully extinguished before leaving the site, dispose of cigarettes appropriately and ensure flammable materials such as gas canisters are not at risk of combustion. These apply whether you are in your property or on holiday near dry vegetation.
    - Keep an eye on the fire risk and adjust your activity when it comes to grilling and working with forest machines.
- Take advantage of information about fire risks and fire bans on the websites of respectively the emergency services and municipality,
- Prepare what needs to be taken in the event of an evacuation due to fire.
- Consider what type of resources, personnel, machines or other equipment that the emergency services can use in wake of an event.

6.3 Heatwave

Heatwaves are becoming more frequent in Europe. In 2023, Europe saw a record number of days with 'extreme heat stress' (Copernicus). Heatwaves are characterised by unusually high temperatures during the days and nights in the summer period. Definitions can vary per criteria used (e.g. climatological heatwave days or heatwaves based on apparent temperatures) and by local impact, however the key elements include a prolonged excess of heat during days and nights (EEA; Copernicus).

The impact of heatwaves on human health is a central issue of this peril. In the summer of 2022, it is estimated that over 61,000 heat-related deaths were recorded in Europe (Ballester et al.) Vulnerable population groups such as the elderly are most at risk from such events, as well as those without adequate temperature mitigation measures in the extreme events (e.g. poor air circulation or thermal insulation) (JRC). However, above a certain threshold the heat is dangerous for all population groups and direct exposure should be mitigated as much as possible (BBC).

The increase in intensity and frequency of heatwaves in Europe has been linked to the effects of climate change (BBC; WWA; MIT; IPCC). The excess heat is further linked to the perils of drought and wildfire as the excess heat can be a trigger for wildfires of dry vegetation.

In terms of damage, besides the effects on human health, heatwaves can also damage agriculture, natural ecosystems, properties, infrastructure and have economic effects marked by a loss of productivity and an increased demand for energy from cooling appliances.

6.3.1 Hazard

Heatwaves and extreme heat can be seen both as long-term and chronic, and acute. It is chronic in the sense that widespread issues arise as temperatures steadily increase. Prolonged hot seasons and higher average temperatures can disrupt livelihoods, put new strains on social services, threaten food security, and challenge long-established ways of life and coping mechanisms. At the same time, extreme heat involves distinct, acute issues that arise when short-term, unusual periods of extreme temperatures and humidity present life-threatening risks to individuals and communities (International Federation of Red Cross and Red Crescent Societies).

There is no universal definition of a heatwave, as different regions or countries have established their own parameters. However, extreme heat has numerous effects on the body and can be fatal depending on the heat and the vulnerability of the individual. Heatstroke and heat exhaustion are specific conditions, while general dehydration, fatigue, and difficulty completing everyday tasks can be other effects of extreme heat (Politico).

In terms of damage caused, excess heat and drought is further connected with an increased risk of subsidence, particularly the shifting of building foundations due to the compression of the unusually dry soil. Following the 2003 heatwave across Europe, large property losses were accumulated from subsidence, totalling around 1.1 bn EUR in damages (SwissRe, 2011). In France, the cost of property damage linked to subsidence has risen sharply over the years, from an average of 1 bn EUR a year between 2016-2020 to an estimated 3 bn EUR for 2022 alone (France Assureurs).

Heat can also cause direct property damage through weakened roofs, wall cracks and paint damage (Aviva, 2022). Other forms of insurance are also linked to heatwaves, such as worker's insurance, event insurance and other measures where the employee or participants are unable to perform required duties due to the excessive heat (Moody's, 2022).

6.3.2 Exposure

In Europe, the exposure to heatwaves is felt more intensely in the southern part of the continent, and this trend will remain in the future. The JRC estimates that in the case of unmitigated climate change, human exposure to severe heatwaves would be multiplied at 40 to 50 times more for Southern Europe, whilst it would be around 30 times in other parts of Europe compared to current exposure levels.

Extreme heat was the most reported hazard in the Risk and Vulnerability Assessments of cities completed in May 2024. Out of the nearly 1,900 assessments, 93% captured this hazard, and the majority further indicated that they expect an increase in both intensity and frequency of this hazard in their locality (JRC).

Extreme temperatures can be exacerbated by the 'urban heat island' phenomenon, where cities experience higher air temperatures than the surrounding rural area. This has been estimated to be a 5-9°Cdifference between the urban and rural temperatures in Europe during extreme heat (UNEP, 2019). Indeed, man-made surfaces that make up vast urban areas, such as roads and buildings, can absorb and re-emit heat which increases the air temperature. Other activities such as energy consumption and urban mobility can also emit further heat over the concentrated urban area which can contribute to the phenomenon (MIT, 2021). As more and more of the population are expected to live in cities in the coming decades, it is therefore of increasing importance for authorities to examine how to keep the city cool. Certain cities have already started doing so, such as the city of Paris, which published in 2023 a report "Paris at 50 degrees" to help prepare the city to future extreme heats (Paris, 2023).

6.3.3 Vulnerability: challenges to adequate protection and possible ways forward

Socio-economic factors can exacerbate a person's exposure risk to extreme heat. Resources are required to be able to stay cool, either through adequately insulated locations (e.g. one's home or office) or through cooling appliance. These can be out of reach from the more financially marginalised population. Without appropriate resources to check for weather warnings, or a broader lack of awareness about the dangers of extreme heat, there is a risk that one does not have options on how to appropriately manage the heat. This is especially relevant for older and vulnerable populations, or lower socio-economic groups of the population.

Urban planning and nature-based solutions can be used to cool cities. This is also a priority of the EU, which draws on increasing green infrastructure (European Commission). Greenery and water-based technologies were also the most frequently used techniques by cities in their strategies to mitigate urban overheating, as noted in an analysis from May 2024 by the JRC.

Planting additional vegetation can have advantages against the heat, especially new tree canopies which can provide shade and protection to the population (Euronews, 2020). For example, this is the desired effect of Barcelona's trees strategy for 2037 to expand and diversify the urban tree canopy, and Sydney's new green policy to plant 200,000 native trees in the area between 2023-2025. Other vegetation can be introduced through 'green roofs' with plants installed that can also absorb sunlight and heat, with the same principle applied to other urban surfaces such as along pavements (Kurn et al., 1994).

Further examples can be found in India, where following the 2010 heatwave the city of Ahmedabad developed a plan for cooling station, cooling roofs and awareness raising (UNEP, 2019). Other cities in Germany, Canada or China are also merging urban planning with nature-based solutions to re-green the city and protect better against heat stress or flooding (GCA, 2019).

Whilst nature-based solutions can be applied widely, there is no one-size-fits-all solution. The measures must take into account the local climate and existing building styles to best adapt these (EEA, 2022). For example, whilst houses in a warm climate may be built to promote a cool interior, houses in a colder climate may instead be built to prioritise heat retention and light.

High temperatures can also generate a **productivity, as well as a work safety problem**. Without proper conditions for work, normal activities in certain sectors of the economy cannot continue as planned as the heat poses a health risk to the workers (Heat-Shield). This is especially the case for manual workers or those that must work outside (e.g. in construction, maintenance, waste services, agriculture, forestry, transportation, tourism, etc). Whilst there is no overarching EU legislation on workers protection which defines a maximum temperature, in most Member States there are regulations on workers conditions which include safe temperatures (Euronews, 2023). In India, to deal with extreme heat, there are trials of parametric insurance programmes linked to the air temperature (Swiss Re, 2024) If the temperature exceeds the limit set for work to proceed over a given period of time previously set in the policy, then the worker is compensated for the day of work that could not be carried out (Bloomberg, 2023).

Heatwaves also create a surge in **energy demands**, which puts additional financial pressure on the population to power cooling devices. This surge can also result in temporary power outages – either due to the strain on the power grid or a by a decision to limit the power available by operators to limit the surge risk (Weather Network, 2023; Bloomberg, 2024). Physical power infrastructure can also be affected by the heat, such as damage to power lines, or nuclear power plants facilities having to close due to high water temperature levels and/or low water levels, as was the case in France in the heatwave of 2003 (Britannica). Without the power to use electric cooling devices, temperatures in poorly insulated buildings or residences can reach dangerous level. It must be noted however, that massive use of air conditioning is also considered a classic case of maladaptation due to the generation of CO_2 emissions (unless the power grid is decarbonised).

6.3.4 Lessons, good practices and potential solutions stemming from past heatwave events

Based on the analysis conducted on heatwaves, several good practices, potential solutions, and valuable lessons related to the growing risk and future protection have been identified. These are outlined and organised by stakeholder group below.

All stakeholders

- **Consider adaptive nature-based or re-greening solutions** to protect against high temperatures and heat stress, especially in the urban environment.

Public authorities

- **Invest in disaster risk management** so as to realise the "multiple dividend of resilience" (Rözer, et al, 2023).
- **Improve or implement alert systems** to notify of extreme heat and warn against exposure. Many countries have such alerts in place, which are available through the meteorological forecasts and determined according to different methods (Casanueva, et al, 2019). A step further is for example the heat-health alert service by the Met Office in the UK, with the public able to sign up for warnings about extreme heat events.
- Make use of public spaces to **offer shelter from the heat** – for example public pools/lakes that are made accessible to the public, or temporary shelters or 'cooling centers' equipped with essential supplies for the heat, as was set up in Barcelona with 'climate shelters'.
- **Harness nature-based solutions** to provide shade and protection from high temperatures in urban areas, such as planting additional trees to promote an urban tree canopy. This also includes transforming urban areas into 'cool islands' as was done in a Paris schoolyard through the OASIS project.
- **Raise awareness** of the dangers of excessive heat and heat stress, especially among the more vulnerable populations. Copernicus reports the tendency of a low-risk perception of heat by the public, vulnerable groups and some health care providers (Copernicus, 2024).
- Consider introducing **guidelines on ensuring workers** safety during extreme heat.
- Take measures to raise awareness and **support the preparedness of population groups particularly vulnerable to heatwaves**, including older people. For example, in Manchester analysis was done to understand the issues associated with heat stress in older people (UNDRR).
    - Install sun protection and awnings and possibly district cooling.
    - Place drinking water fountains where people move.

Insurers

- Gain a deeper understanding of **how different climate risks and hazards interact**. For example, in 2003 in France there were large losses attributed to subsidence (SwissRe). However, it was also noted that other factors not previously addressed (such as varying construction standards and previous damages/accumulation) may have led to an increase in losses for this particular event compared to other events.

- **Encourage policyholders to take precautionary measures** (such as avoiding hottest hours of the day or drinking water) **and adaptive measures** to make their environment more resilient, including property upgrades (e.g. better insulation, windows, airflow/ventilation) and nature-based solutions (e.g. maximising green space, cool roofs) applied to properties.
- **Consider parametric insurance** for specific arrangements.

SMEs, business and property owners

- Take steps to **adapt properties to enhance thermal resistance** – notably through adequate ventilation, air conditioning and insulation. Green solutions, such as adding greenery to roofs, facades and the building surroundings can also provide shade and cooling. This also includes locating server halls and other heat-sensitive equipment to naturally cool spaces, alternatively ensure that overheating is avoided.
- **Review internal processes and policies** with the view to protect workers from extreme heat. This could include thinking about adequacy of work-related transportation, uniforms/protective clothing, access to water, access to cool shelters, work hours (both length of work as well as starting/ending hours to avoid most extreme times of the day).
- **Be aware** of the main warning signs of heat damage to your property and yourself, and act in a preventative manner during the excessive heat (create shade and ventilation, ensure your property is maintained according to public authorities' advice (e.g. WHO guidelines), following insurer's (e.g. advice from Aviva, to property owners).
- **Have supplies at hand** in the event of extreme heat to limit exposure, e.g. access to water and food supplies.
- Establish company-level and sectoral social dialogues, and pursue collective bargaining on climate change adaptation plans, which would include, where appropriate, flexible working time arrangements to effectively address climate risks.
- Inform tenants about ways to keep the property cool and have an on-call system for emergency measures. Pay particular attention to properties with nursing homes, as the elderly and vulnerable have a poorer ability to handle heat, as well as tenants with heat-sensitive equipment. Examples of cooling measures:
    - Draw down the blinds or curtains during the day to block the heat of the sun.
    - Weather in the evenings and nights when the outside temperature is lower.
    - Turn off heat sources such as computers, TVs, and other electrical appliances.
    - Drink plenty of water and take a cold shower.

6.4 Drought

The European Drought Observatory (EDO) defines drought as '[...] a climate extreme characterised by persistent unusual dry weather conditions affecting the hydrological balance. The conditions are usually associated with lack of precipitation, deficit in soil moisture and water reservoir storage, leading to widespread impacts. Droughts can be exacerbated by heatwaves.' Droughts can last for weeks or months, and often cannot be marked by a clear beginning and end point. The IPPC points out that, as climate change accelerates, droughts are increasingly likely to occur (IPCC, 2023).

Drought manifests itself in three primary forms. Firstly, meteorological drought arises from an extended period of insufficient precipitation, disrupting the water balance. Secondly, agricultural and ecological drought occurs when meteorological drought persists, causing a depletion in soil moisture that restricts water availability for both natural vegetation and agricultural crops, thereby impacting ecosystems and agricultural productivity. Lastly, hydrological drought emerges from prolonged deficits in precipitation, which in turn diminishes surface and subsurface water resources. This leads to reduced streamflow in rivers and creeks, a decline in reservoir and lake levels, and a lowering of groundwater tables, culminating in significant challenges for water supply and management systems (EDO).

6.4.1 Hazard

Drought can lead to water scarcity and, as such, can have a severe effect on different economic activities and sectors, including tourism, transportation infrastructure, agriculture, forestry, water resources, and biodiversity. As droughts diminish water levels in rivers and groundwater, inhibit the growth of trees and crops, they intensify pest infestations, and contribute to the escalation of wildfires (European Commission) and to longer wildfire seasons.

In Europe, the bulk of the approximately EUR 9 billion in annual losses attributed to drought primarily impacts agriculture, the energy sector, and public water supplies (European Commission). Drought can moreover increase the risk of subsidence (France Assureurs, 2022), potentially causing insurance premiums to rise, house prices to drop, or mandating engineering efforts to stabilise land or buildings and replace utility pipelines.

The effects of drought are expected to increase without effective implementation of global mitigation efforts as well as adaptation strategies at both EU and national levels (EEA, 2023). In this regard, it should be noted that many European countries do not have dedicated drought risk management strategies in place (Blauhut V. et al., 2022).

6.4.2 Exposure

The incidence of extreme droughts is on the rise across Europe, with consequent damages escalating. With a global average temperature surge of 3°C, forecasts indicate a twofold increase in the frequency of drought occurrences, amplifying annual losses to EUR 40 billion in Europe alone (European Commission).

An assessment by the European Commission's Joint Research Centre (JRC, 2022) indicates that approximately 46% of the European Union's territory is classified as being exposed to drought at 'warning levels', with an additional 11% under high alert. According to the JRC, France, Romania and Hungary, as well as several Mediterranean regions, including Italy, Spain and southern Greece are most affected. It will be important to monitor regular updates to exposure data provided by the European Drought Observatory.

Furthermore, European countries are affected by droughts in non-EU regions from which the EU imports agricultural products. Indeed, researchers estimate that, by the year 2050, a minimum of 40% of the agricultural imports into the EU will be "highly susceptible" to drought (Ercin et al., 2021). This poses important risks to the agri-food economy and goods consumed by Europeans.

6.4.3 Vulnerability

In addition to climate change, geography significantly influences vulnerability to drought, which typically depends on certain geographical features, climate and weather patterns (Blauhut, V. et al, 2022). Furthermore, soil type and quality are important determinants. Sandy soils, for example, drain water quickly and are less able to retain moisture, making them more susceptible to drought impacts.

In addition, contemporary agricultural practices and land use are also key vulnerability factors, with deforestation, overgrazing, and other forms of land degradation reducing vegetation cover and soil moisture retention. In this regard, it should be noted that regions where agriculture is a primary source of livelihood are particularly vulnerable to drought, as crop failures and livestock losses can have significant economic and food security implications.

Finally, inadequate water management practices and infrastructure can exacerbate the impacts of drought. Poorly maintained water supply systems, inefficient irrigation practices, and lack of water storage facilities can worsen water scarcity during drought periods.

6.4.4 Lessons, good practices and potential solutions stemming from past drought events

From the review of droughts, several good practices, potential solutions, and valuable lessons related to the growing risk and future protection have been identified. These are outlined and organised by stakeholder group below.

Public authorities

- **Implement drought management planning strategies and associated action plans** (Blauhut, V. et al, 2022).
    - Macro-level guidance from the EU may be advantageous for both national and international management of drought risks. This guidance should establish a broad framework that accommodates regional variations in management strategies. To facilitate this progress, it is essential to have sector-specific databases, like the EDII, that demonstrate and quantify the diverse impacts of previous droughts. This will raise public awareness and encourage political

action. Furthermore, this information should be integrated into (inter)national drought risk monitoring systems, providing sector-specific insights into drought risk (Blauhut, V. et al., 2022).

- **Avoid maladaptation**:
    - Before implementing an adaptation measure, ensure the availability of solid scientific evidence underpinning the advantages of the measure, and consult hydrological experts to avoid incidences of maladaptation.
    - A key example are large water reservoirs being put in place in certain countries, aimed at helping farmers adapt to climate change. Indeed, while such reservoirs may help to maintain certain agricultural practices in the short term, if not adapted to local circumstances, they may not be a long-term solution to the accelerating impact of climate change on agriculture, while potentially affecting groundwater reserves. Also, while they may be of help to certain farmers, they may make it even more difficult to other farmers to have access to water.
- Subsidence[38]:
    - **Establish monitoring systems** to detect changes in groundwater levels early, allowing for prompt intervention to prevent or minimise subsidence damage.
    - Regularly inspect and **ensure maintenance of infrastructure** such as pipelines and underground utility networks to detect and address potential issues before they lead to subsidence.
- Raise awareness in the population, with a view to **encourage responsible water consumption**, especially in periods of drought.
- Consult key stakeholders on measures aimed at addressing water scarcity.

Insurers

- **Create innovative insurance products** that do not only respond to drought impacts after they occur but also reduce land degradation by implementing suitable strategies beforehand (Tsegai & Kaushik, 2019).
- **Consider incentives to policyholders to better prepare for a drought.**
- **Further embed drought in risk management practices.**
- **Target advertising towards to communities most exposed to drought-related losses** (e.g. individuals and businesses in the agricultural sector).

SMEs, business and property owners

- Before commencing any significant construction projects, **consider seeking expert guidance**, notably from the awareness that there may be consequences associated with installing impermeable driveways and pathways, as well as planting or removing

[38] While subsidence is a standalone peril, it is often associated with drought because the drying and shrinking of clay soils can cause ground movement and structural damage.

trees in close proximity to properties, as these actions can influence soil moisture levels (British Geological Survey, 2021).

- Seek active engagement, through associations, with authorities on climate adaptation measures.
- Pay attention to changes in slopes or watercourses to monitor for signs of erosion, such as trees that start to lean or soil pieces dislodging. Consider planning deep routed trees and shrubs to counteract erosion.

6.5 Storms

The EEA defines a storm as 'an atmospheric disturbance involving perturbations of the prevailing pressure and wind fields on scales ranging from tornadoes to extratropical cyclones'. In this definition, the range of different types of storms is already apparent. Storm types include a thunderstorm (also referred to as severe convective storms), windstorm (also dust or sandstorm), blizzard, hurricane (tropical cyclone), storm surges (coastal areas) and tornadoes, among others (EEA; Outforia). For this peril, the focus will be on severe convective storms (thunderstorms) on land, which are usually characterised by strong winds, heavy rain, thunder, lightning and often hail and temperature changes (SwissRe, 2023).

Storms are among the most frequent and most damaging natural catastrophes. SwissRe estimated that in the first half of 2023, severe thunderstorms accounted for up to 70% of all insured natural catastrophe losses – particularly driven by storms in the US (SwissRe, 2023). MunichRe reported record thunderstorm losses due to storms in the Alpine region and Mediterranean area in 2023 (MunichRe, 2024).

Storms can cause many types of damage to properties, including destruction from high winds (of roof tiles, windows, objects dislodged or carried in the wind), electrical damage from lightning, damage to infrastructure (such as powerlines, roads, railways) and even severe health damage and death (Euronews, 2023; Politico, 2023). The effect of storms with heavy rainfall can cause flooding, which is covered as a separate peril in this chapter. Wildfires can also cause convective storms due to the disruption in the weather (Insurance Information Institute, 2020), which links this chapter to a further peril.

6.5.1 Hazard

Severe convective storms occur when heat from the ground pushes heat and moisture upwards, forming specific clouds. Depending on the atmospheric conditions, this can then generate localised and intense rainfall, wind, hail, etc. They are most common during the summer but can occur all year round (RMS, 2020).

Storms can be measured and defined in different ways. In general, the Beaufort Wind Scale is widely used to determine high winds and issue weather reports or public warnings (RMS, 2020). The wind speed is measured at 10 meters above ground. It should be noted that these are not the same values of wind speed felt at ground level. Other scales exist, depending on the type of storms, for example the Fujita scale for tornados which uses wind speed, or the Saffir-Simpson

Hurricane Wind Scale, which estimates property damage relative to different wind speeds (NWS; NHC).

The most severe type of storms are becoming more frequent in Europe (European Commission; Zurich). This is because the increase in global temperatures due to climate change provides additional moisture in the atmosphere from the increase in water evaporation, which serves as further energy for severe storms (NASA; Munich Re, 2024). It is difficult however to establish a link between climate change, frequency of storms and intensity of winds, especially in relation to past data (Météo-France). A study of two storms over continental Europe in 2018 also noted this (WWA), but found a stronger link between heavier rain and stronger winds linked to climate change in the context of 2023 storms over the black sea (WWA). Aon noted there is little evidence that climate change is impacting the key conditions needed for severe convective storms in the United States, but rather that increased exposure to storms is a key issue driving increased losses.

6.5.2 Exposure

The high wind, heavy rainfall and lightning usually associated with traditional thunderstorms can cause damage to homes and infrastructure, particularly through flooding or lightning strikes. Hail above a certain size generated from thunderstorms can cause serious damage to property. For instance the golf ball sized hail seen in Australia in 2020 broke windshields, killed birds and pulled leaves off trees (NPR). Similar large hailstones of 8-10 centimetres have been seen in Europe, notably in France in 2014 (Moody's, 2020), and hailstones up to 19 centimetres in diameter in Italy in July and August 2023 (Munich Re; CNN).

In Europe, storms are prevalent across the continent, especially across northern and central Europe. In Europe in 2023 alone, storms caused economic losses of 5 billion USD, and 3.6 billion USD in insured losses reported by Aon (AON, 2024). Out of these, 2.1 billion USD of the losses was from a single incident – storm Ciarán – which affected northwestern France in November 2023. Severe convective storms are rated as the second largest loss driver in 2023 according to Aon (2024), second to earthquakes. According to the JRC, "storms" is the fifth most frequently reported hazard in local authority Risk and Vulnerability Assessments, with an occurrence rate of 54%.

Due to the multifaceted nature of storms as a peril, the definition of the coverage and examining the relations between perils requires close attention. As there is no singular definition, there may be different interpretations of what a 'storm' is (Confused.com, 2023).

6.5.3 Vulnerability: challenges to adequate protection

Insurance for storms can be part of different types of products. In many countries, it is included as part of home insurance. The more severe storms are rarer, however when they do occur they can cause damage to a large number of properties localised within a same area, which is a challenge for post-event claims management. This can also include claims to specific property (e.g. cars), agriculture and infrastructure within the same localisation.

A further challenge in insuring storms is defining a set timeframe. The definition of what constitutes a storm may vary and often contains a set time definition for the storm period. For example, this can be 72 hours for a particular storm which represents the period for the occurrence of insured losses. However if there is damage from more than one storm within the time window, this can complicate claims management (Moody's, 2022).

6.5.4 Lessons, good practices and potential solutions from past storm events

Based on the analysis conducted on storms, several good practices, potential solutions, and valuable lessons related to the growing risk and future protection have been identified. These are outlined and organised by stakeholder group below.

All stakeholders

- **Be aware** of the multiple types of damage and linked perils that can be caused by a storm **and take preventative actions** to mitigate the risk.

Public authorities

- **Establish early warning systems** for severe storms, and associated perils (e.g. risk of high winds and flooding).
- **Raise awareness** of the risk of storms and **on how the public can mitigate potential damage** from storms.

Insurers

- **Continue researching and modelling into storms** and the link between this peril and others (e.g. floods) to reflect the latest trends in the coverage options.
- **Clearly set out** the definition of a storm and **what** kind of storm damage **is covered in the relevant insurance policies** (e.g. the parameters and timeframe included regarding damage from rain, flooding, wind, lightning, hail, etc.)
- **Provide policyholders with advice** on how to protect their homes from storm damage and increase resilience to storms (e.g. inspecting roofs and clearing gutters regularly, removing large trees on the property, ensuring resilient foundations for fences, etc.).
- **Consider incentivising policyholders to apply adaptation** and risk management **measures** by offering a reduction in premiums.

SMEs, business and property owners

- **Take measures to increase property resilience** to storms (e.g. inspecting roofs and clearing gutters regularly)
- If large trees are near the property (on the property or a neighbours'), seek to remove the trees where necessary (which may lead to savings on the home insurance policy, as an example reported by 'confused.com' shows (Confused.com, 2023).

7 Annexes

7.1 Annex 1: Overview of data availability and current initiatives

Several studies and tools have been developed to attempt to measure the protection gap. Many of them are using historical economic and insured losses (Holzheu/Turner, 2018; Swiss Re, 2024). To take policy measures to address climate protection gaps in the EU, it is necessary to consider not only the historical view of the protection gap but also the current and future view. EIOPA's dashboard provides a historical and current view of the insurance protection gap for natural catastrophes for 30 European countries, but does not provide a future view.

When it comes to **loss data**, a number of economic and insured loss databases exist but they are usually private databases (for example, Munich Re's NatCatSERVICE or Swiss Re's (SwissRe, 2023) extensive database of events and loss information collected since 1980). Another database that can be used to quantify the historical protection gap is the open-source emergency event database EM-DAT. Tools like Desinventar also support the systematic collection, documentation and analysis of data about losses caused by disasters associated with natural hazards. Finally, another interesting initiative is that of the insurance industry in Norway, which has also shared insurance loss data with municipalities (Climate-ADAPT).

The Norwegian Knowledge Bank (KB) is a national data platform that collects, stores, and utilizes insurance loss data related to natural disasters and public climate-related risk data. The KB was established by the Norwegian Directorate for Civil Protection (DSB) in partnership with Finance Norway between 2017 and 2020, following years of effort in the resilience dialogue. In KB, asset-level insurance loss data is accessible for municipalities, county governors, and the national flood agency. Other stakeholders can access data at the municipality level (Climate-ADAPT). This data fosters a better understanding of risks associated with NatCat events, facilitating informed decision-making for prioritizing climate adaptation and risk reduction measures. In May 2021, an amendment to the Norwegian Civil Protection Act mandated that insurance companies share their data with the KB[39] (SINTEF). Additionally, the EU-funded Soteria project is pilot-testing this model in seven European regions.

Regarding **hazard data**: sectoral databases are increasingly being developed. A couple of examples are:

- European Drought Observatory
- European Floods Portal

For climate change related analyses, Copernicus data can also be of interest. The data is open source and free. Another example is the United Nations Development Programme (UNDP) Human Climate Horizons, which brings forward the effects of climate change on coastal land and flooding and complements the analysis with the impact on people affected.

[39] This amendment was made to comply with GDPR and financial regulations concerning the duty of confidentiality for insurance companies.

With regard to **exposure data,** insured exposure data are for example created by catastrophe model vendors but the data is not publicly available and can differ significantly from one model vendor to the other. Some academic data exists, such as litpop from ETH Zurich, which shows economic exposure data, but it is usually not updated regularly. Finally, public offices hold, but often not centrally, e.g. through building permits, information on exposure data.

For the case of **vulnerability data,** in terms of vulnerability assessment data for local authorities, a source is the Urban Adaptation Map Viewer, curated by the European Environment Agency. It provides an overview of current and future climatic hazards, but also the vulnerability of cities to them, and what their adaptive capacity is. For adaptation measure assessment, a number of good resources for local authorities, but also beyond, can be found in the Urban Adaptation support tool co-developed by the EU Covenant of Mayors and the European Environment Agency.

Finally, the Resilient Planet Data Hub was convened as a cross-sector group with a common view on the critical need to guide resilience policy and capital decision-making, we came together to fix the information and data gap.

Overview of model and analytical capabilities availability and current initiatives

Catastrophe modelling allows insurers and reinsurers, financial institutions, corporations, and public agencies to evaluate and manage natural and man-made catastrophe risk from perils ranging from earthquakes and hurricanes to floods and wildfires. The (re)insurance sector usually uses commercial catastrophe models (such as RMS, Verisk, CoreLogic, Impact Forecasting, JBA). Insurance companies also build their own models.

In recent years, with the emergence of the open-source risk models/tools such as OASIS LFM, the modelling landscape has changed, opening the modelling capabilities to users beyond the insurance sector such as academics, policy makers and businesses. For example, CLIMADA is an open-source tools, developed by the academic community, for which EIOPA designed a user interface to build a bridge between the latest development in climate science and the insurance industry (in particular SMEs and supervisors).Global Earthquake Model (GEM) and Risk Modelling Steering Group (RMSG) are other examples of open-source industry-wide initiatives.

In addition, efforts such as the Risk Data Hub make available a GIS web-platform intended to improve the access and sharing of curated European-wide risk data, tools and methodologies for fostering Disaster Risk Management related actions. The Global Resilience Index Initiative's Global Resilience Index (GRI) risk Viewer also compares risks arising from multiple hazards at a global scale.

Besides traditional natural catastrophe (NatCat) and parametric modelling, several commercial climate risk tools have emerged in the market during the last couple of years. Those tools are using AI and Machine Learning (ML) (e.g. CLIMATIG). These analytical approaches give the possibility of integrating transition risk impacts in addition to physical ones, as is the case of Climate Risk Analytics | VELO® | Riskthinking.AI. Similarly, tools such as Spectra provided by Climate X or Jupiter Intelligence are able to capture both physical and transition risk impacts on a number of exposures, also with detailed amounts of losses for different geographical locations, across a number of scenarios.

Finally, the Global Resilience Index Initiative aim to create global public goods that will enable enhanced access to the next generation of analytics and enable modelling the impacts of climate change across systems and supply chains.

Available forward-looking climate scenario frameworks and protection gap assessments
Most available guidance on climate scenario analysis relies on publicly available research:

- from the IPCC for physical climate change, and;
- from the NGFS (a network of over 100 central banks and financial supervisors that share best practices and contribute to sustainable development of the financial sector) for the effects of climate change on the economy. The NGFS released the latest update of its climate scenarios (Phase IV) in November 2023, including acute physical risk modelling enriched by more hazards (covering droughts and heatwaves, in addition to floods and cyclones in previous releases) and increasing geographical granularity. The NGFS scenarios are modelled using climate-related macroeconomic and financial models, exploring a wide range of transition and physical risk scenarios across different regions and sectors. A range of holistic risk scenarios balancing physical and transition risks is provided, based on (although not exactly aligned with) the IPCC's RCPs.
- From the central banks and supervisors who have already published climate stress tests (notably including the European Central Bank, Banque de France/ACPR and Bank of England/PRA), generally building on work from IPCC and NGFS.

For the estimation of the protection gap, some studies have attempted to provide an indication in expected (future) terms such as Holzheu and Turner's (Holzheu/Turner, 2018) and France Assureurs provided a study '*Changement climatique: quel impact sur l'assurance à l'horizon 2050?'* (France Assureurs, 2021), where they provide a forward-looking perspective on the evolution of the impact of climate change-related events on the French insurance industry.

7.2 Annex 2: Risk reduction examples

Example 1: The city of Burgdorf (Switzerland) receives mobile flood protection from La Mobilière

• **Title**	The city of Burgdorf receives mobile flood protection from La Mobilière
• **Short Description**	The city of Burgdorf in Switzerland has received a mobile flood protection system from Swiss ICMIF member La Mobilière. This complements the existing resources of the Burgdorf fire brigade which can now use the system flexibly in the region to protect buildings at risk.
• **Countr(y)(ies)**	CH, Switzerland
• **Status**	Finalised
• **Type of measure**	C1 Grey option, C2 Technological option
• ***Actors involved***	Local authorities (fire brigades), insurance
• **Sectors involved**	Mainly buildings/housing
• **Hazards /Perils approached**	Floods (including pluvial floods)
• **Upscaling potential**	Based on a risk assessment and defining hotspots, more areas in CH and in the rest of Europe can benefit from such a local cooperation to reduce flood risks
• **Reference(s)**	ICMF, news article, 2023
• **Any other information**	News from April 2023

Example 2: Incorporating bioclimatic design in public spaces in Rethymno, Greece

• **Title**	Incorporating bioclimatic design in public spaces in Rethymno, Greece
• **Short Description**	The coastal town of Rethymno, Greece, is in the process of upgrading its public spaces and streets using bioclimatic designs as a means of reducing ambient temperatures. Its first pilot, constructed in 2016, was a 25,000m2 space that included Iroon Politechniou Square and incorporated the use of compressed soils, cool pavers and photo-catalytic road paint. Weather station measurements taking readings throughout the entire renovation process indicated a reduction in the mean maximum air temperature of 1.69°C and a mean maximum surface temperature of 8.45°C. User thermal comfort was improved by about 46% and the energy needs of the surrounding buildings were also reduced (Tsitoura et al., 2016). The photo catalytic road surface reduced air pollution levels. With a maximum of a 30% cost premium for the project materials and installation, compared to traditional materials, the solution is considered cost effective given the multiple benefits it delivers. As a result, the municipality is implementing this solution in numerous other parts of town.
• **Countr(y)(ies)**	EL/GR, Greece
• **Status**	Finalised
• **Type of measure**	C1 Grey option, C2 Technological option
• ***Actors involved***	Local authority, university/researchers, local businesses
• **Sectors involved**	Built environment
• **Hazards /Perils approached**	Heatwave (air pollution)
• **Upscaling potential**	High - With a maximum of a 30% cost premium for the project materials and installation, compared to traditional materials, the solution is considered cost effective given the multiple benefits it delivers. As a result, the municipality is implementing this solution in numerous other parts of town.
• **Any other information**	Improving the quality of public spaces has additional benefits to those of heat and pollution reduction. Public spaces are critical for building social cohesion, for mental and physical well being and for encouraging social inclusion of groups including the elderly, people with disabilities, migrant groups. There are also economic benefits to local businesses that surround the public squares, as more attractive public spaces result in greater patronage of local businesses.

Example 3: Risk assessment and adaptation advice on heatwaves in Madrid

• **Title**	Risk assessment and adaptation advice on heatwaves in Madrid
• **Short Description**	Zurich Resilience Solutions (ZRS) worked with the Madrid City Council to help them identify and quantify hazard exposure of students (population under 16 in public and private schools) to heat stress, define potential impact scenarios based on a broad range of vulnerabilities such as conditions of schools (like shadowing of playgrounds, water fountains availability, A/C etc.), health issues (children with chronic diseases) or economic limitations of the school area (such as unemployment rate), to finally define adaptation measures for the city's climate resilience plan.
• **Countr(y)(ies)**	ES, Spain
• ***Actors involved***	Zurich Resilience Solutions, Environmental and Sustainability department of the Madrid City Council
• **Sectors involved**	Built environment
• **Hazards /Perils approached**	Heat stress
• **Upscaling potential**	This methodology could be a implemented in a broader scope in terms of climate hazards (e.g. heavy precipitation, drought) and broader exposure (other segments of population, green areas, transport, etc.). This methodology can also be replicated in other cities, including cities in different countries. Europe might join forces with insurers and enhance their resilience to reduce the human suffering and economic costs of extreme weather events.
• **Reference(s)**	Zurich Insurance, 2024

Example 4: Flood forecasting across Europe

• **Title**	Flood forecasting across Europe
• **Short Description**	The use of satellite imagery and advanced terrain models has led to the possibility of providing increasingly accurate flood forecasting. Under development since 2002, the European Flood Awareness System (EFAS) is a pioneering, operational, pan-European flood forecasting and monitoring system. Developed at the Joint Research Centre of the European Commission (EC-JRC), this initiative has been a close collaboration with national hydrological and meteorological services, the European Civil Protection Mechanism of the Emergency Response Coordination Centre (ERCC) and other research institutes. As of 2011, EFAS has been integrated into the Copernicus Emergency Management Service (CEMS) and transitioned to operational status in 2012. EFAS plays a crucial role in providing up-to-date early flood forecasting information, supporting the preparations of national and regional flood risk management authorities prior to potential flood events. Moreover, it offers a distinctive perspective encompassing Europe and neighbouring regions by presenting both forecasted and observed flood events as well as the potential socio-economic ramifications of those events.
• **Countr(y)(ies)**	Europe-wide
• **Status**	Implemented (and-ongoing)
• **Type of measure**	C1 Grey option, C2 Technological option
• ***Actors involved***	European institutions including JRC, National hydrological and meteorological services, the European Civil Protection Mechanism of the Emergency Response Coordination Centre and other research institutes
• **Sectors involved**	Urban/Built environment, Rural, water
• **Hazards /Perils approached**	Flooding

Example 5: Climate Resilience certificates in Sweden

• **Title**	Climate Resilience certificates Sweden
• **Short Description**	In 2021, heavy rainfall in the Swedish city of Gävle caused severe flooding, affecting many properties in the area. The distribution of damage was uneven, making it clear that the individual preconditions of each affected property had a substantial impact on the degree of damage suffered. In many cases, small measures can have a substantial effect on the degree of climate-related hazards tied to natural disasters. In Sweden, the responsibility to undertake measures to decrease such risk today lies with the property owner. However, many owners lack relevant information on how to assess their property's risks to natural disasters as well as hands-on recommendations on how to mitigate those risks. At the same time, financial institutions, insurance companies and many other actors face new European and national legislation that requires them to understand, measure, remedy and account for their risks related to this area. In the case of lenders assessing the risks to their collateral at an individual property level, the ability to get an overview is limited. At best, risks can be described on an area level only, meaning that the individual conditions of the property are being not considered. In this report, we have explored whether a standardised classification system, a so-called climate resilience certificate, that outlines the individual risk exposure of a property could offer a potential solution to this problem – and if it could be both easy to use by private homeowners and meet the needs of industry stakeholders. A CRC could facilitate and improve climate adaptation efforts made by property owners by (i) making it clear, on an individual property level, which owners should take measures (and in certain cases get support) to decrease risk and (ii) creating an incentive to take these measures from lenders, insurance companies and investors
• **Countr(y)(ies)**	SE, Sweden
• **Status**	Ongoing
• **Type of measure**	B1: Financing and incentive instruments, B2: Insurance and risk sharing instruments
• ***Actors involved***	Local authorities, insurance
• **Sectors involved**	Mainly buildings/housing
• **Hazards /Perils approached**	All acute and chronic climate-related risks
• **Upscaling potential**	Upscaling potential to national level, RISE project to support and learn from sister projects in other countries.
• **Reference(s)**	(Climate resilience certificates – a standardised assessment of climate risks in real estate, RI.SE, 2023)

7.3 Annex 3: List of participating organisations of the Climate Resilience Dialogue

AAE	Actuarial Association of Europe
AMICE	Association des assureurs mutuels et coopératifs en Europe/ Association of Mutual Insurers and Insurance Cooperatives in Europe
BEUC	Bureau Européen des Consommateurs/The European Consumer Organisation
BIPAR	European Federation of Insurance and Financial Intermediaries
CRO Forum	Chief Risk Officers Forum
EEA	European Environment Agency
EIOPA	European Insurance and Occupational Pensions Authority
EU-CoM	EU-Covenant of Mayors
FERMA	Federation of European Risk Management Associations
Insurance Europe	Insurance Europe
PEIF	Pan European Insurance Forum
RAB	Reinsurance Advisory Board
SMEunited	SMEunited
UIPI	Union Internationale de la Propriété Immobilière/International Union of Property Owners
UNDRR	UN Office for Disaster Risk Reduction
UNEP FI	United Nations Environment Programme Finance Initiative
World Bank	World Bank

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