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Closing the climate protection gap - Scoping policy and data gaps

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1 Executive summary

The European Union's resilience to climate-related economic losses is not a given. It reflects the myriads of decisions and choices made over time, in different circumstances and with different priorities as well as the decisions being made now and those yet to be made. Making the informed decisions on where to allocate limited time, effort and money in to reduce risk[1] and protect things of value is crucial. Our ability to reduce the share of potential economic losses from climate change occurring to uninsured assets and activities – the climate protection gap – will determine a large part of our societies' resilience. The term 'climate protection gap' is used in reference to the share of non-insured economic losses in total losses after a climate-related catastrophe event. In recent years, it has also been used to refer to the notional gap between likely climate-related impacts and existing resilience measures. This Commission staff working document is part of the knowledge base underpinning the 2021 EU Climate Adaptation Strategy[2], and some of the measures to close the climate protection gap that will be undertaken in the context of the upcoming Renewed Sustainable Finance Strategy[3]. It may be relevant for other policy- and decision-makers on adaptation issues at national, regional and local level.

Macroeconomic aspects: **Given the unavoidable rise of climate pressures in the years ahead, the EU and its Member States need to review their financial preparedness to deal with adverse climate impacts at macroeconomic level.** Climate-driven events pose risks to private and public assets and economic activities. As losses occur, households, firms and governments are affected. Beyond individual impacts that may have adverse and disruptive effects on wellbeing, equality, cohesion, health, productivity and business activities, the increasing frequency and size of climate-related economic losses raises risks of adverse systemic impacts with important spill-overs across borders.

- **Despite existing recommendations from the European Commission and other international organisations, there is currently no mechanism in place in most EU Member States to collect, assess or report economic losses from weather and climate-related extreme events.** Specialist loss datasets provide valuable information on economic losses, but important gaps exist and are exacerbated by the changing baseline for climate-related impacts.
- **Moreover, while the direct economic effects of climate-related disaster losses on specific socio-economic groups have not been studied so far in the EU, there has been an analysis of the unequal exposure[4] to and the impacts of heatwaves, flooding and water scarcity, forest fires, sea-level rise and impacts on the energy system and**

[1] Risk is defined as the potential loss of or damage to assets which could occur in a specific period of time, determined probabilistically as a function of hazard, exposure and vulnerability.
[2] COM(2021) 82 final.
[3] Building on the 2018 Action Plan on financing sustainable growth, the renewed sustainable finance strategy will provide a roadmap with new actions to increase private investment in sustainable projects and activities to support the different actions set out in the European Green Deal and to manage and integrate climate and environmental risks into our financial system. The initiative will also provide additional enabling frameworks for the European Green Deal Investment Plan. A consultation is currently open on the Renewed Sustainable Finance Strategy.
[4] UN-SPIDER defines exposure as the situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. For example, the number of people in a floodplain, or the percentage of imported food.

agriculture for the EU population. For instance, in regions with low GDP, a high proportion of people of low socio-economic status and a high percentage of elderly people overlap with areas affected by high temperatures. Urban flooding and water scarcity are more frequently experienced in southern Europe where more than half of the population lives under permanent water scarcity conditions.

- **Due to climate change over the next decades, the intensity and frequency of extreme weather events is projected to increase substantially.** At the same time, projected annual averages for the EU as a whole should be interpreted with caution. More and more granular data — present and past - is needed as are innovative ways to use the models and data. Nevertheless, data gaps and uncertainty should not delay a stronger approach to climate-related financial risk management.
- **Climate-related phenomena are expected to have substantial impacts on economic activity, affecting GDP levels and growth, and public finances, via several transmission channels, including public expenditure and revenues.** Yet, climate-related fiscal risks are often absent from the fiscal sustainability frameworks of official institutions.
- **The risks from climate change have financial consequences, and may have impacts on financial stability that can result from a number of supply and demand channels.** Financial supervisory authorities around the world are increasingly becoming alert to these risks. The development of financial instruments linked to climate disaster risks would facilitate access to capital markets and the transfer of these risks to investors.
- **Climate-related insurance coverage can be a key financial risk management tool to increase societies' ability to recover from disasters, reduce vulnerability[5] and promote resilience.** However, it has to be acknowledged that not all risks are fully insurable by private insurers. In a first step, it is important to understand to which degree relevant exposures are already protected against risks through private insurance coverage.
- **There is a wide diversity in the relevance and availability of private disaster insurance for natural disasters in the Member States of the European Union.** Current national information, awareness and regulatory frameworks for climate-related disaster risk tend to be weak and climate risk data governance is lacking. The insurance industry's expertise in assessing and quantifying risks can play a role in promoting 'build back better' or even 'build forward better' principles. Where private insurers cannot cover or can only cover part of the relevant risks, governments could consider public-private partnerships.
- **Public sector responses to climate-related extreme events fall within the remit of disaster risk management (DRM)**. From a public finance perspective, robust and effective DRM frameworks and disaster risk financing strategies reduce the fiscal cost of climate-related disasters while providing the adequate amounts and types of financial support for prevention, protection, preparedness, emergency response and recovery. A common EU level approach to DRM is lacking as legal requirements are either fragmented (e.g. different for floods compared to other types of disasters), with different degree of legally binding requirements and mainly cover aspects relevant for civil

[5] UN-SPIDER defines vulnerability as the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

protection. Without a commonly agreed approach to risk assessment, practices vary quite substantially across Member States.

Microeconomic aspects: **Climate-related risk management is best designed at sectoral level.** It is therefore important to re-examine and, where relevant, redesign policy instruments that integrate climate–related disaster risk management, following a set of flexible policy coherence principles that can be adapted to all sectors and circumstances. Such policy coherence principles are presented in this staff working document and include: 1) taking into account climate-related disaster risk before creating new exposure, 2) reducing existing climate-related risk by building up resilience, and 3) managing risk financing via risk transfer, notably through climate disaster risk insurance take-up.

- **Albeit to differing degrees, the most significant EU spending programmes apply the three policy coherence principles.** For instance, under the TEN-E revision proposal, the criteria for the selection of Projects of Common Interest have been reinforced to include wider climate impact and reinforced sustainability criteria. Moreover, the Common Provisions Regulation[6] covers climate resilience aspects well in the current cohesion policy legislative framework.
- **EU policy settings are also analysed in this staff working document for the ways they address the climate protection gap.** For instance, under the Commission's sustainable finance action plan, a number of actions were taken to redirect private capital towards sustainable investment, including to enhance climate change adaptation. Further actions on prudential rules are being considered in the preparations for the renewed sustainable finance strategy. In competition policy, Article 107(2)(b) of the Treaty on the Functioning of the European Union (TFEU) stipulates that state aid to make good the damage caused by natural disasters shall be compatible with the internal market.
- **In addition to transferring or mutualising risk, private insurance can act as a risk management tool.** For the private insurance sector, a key reason for incomplete supply is a lack of interest or capacity from insurers in a small scale or high-risk business. On the demand side, potential beneficiaries may not be fully aware of the risks posed by climate-related disasters, aggravated by climate change, or the financial consequences of such risks. Finally, disaster insurance of public assets is a key element of a disaster risk financing strategy. Beyond risk-based premiums, better determination and measurement of risks, or public-private partnerships, governments can also set incentives via taxation or subsidies. Another important aspect is to understand the extent to which insurance products across Member States are comparable in terms of accessibility, coverage, risk pricing, and options.

Data aspects**: Climate-related disaster risk and loss data are crucial to understanding the resilience gap and its many aspects**. It is at the heart of DRM. At the same time, analysing climate-related economic loss data is fraught with methodological challenges given the high variability of data from year to year, the underlying nature of the data, its uneven quality and

[6] Regulation (EU) No 1303/2013.

incompleteness. Section 4 analyses how to promote further open, non-discriminatory and equal access to climate risk and loss relevant data for the benefits of all parts of society.

- **Closing the data availability gap requires following three consecutive and necessary stages**: data existence, collection and access. At EU policy level, climate-related disaster loss data is needed for several policy areas. For example, to improve the economic foundation of adaptation policy and disaster management planning, to increase transparency about climate risks, to inform the European Semester, or to tailor Common Agricultural Policy support for loss recovery and prevention. Currently available databases are insufficient in terms of granularity and combinations of data, and few are open databases.
- **Today, interest in data on losses from disasters, in particular from climate-related disasters, has spread to all sections of society, including academia and the science of climate impacts**. The insurance industry itself has indicated that it would benefit in multiple ways from enhanced loss data recording, collection and sharing and their flow-on effects. Businesses and the financial sector require data for sustainable investment decisions and for risk management, and insights from disclosure and data, where they exist, tends to lead to record investment. Cities require data in order to adequately identify impact hotspots and vulnerabilities, and invest in the best possibly designed adaptation and disaster risk reduction measures at community level.
- **Loss data recording is currently patchy and fraught with methodological issues.** Non-insured loss data is only sporadically recorded across the EU and typically includes losses on public assets, agriculture and forestry. Where data is already recorded, current recording practices are sub-optimal. Where data is not recorded, agreed unified metadata, terminology, metrics and recording mandates are lacking. Developing a harmonised standard across the EU would build upon already existing specifications agreed in the Risk Data Hub and the Sendai Framework for Disaster Risk Reduction context.
- **A harmonised format for climate-related disaster loss data records should be developed to ensure that the available standardised data can be collected, collated and curated**. A notable barrier to the set-up of authoritative national level climate-related and or disaster-loss databases across the EU is the diversity of actors involved in the disaster and climate risk management cycle. This approach can also be expanded to other types of risks, such as geological or epidemiological.
- **The last and crucial step is to ensure that data is also made accessible to as wide a public as possible and in as flexible, disaggregated and customised a manner as possible**. There are commercial and incentive-related obstacles to making data as accessible as possible, in particular when such data is provided by the insurance industry, and any such process must comply with data protection rules.
- **The use of climate-related risk data for the benefits of all parts of society also requires adequate tools to assess climate-related physical risks**. Climate risk and vulnerability assessment tools are complex and costly analyses which would exceed the capacity of smaller administrations, the financial sector, businesses or citizens. In general, the objective of rapid analysis is to obtain a first screening of risks with informative purposes to decide whether a more extensive analysis is needed and, when possible, identify potential initial responses. While some rapid assessment tools do exist

for some hazards[7], sectors and for vulnerability assessments, they are mostly low resolution and lack calibration and validation with local data.

[7] UN-SPIDER defined a hazard as a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Here hazards include acute and chronic weather climate events.

2 Macro-economic aspects

The new Adaptation Strategy set out a long-term vision for 2050, for the EU to be a climate-resilient society, fully adapted to the unavoidable impacts of climate change. Given the unavoidable rise of climate pressures in the years ahead, under any emissions reduction scenario[8], serious thought should be given to how prepared the EU and its Member States' financial risk management strategies are to deal with the impacts of climate change. Climate risks[9] are notoriously complex as they involve interacting, nonlinear and fundamentally unpredictable environmental, social, economic and geopolitical dynamics that may be irreversibly transformed by the growing concentration of greenhouse gases in the atmosphere. In this context of deep uncertainty, extrapolating historical trends to predict impacts is of little use and the financial community has already moved-on to scenario-based analysis. Moreover, no single model or scenario can provide a full picture of the potential macroeconomic, sectoral and firm-level impacts caused by climate change. This section describes the main climate-related physical risks threatening the EU and the available evidence on their impacts on the economy and society with particular attention given to the distribution of risks and losses. It also looks at macro-economic risk management frameworks and ways to enhance financial stability and fiscal sustainability when confronted with extreme climate impacts. Finally, it assesses existing responses and identifies policy gaps that hamper climate physical risk management capabilities and predictive analytics in the EU.

2.1 Current economic losses and future projections

2.1.1 Current knowledge on past economic losses from climate-related events

Specialist datasets provide several conclusions on economic losses, the relative impact of different types of events, insurance coverage and the costs of large events[10]. First, cumulative direct economic losses from climate-related events totalled *at least* EUR 419 billion (inflation adjusted) in the EU27 between 1980 and 2019. In the period 2010-2019, average annual economic losses were EUR 12 billion[11]. Second, while this is a small fraction of EU GDP (<0,1%), annual losses vary substantially year-on-year depending on the occurrence of major disaster events, and can be substantial in terms of GDP in individual countries or regions. A large share of the total reported losses were caused by a small number of particularly costly events. Specifically, more than 60 % of economic losses were caused by less than 3 % of all unique registered events. Third, among all types of natural disasters for which data is available, those caused by weather and climate-related extremes account for over 80 % of losses over the period 1980-2019 and 95% of fatalities[12]. There were 85 570 casualties, originating overwhelmingly

[8] Due to a degree of inertia of the biophysical sphere, current emissions will have effects, no matter the degree success in GHG emissions reduction.

[9] Risk is defined as the potential loss of or damage to assets which could occur in a specific period of time, determined probabilistically as a function of hazard, exposure and vulnerability.

[10] Based on reinsurer Munich Re's NATCATService. See https://www.eea.europa.eu/data-and-maps/indicators/direct-losses-from-weather-disasters-4/assessment for details.

[11] There is evidence that improved flood protection and prevention has contributed to reducing losses over time in some cases, notably in 2013 floods in Germany as compared to similar 2002 floods although we cannot scientifically assess these factors at large scale.

[12] The remaining hazards are geotechnical ones, like earthquakes, landslides and volcanoes.

from the 2003 heatwave. Fourth, just over 30% of these (mostly privately-held) losses were insured over the same period. The remaining share are referred to as the climate insurance protection gap, with high variations across Member States (share of insured losses) from 1-2% in LT, RO, EL, CY, HU, HR, to over 50% in BE, LU, DK, IE, FR)[13]. However, this does not reflect the typical share of insured losses in recent years for some countries (see Section 2.3.1.). Lastly, the five most expensive climate extreme events in EU Member States were the following, in decreasing order of magnitude, in 2017 values:

- the 2002 flood in Central Europe (over EUR 21 billion in losses, only 15% of this value was insured);
- the 2003 drought and heat wave (almost EUR 15 billion in losses);
- the 1999 winter storm Lothar (around EUR 13 billion in losses);
- the October 2000 flood in Italy and France (around EUR 13 billion in losses); and,
- the 2013 floods in central Europe (almost EUR 11 billion in losses). Retrospective analysis conducted by Swiss Re[14] put the total combined economic losses caused by these floods in central Europe between EUR 11.9 and EUR 16 billion with only EUR 2.4 - 3.8 billion in insured losses.

Despite existing recommendations from the European Commission and other international organisations[15], most EU Member States currently no mechanism in place to collect, assess or report economic losses from weather and climate-related extreme events[16]. The OECD[17] conducted a specific disaster loss data survey among its members in 2016. A similar analysis[18] estimates that climate-related disasters caused USD 2.245 billion globally between 1998 and 2017 and rose by 151% between 1978 and 2017.

Existing gaps in predicting extreme events are exacerbated by the changing baseline for climate-related impacts. It is commonly agreed in the scientific and the insurance community[19] that the majority of the trend in increasing losses from natural catastrophes comes from exposure accumulation through economic development and urbanisation. At the same time, our ability to detect whether extreme events are linked to climate change (attribution science) has made

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[13] EEA: economic losses from climate related extremes in Europe.

[14] For Germany alone, economic losses were reported to be EUR 10 billion and insured losses EUR 2.4 billion in 2013.
Zurich, Risk nexus: central European floods 2013: a retrospective, June 10 2013, available at: https://www.zurich.com/en/knowledge/topics/flood-resilience/risk-nexus-central-european-floods-2013-a-retrospective.

[15] OECD, World Bank, Sendai Framework, notably.

[16] At the EU level, the Union Civil Protection Mechanism is the key instrument covering disaster risk reduction. A new regulation revising the UCPM decision was approved by co-legislators and Article 6(1) of the Regulaiton includes a new requirement that Member State shall *"in line with international commitments, improve the collection of disaster loss data at national or the appropriate sub-national level to ensure evidence-based scenario building [as referred to in Article 10(1)] and the identification of gaps in disaster response capacities"* Proposal COM(2020)220.

[17] OECD, 'Improving the evidence base on the costs of disasters', Joint Expert Meeting on Disaster Loss Data, 26-28 October 2016, available at: https://www.oecd.org/gov/risk/Issues-Paper-Improving-Evidence-base-on-the-Costs-of-Disasters.pdf

[18] Wallemacq, P., Below, R., McLean, D., UNISDR, CRED, Economic losses, poverty & disasters (1998-2017), CRED, 2018, available at: https://www.cred.be/unisdr-and-cred-report-economic-losses-poverty-disasters-1998-2017.

[19] IPCC, Climate change 2014: Synthesis Report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], IPCC, Geneva, Switzerland, 2014.
Swiss Re Institute, Natural catastrophes in times of economic accumulation and climate change, Sigma, No.2, 2020.

significant progress in recent years, providing estimates of the probability that global climate change has affected a specific observed extreme weather event. A recent review of these studies shows that, globally and in the EU, the large majority of the analysed heat waves, and a majority of droughts and heavy rain and flooding events have become more likely and/or severe as a result of global climate change.[20] The consensus is also that, as global temperatures rise, the frequency of these events will increase and that they will make a growing contribution to losses over the coming decades[21], especially in the absence of adaptation action (see Section 2.1.2.). It follows that unless strong adaptation measures are taken, the impact of climate change on certain sectors and regions[22] of the European Union is set to increase. This, in turn, affects the very premises or baselines on which many of the EU's macro-economic policies and instruments are based.

For instance, agricultural losses from droughts are already strongly affecting the baseline scenario which informed the design of the common agricultural policy. In 2018, the severe drought that affected large areas of Europe resulted in widespread losses in agriculture and forestry. This drought produced an overall loss of around EUR 3.3 billion, making it the year's costliest event in Europe, according to Munich Re[23]. Only a small portion of this, namely EUR 230 million, was privately insured. Similarly, if increased flood protection measures are not implemented and insurance take-up does not increase to similar levels across Member States, the flood protection gap could widen. Asymmetrical withdrawals from the Solidarity Fund (EUSF), the EU's main solidarity instrument, could also increase, challenging the very concept of solidarity in case of the exceptional and uninsurable disasters which the instrument was designed to respond to. In the 18 years of existence of the EUSF, Member States whose insurance penetration lagged behind are overrepresented in its beneficiaries and the five Member States who never sought support from the EUSF are those with either very high insurance penetration rates or very strong adaptation measures in place. As shown by the COVID-19 crisis and the discussions around the possible greening of state aid rules relating to natural disasters, Member States are not equal when it comes to supporting their economies in the aftermath of a disaster. Should climate-related disasters increase in frequency and destructiveness, as available scientific knowledge suggests, increasingly large and no-longer exceptional post-disaster national state aid packages could endanger the level playing field on which the operation and benefits of the single market are predicated.

While current reporting requirements may not be sufficient, the Commission has taken several remedial steps. From March 2021, and every two years thereafter, under the 2018 EU

[20] For instance, the temperatures experienced in July 2019 in the Netherlands and France would have had little chance of occurring without human-induced climate change, while it is estimated the likelihood of recording temperature as high as those experienced this summer in the UK and Germany was made 10 times higher by climate change. https://www.worldweatherattribution.org/human-contribution-to-the-record-breaking-july-2019-heat-wave-in-western-europe/. See also, for Australian fires https://www.nature.com/articles/d41586-020-00627-y.

[21] Swiss Re SIGMA report 2020 "'Climate change effects show most notably in their growing contribution to losses from secondary perils. In each of 2017, 2018 and 2019, secondary perils, which can be small to mid-sized events, or secondary effects of a primary peril, accounted for a lion's share of the respective years' total losses. "

[22] Which already are particularly vulnerable, e.g., to droughts/floods

[23] Munich Re "The natural disasters of 2018 in figures".

Governance Regulation[24], Member States are due to report on institutional arrangements and governance at the national level for the collection, ownership and re-use of relevant data (such as climate-related disaster loss data or risk data) and access to it. However, this does not include data on the size of the losses at this stage. Likewise, under the Union Civil Protection Mechanism(UCPM), Member States need to report every three year on systems for collecting disaster loss data. A revision[25] of the Union Civil Protection Mechanism in the area of civil protection introduced a new requirement for Member States to improve the collection of disaster loss data at national or the appropriate sub-national level, for the purpose of evidence-based scenario building and the identification of gaps in disaster response capacities. The revision also added new requirements for the development of disaster resilience goals. The goals shall be based on current and forward looking scenarios, including the impact of climate change on disaster risk data on past events and cross-sectoral impact analysis with a particular focus on vulnerable people. Recent work on *"Economics of Prevention and Preparedness"* includes an analysis of existing fiscal and economic impacts of disasters and opportunities for enhanced financial management of disaster risks, including climate-related risks, exploring the extent to which currently available disaster risk and economic data can be used to assess economic impacts of disasters.[26]

2.1.2 Projecting future economic impacts from climate change and uncertainty

Due to climate change over the next decades, the intensity and frequency of extreme weather events is projected to increase substantially. Once-in-100-year extreme events may become, for example, once-in-20 or 10 years as average losses and frequency of extremes are projected to increase several-fold. One set of estimates by Swiss Re projects that global GDP could lose between 4% and 18% by 2050 depending on climate scenarios of between below 2°C (Paris Agreement targets) and 3.2°C increase. For Europe, this could range from 3% to 11% by 2050.[27]

At the same time, projected annual averages for the EU as a whole should be interpreted with caution. In single years, losses may be a multiple of annual averages, while they can be lower in other years. Also, the geographical distribution and level of aggregation of the losses may be important. If they are concentrated in a few countries or regions, the macroeconomic significance and the socio-economic impacts may be much larger than the average number for Europe as a whole would signal. A small shift in averages hides larger shifts in many local averages and more dramatic changes in terms of heatwaves and extreme weather events with non-linear socio-economic impacts[28]. Geographically granular projections are useful both for increasing awareness and demand for adaptation - by rendering the abstraction of climate change

[24] See Regulation (EU) 2018/1999 of 11 December 2018 on the Governance of the Energy Union and Climate Action, annex VIII.
[25] REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism. Adopted 10 May 2021.
[26] Forthcoming report by World Bank Group, c "Investment in Disaster Risk Management in Europe makes sense" and "Financial Risk and Opportunities to Build Resilience", 2021.
[27] Swiss Re report on projected GDP losses from climate change.
[28] Burke, M., Hsiang, S. M., & Miguel, E. (2015). Global non-linear effect of temperature on economic production. Nature, 527(7577), 235-239.

more concrete and relevant - and for improvements in efficiency of adaptation by allowing limited budgets to be targeted primarily at adapting to the most locally relevant changes. Several different models serve the quantitative analysis of the plausible impacts of climate change on the economy, as well as of the impacts of climate policy (environmental taxes, regulations, etc.). Annex I presents some illustrative projections by PESETA[29] and COACCH[30] to give an indication of the large increases in projected losses.

More data — present and past - is needed as are innovative ways to use these models and data. Scientists are working on models that capture a richer suite of couplings and feedbacks in the Earth system. However, the complexity of assessing likely financial impacts of climate change on the EU economy is staggering. To put things into perspective, it is perhaps useful to recall that the latest climate models — run for the IPCC sixth assessment report, due in 2021 — indicate a much larger climate sensitivity than in previous models suggesting that tipping points could be exceeded even by between 1 and 2 °C of warming. They could thus already have been triggered. Importantly, however, even if this is the case, the speed at which cascading events unfold is still within the control of our collective emissions reduction efforts. As for the Greenland ice sheet, for example, the rate of melting depends on the magnitude of warming above the tipping point.

Data gaps and uncertainty should not delay an enhanced approach to climate-related financial risk management. Climate change poses an unprecedented challenge to the governance of socio-economic systems. The potential economic implications of physical and transition risks related to climate change have been debated for decades. Yet, the financial implications of climate change have been largely ignored. Financial stability and climate stability are nevertheless two interconnected public goods, as the former is needed for the latter to be addressed decisively, and adaptation policy aspects have been analysed much less than mitigation policy. We may not be able to ascertain the remaining uncertainties precisely for some time, including the speed and scale at which human-induced damage to our climate occur. However, it is certain that improved understanding of our vulnerability[31] to climate change, and reducing this vulnerability through an enhanced risk management framework are crucial to navigating the years ahead with a sense of direction on climate mitigation policy, climate adaptation policy, and financial stability policy alike.

2.1.3 Achieving resilience in a fair and just way: the distribution of effects

It is crucial to ensure that the most vulnerable among us are resilient to climate-related losses given that impacts tend to weigh disproportionately on the socially and economically underprivileged. Adverse effects on existing inequalities and vulnerabilities have been studied at a global level, and findings are not surprising: health effects of extreme-weather events tend to weigh disproportionately on the most vulnerable, and the socially and economically

[29] PESETA is the JRC's regular assessment of the impact of climate change in Europe, the fourth edition has just been published.
[30] COACCH (CO-designing the Assessment of Climate CHange costs) is H2020 innovative research project that gathers leading experts on climate change sciences from 14 European research institutions. https://www.coacch.eu/policy-briefs/
[31] UN-SPIDER defines vulnerability as the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

underprivileged. Such is the case, for example, of increases in summer heat-related mortality or of increases in the risk of accidents and impacts on wider well-being from extreme weather events such as floods, fires and storms. People living in low-income urban areas with poor infrastructure and population groups with lower incomes and assets are typically more exposed to adverse climate-related impacts and have less capacity to face them. Given that unemployed and socially marginalised people are generally among the most vulnerable to risks, and given that Europe's ageing population is disproportionately affected by reduced mobility or health impediments, a higher share of these groups in the EU population is most probably particularly vulnerable to climate change impacts[32]. Achieving resilience in a just and fair way requires policies that target those with greater exposure and vulnerability, and embedding social and geographical equity within resilience planning.

Yet, to date, there has been no detailed study in the EU of the direct economic effects of climate-related disaster losses on specific socio-economic groups. By definition, the most vulnerable[33] do not tend to be those with the most assets to protect. Focusing on direct economic losses may not be the most useful angle to explore to understand distributional effects. Furthermore, using only economic damage metrics hides other regressive impacts of climate related disasters, exacerbated by climate change. For instance, damages to low income households may have long-term consequences on their ability to recover, despite the relatively low economic value of the lost assets. Furthermore, poorer households may be inclined to maintain ownership of or acquire assets that, as a result of higher or increasing climate exposure, are less expensive, and may consequently face barriers to being insured against disaster risks.

However, the unequal exposure to, and the impacts of, high temperatures for the EU population have been analysed[34]. As vulnerable groups[35] tend to spend most of their time in buildings, indoor temperatures are a crucial factor influencing their exposure to heat. Counterintuitively, newer buildings, characterised by higher thermal insulation standards against cold temperatures may be at risk of summer overheating[36]. At the other end of the spectrum, houses inhabited by lower-income groups have also been found to be subject to overheating due to poorer insulation or building standards[37]. 6.9% of EU27 persons lived in a household unable

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[32] "Extremely impoverished people are at most risk from climate change, water scarcity, flooding, limited access to energy and land degradation. They tend to live in vulnerable areas, have no insurance and cannot afford relocation or rebuilding after calamities."' Quoted from the European Commission's Foresight website, no source indicated.
For a summary of the various aspects of social vulnerability based on evidence review, see https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/tp_1-2018

[33] Except, perhaps, age-wise.

[34] EEA Report No 22/2018 Unequal exposure and unequal impacts: social vulnerability to air pollution, noise and extreme temperatures in Europe.

[35] In this case, the elderly, those in poor health and children.

[36] Pathan, A., Mavrogianni, A., Summerfield, A., Oreszczyn, T., & Davies, M. (2017). Monitoring summer indoor overheating in the London housing stock. *Energy and Buildings*, *141*, 361-378.

[37] See EEA Urban adaptation report 2020, see page 28: As was found in Nürnberg (Germany) for example (Seebaß, 2017). Also, many victims of the 2003 heatwave in France lived in top-floor apartments where the temperatures reached 40°C (Poumadère et al., 2005). In Athens, during three extended heatwaves in 2007, temperatures were monitored in 50 low-income houses, recording a maximum of 40°C and an average minimum temperature above 28°C for the whole period of observation (Sakka et al., 2012). Similarly, temperatures exceeding 28°C were recorded in social housing in Spain, where residents were in their dwellings for most of this hot period (Escandón et al., 2019).

to keep its home warm in 2019[38]. Energy poverty - including the inability to keep a person's home adequately warm and being in arrears on utility bills - is estimated to affect 50 million people in Europe[39]. In general, energy poverty indicators followed a similar trend to being at risk of poverty or social exclusion in the last decade.

Regions with low GDP, a high proportion of people of low socio-economic status and a high percentage of elderly people overlap with areas affected by high temperatures (Figure 1). The areas most affected by both long-term unemployment and high temperatures are located in parts of Bulgaria, Croatia, Greece, Italy and Spain. Lower levels of education and areas with substantial average numbers of hot days overlap spatially in southern Portugal and parts of Bulgaria and, to a lesser extent, in parts of Greece, Hungary, Italy and Romania.[40] Finally, the average highest urban heat island intensities for school locations were found in Greece, Croatia and Bulgaria. As for social aspects, given the lack of geo-located data about the current monetary impact of climate-related disasters, presenting sub-national geographic distributional effects is only possible through a vulnerability-to-hazard[41] approach. Indeed, Figure 2 shows it is difficult to draw general conclusions from multi-hazard maps[42].

[38] According to Eurostat statistics on income and living conditions, 6.9% of the general population lived in a household unable to keep its home adequately warm in 2019 in EU27, with this share rising to 18.2% among persons below the at-risk-of-poverty threshold. In 2012, over 20 % (21.4%) of the general population in EU27 lived in a dwelling not comfortably cool during summer; with this share rising to 28.2% for the population in the lowest income quintile.

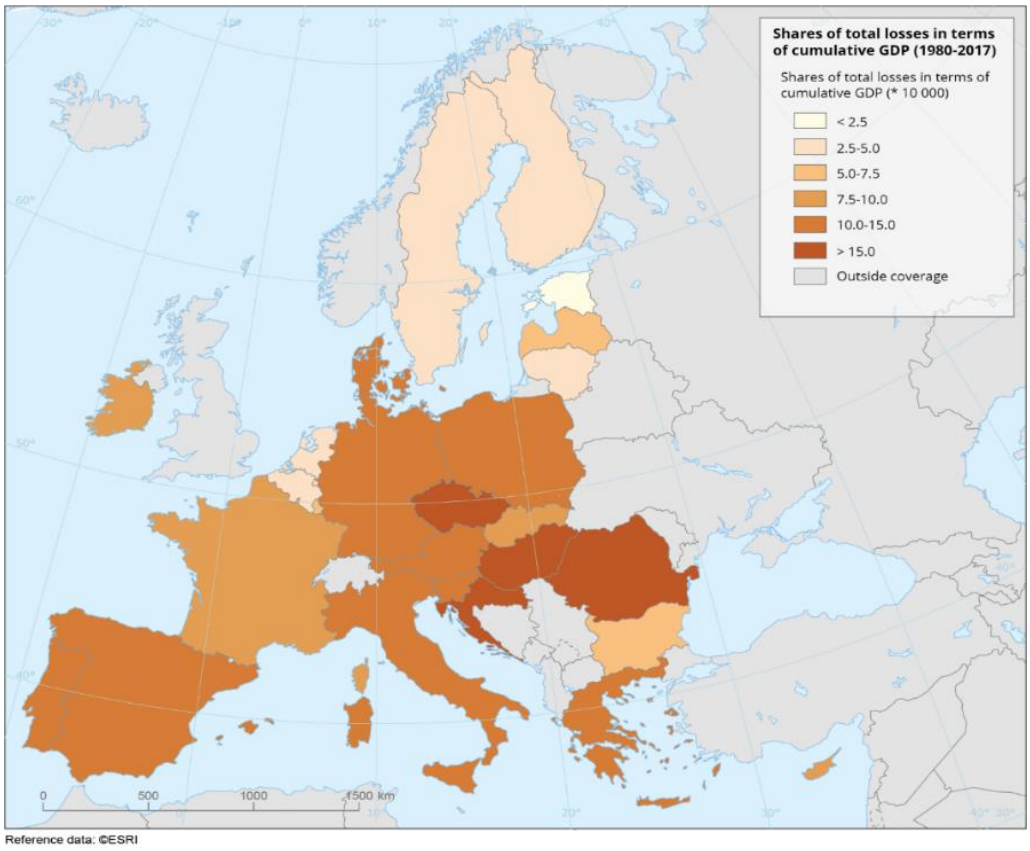
[39] Thomson, H., & Bouzarovski, S. (2018). Addressing energy poverty in the European Union: State of play and action. *EU Energy Poverty Observatory, Manchester*.

[40] EEA Report No 22/2018 Unequal exposure and unequal impacts: social vulnerability to air pollution, noise and extreme temperatures in Europe

[41] UN-SPIDER defined a hazard as a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Here hazards include acute and chronic weather climate events.

[42] Tapia, C., Abajo, B., Feliu, E., Mendizabal, M., Martinez, J. A., Fernández, J. G.,… & Lejarazu, A. (2017). Profiling urban vulnerabilities to climate change: An indicator-based vulnerability assessment for European cities. *Ecological indicators*, *78*, 142-155. Available at: https://www.sciencedirect.com/science/article/pii/S1470160X17301036

Figure 1: Shares of total losses in cumulative GDP (1980 - 2017)

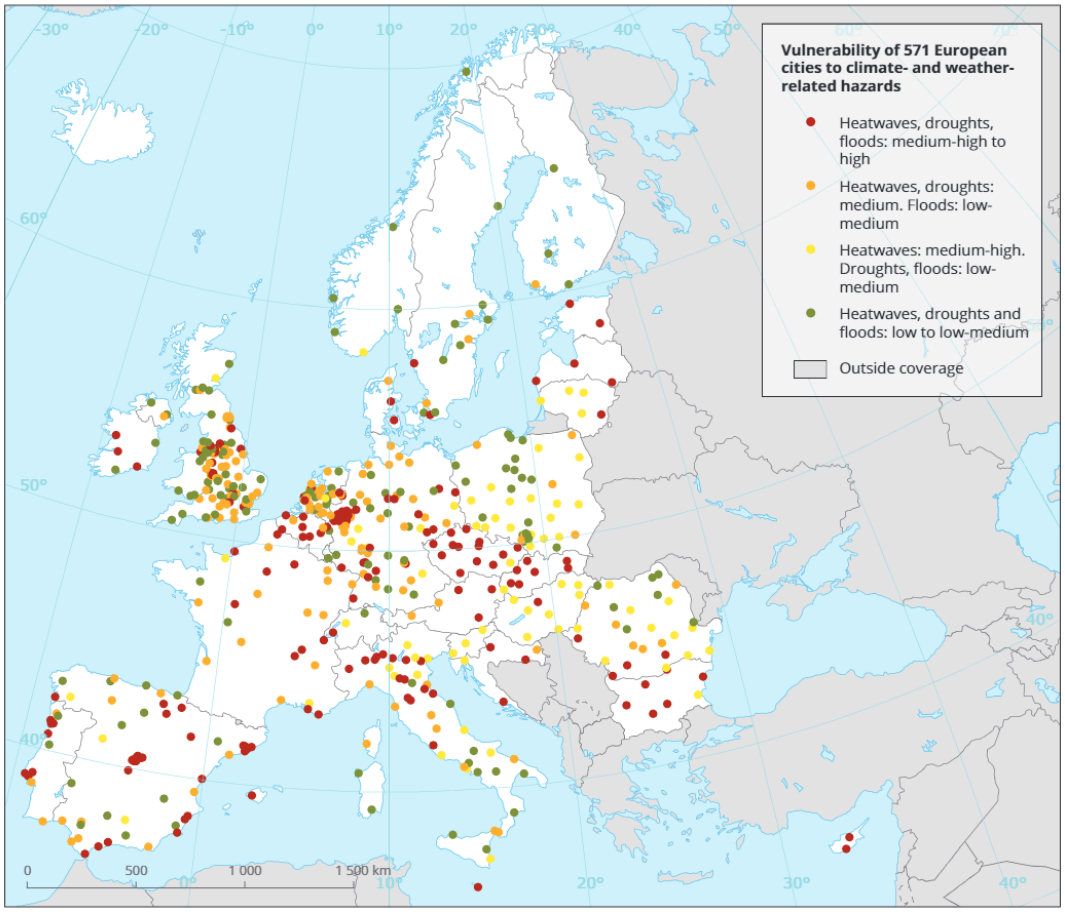


Source: European Environment Agency (*https://www.eea.europa.eu/data-and-maps/figures/shares-of-total-losses-in*)

Correlations between socio-economic status aspects of vulnerability and extreme temperatures are much less pronounced for cities than for NUTS regions[43]. Indeed, in terms of income or levels of education, cities usually differ from the regions in which they are located. However, they experience air temperatures in excess of rural values because of the urban heat island (UHI) effect. Cities in South-Eastern Europe with the highest projected increase in temperatures are among those with the lowest provision of green space and the most pronounced UHI effect. Differences from average urban area temperatures in European cities caused by UHI vary widely, reaching as high as 8.9 °C[44]. Cities in northern Europe have lower temperature thresholds from which heat-related mortality begins to increase, while cities with higher average temperatures have higher thresholds.[45]

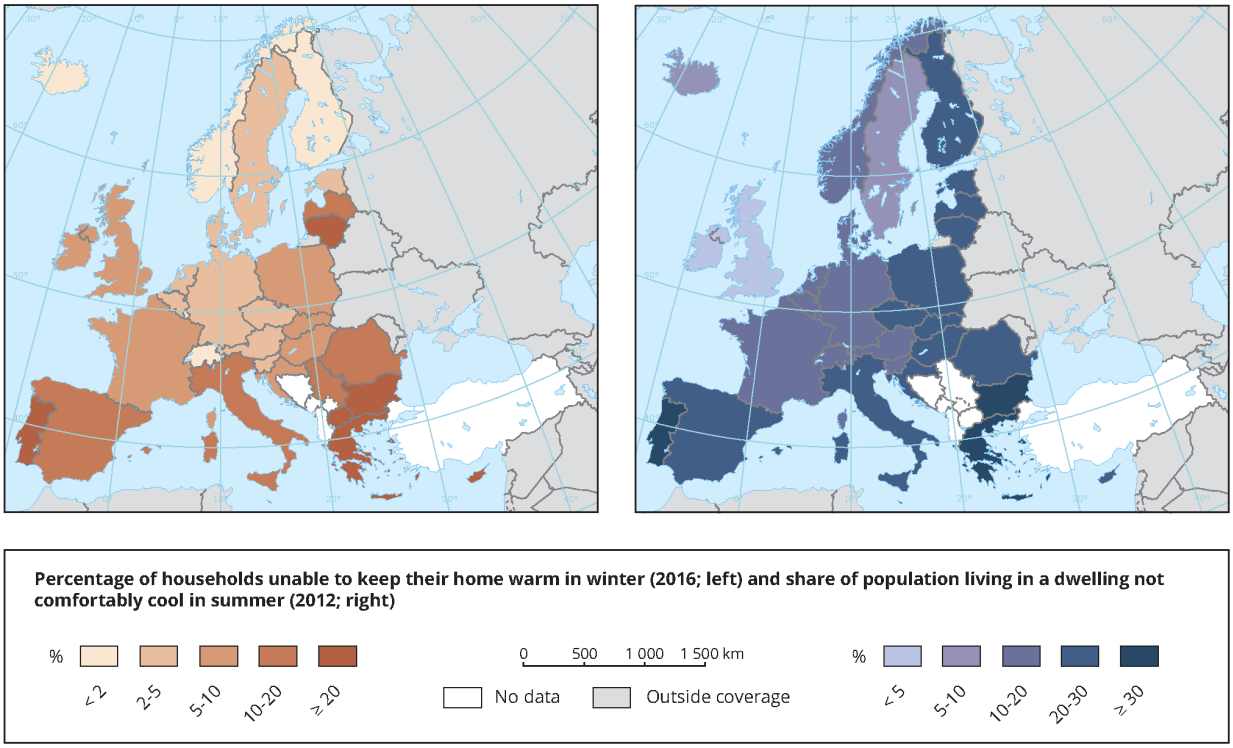
[43] NUTS regions: Nomenclature of Territorial Units for Statistics. https://ec.europa.eu/eurostat/web/nuts/background
[44] For nighttime temperatures in central Paris under heatwave conditions.
[45] Baccini et al., 2011; 27 Gosling et al., 2007.

Figure 2: Vulnerability of 571 European cities to climate- and weather-related hazards



Source: EEA (2020) adapted from Tapia et al. (2017).
Cluster 1 - cities with low to medium vulnerability to heatwaves, droughts and floods.
Cluster 2 - cities with medium to high vulnerability to heatwaves, droughts and floods.
Cluster 3- cities with average vulnerability to heatwaves and droughts; and low to medium vulnerability to floods.
Cluster 4 - cities with relatively high vulnerability to heatwaves, droughts and floods.
Cluster 5 – cities with relatively high vulnerability to droughts, medium to high vulnerability to floods and medium to high vulnerability to heatwaves.
Cluster 6 – cities with low vulnerability to droughts and floods, and low to medium vulnerability to heatwaves.
Cluster 7 - cities with medium to low vulnerability to droughts and floods, and medium to high vulnerability to heatwaves.
Full cluster descriptions can be found in (Tapia et al., 2017) and Urban Adaptation Map Viewer.

Figure 3: Household temperature adaptation



Source. EAA. https://www.eea.europa.eu/publications/unequal-exposure-and-unequal-impacts/

In some vulnerable regions, tourism-related or other economic activities may be the key employment and economic value generator.[46] Overall losses - beyond losses to physical assets only - due to disruptions to business and industry, and to the interconnectivity between people's livelihoods and their local environments, can be significant. Some climate-related disasters can have long-reaching effects outside the physical scope of the disaster, especially on tourism sector, by reducing attractiveness, due to local flooding, loss of an important cultural site, or risk of forest fires, for example. These effects can also lead to loss of income and disproportionately affect demand for low-skilled jobs.

The European insurance industry is increasingly concerned about losses from urban flooding, and in some Member States, it has challenged public authorities managing sewers to cover incurred insured losses (Denmark, Sweden)[47]. The European Environment Agency's floodplain statistics show that, across the EU-27 and the UK, between 2012 and 2018, urban sprawl occurred on 35km^2 of floodplains, urban development on 99km^2 of floodplains and sprawl of economic sites and infrastructure on 290km^2 of flood plains.[48] This highlights that

[46] Dimitrijevics, A, Dohring, B., Varga, J. & in 't Veld, J. (2021), *Economic impacts of climate change and mitigation*, Quarterly Report on the Euro Area (QREA), 20(1), 23-45.
[47] https://www.svenskforsakring.se/globalassets/rapporter/klimat/weather-related-damage-in-the-nordic-countries.pdf
[48] EEA, 2019, Floodplains: a natural system to preserve and restore, EEA Report No 24/2019, European Environment Agency

short-term interests and societal benefits (increased housing availability, jobs in industrial areas) outweigh longer-term flood risk management interests and potential increases in damages or costs[49]. A particular concern is the rise of urban flooding, which typically follows short but more intense and more frequent short-term precipitation, leading to substantial damages by exceeding the capacity of urban sewage systems. An example of such events was observed in Dortmund, Germany, in 2008, with registered losses of EUR 17.2 million from a 200 mm of rainfall event which lasted 3 hours[50]. Most spectacularly, in Copenhagen in 2011, 135mm of rain fell over two hours causing losses of more than EUR 1 billion[51]. Such heavy rainfall events are becoming increasingly frequent. Lisbon experienced 109 intense rainfall events between 2001 and 2011[52]. The relatively old sewer network infrastructure in European cities is often not capable of dealing with higher volumes of rainwater during periods of intense precipitation. This is made worse by increased land cover and impermeability[53].

At the same time, water scarcity is more frequently experienced in southern Europe where more than half of the population lives under permanent water scarcity conditions. This is particularly true during summer due to higher water use from agriculture, public water supply and tourism. Because of very intensive irrigation, the Middle Apennines and the Po Basin in Italy, the Guadiana River in Portugal and Spain and the Segura River in Spain, experience severe water stress almost all year long. Moreover, water scarcity is not limited to southern Europe, and is driven in other regions by significant urbanisation, combined with high use from the energy and industrial sectors for cooling purposes and from the public water supply sector. Higher pressures than the regional average can be observed in the wider area of Copenhagen and Stockholm, for example[54].

While droughts are predominantly considered a phenomenon affecting rural areas because of their impact on agriculture, European cities have also been experiencing droughts. Until recently, this was mainly the case in southern European cities. This has now started to change with recent episodes of drought in north-western and central Europe, such as in 2018. Prolonged periods of water scarcity can be costly for cities. The drought in Barcelona in 2007-08 resulted in a total cost of EUR 1.6 billion, representing nearly 0.5% of the Catalonia region's GDP. These costs included losses from the interruption of industrial production in various sectors (EUR 540 million) and indirect costs to the regional economy due to reduced productivity in other economic sectors (EUR 360 million). The direct costs of emergency measures implemented

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https://www.eea.europa.eu/publications/floodplains-a-natural-system-to-preserve-and-restore

[49] Klijn, F., Kreibich, H., De Moel, H., & Penning-Rowsell, E. (2015). Adaptive flood risk management planning based on a comprehensive flood risk conceptualisation. *Mitigation and Adaptation Strategies for Global Change*, *20*(6), 845-864.

[50] Rözer, V., Müller, M., Bubeck, P., Kienzler, S., Thieken, A., Pech, I., ... & Kreibich, H. (2016). Coping with pluvial floods by private households. *Water*, *8*(7), 304.

[51] https://climate-adapt.eea.europa.eu/metadata/case-studies/the-economics-of-managing-heavy-rains-and-stormwater-in-copenhagen-2013-the-cloudburst-management-plan

[52] Leal, M., & Ramos, C. (2017). The potential of two types of urban flooding to cause material damages in Lisbon, Portugal.

[53] Skougaard Kaspersen, P., Høegh Ravn, N., Arnbjerg-Nielsen, K., Madsen, H., & Drews, M. (2017). Comparison of the impacts of urban development and climate change on exposing European cities to pluvial flooding. *Hydrology and Earth System Sciences*, *21*(8), 4131-4147.

[54] EEA Report No 12/2020EEA assessment report presenting the status quo of adaptation to climate change at the local government level, with particular focus on cities. See Section 2.6.1 p. 41.
The economics of managing heavy rains and stormwater in Copenhagen – The Cloudburst Management Plan — Climate-ADAPT (europa.eu)

during the period reached nearly EUR 82 million and welfare losses came to over EUR 691 million due to restrictions of outdoor water uses.[55]

In addition, while forest fires remain largely a southern European phenomenon, they have also started affecting people in northern European cities in recent years. For example, within Greater Manchester in the United Kingdom or Riga in Latvia, or Sweden, which experienced its worst fire season ever in 2018.[56] The increasing frequency and magnitude of droughts and heatwaves under the changing climate pushes the increased risk of forest fires northwards[57].

The impact of higher temperatures, changes in precipitation regimes and rising sea levels affect – directly or indirectly – the productivity of nearly all economic sectors in all EU Member States, including transport. Impacts of climate variability and change on European transport systems were studied in several European projects[58], though there is a lack of reliable information relevant to the vulnerability of the different modes of transportation. Direct costs borne by the transport sector, such as those from infrastructure repair or maintenance and vehicle damage and increased operational costs, have been estimated at EUR 2.5 billion annually for the period 1998 - 2010, and indirect costs from transport disruptions at EUR 1 billion annually. Rail has been the most affected mode of transportation, with 'hot spots' in Eastern Europe and Scandinavia, whereas the effects on roads, mainly from weather related road accidents, have been found to be more evenly distributed.

Climate change and extreme weather events increasingly impact all components of the energy system[59]. They affect the availability of primary energy sources[60], the transformation, transmission, distribution and storage of energy, and energy demand. However, from the policy perspective, overall impacts on society would be much higher than the direct losses, because damage to critical energy infrastructure can result in failures and cascading effects on related and dependent infrastructures, with far- reaching economic and social consequences[61]. While there is little data available on current direct economic costs to the energy sector from climate-related disasters, an examination of about 40 major blackouts worldwide over the past 40 years found that extreme weather was the most important primary cause of damage to critical infrastructure. Within this category, storm damage to the transmission system was the cause of half of the failures. Other notable weather effects were drought (loss of cooling water) and ice build- up on transmission lines[62].

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[55] Mesa-Jurado, M. A., Martin-Ortega, J., Ruto, E., & Berbel, J. (2012). The economic value of guaranteed water supply for irrigation under scarcity conditions. *Agricultural water management*, *113*, 10-18.

[56] EEA - forest fires.

[57] See maps of projections https://www.eea.europa.eu/data-and-maps/indicators/forest-fire-danger-3/assessmentwhat and Projections of Fire Weather Index (PESETA III).

[58] The EU-FP7 WEATHER www.weather-project.eu and EWENT Projects www.weather-project.eu/weather/inhalte/research-network/ewent.php

[59] For more see https://www.eea.europa.eu/publications/adaptation-in-energy-system

[60] In particular renewable energy sources.

[61] (Karagiannis et al., 2017; Varianou Mikellidou et al., 2017)

[62] Boston, A. (2013). Delivering a secure electricity supply on a low carbon pathway. Energy Policy, 52, 55-59.

Agricultural production strongly depends on climate conditions. Changes in mean temperature and precipitation, as well as weather and climate extremes, are already influencing crop yields and livestock productivity in many European regions with various impacts. While increases in the length of growing seasons improve the suitability for growing crops in northern Europe, the negative effects of climate change lead to yield losses across Europe, mostly in southern Europe. Socio- economic disparities in the agricultural sector spread across the whole economy, with macro- economic effects influencing food prices, farm incomes and ultimately food security at local, regional and global scales. The consequences of climate change can then become stressors that ignite a mix of underlying causes that can even erupt into social revolutions[63]. Several research initiatives have been carried out to quantify the economic consequences of climate change on agriculture using a series of metrics. More rarely, economic analysis considers impacts on well- being or welfare, for example consumers' and producers' surplus, and the costs to society[64]. However, it is still hard to estimate the economic impacts of climate change on the European agricultural sector today, although reported losses have been rising.

2.2 Macro-financial and fiscal aspects of the climate protection gap

2.2.1 Public debt sustainability analysis

Climate-related phenomena are expected to have substantial impacts on economic activity and public finances, through several transmission channels. Looking at extreme weather events, transmission can occur via the supply side through impacts on the main growth drivers (impacts on productivity, land, capital and labour) and/or the demand side (consumption, investment and trade effects)[65]. The demand effects could be persistent (e.g. protracted demand for climate-resilient durable goods and investment) with negative effects on consumption offsetting potential positive effects on output driven by the investment increase. The impacts on public finances would also be expected to materialise either directly (e.g. direct losses on damaged public assets, increase of public spending to replace damaged infrastructures, materialisation of explicit state guarantees) and/or indirectly (e.g. due to disruption of economic activity). In case of risks to financial stability, when public support to distressed financial institutions is called for, public finances would also be significantly affected (i.e. through the materialisation of implicit contingent liabilities).

Climate-related fiscal risks are often absent from the fiscal sustainability frameworks of official institutions, notably due to the current inherent difficulty in quantifying such aspects. Notwithstanding these difficulties, several institutions have recently started to develop modules in their fiscal sustainability frameworks that look at climate-related fiscal risks. Some institutions (e.g. UK Office for Budget Responsibility (OBR), or Swiss Federal Finance

[63] Starting from the winter of 2006/2007, the severe drought in Syria, exacerbated by rising temperatures, caused extensive crop and livestock failure in 2007- 2010: wheat production failed and livestock mortality reached 85 %. Food prices increased by 40 % in the region and this contributed to starvation in Syria (Kelley et al., 2015). Climate- driven price hikes in agricultural commodities contributed to start of the 'Arab Spring' (Werrell and Femia, 2013; Perez, 2013).

[64] Stevanović, M., Popp, A., Lotze-Campen, H., Dietrich, J. P., Müller, C., Bonsch, M., ... & Weindl, I. (2016). The impact of high-end climate change on agricultural welfare. *Science advances*, *2*(8), e1501452.

[65] See Batten (2018) for more detail decomposition of macro-economic impact of climate change.

Administration) have taken first steps toward integrating climate change into their fiscal sustainability frameworks, essentially by starting to develop concepts and definitions. The UK OBR, building on the Bank of England taxonomy for assessing climate-related financial stability risks, distinguishes between: i) extreme weather event risks, as unexpected shocks with short-term impact, and ii) transition risks, related to fiscal consequences of adaptation and mitigation policies, which are foreseeable and building slowly over the medium-term. Other national and international institutions are increasingly integrating the climate change dimension into their fiscal risk analysis, with first quantifications focusing on natural disasters. The IMF and World Bank recently introduced a tailored stress test for natural disasters[66] in their revised Joint Debt Sustainability Framework for Low-Income Countries[67]. Their 'natural disaster' stress test is only triggered for countries vulnerable to such risks[68] and tailored to the country-specific history[69], while not being directly linked to the future expected effects of climate change.

Several strands of academic literature have started to look at the impact of weather- and climate-related events on the economy. The literature exploring the impact of weather- and climate-related hazards on the economy has been growing in recent years as a result of the rising losses from extreme events in many regions and sectors[70], especially in Europe. The 'Economic Amplification Ratio'[71], namely the ratio of the overall production losses due to an event to its direct costs, could be used to improve the cost-benefit analysis of prevention measures. From a methodological perspective, analysis suggests that changes in the distribution of extremes may entail significant GDP losses in absence of specific adaptation plans. It suggests, therefore, that for more accurate estimates of economic damages for climate-related events, researchers should take into account the distribution of extremes instead of their average cost and make explicit assumptions on the organization of future economies.[72] A Disaster Risk Assessment tool (DRAT) was developed[73] to help policy makers in Italy in prioritising areas for possible disaster-risk interventions and making effective choices in presence of tight public budgets. Applied to Italian municipalities, this work lays out a comprehensive assessment of hazard, exposure, vulnerability and resilience related to natural disasters. The combination of these dimensions is especially useful to identify geographic locations that are characterised by high hazard, exposure,

[66] IMF - Review of the debt sustainability framework for low income countries : proposed reforms.
[67] Joint World Bank-IMF Debt Sustainability Framework for Low-Income Countries.
[68] Exposure defined as: i) small states vulnerable to natural disasters; and/or ii) countries with frequent events (i.e. 2 disasters every 3 years) and significant economic losses (above 5% of GDP per year).
[69] The default calibration of the shocks are based on evidence from historical data from the Emergency Events (EM-DAT) database over the period 1950-2018. It includes a direct shock on debt defined as a one-off shock of 10 pps. to the debt-to-GDP ratio in the second year of the projection period, and interactions with other macro variables in the year of impact that capture indirect effects on growth and exports (i.e. real GDP growth and exports are lowered by 1.5 and 3.5 pps., respectively). While the default values of the shocks are calibrated based on an event analysis of past episodes with measured economic losses of at least 5% of GDP, they can be customized to country-specific history.
[70] For example, CRED and UNISDR (2018) report that climate-related disasters caused United States of America 2,245 billion over 1998-2017. Impressively, it is found that reported losses from extreme weather events rose by 251% between these two 20-year periods.
[71] Stéphane Hallegatte, Jean Charles Hourcade, Patrice Dumas (2007), Why economic dynamics matter in assessing climate change damages: illustration on extreme events, *Ecological Economics*, Elsevier, 62 (2), pp.330-340.
[72] Stéphane Hallegatte, Jean Charles Hourcade, Patrice Dumas (2007), Why economic dynamics matter in assessing climate change damages: illustration on extreme events, *Ecological Economics*, Elsevier, 62 (2), pp.330-340.
[73] Marin, G., Modica, M., Paleari, S., & Zoboli, R. (2019). Disaster Risk Management: Building the 'Disaster Risk Assessment Tool'for Italy. SEEDS Working Papers Series, 3, 2019.

vulnerability and low resilience. This provides a background for the formulation of public measures aimed at providing financial support for reducing vulnerability and climate-related disasters. Another study analyses[74] the relationship between bank lending and catastrophe risk for Italian firms located in areas at risk of flooding.[75] The implementation of this type of analysis has been attempted also in structural macroeconomic models where it is possible to include the probability of climate-related risks affecting the decision of economic agents.[76] Finally, recent work on estimates of the disaster financing gap combines disaster loss data and macroeconomic data, including on public finances and insurance.[77]

The Commission has started to develop a climate change 'module' in its fiscal sustainability framework. The European Commission 2019 Debt Sustainability Monitor has published a first conceptual framework on how to introduce climate change impacts on growth and public finances in public Debt Sustainability Analysis (DSA).[78] It distinguishes between impacts that are either temporary (e.g. adverse weather events tend to cause immediate damage which may last over the medium-term, but may be reversed, depending on country-specificities) or more persistent, reflecting the gradual transformation of the environment (e.g. permanent losses due to the gradual changes in temperature). The impact of extreme weather events on growth and public finances can be evaluated through customised stress test scenarios, where the shocks to growth and public finances, including on debt, would be calibrated based on a probability distribution of occurrence and country-specific characteristics (e.g. past history of weather events, degree of adaptation policies implemented, insurance protection). The event impact can be modelled as directly affecting government accounts and debt trajectory (e.g. spending to replace damaged public infrastructure); or indirectly, for example, through GDP effects (e.g. lower tax revenue due to economic slowdown). Such a customized scenario could be designed as a triggered stress test of the baseline, only for country-specific risk exposures such as vulnerabilities to climate-related disasters with significant macro-fiscal impact.[79]

Other initiatives may also assess climate-related fiscal risks. Based on available information[80], deterministic stress tests could be calibrated to illustrate *indirect* effects on public

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[74] Faiella, I., & Natoli, F. (2018). Natural catastrophes and bank lending: the case of flood risk in Italy. Bank of Italy Occasional Paper, (457).

[75] Giovanni Marin & Marco Modica & Susanna Paleari & Roberto Zoboli (2019). "Disaster Risk Management: Building the 'Disaster Risk Assessment Tool' for Italy," SEEDS Working Papers 0319, SEEDS, Sustainability Environmental Economics and Dynamics Studies, revised Feb 2019.

[76] See for example: Fernández- Villaverde, J., & Levintal, O. (2018). Solution methods for models with rare disasters. Quantitative Economics, 9(2), 903-944.
Cantelmo, M. A., Melina, M. G., & Papageorgiou, M. C. (2019). Macroeconomic outcomes in disaster-prone countries. International Monetary Fund.

[77] World Bank Group report on the Economics of prevention and preparedness "Financial Risk and Opportunities to Build Resilience", 2021.

[78] See European Commission, 2019 Debt Sustainability Monitor, Box 5.3., "Including climate change risks in the DSA: concepts and definition".

[79] For example, the EC Joint Research Centre (JRC) has provided quantifications of possible consequences of climate change in the EU in selected vulnerable sectors, in absence of adaptation and mitigation policies (i.e. PESETA project). While the absolute estimates may be surrounded by large uncertainty, the results could be used as an indication of the relative exposure of the different sectors and regions in EU, and therefore, provide a useful signal that can be used as a trigger for eligibility of the regions with large exposure (in relative terms) to customized stress test scenarios. Similarly, the EEA report (2019) can provide an indication of the relative climate risks exposure across different EU Member States by peril.

[80] e.g. MunichRe/NatCatSERVICE, SwissRe/SIGMA, ED-MAT databases.

finances from total economic losses for relevant countries, in line with other international institutions' practice such as the International Monetary Fund.[81] The degree of interaction between real output losses and other variables - such as the primary balance, inflation and interest rates following each event - can be adjusted to reflect country-specific information.[82] The impact on output can be calibrated based on country- and event- specific characteristics (e.g. degree of adaptation measures implemented, degree of insurance penetration, resilience of the insurance sector by hazard, as described in regular stress test reports by the European Insurance and Occupational Pensions Authority (EIOPA), presence of other financial instruments such as cat bonds, where relevant). The Commission has developed a 'green budgeting' reference framework aimed at improving the reporting of climate and other environmental impacts in national budgets as part of the European Green Deal. The Commission has also carried out a study on the feasibility of a model to assess the capability of the EU insurance sector to absorb unexpected losses from natural disasters at country level. Such a model will allow for the identification of Member States with a comparatively low level of insurance penetration compared to the risks they are facing. This information would be essential to assess the risks that natural catastrophes ultimately pose on public finances (i.e. potential impact on public finances from the materialisation of implicit contingent liabilities stemming from the insurance sector).

However, practical challenges remain in producing robust methodologies. Building customized methodologies in debt sustainability analysis (DSA) for different weather hazards and climate change risks and policies requires both datasets on past natural events and macro-economic impact assessments of the planned policies and post disaster measures at country level. In the context of a DSA, such quantified elements are notably needed to calibrate the shocks and the economic response to different extreme weather events. Yet, current data collection, modelling tools and fiscal frameworks present important limitations for that purpose. The existing international datasets recording extreme weather events are not fully publicly available and sometimes provide a partial reporting of impacts of such events. While the latter can be explained by the different objectives pursued by the entities undertaking such data collection (e.g. insurance companies SwissRe/MunichRe database), humanitarian support (e.g. CRED[83]), the different databases do not follow a harmonised standard of reporting of losses, in particular for total economic losses. The quality of reporting of total economic losses also appears more heterogeneous than that of other variables (e.g. insured losses, demographic/health variables). This makes the disaggregation of total economic losses between private and public sector difficult. In terms of macro-economic impacts of policy measures, in the National Energy and Climate Plans (NECPs) provided by Member States at the end of 2019, the estimates of the total costs of the policy commitments in relation to the climate and energy targets[84] were available for many Member States. Member States presented an improved general overview of the expected investments needed to achieve the various objectives, targets and contributions. However, some

[81] IMF (2013) Debt Sustainability Framework for Market Access Countries, macro-fiscal stress tests.

[82] The calibration of the interactions of the output loss with other variables can be based on macro modelling estimates and on the academic literature on the quantification of the economic and financial impact of extreme events.

[83] When looking at natural disasters over Europe, 2944 events are recorded by MunichRe over 1980-2018 against 1879 events by EM-DAT since 1900.

[84] The NECPs provided in 2019 relate to the implementation of the energy and climate targets providing a 40% reduction of carbon emissions by 2030.

of the plans lack details and do not allow to compare or add up the total investment needs for energy and climate objectives Moreover, uncertainty appears large in the medium and long run and NECPs do not provide any view of the disaggregation of public and private investment needs. Current reporting under the Stability and Convergence Programmes also does not include a commonly agreed framework for estimates of climate-related fiscal costs. A review of practices carried by the Commission[85] points to the very limited use of green budgeting[86] in the EU, with information found only for a handful of Member States. Current practices also show a wide diversity in terms of the scope of budgetary items considered.

2.2.2 Financial sector climate physical risk stress testing

Climate change gives rise to two types of risks with financial consequences: transition risks, and physical risks. Transition risks stem from the impact on asset values of policy actions to adapt to and mitigate the effects of climate change. Physical risks stem from the realisation of actual climate-change driven events, such as floods, fires and heatwaves, among others. This distinction is analytically useful, but in practice physical and transition risks are not independent of each other. For example, the absence of sufficiently forceful policy measures aggravates physical risks, while excessive or misplaced climate policy may intensify transition risks[87].

Moreover, extreme climate-driven events can be both acute (sudden) and chronic (more gradual but nonetheless equally damaging), such as changes in precipitation, extreme weather variability, ocean acidification, and rising sea levels. Whereas these risks obviously matter to the governments and individual companies and households exposed to them (either directly or indirectly, via such links as bank loans backed by affected collateral or insurance and compensation claims), they can also have adverse systemic impacts, such as financial stability implications. This is because by their very nature they tend to affect many players at the same time. The extent to which the adverse effects from the materialisation of such risks affect the real economy depend to an important degree on how losses are ultimately allocated, and the extent to which they are covered and anticipated (see also discussion of insurance penetration and of public versus private insurance in section 3).

The impacts of climate change on financial stability can stem from a number of supply and demand channels. Physical risks have already been playing an increasing role in eroding the collateral and asset values of investors. In the case of non-life insurers, liabilities are particularly exposed to the frequency and severity of climate and weather-related events that damage property or disrupt trade[88]. The share of weather-related catastrophe losses has increased steadily

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[85] 2020 Report on public finances in EMU. pp.41-44.

[86] Green budgeting is here defined as 'a budgetary process whereby the environmental contributions of budgetary items are identified and assessed with respect to specific performance indicators, with the objective of better aligning budgetary policies with environmental goals (i.e., the contribution of budgetary items to green objectives)'.

[87] Vermeulen, S. J., Dinesh, D., Howden, S. M., Cramer, L., & Thornton, P. K. (2018). Transformation in practice: a review of empirical cases of transformational adaptation in agriculture under climate change. *Frontiers in Sustainable Food Systems*, 2, 65.

[88] Gassebner, M., Keck, A., & Teh, R. (2010). Shaken, not stirred: the impact of disasters on international trade. *Review of International Economics*, *18*(2), 351-368.

Bunten, D. M., & Kahn, M. E. (2014). *The impact of emerging climate risks on urban real estate price dynamics* (No. w20018). National Bureau of Economic Research.

to account for over 80% of insured catastrophe losses in 2018 while, at the same time, the frequency of weather-related loss events hit a record in 2018 – in 2020, and remained the main driver of losses[89]. On the demand side, extreme climate events could reduce household wealth and consequently private consumption[90]. Uncertainty about future demand and growth prospects in a sharply changing climate can dampen business investment, with substantial impacts on prices[91]. One example is the possibility of natural disasters that reduce collateral values of the housing stock and, if they are not insured against, weaken households' balance sheets, in turn reducing household consumption[92]. Insured losses, on the other hand, may place insurers and reinsurers in a situation of fragility as claims for damages keep increasing[93]. More broadly, damages to assets affect the longevity of physical capital through an increased speed of capital depreciation[94]. On the supply side, natural disasters can disrupt business activity and trade and destroy infrastructure, diverting capital from technology and innovation to reconstruction and replacement[95]. Climate change can also trigger massive migration flows, cause potential social conflicts, and impact labour market dynamics[96]. These macroeconomic and financial shocks can further interact and amplify each other, as experience shows[97]. Studies estimate that the financial value at risk from climate physical risk could be up to 17% depending on the mean average temperature rise[98]. Another analysis[99] provides insights into the origins of some catastrophic risks by modelling and forecasting their impact. The analysis is fully empirical, making use of a vast quantity of financial, economic and climate-related data. Different models are put forward to estimate the effect of higher natural disaster risk on the catastrophe bonds market. Specifically, it provides and quantifies relevant feedback effects of global warming for natural environment that, in turn, translates into higher catastrophe bonds risk with severe repercussions on financial markets. It concludes showing how the falling trend in the return per unit of risk of catastrophe bonds is fully consistent with the evolution of natural disaster risk with important implications to the insurance-linked securities market.[100]

Albouy, D., Graf, W., Kellogg, R., & Wolff, H. (2013). *Climate amenities, climate change, and American quality of life* (No. w18925). National Bureau of Economic Research.

[89] Swiss Re SIGMA report No4/.2020

[90] Hallegatte, S. (2009). Strategies to adapt to an uncertain climate change. *Global environmental change*, *19*(2), 240-247.

[91] Parker, M. (2018). The impact of disasters on inflation. *Economics of Disasters and Climate Change*, *2*(1), 21-48.

[92] NGFS A sustainable and responsible investment guide for central banks' portfolio management October 2019.

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[94] Fankhauser, S., & Tol, R. S. (2005). On climate change and economic growth. *Resource and Energy Economics*, *27*(1), 1-17.

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[96] Stapleton, S. O., Nadin, R., Watson, C., & Kellett, J. (2017). *Climate change, migration and displacement: The need for a risk-informed and coherent approach*. Overseas Development Institute.

[97] Bordo, M. D., Mizrach, B., & Schwartz, A. J. (1995). Real versus pseudo-international systemic risk: some lessons from history. *NBER working paper*, (w5371).

Bordo, M. D., & Murshid, A. P. (2001). Are financial crises becoming more contagious?: What is the historical evidence on contagion?. In *International financial contagion* (pp. 367-403). Springer, Boston, MA.

[98] See NGFS, April 2019, also " One study found that almost 2% of the world's financial assets are at risk if the global mean surface temperature rises by 2.5°C compared to pre-industrial levels (Dietz, Bowen, Dixon and Gradwell "Climate value at risk' of global financial assets" Nature Climate Change, 2016). Warming of 5°C could result in losses equal to 5% of the global stock of manageable assets ("The cost of inaction: Recognising the value at risk from climate change", The Economist Intelligence Unit, 2015)."

[99] Morana, C., & Sbrana, G. (2019). Climate change implications for the catastrophe bonds market: An empirical analysis. *Economic Modelling*, *81*, 274-294.

[100] Morana, Claudio & Sbrana, Giacomo (2019), "Climate change implications for the catastrophe bonds market: An empirical analysis," *Economic Modelling, Elsevier*, vol. 81(C), pages 274-294.

Financial supervisory authorities around the world are increasingly becoming alert to the potential financial stability risks that climate change poses. For the EU, the European Systemic Risk Board (ESRB) has set up a project team on Climate Risk Monitoring to advance towards a stress test methodology for the EU financial sector focusing on climate-related systemic risks, including through a pilot risk monitoring framework, the identification of relevant data gaps, and the analysis of the relevant transmission channels.

Climate risk stress testing poses several challenges. For instance, many climate-related physical risks (e.g., aggregate temperature increase) are expected over much longer horizons than the typical stress-test models (2-5 years). Moreover, the difficulty in treating physical and transition risk lies in limited cross-disciplinary modelling – and using traditional macro-financial approaches with those informed by climate science. Annex II explains these challenges in more detail and outlines the lessons provided by modelling efforts in the insurance sector, and specific projects.

Several initiatives by the Commission and EIOPA could help improve the analysis of climate risks. A number of elements in the Commission's forthcoming renewed sustainable finance strategy are intended to help companies strengthen their financial management of physical risks and contribute to the release of crucial vulnerability and exposure data. The **Revision of the Non-Financial Reporting Directive**[101] will also help ensure that publicly-available information about underlying activities' vulnerability to climate physical risk be made more comparable and reliable, so that investors are better informed about the sustainability of their investments. EIOPA is developing **an approach to cover climate-related risks**, within the broader methodological improvements to the bottom-up stress testing for insurance sector. The Commission already developed a micro simulation model (SYMBOL) to estimate individual banks' economic losses and liquidity shortfalls compatible with the existing bank prudential regulatory framework. **Horizon Europe, the new Framework Programme for Research & Innovation, will continue to support projects and initiatives that address the Climate Protection Gap**. Most notably, the Mission on "Adaptation to Climate Change, including Societal Transformation"—one of **Horizon Europe's flagship initiatives**—will support the development of models with better and more granular resolution of connective events and better capacity and skills of seasonal to decadal climate prediction. It will also support the assessment of compound and cascading risks, indirect and intangible losses, spillover effects and propagation of risks across value chains, social and ecological networks.

2.3 Policy approaches

2.3.1 Insurance coverage

Climate-related insurance can be a key tool to manage financial risk, better enabling societies to recover from disasters, reducing their vulnerability and promoting their resilience. First, insurance has the potential to provide the flow of capital to support communities and build infrastructure back after disasters. Without adequate insurance, the

[101] COM(2021) 189 final.

burden of paying for losses falls largely on individual citizens or governments with significant impact on already-strained government budgets and economic and social hardship for those affected. Countries with high insurance coverage recover faster from disasters. Yet, there is a large 'protection gap' – or underinsurance – in the European Union: currently, between 65%[102] and 70%[103] of total losses are not insured. Second, high natural disaster insurance penetration contributes to building wider understanding of climate-change risks, and can help promote measures that individuals and communities can use to improve their protection from climate change driven disasters. For example, (re)insurance expertise in risk evaluation can help to make the economic case for flood defences or for changes to how and where buildings are constructed. Using insurance is a step away from crisis and towards risk management and strengthens socio-economic resilience under a changing climate. It is one of the available disaster-risk financing options available to governments and individuals, which is considered in the design of a broader national disaster risk financing strategy that can also include other financial securities, disaster reserves and contribution from the budget.

2.3.1.1 Relevance and insurance penetration

Beyond the general considerations noted above, the transfer of risk to private insurance companies could bring significant benefits. These include the aggregation of knowledge (translation of complex risk characteristics into simple metrics such as monetary amounts or insurance premiums), incentives for resilience (risk reduction can translate into lower risk-based premiums, or insurance coverage becoming available, or more favourable conditions), efficiency (competition between insurers and innovation drives down the administrative cost) and reliability (robust prudential rules in cases of adverse circumstances).

However, it has to be acknowledged that not all risks are fully insurable by private insurers. While a higher penetration for risk transfer mechanism tools, such as insurance, is potentially beneficial for private and public actors, the tools should be carefully designed to ensure that they do not undermine the need to reduce vulnerability to climate change in the long run and therefore become a barrier to adaptation[104]. Any analysis on climate protection gaps should therefore start with an identification of the relevant risks at national and/or regional level[105] and types of desired coverage (e.g. property, marine/ aviation/transport (MAT), business interruption, agriculture). This should be followed by an assessment of whether the private insurance sector can realistically cover these risks or parts thereof in a manner that is beneficial to policyholders. Where this is the case, public authorities can consider actions to narrow the insurance protection gap (see Section 3.4).

As a starting point for assessing the prospects of narrowing the gap, one has to examine to what extent private insurance coverage today (insurance penetration) already protects relevant exposures against risks. Furthermore, it would be useful to understand where and how

[102] EIOPA Pilot dashboard.
[103] EEA - Economic losses from climate-related extremes in Europe.
[104] In economics, 'moral hazard' occurs when an entity has an incentive to increase its exposure to risk because it does not bear the full costs of that risk. Accordingly, insurance, if poorly designed, can remove the incentive to reduce risk (e.g. by preventive measures) or even incentivise higher risk-taking.
[105] Not all types of climate change risks are relevant for all countries and/or regions. For instance, earthquake or avalanche risk affect only a sub-set of Union Member States.

climate change increases the vulnerability of assets in mature insurance markets to a point where insurance products may become too expensive, leading to an increasing number of households or companies without insurance coverage. This issue has important social implications as uninsured or under-insured parts of society in vulnerable areas may never be able to recover financially, unless public budgets provide the recovery funding. Where this is the case, insurance products may 'price out' potential insurance policyholders at high risk and climate change can thus exacerbate the protection gap further. Annex III explains the measurement of insurance penetration and uses the example of flood insurance to assess insurance penetration in Member States.

2.3.1.2 EIOPA dashboard for natural catastrophes

To support the measuring and monitoring of the natural disaster insurance protection gap and to encourage measures to narrow that gap in the European Union, EIOPA has developed a pilot dashboard. The pilot dashboard[106] provides two views of the protection gap per Member State for different perils[107] (for example for floods): (a) a historical protection gap based on the difference between past economic and insured losses and (b) an estimation of today's protection gap which is calculated using hazard, vulnerability, exposure and insurance coverage data[108]. The latter is an example of a penetration rate based on modelled damages, as described in Annex III. For this purpose, EIOPA has combined data from several sources, including the Commission's Risk Data Hub[109], expert knowledge from national insurance supervisors.

The dashboard aims to help policy-makers take informed decisions on reducing the climate protection gap. It can increase awareness of protection gap issues for different stakeholders, identify at-risk regions and where the protection gap is coming from, support pro-active prevention actions, promote a science-based approach to protection gap management and risk-informed decision-making, and develop synergies between EU and national policies to improve protection gap management.

2.3.1.3 Outreach to the insurance industry

Through the NAIAD project, Commission staff interviewed 18 national insurance industry associations[110] and confirmed the wide diversity in the relevance of private natural disaster insurance in Member States. Some common messages and recommendations for the EU and national action to improve climate-related disaster insurance penetration in the European Union emerged, some of which have macro-economic aspects.

Current national information, awareness and regulatory frameworks for climate-related disaster risk tend to be weak. Many homeowners, SME and communities underestimate their vulnerability to climate change-related risks. More user-friendly risk maps are needed to increase

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[106] EIOPA pilot dashboard.
[107] The term peril is used interchangeably with the term hazard.
[108] The protection gap is indeed not necessarily high if insurance penetration is low, it depends on whether the expected hazard is also high (for example lack of insurance against coastal see flooding in land-locked Austria does not reflect a protection gap).
[109] DRMKC Risk Data Hub.
[110] NAIAD White Paper, 'Allies for Climate Resilience', available at: http://naiad2020.eu/wp-content/uploads/2021/02/NAIADwhitepaper.pdf.

the relevance and the customisation of climate-related risk information for EU citizens and businesses. Spatial planning governance is also lagging behind in many Member States as too many assets are still built or renovated without proper attention to resilience and adaptation needs in risk zones. The Commission's Renovation Wave Strategy aims to address part of this challenge, including by accelerating work with standardisation organisations on climate resilience standards for buildings.[111]

Where private insurers can only cover parts of the relevant risks, governments could consider public involvement in the insurance market. This can take various forms. For example, both Spain and France operate co-insurance or reinsurance mechanisms which pool risks from a large number of insured. The schemes also bundle multiple risks leading to a diversification across hazards. Government interventions can achieve comprehensive cover for their citizens and allow monitoring the development of premium pricing, but they can also crowd out the private insurance sector. Furthermore, moral hazard might develop into pressure on government-led schemes to take on an increasing portion of risks. The design of such schemes can therefore consider how limits on the involvement of public entities are set (i.e. the scope of the activity of the public (re)insurers as well as volume limits at granular level). Government schemes can also make use of retro-cession with reinsurers from the private sector. This would ensure that both the insurance and reinsurance markets hold some of the risk alongside the government.

The insurance industry's expertise in assessing and quantifying vulnerability to risks can play a role in promoting 'build back better' or even 'build forward better' principles. This expertise, if effectively shared with other stakeholders, such as in a public private partnership context, can contribute to buildings being rebuilt to better withstand future climate risk. Where insurance coverage after reconstruction is sought, possibly including some type of government subsidy for the insurance premium, the lower risk from improved building codes may also reflect the level of risk-based insurance premiums.

2.3.2 Public sector disaster financial risk management

Public sector responses to climate-related and extreme weather events fall within the remit of disaster risk management. Disaster risk management (DRM) encompasses all those approaches and policy tools aimed at reducing ex-ante risk and limiting ex-post the costs of natural and man-made disasters. Traditionally, DRM hinges on specific phases: risk assessment, prevention, preparedness, response and recovery.[112] Overall, the public sector plays a crucial role in DRM through setting legal requirements and procedures and providing the necessary resources for each phase of the DRM process.[113] Disaster risk financing strategies build on DRM elements such as disaster risk assessments.

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[111] COM(2020) 664 final.

[112] Poljansek, K., Marín Ferrer, M., De Groeve, T., & Clark, I. (2017). *Science for disaster risk management 2017: knowing better and losing less*. ETH Zurich.

[113] See https://www.undrr.org/terminology and JRC (2017) https://ec.europa.eu/jrc/en/publication/science-disaster-risk-management-2017-knowing-better-and-losing-less.

From a public finance perspective, robust and effective disaster risk management frameworks and disaster risk financing strategies reduce the fiscal cost of climate-related disasters while providing the adequate amounts and types of financial support. Several common features fostering robustness and effectiveness emerge from good practices and relevant international experience. First, the availability of appropriate risk information is the foundation of a robust disaster costs or risk mitigation assessment, contributes to sound decisions on policy priorities and design and to informed public investment decisions. Second, the provision of funds in the budgets of the authorities involved in the different DRM phases endows the process with the resources needed to develop the planning and implementing capabilities. Third, from a budgetary perspective, a disaster risk financing strategy is country-specific and builds on a combination of budgetary resources and risk sharing instruments such as insurance adapted to the severity and frequency of disasters. Finally, planning and dealing with the consequences of disasters is easier when the disaster cost sharing is clear for all stakeholders in advance.

Ex-ante risk sharing agreements can provide a clear definition of the roles held by the relevant actors in the public and private sectors. The consequences of natural disasters can be so serious that they can overwhelm the fiscal reserves and the capacity to access financial markets, incentivizing Member States countries to consider risk-sharing solutions. A well-developed insurance market, prevention system and other financial instruments for transferring risks allow private and public assets to be fully or partially protected against the effects of natural disasters. Strong Disaster Risk Financing (DRF) strategies make use of different available options for risk-sharing. Besides traditional insurance, these options include parametric insurance[114] and state contingent debt instruments.[115] Clarifying the DRF allocation ex-ante acts as an incentive for insurance subscription, therefore reducing the impact natural disasters have on public finances.

A common EU level approach to DRM is lacking, as legal requirements are either fragmented or cover aspects relevant for civil protection mainly. Decision 1313/2013 of the European Parliament and of the Council on a Union Civil Protection Mechanism (UCPM) aims at providing a common framework on risk assessments within the EU. The framework requires Member States to produce national risk assessments (NRAs) and assessments of risk management capabilities and report thereupon to the Commission every three years with a view to promoting effective and coherent prevention of and preparedness for disasters. It refers to existing guidelines issued in 2010. In 2019, guidelines were adopted on the reporting of summary information about these national risk assessments. However, the production and submission of NRAs to the Commission is conducted on a voluntary basis, making the exercise uneven and patchy across Member States. Legislation on preparedness and prevention is scattered across legal documents and has a narrow focus, including the 2007 Flood Directive, the 2000 Water Framework Directive, the 2009 Nuclear Safety Directive and the 1985 Environmental Impact Assessment Directive. More recently, some coherence in approaches has

[114] This type of insurance makes payments dependent on certain predetermined parameter values (wind speed, rainfall levels)
[115] IMF definition: state contingent debt instruments are instruments that bear contractual debt service obligations tied to a predefined state variable and are designed to alleviate pressure on sovereign indebtedness and / or financing needs in a bad state of the world.

been sought. The reporting guidelines on DRM[116] have been updated to merge the existing NRAs and risk management capability assessments into the template of the future reports. This additional effort regards the reporting of planned and implemented national climate change and adaptation policies by March 2021 under Regulation 1999/2018 on the Governance of the Energy Union and Climate Action. However, there was no explicit requirement for the Commission to review the reports on climate change adaptation regularly.

The draft Climate Law[117] aims to bridge these gaps. Depending on the final agreement between co-legislators, it would create a legal obligation to set up national adaptation policies with some specific features and assess the collective progress made by all Member States on adaptation, the adequacy of Union adaptation measures, and the adequacy of national measures to ensure progress on adaptation. The proposal has not yet been formally adopted by co-legislators but has been agreed at political level.

Absent a common framework and methodology, approaches to risk assessment will continue to vary substantially across Member States. As regards NRAs in particular, documents vary considerably in length, detail, focus and methodological approaches. For example, some report summary conclusions of the national risk assessments, others the full detailed assessments. Some address complex risk scenarios, which are cascading effects of natural or manmade threats and others assess relevant natural hazards only. In other cases, worst-case scenario approaches are considered, including a compound set of interdependent risks.

National reporting on resource allocation and financial management of DRM phases remain quite limited, and related guidance is still underdeveloped. In their capabilities assessment reports, Member States provide some, albeit incomplete, information on the process to determine the DRM financial needs and how the funds are secured in the budgets for risk prevention and preparedness. Overall, the main reported sources of financing are national budgets (state, regions, local authorities), implying ad-hoc and ex-post reallocations, and the EU Solidarity fund. The flexibility embedded in the budget determines how flexibly supplementary disaster-related needs can be met beyond what is already budgeted. The investment needs for preparedness and prevention are rarely linked to the risk assessments. The disaster risk cost-sharing arrangements between stakeholders are either unclear or the public sector is solely responsible.[118] Finally, financing for the post-disaster phases of recovery and reconstruction is country-specific and no common view on such arrangements is currently available.

However, synergies could be sought in the existing reporting requirements under different policy frameworks. This is the case of the EU Adaptation and the EU Disaster Risk Management Frameworks. The EU Governance Regulation[119] reporting rules on adaptation provide that Member States report information on 1) institutional arrangements and governance at the national level for assessing climate vulnerability and risks, 2) information regarding the collection, ownership and re-use of relevant data (such as climate-related disaster loss data or

[116] Commission Notice (2019/C 428/07).
[117] COM(2020) 80 final.
[118] 2020 Public Finances in the EMU Institutional Paper 147, February 2021.
[119] Regulation(2018) 1999.

risk data) and access to it and 3) information regarding the integration of climate change impacts and adaptation planning into disaster risk management frameworks and vice versa. This monitoring information can be useful across policy fields and governance levels, but the data collected demands careful consideration and interpretation as it is not automatically transferable.

The development of robust DRF strategies relies on an informed view on the financing instruments available to manage disasters. There is no single instrument to manage the impacts of disasters but a multitude of them. A DRF strategy makes use of different instruments to manage various types of risks according to their magnitude and frequency. These instruments can be budgetary, such as budgetary reallocations to rainy-day funds, contingency reserves, natural disaster funds and contingent credit lines. When the expected impact from a disaster is clearly above the possibility to mobilize the available budgetary resources, risk transfer mechanisms such as traditional or parametric insurance or other financial instruments such as cat bonds can be used.

3 Micro-economic aspects

3.1 Introduction

Given the variety of policy instruments at the disposal of the European Commission and their often-sectoral nature, climate-related risk management is best designed at sectoral level. It is therefore important to re-examine and, where relevant, redesign policy instruments that integrate climate adaptation considerations and climate–related disaster risk management, following a set of flexible policy coherence principles that can be adapted to all sectors and circumstances.

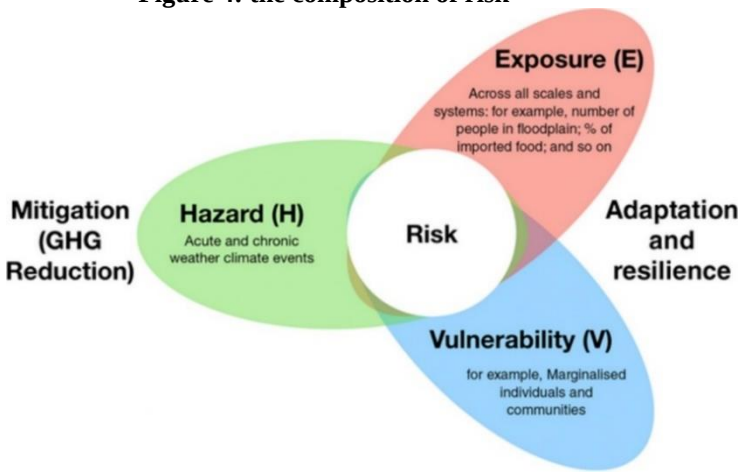
The European Union's mix of policies affects almost all aspects of public and private decision-making with regard to exposure and vulnerability to natural disasters on its territory. It does so through its own funding rules, through the rules that frame other public and private investment decisions and through its own approach to risk management in the development of its thematic policy areas.

As a result of climate change, policies dealing with natural disasters increasingly have to strike the right balance between individual responsibility and solidarity. Climate-related events of destructive force are no longer of a strictly exceptional nature, the occurrence of extreme weather events is foreseeable at intervals that are narrowing and with ever more precise location information, in particular for riverine floods. Slow onset events such as drought, sea level rise and coastal flooding are on a stubborn and identifiable trajectory for decades to come. In this context, when climate-related hazards turn into disasters, drawing the line between human failure and an Act of God, carelessness and bad luck, or between lack of responsibility and what calls for unqualified solidarity, is a delicate balancing act.

Climate change is therefore revolutionising the very concept of 'natural catastrophe' as it is enshrined in the Treaty, in our rules, in our conceptual frameworks and our language. In some sectors and areas of Europe, change is now happening so quickly that adjusting to the new normal has become a question of shifting baselines to which risk assessment tools and decision-making must adapt. As natural hazard events occur and will continue to occur at intensities not

previously experienced, and with consequences previously unimagined, risk management capabilities and predictive analytics should be increased substantially and mainstreamed throughout policies. While some things cannot be controlled – such as restoring glaciers, engineering oceanic currents to flow, or entirely preventing droughts and heatwaves - the future is not somewhere we are going but something we are creating. Through increasingly ambitious mitigation action globally, the EU and the world can still avoid the most dangerous adverse impacts of climate change. Furthermore, while hazards will increase, their translation into disasters is not inevitable. As figure 4 shows, risk is a function of exposure, hazard and vulnerability. It falls on all of society to manage and decrease our exposure and vulnerability and improve our preparedness. In other words, managing risk better and being climate-smart by implementing three principles: accounting for risk before creating new exposure, reducing existing risk, and managing residual financial risk.

Figure 4: the composition of risk



3.2 Policy coherence principles

3.2.1 Principle 1: accounting for risk before creating new exposure

Action should not ignore risks that will be associated with the creation of new exposures and climate change risks should be part of any trade-off in decision-making. This principle follows from the fact that people, housing, infrastructure and assets are most susceptible to impacts when they have been physically placed in hazardous areas, and when the standard to which they have been built does not meet contemporary or anticipated resilient building standards and codes. Some places previously not exposed have progressively become more exposed. The incentive to building knowingly or unknowingly in hazardous locations is influenced by several factors and values[120].

Climate-related risk should be duly considered throughout all decision-making phases of creating new exposure and clear responsibilities and climate risk-ownership should be

[120] These include affordability; servicing established communities, being amongst your community, being safe and secure, or, as far as housing is concerned, wanting to live close to town centres, close to your work, or schools and other amenities or in the country side, along rivers and coasts and other natural features.

allocated. This would promote the financial management of residual risk and related insurance penetration and reinforce climate risk accountability throughout the decision-making chain. Before making these decisions, people may not appreciate the risks involved, or may not be sufficiently prepared for climate related hazards because of limited awareness, means, and willingness to address the risks or because of disincentives at play. Similarly, collective planning decisions to place housing, infrastructure and assets in particular locations include considering different factors of benefit to different groups, such as ensuring equitable access to affordable housing, providing high quality infrastructure, or providing an economic return. Initial decisions about undertaking a new development may only consider short term trade-offs while, in the phase following completion, the risk is substantially transferred to owners and residents. From this point onward, people are exposed for a much longer period of time. Large resources are invested at individual level into these assets, and the ability to access additional sources of discretionary funding to recover following a disaster may be limited. However, until recently, the consequences of disasters were rarely attributed to the legacy of the systemic decisions that generated the risks. They were much more likely to be attributed to human error, an uncontrollable natural event, or a combination of both. In a climate-damaged world, our risk management practises should be upgraded significantly, responsibilities for climate risk assessment and ownership should be allocated and perverse incentives for continued risk-generating behaviour should be removed.

Business continuity should also be a crucial part of the natural disaster resilience aspects of these assets. The disruption from a natural disaster typically triggers cascading effects across society, exposing vulnerabilities and inequities. Criteria against which trade-offs should be assessed include, but are not limited to, the following:

- high levels of dependency and growing system interconnectedness;
- just-in-time supply, low levels of storage, hub and spoke distributions;
- few alternative sources/routes/suppliers;
- dependence on imports to meet demand;
- high expectations of continuous ongoing supply/service;
- low socio-economic tolerance for loss and disruption.

3.2.2 **Principle 2: reducing existing risk**

The adaptation investment gap is vast and while measuring it is still a matter for research, all agree that the stock of existing assets at risk on the landscape is large. Risk-ownership for these assets is diversified. Some are private assets, others are publicly held assets or infrastructure. For private assets, new rules on climate physical risk assessment and disclosures increasingly aim to incentivise risk owners (financial actors, businesses) to reduce existing risk to their assets or property[121]. For public assets, all governance levels are risk-owners. Public authorities, including those managing EU funds, could be incentivised to conduct similar risk assessments including cost-benefit or cost effectiveness analyses of risk reduction investments. They could also be incentivised to identify where economic losses are the highest, in particular

[121] See section 2.2.2.

where they overlap with socio-economic vulnerability. Such incentives would help prioritise public investments towards these critical areas, as well as towards vulnerability hotspots where critical infrastructure systems interconnect and the failure of which would have cascading impacts on society.

3.2.3 **Principle 3: managing residual financial risk**

When it is not possible or feasible to eliminate or reduce climate-related risk, economically viable solutions are needed for the transfer or mutualisation of financial risk. These solutions, such as private insurance, privately and/or publicly funded pools, or other tools with potential public support can improve decision-making. They can help to accelerate economic recovery after disasters, mutualise risks while promoting resilience, manage distributional aspects of climate-related impacts, and give risk-owners the time and financial space they need to adapt by remaining in the tolerable risk space through financial buffering. However, managing residual financial risk should be designed in a way that promotes further resilience and adaptation, and avoids creating perverse incentives.

3.3 Current programmes and policies

3.3.1 **EU funding and climate adaptation**

Albeit with different levels of ambition, all major EU spending programmes include sustainability or climate proofing provisions in the 2021-2027 Multiannual Financial Framework (MFF), pending remaining agreements and formal adoptions between co-legislators. The EU is recognised as a frontrunner in mainstreaming climate action into EU budget programmes and financial instruments. The previous Multiannual Financial Framework (MFF) 2014-2020 ensured climate mainstreaming via a target of at least 20% of the European budget to be spent on climate-related expenditure, and specific actions taken under the various EU funds to integrate climate objectives into the relevant policy areas. Building on the current experience and the commitments to implement the Paris Agreement and the United Nations Sustainable Development Goals, the level of ambition for the new MFF has been raised, with 30% of the EU budget to contribute to climate objectives and to support the implementation of the EU's climate and energy targets for 2030. There is no distinction between climate mitigation and climate adaptation in terms of reaching the target, with both objectives being eligible to count towards the 30%[122]. For instance, the legal proposals for Connecting Europe Facility (CEF), the Common Provisions Regulation, which among others covers the European Regional Development Fund (ERDF) and the Cohesion Fund (CF) include requirements related to the climate proofing of infrastructure. The InvestEU Regulation includes provisions related to the sustainability proofing of all financing and investment operations above a certain size[123], with climate being one of the dimensions to be considered together with the environment and social dimensions. Under the new MFF, the Guidance on the climate proofing of infrastructure 2021-2027 can be a significant tool to implement these climate-proofing provisions, both for centrally managed and shared programmes. The Guidance aims to include both emissions reduction and

[122] Long-term EU budget 2021-2027 and recovery package.
[123] For InvestEU, proofing requirements are expanded beyond infrastructure projects.

climate adaptation aspects. The European Green Deal Communication and the European Green Deal Investment Plan Communication only reinforce these commitments in terms of sustainability and put forward a comprehensive framework for the sustainability transition from every corner of the EU. Climate adaptation also forms a part of the Covid-19 pandemic recovery effort. Supporting the recovery will remain a central goal of macro-fiscal policy in the short and medium term. The Recovery and Resilience Facility, the flagship instrument of the EU's recovery instrument Next Generation EU, will provide Member States with up to EUR 672.5 billion of funds up to 2026 to support their economic recovery and long-term resilience. The national recovery and resilience plans are expected to support investments and reforms, including to improve climate resilience across the EU. At least 37% of the allocation of the plans should be directed to climate action, with includes adaptation efforts. At the moment, many draft plans involve measures to strengthen climate resilience and adaptation, in areas such as flooding, water management and forest fires.

3.3.2 Projects and funding programmes and the policy coherence principles

Albeit to differing degrees, the most significant EU spending programmes apply the three policy coherence principles[124] outlined in Section 3.2. The EU budget will play a crucial role in addressing the long-term investments needs both for adaptation and mitigation, as well as in raising awareness on the importance of climate-related resilience on the market. Annex IV performs an analysis of the alignment of the most significant programmes with the policy coherence principles.

Under the TEN-E revision proposal, the sustainability criteria for the selection of Projects of Common Interest have been reinforced and provisions on climate impact have been added. The sustainability criteria for the assessment of candidate projects have been strengthened and made mandatory. Moreover, the Regulation introduces a requirement for projects of common interest to integrate climate adaptation measures and the 'do no significant harm' principle[125].

A revision of the TEN-T guidelines is currently ongoing[126] and is included in the action plan of the European Green Deal Communication[127]. It covers efficiency enhancements, the question of charging and refuelling infrastructure for alternative fuels and infrastructure standards and requirements that are adapted to climate change challenges and ensure a high level of resilience.

The CEF 2 Regulation includes climate resilience as an element to be taken into consideration in the award process. The CEF 2 Regulation[128] requires that the assessment of proposals against the award criteria shall take into account, where relevant, the resilience to the

[124] The programmes mentioned below and in Annex IV have not all been formally adopted by co-legislators.
[125] COM(2020) 824 final.
[126] Evaluation forthcoming, legislative proposal aimed for June 2021. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12532-Revision-of-Regulation-on-Union-guidelines-for-the-development-of-the-trans-European-transport-network-TEN-T-
[127] COM(2019) 640 final.
[128] COM(2018)438 final.

adverse impacts of climate change through a climate vulnerability and risk assessment, including the relevant adaptation measures.

The Common Provisions Regulation (CPR) covers climate resilience aspects well in the current cohesion policy legislative framework. Managing authorities gained substantial experience from the application of climate proofing requirements for major projects already under the 2014-2020 MFF, allowing for a good alignment with the first two policy coherence principles[129]. For the 2021-2027 period, 'enabling conditions' have been proposed, linked to Member State disaster risk management planning, in line with the EU Civil Protection Mechanism and linked to climate change adaptation strategies. Before Member States can receive reimbursement of investments in climate change adaptation and disaster risk management, Member States have to fulfil the enabling condition. It entails having a national or regional disaster risk management plan, established on the basis of risk assessment, taking account of the likely impacts of climate change and the existing climate change adaptation strategies.[130]

While the EU Solidarity Fund is not directly designed for climate resilience, resilience aspects are encouraged. It is an instrument primarily designed to contribute to post-disaster emergency relief in Member States and accession countries confronted with devastating natural disasters and major public health emergencies. It is intended to provide financial assistance to cover part of essential emergency and recovery response actions. The resilience aspect, although not specifically underlined in the regulation, is encouraged by promoting better coordination and complementarity with financial resources from other sources. Therefore, the alignment with the three policy coherence principles is moderate.

The InvestEU Regulation covers the first two principles well, with climate adaptation expenditures being eligible for financing and climate proofing requirements, ensuring that financing goes to resilient assets. For the third principle, managing residual financing risk, the sustainability proofing requirements will help with raising awareness of climate adaptation considerations in the financing and investment decision-making process.

The legislative framework of the Union Civil Protection Mechanism raises awareness of the impact of climate change on the risk of disasters and stresses the important role of preventive measures. It does this notably via a training programme for civil protection and emergency management personnel. The first two principles are addressed through reporting requirements and the technical and financial assistance provided to Member States. For the third principle, Member States are asked to report how the insurance sector is part of the wider disaster risk management framework.[131]

[129] Before a major project is approved, the managing authority is required to provide an analysis of the environmental impact, taking into account climate change adaptation and mitigation needs, and disaster resilience.
[130] COM(2018) 375 final, Article 11.
[131] Commission Notice Reporting Guidelines on Disaster Risk Management, Art. 6(1)d of Decision No 1313/2013/EU (2019/C 428/07).

The range of tools available under the Common Agricultural Policy reflect the close inter-linkages between economic, environmental and climate considerations. They can be distinguished on grounds of the type of beneficiary, funding source, and type of risks or perils addressed.

Investments under the Digital Europe Programme (DEP) support the Union's twin objectives of a green transition and digital transformation. Under the DEP, the Destination Earth initiative[132] will develop a very high precision digital model of the Earth to anticipate, monitor, better understand and react to climate change related challenges, including environmental disasters and related socio-economic crises. The Digital Twins, (the first ones on climate adaptation and natural disasters) will improve the vulnerability assessment. The initiative is hence well aligned with the policy principles 1 and 2. Also under the Digital Europe Programme, a Green Deal data space will be set up, to aggregate currently fragmented and dispersed data from various ecosystems, both for/from the private and public sector. It will offer an interoperable, trusted IT environment, for data processing, and a set of rules of legislative, administrative and contractual nature that determine the rights of access to and processing of the data.

The European Investment Bank, as the EU's climate bank, outlines in its climate roadmap[133] the ways in which it will ensure that its operations are aligned with both the temperature and climate-resilience goals of the Paris Agreement. In order for the EIB finance to be consistent with a pathway to climate resilient development (Article 2.1c of Paris Agreement), the EIB will strengthen its efforts to ensure that all the operations it supports are adapted to current weather variability and future climate change. This will be done through adequate project-level management of physical climate risk – as assessed by the Bank's Climate Risk Assessment system, and consistent with a broader strategic context of climate resilience. This approach will cover all sectors vulnerable to the negative effects of climate change, including agriculture, buildings, energy, forestry, transport, urban development, water and wastewater management, and industry.

The Recovery and Resilience Facility Regulation aims to support measures mainstreaming climate action and contributing to the green transition. As noted, climate actions must account for 37% of the overall allocation of funds. Adaption and resilience measures are included here, as well as mitigation actions, in line with the second coherence principles of reducing existing risk, by for example encouraging investments in infrastructure to make them more resilient to the impacts of climate change, such as increased extremes in temperature. As such, it recognises awareness of climate exposure as an element of the green transition. Another core of the Regulation is the provision that no measure included in a Recovery and Resilience Plan should 'do no significant harm' to one of the six environmental objectives within the meaning of Article 17 of the Taxonomy Regulation (climate change mitigation, adaptation, pollution, water impacts, circular economy and biodiversity). This safeguard, regarding measures that might have positive impacts from a social or economic context, but will not be supported due to the do no significant

[132] Destination Earth brochure.
[133] The EIB Group Climate Bank Roadmap 2021-2025.

harm concept, is also in line with the second principle of reducing environmental risk, including climate adaptation.

3.3.3 **EU policy settings**

The European Green Deal Communication and the Commission 2020 work programme propose the Green Oath to 'do no harm' as a principle for sustainability. The Commission proposal for a Climate Law[134] also requires that '*relevant Union institutions and the Member States'* ensure continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change in accordance with Article 7 of the Paris Agreement. Minimising risks from climate impacts must be at the core of the 'do no harm' principle, as neglecting to do so would result in avoidable destruction of economic value, of livelihoods and in most cases, of the environment as well[135]. In Annex V, a series of existing EU policy settings in a range of policy areas have been tested against the 'do no harm' and adaptation policy coherence principles.

Under the Commission's sustainable finance action plan[136], a number of actions were taken to redirect private capital towards sustainable investment, including investment in better adapting to climate change. The actions concern the various financial services sectors, including credit institutions and investment firms, asset managers, insurance companies and pension funds (institutions for occupational retirement provision or IORPs). As part of the European Green Deal, the Commission has committed to putting forward a proposal to review the Non-Financial Reporting Directive (NFRD). It is widely recognised that the information currently reported by companies under the scope the Directive does not meet the needs of intended users. Among other things, a large amount of information considered relevant by users is not reported, and reported information is not sufficiently comparable or reliable.

Further actions on prudential rules are being considered in the context of the preparations for the renewed sustainable finance strategy. As announced in the 2021 Adaptation Strategy, the Commission will identify and promote best practices in financial instruments for risk management. For insurance and reinsurance companies for instance, the Solvency II Directive (Directive 2009/138/EC) achieves a high level of harmonisation of the prudential rules. Quantitative requirements ensure that insurers hold capital to absorb potential losses, among others, from decreases in the value of their assets. Qualitative requirements ensure, among others, that insurers understand the risk of their investments and are able to manage those risks. Indeed, insurers carry a dual role as investors and underwriters of risk and therefore should consider both assets and liabilities in the context of climate change adaptation. EIOPA has delivered advice and an opinion on integrating sustainability in Solvency II.[137] The European Commission's Review of the Solvency II Directive will look, among others, at the contribution of the insurance sector to the European Green Deal and at the strengthening of the single market

[134] COM(2020) 80 final.
[135] The environmental impact of non-resilience is high as exemplified by fires (of forests and of assets), water wastage, floods, over use of some types of fertilizers or emissions linked to managing debris and rebuilding etc.
[136] COM(2018) 97.
[137] EIOPA - Opinion on Sustainability within Solvency II, EIOPA - Technical advice on sustainability in Solvency II and IDD.

for insurance[138]. As part of its activities on the assessment of market developments, EIOPA has produced an analysis on insurers' pricing and underwriting practices in light of climate change[139]. That analysis supports the identification of good practices by insurance companies to enhance adaptation by their policyholders (i.e. the concept of impact underwriting). Insurance products can be designed to incentivise increased resilience before a disaster and or improvements being made after a disaster (build-back-better, replacement).

The upcoming legislative proposal on Sustainable Corporate Governance[140] aims, among others, at integrating sustainability risks in corporate governance. Directors of limited liability companies would have a duty to identify the sustainability risks faced by their companies, including via their supply and value chains, as well as a duty to manage those risks and address them in the corporate strategy.

The Pan-European Personal Pension Product (PEPP) Regulation requires PEPP providers to invest in accordance with the 'prudent person' rule in the best long-term interest of PEPP savers. The Regulation states explicitly that, within the prudent person rule, PEPP providers "shall take into account the potential long-term impact of investment decisions on environmental, social and governance factors".

Resilience considerations are essential to ensure that public funds are spent with due regard to safeguarding the value of investments made over time. Public authorities are the principal buyers in sectors, which are some of the most adversely affected by the impact of climate change and natural disasters such as energy, transport or social protection and the provision of health. Public authorities are also the principal buyers in sectors that are crucial to increased climate and risk management literacy, such as education. EU directives on public procurement[141] cover tenders that are expected to be worth more than a given amount and consider multiple quality aspects when purchasing works, goods or services. These include protecting the environment, supporting social considerations and fostering innovation. However, resilience to climate, environmental or biosafety risks are not specifically included. Similarly, in the development of Green Public Procurement criteria, there is no systematic focus, to date, to ensure that public buyers take into account climate-related risks in their purchases. To date, despite quality aspect provisions, 55% of procurement procedures use price as the only award criterion for public contracts. This might be an indication that public buyers are not always prioritising quality, sustainability and innovation or resilience at the award stage of public contracts.

Article 107(2)(b) of the Treaty on the Functioning of the European Union (TFEU) stipulates that State aid to make good the damage caused by natural disasters must be compatible with the internal market. According to Article 108 TFEU, any intentions from Member States to grant such aid must be notified to the Commission, which is responsible for

[138] Review of Solvency II.
[139] EIOPA - Discussion paper on non-life underwriting and pricing in light of climate change.
[140] This initiative has been subject to a public consultation at the end of 2020 and is intended for adoption in the second quarter of 2021.
[141] Directive 2014/24/EU on public procurement; Directive 2014/25/EU of the European Parliament and of the Council of 26 February 2014 on procurement by entities operating in the water, energy, transport and postal services sectors.

verifying the occurrence of the natural disaster invoked to justify the granting of aid. There are potential disincentives to reducing existing risk in ex-ante schemes and ex-post aid that would not rule-out support to losses arising from claimants that are responsible for the damage suffered or did not take any measure to mitigate their damages. The European Commission assessment framework takes this risk into account. The framework ensures that the aid is complementary to insurance pay-outs and that the combination of aid and insurance pay-out does not exceed total damage.

Before the 2021 Adaptation Strategy, the EU was an early actor on adaptation, producing a Green Paper[142] and a White Paper[143] to pave the way for the adoption in 2013 of a first Strategy on adaptation to climate change. This first strategy was welcomed by the Member States and positively evaluated in 2018[144]. That strategy aimed to enhance the preparedness and capacity of all governance levels to respond to the impacts of climate change and make Europe more climate-resilient. Today the speed of adaptation action is varying across the EU but all 27 Member States have adopted national adaptation strategies or plans[145]. In the EU countries, most vulnerability assessments are produced, and adaptation options are identified, for agriculture, health, biodiversity, forestry and energy. The main sectors in which national policy instruments promote adaptation are water, agriculture, biodiversity and forestry, whereas health and energy are lagging behind.

The current COVID-19 crisis has revealed gaps in the national and EU disaster risk management structures, including the Union Civil Protection Mechanism (UCPM). As such, it represents an impetus and a window for the EU as a whole to draw lessons and start working towards European emergency management that is fit for the future.[146] One of the important novelties introduced with the revised UCPM legislation is the concept of Union disaster resilience goals. These goals will be developed in the area of civil protection to support prevention and preparedness with the aim of improving the capacity to withstand effects of disasters with cross-border impacts. The goals will have to be based on current and forward-looking scenarios, including the impacts of climate change on disaster risk, data on past events and cross-sectoral impact analysis with a particular attention to vulnerable groups. Member States are required to take into account the Union disaster resilience goals when developing and refining their disaster risk management planning. The Commission and the Member States will also work together to improve cross-sectoral disaster risk management planning at Union level, both for natural and man-made disasters likely to have a cross-border effect, including the adverse effects of climate change. The planning will include scenario-building at Union level for disaster prevention, preparedness and response.

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[142] COM(2007) 354.
[143] COM(2009) 147.
[144] COM(2018)738.
[145] EEA report No 6/2020 Monitoring and evaluation of national adaptation policies throughout the policy cycle — European Environment Agency (europa.eu)
[146] Joint statement of the members of the European Council on 26 March 2020 calling for a more *"ambitious wide-ranging crisis management system*. European Parliament resolution of 17 April 2020 called on the Commission to strengthen European disaster risk management, preparedness and prevention.

The Directives on Environmental Assessment help to ensure that environmental considerations are taken into account when preparing projects, plans and programmes.[147] Projects and programmes co-financed by the EU, including some which may not be covered by the climate and sustainability proofing guidelines have to comply with the Environmental Impact Assessment (EIA)[148] and Strategic Environmental Assessment (SEA) Directives[149] to receive approval for financial assistance. They are therefore crucial tools for sustainable development, in which due considerations for climate and environmental risks should be mainstreamed.

3.4 Creating an environment for the development of insurance solutions

In addition to transferring or mutualising risk, private insurance can also act as a risk management tool. As one example of alternatives to private insurance, Figure 5 below gives a definition of 'mutual funds' that are common in the agricultural sectors of some Member States. Private insurance coverage entails the translation of individual risk into a monetary insurance premium. A well-functioning insurance market thereby allows protection against risk while also providing an incentive to reduce or mitigate risks. A high insurance coverage for residual financial risks from climate change is therefore deemed desirable.

Figure 5: Mutual funds as alternative to insurance in the agricultural sector

Mutual funds are schemes accredited under national law for affiliated farmers who decide to pool risks[150]. Mutual funds can pay financial compensations to affiliated farmers for production losses stemming from a defined list of possible risks:

- the outbreak of adverse climatic events;
- an animal or plant disease;
- pest infestation; or
- an environmental incident[151].

Mutual funds can also stabilise farmers' income in case of a sharp drop in income.[152]

However, a transfer of risks to the private insurers and the subsequent reliance on those companies after disasters requires safeguards. The transfer of risk requires sufficient protection of consumers and other types of insurance customers. For instance, insufficient pre-contractual information or unclear contractual terms like exclusions, limits or deductibles could mislead customers and suggest a false sense of resilience.

[147] Environmental assessment for public plans or programmes are undertaken on the basis of the SEA Directive and environmental assessment for individual projects, such as a dam, motorway, airport or factory are undertaken on the basis of the EIA Directive.
[148] Directive 2011/92/EU as amended by Directive 2014/52/EU.
[149] Directive 2001/42/EC (known as 'Strategic Environmental Assessment' – SEA Directive).
[150] See Art. 36 (3) of Regulation (EU) No 1305/2013.
[151] See Art. 36 (1) (b) of Regulation (EU) No 1305/2013.
[152] See Art. 36 (3) of Regulation (EU) No 1305/2013

Furthermore, it has to be acknowledged that not all risks are fully insurable by private insurers. While higher insurance penetration is potentially beneficial for private and public actors, the products need to be carefully designed to ensure that they do not undermine the need to reduce vulnerability to climate change in the long run and therefore become a barrier to adaptation. Any analysis on climate protection gaps should therefore start with an identification of the relevant risks at national or regional level and types of desired coverage (e.g. property, marine/ aviation/transport, business interruption, agriculture) followed by an assessment of whether the private insurance sector can realistically cover all or parts of these risks at an affordable premium and in a manner that is beneficial to policyholders.

3.4.1 Availability of insurance solutions

When analysing insurance penetration for climate-related risks, the first step is to understand the reasons why some risks are not covered. The pre-requisites for insurance products to be offered by private insurers are often referred to as *insurability*. Figure 6 below lists some necessary conditions and characteristics for private insurers to be able to offer insurance coverage against a certain risk. Further aspects that can affect insurability are the availability of reinsurance and other options for the insurers to cede part of the assumed risk to third parties as well as the ability to set insurance premiums aside as reserves to cover for losses that might materialise in subsequent financial periods (intertemporal risk transfer).

Figure 6: Insurability

Pre-requisite	(Counter-) Example
The risk is of random nature and is not (entirely) within the control of the prospective policyholder.	A typical example is property insurance, which usually covers a property against a clearly defined set of risks (e.g. fire, loss caused by damage of main water pipes, vandalism). Claims which are intentionally (or as a result of gross negligence) caused by the policyholder are typically not covered.
The insurer is able to estimate key characteristics on the distribution of the risk (frequency, severity and dependencies) for the risk.	One example is car insurance where a very large number of similar risks are pooled by insurers (i.e. sufficient data is available for reliable estimation of the expected losses). In contrast, on topic of cyber insurance for example, debates are ongoing to understand whether insurers have enough data to price several types of cyber risk and whether and how the collection of data needs to be improved.
The risks pooled by the insurer are diversified.	Where the same event can affect a large share

The risks are of low correlation or even independent from each other or negatively correlated.	of policyholders, the potential for diversification can be undermined. Beyond considerations on diversification among policyholders for the same product, insurers diversify, for instance with regards to different lines of business or (geographical) regions, and thereby define within their risk strategy the maximum amount of risks they can cover, in property insurance in one region, for instance. They also define other risk mitigating factors like reinsurance to potentially being able to increase the coverage.
The redistribution of the risk would translate into a realistically affordable insurance premium.	A typical example is property insurance. The potential loss for the individual policyholder is the full loss of the property through fire, for example, which is financially existence-threatening. As the probability of such a complete loss is remote and shared within the risk pool the premium is affordable for the policyholder. The risk of some types of natural catastrophes can typically not be insured solely by private insurers, because the risk-sharing mechanism would be suspended by all customers being hit by the same risk at the same time. The amplitude of the losses exceeds the financial capacity of the insurers involved.
The insurance premium is based on the expected loss value, which is the individual expected claims ratio on the insured item or person. In contrast to social insurance or funding programmes higher risks will automatically pay comparatively higher premiums.	Property insurance in a high risk area (e.g. vulnerable to flooding) will – in line with the higher risk - be more expensive than building insurance situated in a low risk area.
It is possible with reasonable effort to verify whether the risk has materialised.	Whether or not an object has been lost is more difficult to verify than a damage. Insurance contracts may therefore exclude coverage for loss.
It is possible for insurers to address, at least partially, issues stemming from asymmetric information and moral hazard.	Deductibles apply to many insurance products to make sure that some incentive remains with the policyholder to take action to mitigate the risk.

Starting with the private insurance sector, a key reason for incomplete supply is insurers' lack of interest or capacity to deal with a small-scale or high-risk business. Indeed, some risks imply too large a size (risk severity), even when the occurrence has a very low likelihood. Then, when offering such products, insurance undertakings would have to limit their own risks by offering limited coverage or scope if no other risk-mitigating tools (such as reinsurance or public protection schemes) are available. Such exclusions from cover would in turn be considered unsatisfactory and not generate sufficient demand. In contrast, other risks may have such a high or increasingly higher probability or frequency of occurrence or severity that they are not insurable (see Figure 6 above) and covering such events through market-based insurance would imply an unrealistically high premium. For all types of mechanisms, from fully private to entirely public, another obvious obstacle lies in the insufficiency of statistical data on risks, be it in scope or quality, which prevents accurate risk estimation for premium and compensation settings. For both of these categories of reasons, the barriers are aggravated by the fact that the risk itself is often difficult to clearly define, identify or isolate as it is dependent on other events as well as on human decisions, and that the nature of the risk itself is changing with accelerating climate change.

Increasing insurance penetration for climate-related risks may require public-private sector cooperation. While the coverage of certain risks may be possible for the private insurance industry and can be bundled within certain products, a portion of extreme risks may not be financially bearable for insurers, and governments may need to step in. Likewise, public-private insurance plans can build capacity and trust. Moreover, financial incentives such as reduced insurance premiums or lower deductibles can encourage policyholders of existing assets to take part in risk-mitigation activities (i.e. preventive measures), to protect their property against climate-related losses, for instance. Further, disaster insurance and compensation arrangements can encourage public and private entities to reduce or mitigate risks and recognise the benefits of utilising the capacity of national and international (re)insurance and capital markets to absorb disaster losses. Partial insurance, where policyholders may still benefit from partial compensation, may also help as a way for public authorities to address specific socio-economic vulnerabilities.

Public investment in risk reduction and prevention measures can in some cases be supported through risk pricing by insurers. In the realm of preventive and pre-emptive adaptation measures, such as adapted infrastructure and housing, effective land-use and building standards as well as targeted investments in loss prevention are also important. If made, the short-term fiscal cost of such investments would reduce future disaster-related expenditures and the insurance market would also be more likely to provide coverage against these disasters. Concerning the most vulnerable, who live in hazardous areas, programmes that finance relocation can be very effective in risk and vulnerability reduction. Similarly, where data is available, avoiding new exposure to hazardous, or soon to-be areas is a crucial step. Risk-pricing by private insurers can incentivise such behaviour.

3.4.2 **Risk awareness and risk-transfer solutions**

On the demand side, potential beneficiaries may not be fully aware of the risks posed by climate-related disasters or the financial consequences of such risks. They may underestimate such risks or the related losses, certain disasters with a currently low frequency may not seem worth the premiums paid, or even worth the effort of purchasing insurance coverage (status quo effect). Sometimes the safety net provided by public funds or the trust in public-private solidarity or risk mitigation may also prove to be a disincentive to purchasing insurance coverage. In addition, potential beneficiaries may not always fully understand the financial conditions or the consequences of such risks for their own wealth. Sometimes they choose not to take insurance or are simply not aware that insurance cover is available for such risks. Another key factor is the risk ownership or responsibility. When there is no clear allocation or understanding of risk ownership or property rights or liabilities, there is no incentive, and sometimes not even the possibility, of being insured against this risk. On both the demand and supply sides, increased insurance penetration can also be an important target of public-private sector cooperation, for instance, through economies of scale for reduced premiums. In some cases, governments have also made insurance mandatory or required bundling across risks with the objective of achieving more wide-spread insurance coverage. In many of those cases, the governments have undertaken complementary actions to ensure that the mandatory demand for insurance is met with sufficient supply of affordable insurance products.

Financial communication can improve risk awareness and knowledge on risk-transfer solutions. This concerns the information at the time of making investment decisions as well as when being offered, for instance, home insurance products or purchasing a property. Persons registering at a new address can be provided information on national disaster databases, adaptation and disaster risk reduction plans by municipalities and local governments. To reduce adverse incentives from public funds, these can be conditional upon the potential recipients implementing pre-defined risk-mitigation measures or avoid incentives against risk mitigation. As a general means, detailed assessment and risk mapping can be carried out. On financial literacy issues, insurance companies are already required to explain in plain language to policyholders what they are covered for and for what they are not at contract inception[153]. In addition, insurance distributors are obliged to engage in a dialogue with the customer and to make sure that insurance policies proposed correspond to the customer's demands and needs.

3.4.3 **Affordability incentives for risk transfer solutions**

Affordability of insurance risk transfer solutions is a two-step issue. Premiums in general can be too high, or unrealistic in the sense of Figure 6. This is because the risks imply too large a size or have a high or increasingly high probability or frequency of occurrence that they would imply an unrealistic premium that would not make the product accessible. This affects the availability of insurance products. Once the supply actually exists, the frequency, severity or dependency characteristics of the risks may still imply high risk-based premiums, which make the insurance products unaffordable, at least for certain groups. This also impacts the demand for insurance.

[153] Directive (EU) 2016/97.

Indeed, there might still be sections of the population and the economy that do not have the means to purchase private insurance coverage even where it is widely available at reasonable prices. Examples might include low income households and micro- or small-sized enterprises.

Beyond risk-based premiums, better determining and measuring risks or public-private joint solutions, an effective incentive for taking out insurance could be through taxation or subsidies. For example, through a favourable insurance premium tax rate for insurance against climate change risk. Fiscal measures such as tax rebates or the suspension of tax payments also give an incentive to purchase insurance and to avoid moral hazard. Another possible solution would then be the deductibility of insurance premiums from taxable income where not already in place for both corporations and retail customers. As for the social issue of more financially vulnerable groups, there are numerous possible ideas that could be used by different levels of governments as well as by insurance markets in line with their specific market situation. These include possible subsidies on insurance premiums, or offering special rebates, such as a small rebate on house insurance when buying natural catastrophe insurance coverage also climate change related risks.

3.4.4 Cross-border differences in risk transfer solutions

Another important aspect to understand is the extent to which insurance solutions across Member States are comparable in terms of accessibility, coverage, risk pricing, and options. However, a detailed and coherent overview and assessment of the landscape in natural disaster insurance solutions across EU Member States is missing. While there are several sources of information, they are seldom comparable, and do not cover all 27 countries. This lack of consistent and coherent information is a barrier to informed policymaking and efforts to close the insurance protection gap. Aspects that are still poorly understood include differences in insurance products across the European Union, differences in risk pricing and differences in the share of disposable income devoted to insurance premiums across EU Member States. Given the current lack of detailed knowledge on natural disaster insurance products and their prices, country diagnostic assessments would be useful.

4 Data aspects

4.1 Introduction

Data on climate-related disaster losses is crucial to understanding the resilience gap and its many aspects. Data is needed by hazard, by economic sector, by type of risk-owner, by vulnerability profile, by region, by ecosystem-type and by final loss bearer. Ideally, such data would be collected in a uniform way and documented with the right set of metadata and time-series of loss data, to reveal the relationships between exposure, capacity, vulnerability and overall resilience. It would allow a comprehensive assessment of socially, temporal and spatially disaggregated climate impact data. It would also support the design of a finely calibrated, fair and evidence-based response able to build back better or rather forward and increase the overall resilience of a community.

Climate-related disaster loss data is at the heart of climate disaster risk management. Its increased availability is the fuel that can improve the relevance and accuracy of the models we

need to improve our predictive analytics, assess climate physical risks going forward and design a commensurate climate resilience strategy. Investment decisions must be climate-informed, for households investing in a new home or renovating it, for SMEs or larger businesses setting up or managing their activities, for banks agreeing to new loans, or for cities planning their investments and zoning developments. The existing climate-risk data tools are not user-friendly for the wider public. This would ensure that vulnerability is not increased by climate-blind decisions. The ability for people and organisations to navigate their way through climate-related disasters and for governments to identify those most vulnerable is contingent upon the availability of the right climate-risk data and the right risk assessment tools.

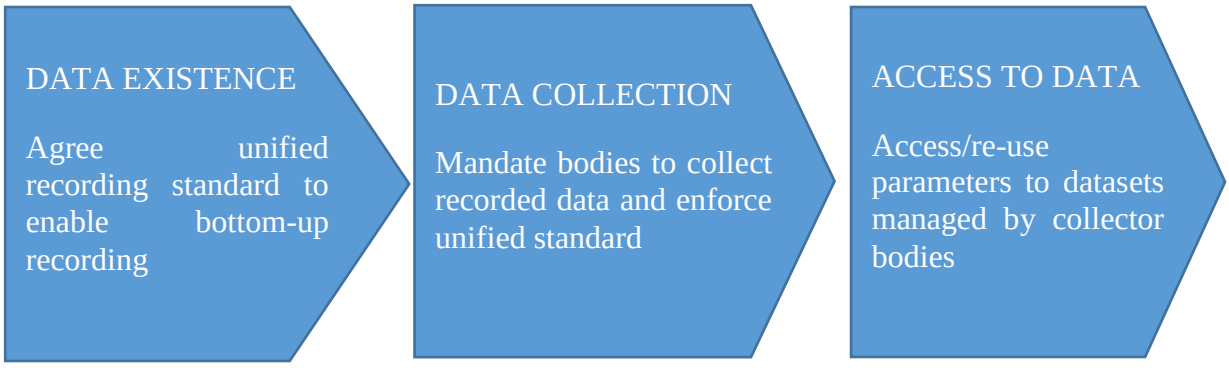
Analysing climate-related economic loss data is fraught with methodological challenges given the high variability of data from year to year, the underlying nature of the data and its uneven quality and incompleteness. For instance, the existing figures underestimate the real extent of climate-related disaster losses. Losses to publicly held assets are not systematically included and neither are losses from all types of climate-related perils. For example, they generally do not include losses from slow-onset events such as coastal erosion or subsidence, nor losses to ecosystems, their degradation and the resulting loss of ecosystem services, cultural heritage or loss of life. Losses from flow-on effects from business interruptions either within or across Member States are unaccounted. However, these losses are projected to increase over the next decades unless adaptation investments are unleashed at scale. Taking into consideration the degree of integration of EU economies, understanding the EU's climate protection gap better, how best to measure and monitor it, and reducing it, must be strategic priorities for the EU.

4.2 Climate-related disaster loss data

Closing the data availability gap requires three consecutive and necessary stages:

(1) Closing the data existence gap: identifying whether data from climate-related disaster events and their financial consequences is being recorded, and where it is, a certain type of metadata, terminology and metrics (i.e. recording standards) is needed for policy and based on current data practices.
(2) Closing the data collection gap: recognising that where recorded data is being collected, managed and published, a mandate needs to be given to a collector entity able to enforce the use of the above-mentioned recording standards.
(3) Closing the access-to-data gap: identifying whether access or re-use rights for collected data is already granted to all parts of society and, where it is not, identifying how to unlock it.

Figure 7: The three stages to closing the data availability gap



4.2.1 **Loss data gap assessment: EU policy needs**[154]

At EU policy level, climate-related disaster loss data is needed for the following policy areas:

- **To ensure a better economic foundation for adaptation policy**: this includes developing ways to measure the EU's current vulnerability, assessing the current cost of inaction for not strengthening resilience in the EU for different temperature scenarios, timescales and socio-economic scenarios, and understanding and monitoring of financial impacts for all parts of society.
- **To increase transparency about climate risks and adverse climate impacts** so that private investors can take better informed and more responsible investment decisions and in doing so reduce greenwashing. This involves improved recording and modelling of economic costs of natural hazards and has implications for risk prevention, risk transfer policies and designing of insurance products and disaster risk financing strategies.
- **To inform the European Semester:** expected economic losses related to climate change have potentially increasingly large implications on EU Member States' fiscal stability and sustainability. In the absence of financial protection tools to cope with disasters, the incidence of major disasters in several EU Member States may exacerbate economic imbalances and deteriorate credit ratings. Better access to loss data would be important to understand implicit and explicit government liabilities.
- **To monitor implementation of disaster risk management planning** in accordance with the Union Civil Protection Mechanism (UCPM) legislation.
- **To illustrate the natural catastrophe insurance protection gap** in all Member States by publishing a dashboard.
- **To improve implementation of EU environmental policy by establishing a framework for measures** to reduce risks of flood damage and adverse consequences for human health, the environment, cultural heritage and economic activity under the Floods Directive.
- **To support the development of the EU Observatory on** deforestation, forest degradation, and changes in the world's forest cover, with a view to supporting further forest policy development and implementation.
- **To tailor Common Agriculture Policy (CAP) support for loss recovery and prevention**, identify prone areas and commodities with higher losses, and assess the vulnerability of rural populations.

[154] The following assessment pertains to a part of climate-related disaster loss data: losses incurred by individuals and businesses from buildings, infrastructure, agriculture and commercial forestry operations (i.e. those losses than are typically insured) and from the private and public cost of emergency response and recovery. Access to data is understood to be at asset and larger spatial unit level – regional and country level. Meteorological climate events, hydrological climate events, ocean climate events, mass movements, geophysical events, and biological events are included.

- **To monitor Sustainable Development Goals** in an EU context, broken down by Member States.
- **To further tailor Copernicus Services**[155] to assess climate risk and weather-related hazard products based on users' needs.
- **To update the indicator work on economic losses** from weather and climate-related events and extend it with information for transnational regions and economic sectors, for different types and subtypes, and where possible making the information on trends available.

The databases currently available have insufficient granularity and combinations of data. Munich Reinsurance Company's (Munich Re) NatCatSERVICE is one of the most comprehensive databases on disaster loss data. However, the database that Munich Re makes available has limitations in terms of granularity and combining aggregation with time series. The Commission's Risk Data Hub[156] has developed common disaster loss language and metrics with the help of a group of Member State experts participating on a voluntary basis for the needs of the Hub. These taxonomy and metrics have been positively checked against the international guidance developed in the context of the Sendai Framework for Disaster Risk Reduction, which already mandates its signatories, including all EU Member States, to collect and report disaster loss data, aggregated at national level. However, reporting is of uneven quality with many gaps.

Of the other three main, well-established global loss databases, including multiple hazard types, only two are open databases[157]**:**

- **EM-DAT**[158] is a publicly accessible global, multi-hazard database provided by the Centre for Research on the Epidemiology of Disasters at the Louvain University in Belgium, maintained with the support of the World Health Organisation and the United States Agency for International Development. EM-DAT is the most comprehensive international database containing loss data starting from around 1900. Its main drawback is that an event entry into the database is linked to the number of fatalities. While most records include details about fatalities, missing and impacted people, approximately 70% of the records include no information on economic losses.
- **The Sendai Framework for Disaster Risk Reduction**[159] includes the Sendai Framework Monitor[160], which tracks progress in the implementation of the seven targets of the Sendai Framework. It includes reporting on direct economic losses (Target C of the Framework is to "reduce direct disaster economic loss in relation to global gross domestic product by 2030") for the period 2015-2030. This reporting is still in its early stages and the extent and the quality of the data has yet to be improved to allow the

[155] Copernicus Services | Copernicus.
[156] DRMKC Risk Data Hub.
[157] Other relevant practices of regional or local loss and damage datasets include Pereira et al., 2016 (DISASTER dataset), Petrucci et al., 2018 (MEFF datasets), Napolitano et al., 2017 (LAND-deFeND), San-Martin et al., 2018 (DamaGIS), Copernicus datasets such as WICS (windstorm/extra tropical), EMSR-Rapid mapping, HANZE (river floods, coastal floods, flash floods), DFO (river floods), GLC (landslide), and EDII (droughts).
[158] The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium, www.emdat.be
[159] Sendai Framework for Disaster Risk Reduction 2015-2030 | UNDRR.
[160] UNDRR Sendai monitor.

identification of reliable national, global or regional trends. Its subsystem, DesInventar[161] is a publicly accessible multi-hazard loss database that allows for the creation and maintenance of a fully compiled loss database to gather data needed for the Sendai Global Targets, including Target C. However, EU coverage is low, so far (see 3.2.3).

- The **CATDAT** Natural Hazards Loss Database[162] is another quality-assured database for natural perils covering over 60,000 events but it is not publicly accessible.
- **PERILS**[163] is a loss data aggregator owned by some of the biggest insurance companies and reinsurers, mostly European but also from Canada and Australia. Insurance companies representing 71% of the market in these countries have agreed to share their data. Eastern Europe coverage is patchy. A calculation is used to infer the data for the remaining 29% of the market. These same companies, reinsurers and brokers participating in the loss collection can then download the anonymized raw data for a fee. PERILS is designed for insurance industry use.
- The **Copernicus Emergency Management Service**[164] **and its early warning and monitoring capabilities** can be considered as a source of information and data from the monitoring of impacted areas and infrastructures.
- The **European Marine Observation and Data Network (EMODnet)**[165] provides access to reliable data on parameters such as sea-level rise and coastal erosion on coasts of all European seas and together with China's National Marine Data and Information Service is doing the same for the Indian Ocean.[166] It can be considered as a source of information and data to monitor climate change impacts.

4.2.2 Loss data gap assessment: data needed by 'all parts of society'

Today, interest in disaster-related loss data, in particular for climate-related disasters, has spread to all parts of society, including academia and the science of climate impacts. Catastrophe modelling is the science of making probabilistic predictions of financial risk due to natural and man-made catastrophic events. It has developed almost exclusively in the private sector, driven by the needs of insurers and reinsurers to understand and quantify their risk. From its start in earthquake modelling in the 1980s, catastrophe modelling has expanded to include hurricanes, storms and floods. Climate models at different resolutions are used by academics worldwide to explore the range and uncertainty of changes in mean and extreme climate over the coming century and longer. While there are clear limitations in these models, their value lies in understanding the ramifications of the broadest changes both for society and for spurring effective climate change policy. Although it is already in high demand given the value of

[161] DesInventarInventory Systems on the Effects of Disasters, http://www.desinventar.org/
[162] Daniell, J. E., Wenzel, F., & Schaefer, A. M. (2018). The use of historic loss data for insurance and total loss modeling. In *Risk modeling for hazards and disasters* (pp. 107-137). Elsevier.
[163] Home | Perils.
[164] Copernicus Emergency Management Service.
[165] Central Portal | Your gateway to marine data in Europe (emodnet.eu).
[166] A national meteorological office has reported that the improved topographic maps of the North Sea have massively improved forecasts of storm surges in the North Sea. Development will continue to further reduce the uncertainties that hamper investment in cooperation with the Copernicus programme and Destination Earth. The Commission is undergoing an assessment of options to improve the coherence and efficiency of ocean observations by different communities – fisheries, environment, research, navigation etc.

increasing awareness in decision-making, the science of linking climate models together with impact models is relatively new. To be correctly calibrated, these models are still crucially lacking quality data observation points linking a particular event to a particular location with associated economic losses. Academics and disaster modellers are therefore increasingly working together to achieve this, often together with the insurance industry, as is exemplified by the EU-funded H2020 Insurance project[167]. However, too few open source high quality event-to-loss data records are available. This, in turn, hampers the development of models that can improve our understanding of the impacts of a broader range of perils, the impact on specific areas of the EU, or provide results that are more accurate.

Figure 8: Example of the Loss Data Knowledge Bank in Norway[168]

Initially led on a pilot basis at the initiative of Finance Norway (the Norwegian national insurance industry association), the sharing of asset-level loss data with the planning and infrastructure departments of nine pilot cities (Bærum, Grue, Kongsvinger, Løten, Nord-Odal, Ringsaker, Stavanger, Tromsø and Trondheim) led to a decision to codify the practice at national level. The Norwegian Directorate of Civil Protection (DSB), the National Flood Agency, the State Road directorate and Finance Norway agreed to develop a national loss data platform under DSB, 'The Knowledge Bank', and to extend access to local insurers' loss data for all cities in Norway. The set-up of this database for public use and research using aggregate, anonymised data on climate-related damage from the insurance companies and the Norwegian Natural Perils Pool was based on a recommendation to Norway's Ministry of the Environment that was published in the Official Norwegian Report NOU 2010.

The insurance industry itself has indicated that it would benefit in multiple ways from more recording, collecting and sharing of loss data and from their flow-on effects. They would benefit from more accurate catastrophe modelling, a finer understanding of the total size of economic losses, a more precise picture of climate physical risks pertaining to portfolio investments, and a more accurate pricing of its services, among others.

Businesses and the financial sector need data to make sustainable investment decisions, and insights from disclosure and data, where they exist, tend to lead to record investment.[169] As far as climate-related data is concerned, efforts have mostly focused on greenhouse gas related data. However, the European Commission's Sustainable Finance Action plan has also successfully translated into new requirements for businesses and the financial sector to assess, disclose and reduce the climate-physical risks to which their activities are exposed. The assessment requires much finer physical risk assessments models than have been developed until

[167] Horizon 2020_Insurance (oasishub.co)
[168] See also the case study in Climate ADAPT: Use of insurance loss data by local authorities in Norway — Climate-ADAPT (europa.eu)
[169] See the case study of Turin in Climat ADAPT: Insurance company supporting adaptation action in small and medium size enterprises in Turin (Italy) — Climate-ADAPT (europa.eu)

now and loss data availability would not only allow models to be more precise, but also provide investors with quantitative information on climate-related losses related to a particular asset[170].

Figure 9: Danish public-private partnerships[171]

A legally binding document was signed between the insurance industry and the city of Copenhagen to organise the sharing of around 90% of the loss data associated to claims. The pilot was then extended to 70 of 98 Danish local governments and cities, covering 90% of the Danish population. The same loss data sharing exercise was conducted in 2013 and then again in 2016, with general positive feedback from both the insurance industry and the municipalities, despite the considerable time and resources committed to extracting, compiling and processing data on an ad-hoc basis. Since then, the practice has been codified in Norway (see box 9). The European Commission, as part of the EU Urban Adaptation Partnership, has explored ways to promote open access of insurance data for climate risk management for the benefit of cities and a series of workshops and interviews have been conducted with insurance and city stakeholders as part of the H2020 NAIAD project.

Denmark has also elaborated methods for reporting, estimating, documenting and storing damage and loss data. In relation to storms, storm surges, windfall and flooding from lakes and streams, data is stored by the Storm Council. This Council consists of an independent chairman and representatives from local authorities, government departments, insurance companies and the Customer Council. As regards the cost of natural disasters for citizens and private companies, damage and loss data are also collected by Insurance & Pension Denmark, the association of all insurance and pension companies in Denmark. Anonymous statistics are published on their website.

Cities require data to adequately identify impact hotspots and vulnerabilities, and invest in the best possibly designed adaptation and disaster risk reduction measures at community level. This can build community resilience to increased climate pressures and can decrease pressure on insurance pay-outs, thereby reducing the likelihood of high premiums for the community. A logical consequence would be that premiums decrease and therefore penetration increases in markets where natural disaster insurance is voluntary. In Europe, this practice started as a pilot in Denmark, after the 2011 flash floods in Copenhagen. Where insurance penetration for climate-related disasters is high, the insurance industry sits on a trove of asset-level data on previously experienced damages and losses incurred from extreme-weather events, which, when collated, provide an invaluable fully costed map of exposures and vulnerabilities at local level.

To date, the retail-banking sector has often relied on insurance coverage to address natural disaster risks. However, the upcoming Renewed Sustainable Finance Strategy may contribute to increasing the retail banking sector's interest for climate-related vulnerability information on loan books and for climate-related disaster loss generally.

[170] H2020 NAIAD project: http://naiad2020.eu/mooc/

[171] The conclusions from the data sharing exercise are summarised in the case study in the EEA urban adaptation report 2020: https://www.eea.europa.eu/publications/urban-adaptation-in-europe see Box 6.6., page 129.

Access to community and asset-level loss data is also important for transparent and straightforward information sharing with the general public. This is currently the case in some Member States, and can help inform citizens before they take significant investment decisions such as buying a new home or an investment property. By contrast, with forward-looking climate risk assessment information – which should also be shared with citizens on these occasions – loss data has the advantage of not being speculative and therefore immediately apprehensible.

In recent years, institutional calls to share data on losses from climate-related disasters has grown louder, while civil society's need for such data has become more pressing. This can be explained by the growing awareness of the impact of climate change, the mounting losses from it and the growing discernible trend in climate-related hazards.

Systematic collection of disaster loss data is required in the voluntary 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR) and global Sustainable Development Goals (SDGs) reporting. The global indicator set on monitoring the Sustainable Development Goals contains five different indicators taken from the SFDRR.[172] For monitoring sustainable development in the European Union the annual report on progress towards the SDGs by Eurostat also uses an indicator on economic loss in relation to GDP from the SFDRR.[173] The SFDRR advocates multi-hazard, inclusive, science-based and risk-informed decision-making, and lays down priorities for action and policy targets. Progress in achieving these targets is monitored and Member States' participation to the 2015 Sendai Framework requires them to submit nationally aggregated disaster loss data. Yet, effective monitoring relies on the availability, accessibility and quality of relevant data, which is recommended rather than mandated by these frameworks. In the EU, only Sweden currently has fully valid SFDRR economic loss indicators. Poland, and Slovakia are in the process of validating their indicators, and Romania, Estonia, Finland and Slovenia have had some of their indicators validated. Furthermore, not every EU Member State has assigned a National Focal Point for reporting to Sendai. Austria, Bulgaria, the Republic of Cyprus, Denmark, Estonia, Finland, France, Ireland, Latvia, Lithuania, Malta, Netherlands, Portugal, Slovakia, and Slovenia all have to officially declare national platforms, which are to perform advocacy, coordination, analysis, and advice on disaster risk reduction.

In 2014, the OECD Council adopted recommendations on critical risks that call for the collection and analysis of disaster losses from location-based inventories of exposed populations, assets, and infrastructures and the development of these inventories. The recommendations also include an honest and realistic dialogue on risk among stakeholders, and public access to risk information. These were complemented by new Recommendations on Disaster Risk Financing Strategies in 2017[174], which provide guidance on the strategies for the

[172] UN SDG indicators.
[173] Eurostat SDG indicators.
[174] OECD Recommendation on disaster risk financing strategies.

financial management of disaster risks and call for the set-up of national loss databases[175] on which Member States are expected to report by 2023.

With a view to contributing to sustainable development, the 2015 Paris Agreement specifies a global goal on adaptation to improve adaptive capacity, strengthen resilience and reduce vulnerability to climate change. Parties to the Paris Agreement are encouraged to report, on a voluntary basis and every two years in the context of adaptation reporting under the Enhanced Transparency Framework, information on current and projected climate trends and hazards, as well as observed and potential impacts of climate change, including those related to extreme weather events and slow onset events.

The European Commission has also added its voice to existing international recommendations. The EU Civil Protection Mechanism legislation requires Member States to further develop risk assessments at national or appropriate sub-national level. The guidelines[176] developed to support this process in 2010 already included a series of recommendations related to the recording of disaster loss data. The Commission requires the submission of summaries of risk assessments and risk management capability for key risks by the end of 2020 and every three years thereafter. The reporting guidelines[177] for this process include questions on what methods are being developed to report damage, whether the data are collected by risk or by disaster loss type, on who contributes to damage reporting and whether and how this data is shared. The revision of the UCPM[178] due to the COVID-19 crisis, also explicitly requires Member States to improve disaster loss data collection at the national or appropriate sub-national level to support evidence-based scenario building and identification of gaps in disaster response capacities. More recently, the 2018 European Union Energy Governance Regulation[179] requires Member States to report by 15 March 2021, and every two years thereafter, on institutional arrangements and governance at the national level for the collection, ownership and re-use of relevant data, and access to it. Finally, the Draft Climate Law, which still remains to be formally adopted by co-legislators, would provide that Member States shall develop and implement adaptation strategies and plans that include comprehensive risk management frameworks, based on robust climate and vulnerability baselines and progress assessments. **However, to date, there is no legal requirement for Member States to mandate the recording of climate-related disaster loss data according to a specific methodology.**

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[175] ‘’RECOMMENDS that Adherents promote comprehensive risk assessment processes that allow for the estimation of exposures and the identification of financial vulnerabilities by […] Ensuring that data on assets, structural vulnerabilities, hazards and past losses necessary for the quantification of potential exposures is produced, collected, shared and made publicly available, subject to applicable confidentiality and privacy requirements. Efforts to harmonise the collection and reporting of data nationally, regionally and internationally should be made. Post-disaster loss assessments should be completed for significant events, undertaken based on a consistent methodology and co-ordinated with the private sector, in order to support the availability of data necessary for evaluating exposures to disaster risk going forward.”

[176] SEC(2010) 1626 final: Risk Assessment and Mapping Guidelines for Disaster Management.

[177] Commission Notice (2019/C 428/07).

[178] REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism. Adopted 10 May 2021.

[179] See Implementing Act’s annex VIII on article 19 reporting.

The Commission Staff Working Document, 'The Overview of Disaster Risks the EU May face'[180], a deliverable the Commission was tasked to produce based on the Union Civil Protection Mechanism legislation strongly elevates the persistent lack of uniform loss data collection as a material impediment to 'fit for purpose' disaster risk management frameworks.[181]

4.2.3 Data existence: a standard for recording climate-related disaster loss data

Loss data recording is currently patchy and fraught with methodological issues. Insured loss data is generally recorded by individual insurers. Methodological issues linked to its recording and relevance for non-insurance processes include:

- accurate ex-ante valuation of the affected asset as opposed to insurance claims paid, both fields being of interest;
- percentage attribution of a given loss to an event or a specific peril type intensity in case of combination of events;
- accurate valuation of a loss, including the specific percentage loss attribution to indirect effects if any; and,
- exact pay-out amount to the policy-holder, indication of applied deductible and whether the remaining loss was compensated by public support or not.

Data on non-insured losses is only sporadically recorded across the EU and typically includes public authorities' economic losses, agricultural and forestry losses. Certain categories of interest for policy currently do not always exist, such as knowing whether the risk was privately insured, self-insured or not insured for public assets. Costs of emergency response and recovery[182] are also of interest. For agricultural losses, the unrealised value of crop loss also has to be evaluated. As for forestry losses, it was noted that due to the significant recent drought and bark-beetle events, forest management policies were shaken in the most affected Member States. The modelling of forest loss from climate-related events is in flux in many areas of the EU and increased sources of event or loss data points would be needed.

Where data is already recorded today, in particular data about the insurance industry's recording practices, the current recording practices for climate-related disaster loss data were suboptimal. They do not provide the wider community with sufficiently accurate and comparable data to increase society's knowledge about climate-related loss and support the development of risk-informed resilience strategies. Some detailed recording parameters are already set by reinsurers and supervisors for reporting, contractual and prudential purposes. However, these parameters do not match, nor exhaust, recording, knowledge development and risk management policy needs. In addition, the climate-related data needs of the (re)insurance industry and its supervisory authorities for underwriting and prudential purposes also justify a

[180] SWD(2020)330 final.
[181] SWD(2020) 330 final.
[182] Recovery includes investments to build back better in line with the SFDRR methodology: The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better".

new approach to climate-related disaster loss data recording (and sharing – see next sub-sections) across industry players.

Where data is not recorded today, agreed unified metadata, terminology, metrics and recording mandates are also lacking. Recovery data should specify the loss absorption mechanism chosen by the State. Specific metrics should be agreed by agriculture and forestry experts for these sectors' related losses. Finally, alignment with the Sendai reporting framework would facilitate the task of authorities already familiarised with loss data collection and reporting.

The European Commission is well placed to advise on metadata, terminology and loss metrics as it can rely on its experience of running the Disaster Risk Management Knowledge Community Data Hub database. This database has been specifically designed to collect loss and risk-related data from natural, technological and malicious hazards or threats. Currently, the Risk Data Hub covers the following hazards: floods, forest fire, earthquake, landslide and subsidence. Data regarding droughts, oil spills and radiological dispersion will be available soon, with other hazards and threats to be incorporated in the future. The architecture of the Risk Data Hub is compatible with the Sendai reporting guidelines.

To improve loss data recording standards, the Commission agreed with loss experts on recommendations for risk assessment.[183] These recommendations provide a harmonised structure to the evaluation of exposure and losses across hazards and threats. The Commission has also published a compendium of worldwide knowledge (>300 experts involved) on post-event impact assessment titled 'Science for DRM 2020'. [184] However, to date, fragmentation of available loss data remains. An important limitation is the lack of uniformity in data specifications across value sets, which makes comparisons less reliable and statistics inconsistent.

Developing a harmonised standard across the EU would not require starting from scratch but rather build upon already solidified specifications agreed in the Risk Data Hub and the Sendai context. These would need to be complemented by an agreed data recording standard made up of metadata, terminology and metrics that fit with new, broader public and private climate risk financial management policy objectives and the building blocks already identified in the disaster risk management context.

Data on total economic losses should rely on a common understanding and the same definitions for both insurers and the public sector. Broad participation would be key to further refine the definition of sub-components of these losses. For insured losses, insurers already report claims data according to lines of business, as per EU Solvency II rules. For non-insured losses, a recording standard using the same metadata, terminology and metric could be

[183] In 2013, an EU expert Working Group on disaster damage and loss data was established to identify the gaps and challenges for recording loss data in the EU and establish a common framework in the EU for recording disaster damage and loss data[15]. The group has worked with participants from Member States, UNISDR, and academia, and has addressed many of the technical and institutional challenges associated with loss data collection, recording, and sharing.

[184] Disaster Risk Management Knowledge Centre.

developed by expert groups, and with the concerned sectors and the future users of the enhanced data sets.

Reporting on policies and the environment under existing environmental legislation provides essential facts and information for informed decision-making and is the main instrument to mandate the recording and collection of evidence for policy implementation and evaluation. Currently, no climate-related disaster loss data is recorded under existing regulatory reporting. To support better-informed decision-making on climate adaptation and the impact of the environment on society and the economy, recording of loss data could be considered when reviewing parts of the environmental acquis.

4.2.4 Data collection: supporting or mandating the collection of standardised loss data records

For insured loss data, improving the collection of standardised loss data sets could first be achieved through voluntary data collection. This would have the potential to achieve high loss data market coverage in a potentially shorter time than through legislation by focusing efforts on enrolling large and medium-sized companies in each national market. Data collection is already organised by national insurance associations in several Member States, including in Norway and in the past in Denmark. Systematic data collections may be put in place more easily in Member States where natural disaster insurance is essentially a public-private coverage system (e.g. France or Spain). Outreach to national insurance industry associations confirmed the readiness to organise such a collection system in several EU Member States' markets, though clarity would be needed as regards compliance with competition rules[185], legal and technical aspects related to the processing of personal data [186] and financial support. The Commission proposal for a Data Governance Act would help in this respect, notably through proposals for data altruism.[187]

For non-insured loss data, the collection and curating of loss data records would ideally be centralised at national level. Indeed, the review of several country best practices conducted by the OECD shows that the common local-to-national recording approach ensures a high degree of detail and reliability of information, provided survey and loss-recording guidelines are communicated to all responsible government entities to ensure overall consistency of data recording. Social and direct costs as well as losses due to business interruption could even be collected by local municipalities shortly after the occurrence of a disaster. On the other hand,

[185] Competition rules are already clear, if access to the aggregated and anonymised data is granted to the industry, it would be important to ensure that not only large/medium companies that have contributed their data can gain access. The data would need to be made accessible on fair, reasonable terms and in a non-discriminatory manner, in law and in fact, to all operators active in the relevant sphere – that is, to any insurance undertaking which requests access, including also insurance undertakings which are not active on the geographic or product market to which the data relate. If such accessibility were not guaranteed, some operators would be placed at a disadvantage, since they would have less information for the for the purpose of risk assessment, which would also not facilitate the entry of new operators on to the market.

[186] When personal data is processed, this processing should fully comply with Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

[187] COM/2020/767 final.

indirect and intangible costs could be estimated by national agencies that help to aggregate the loss data for research in the long run. After such a loss information collection process is completed, aggregate data could be classified by hazard type, public and private losses.[188]

Non-insured loss data in the EU is currently collected by various governmental actors, research institutions, insurance associations, and re-insurers with different scopes, purposes and methodologies. Of the 27 Member States, 12 have a single institution mandated to collect disaster-related loss data.[189] France, Germany, Greece, Italy and Sweden have publicly accessible national disaster databases although information on losses is not specifically shared and access can be only partial. Belgium, Germany, Italy and Spain have databases with partial loss recording, which is disaster-specific and limited to floods. Data collection methodologies differ significantly across these Member States.

A notable barrier to setting up authoritative national databases across the EU on losses due to the climate and/or disasters is the diversity of areas concerned in the disaster and climate risk management cycle: finance, civil protection, environment and climate, water and agriculture. Typically, the responsibility for setting up such a database would sit across responsibilities and budgetary allocations. While most potential public entities' users of the data are interested in this type of data, setting-up the collection system does not fall currently within the mandate of any specific body. It would be advisable for each Member State to appoint one specific body to collect all economic losses from natural disasters including those flowing from the insurance industry and ensure that the collected data meets specific qualitative and quantitative criteria. At the same time, sectoral bodies could be appointed or continue to collate sub-data sets should it be easiest to do so for example for agricultural related losses.

Several EU initiatives may help improve the collection of standardised loss data. The Directive on public access to environmental information (Directive 2003/4/EC) and the Directive on establishing an Infrastructure for Spatial Information in the European Community (INSPIRE Directive 2007/02/EC) mandate the accessibility and sharing of environmental information already collected and held by, and for, public administrations. The Commission has started a mandatory evaluation of the INSPIRE directive. This will be followed up with a possible review of the legal framework as part of the "GreenData4All" initiative that has been announced in the Commission Communication "A European strategy for data" (COM(2020) 66 final). This initiative aims to update both the INSPIRE Directive and the public access to environmental information Directive to a more contemporary state of technology, promoting active dissemination and sharing of government and privately-held public data in support of the environmental acquis and the Green Deal objectives. The revision of the Union Civil Protection Mechanism legislation[190] requires that Member States improve disaster loss data collection at the national or appropriate sub-national level to ensure evidence-based scenario building for transboundary and cross-sectoral disaster management. Finally, the review foreseen by the draft Climate Law in 2023 or a future revision of the Energy Governance Regulation or its

[188] See Figure 7 on p. 26. http://www.oecd.org/governance/risk/improving-the-evidence-base-on-the-costs-of-disasters.htm
[189] https://publications.jrc.ec.europa.eu/repository/handle/JRC92290
[190] REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism. Adopted 10 May 2021.

Implementing Act dedicated to adaptation reporting could offer the opportunity to require the appointment of a single national body tasked with the collection, collation and curation of natural disaster loss data.

4.2.5 Data access: opening access to collected loss data to all parts of society

The last and crucial step is to ensure that data is also made accessible to as wide a public as possible and in as flexible, disaggregated and customised a manner as possible. Despite the multitude of existing loss data related databases, several reasons explain the dearth of open access, nation-wide, multi-hazard loss databases. Some originate from the insurance industry's reluctance to either pool or share loss data, while some can be attributable to public authorities' benign neglect attitude to the policy relevance of disaster loss data.

Commercial issues apply. Historically, these climate-related loss databases have mostly been seen as a research and development branch of main relevance for the reinsurance sector and have also been used by the insurance industry in order to inform internal natural catastrophe models, risk pricing and underwriting practices. In this context loss data may be considered commercially valuable to complement the information given by model vendors'[191] black box models, who take up 80% of the insurance model market in the EU. The combination of big data and increased awareness about climate change could be seen as having turned climate data into a potentially more lucrative market. Re-insurers have revamped their mainly research-oriented approach towards loss data collecting activities more strongly as a business-type activity. In this context, the (re)insurance industry is ambivalent on the issue of open loss data given the potential of a climate services consultancies market. Discussions with the group of insurers and reinsurers taking part in the H2020_Insurance Open Loss Data modelling framework shows that a growing part of the industry may nevertheless be rallying to the idea of making a distinction between the common interest in open-access loss data and the development of revenue-generating climate advisory services and tools. Indeed, total economic loss data can only be efficiently collected by the public sector and the data is a critical part of a better understanding of risks and the development of revenue-generating tools going forward.

Processing of climate-related loss data must apply legal requirements. Wherever personal data is processed, this processing has to fully comply with data protection rules (Regulation (EU) 2016/679 (GDPR))[192]. Data sharing and conditions of access to loss data has to be in line with the rules on data protection, privacy and competition[193]. In particular, if the processing is based on an EU or national legislation establishing a legal obligation or the performance of a task

[192] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

[193] The Commission's Guidelines on the applicability of Article 101 of the Treaty on the Functioning of the European Union to horizontal co-operation agreements indeed recognizes that there may be pro-competitive, efficiency benefits of information exchange between competitors and that information exchange is a common feature of many competitive markets. Information exchange systems should not, however enable or facilitate anti-competitive behaviour such as collusion or foreclosure. The Guidelines on the applicability of Article 101 of the Treaty on the Functioning of the European Union to horizontal co-operation agreements set out principles to be followed in the design information exchange systems and in the access conditions established in relation to these systems to seek to ensure compliance with Article 101.

carried out in the public interest, this legislation has to provide specific and suitable measures to safeguard the rights and freedoms of data subjects. The legislation should also respect the principles enshrined in the GDPR, such as purpose limitation, data minimization, storage limitation and integrity of personal data. These rules do not prevent the collection and sharing of loss data as far as the said principles, conditions and safeguards are taken into account. There are novel techniques, such as federated learning which uses machine learning to allow multiple parties to build a common model without sharing data, which can address data protection and privacy issues.

Actors may perceive data sharing as being against their own interests. This is due to the current fragmentation of public governance responsibilities related to loss data on the one hand, and to the fact that the value of loss data sharing systems increases as more data is pooled and greater coverage is achieved on the other hand. Indeed, insurers may be of the opinion that they are - at least in the short term - potentially giving away more than they may get from the collected data. The sheer abundance of data sharing systems in the insurance sector could serve to indicate that this potential inertia regarding climate-related disaster loss data might ultimately be unjustified.

Costs and lack of funding may be an obstacle. Initial set up costs could be co-financed as a public-private partnership involving EU funds. Running costs for the recorders could be alleviated by automatic uploads and a potential cost-based fee for accessing the data.

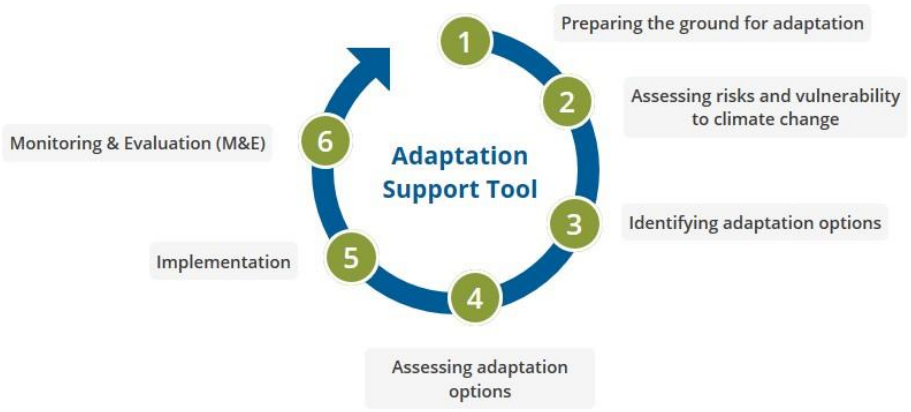
4.3 Climate-related physical risk tools

The use of climate-related risk data for the benefits of all parts of society also requires adequate tools to assess climate-related physical risks. A useful conceptual framework to refer to is the adaptation policy cycle, as represented in the Adaptation Support Tool (AST) by Climate-ADAPT[194] (Figure 10). The six AST steps offer a useful identification of the crucial character of the climate risk assessment phase in the adaptation process. Decision-making should be informed by the best available risk-related evidence. This evidence is usually brought by climate change impacts, vulnerability or risks assessments tools that gather and analyse this evidence to support policymaking and decision-making more generally.

This sub-section explores the availability of climate change impacts, vulnerability or risk assessments tools. It performs three gap analyses: the European Commission's own needs for climate physical risk analysis tools, the needs of the Commission's policy-stakeholders - in particular, those whose needs arise from EU legislation - and the need for easy and convenient risk assessment tools from all parts of society.

[194] Climate ADAPT adaptation support tool.

Figure 10: The Climate-ADAPT 'Adaptation Support Tool'



4.3.1 Gap analysis: review of the availability of in-depth climate risk assessment and vulnerability models, and tools

To inform the preparation of the revised Adaptation Strategy, the Commission commissioned a study[195] which provided a comprehensive desk review of available climate adaptation models and tools to support better informed decision making at multiple governance levels. The study analysed underlying hazards, exposure, vulnerability data gaps (see Figure 11) modelling gaps and remaining research gaps which in turn highlighted which of the typical policy needs are still unmet.

Figure 11: Relationship between climate physical risk, hazard, exposure and vulnerability

The study found that:

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[195] https://op.europa.eu/en/publication-detail/-/publication/9383d16e-7651-11eb-9ac9-01aa75ed71a1/language-en/format-PDF/source-search

- The spatial-temporal resolution of available models is mostly still too coarse for most high-resolution risk assessments. The shortcoming is particularly acute for the analysis of risks or vulnerabilities and implementation of adaptation measures at the urban and asset level.
- More information is required on the cost of adaptation. While information can be available and gathered for specific actions and contexts, the extension of adaptation analyses that require aggregation at the wider scale, such as the regional, national or larger one, becomes challenging.
- Models and assessments do not yet address feedbacks and interactions in a satisfactory way, such as the role played by multi hazard, cascading and compounding effects.
- There is not yet a common and consolidated practice in the communication of uncertainty to non-specialist audiences. Online services to analyse climate data are mostly addressed to scientists and of difficult usability for end-users in the policy domain

4.3.2 Gaps and suitability of existing rapid analysis tools

Climate risk and vulnerability assessment tools are complex and costly for performing analyses and would exceed the funding capacity of smaller administrations, the financial sector, businesses or private individuals. Moreover, the time needed to release such analyses is often too long compared to that of decision making. Methods facilitating quick and operational insights from adaptation modelling for policy assessment are therefore needed. The question is whether these rapid analysis tools are available and if so, whether they are suitable for the needs of these stakeholders. The above-mentioned adaptation modelling study reviewed rapid analysis tools designed for two different purposes: 1) quick and indicative analysis of emerging issues and 2) fast and simplified models or methods able to process multiple scenarios and policy options within acceptable computational time for decision-making applications at local level.

In general, the objective of rapid analysis is to obtain a first screening of risks with informative purposes to decide whether a more extensive analysis is needed and, when possible, identify potential initial responses. These tools would be suited for many screening exercises to scope potential climate-related risks affecting retail investments. A rapidly growing group of tools based on open data are made available through online climate service platforms and are especially suited for obtaining a first glance of potential risks under climate change scenarios. Many of Copernicus' services fall under this category.

While some rapid assessment tools do exist for some hazards, sectors and for vulnerability assessments, they are mostly low resolution and lack calibration and validation with local data. These tools are not suitable for use by cities, businesses or citizens except for indicative information on the most extreme events, heatwaves, coastal erosion and coastal flooding and heavy precipitation. Some general coarse-resolution, user-friendly information can also be found on risks for forestry, critical infrastructures, buildings and transport operations although not at asset level. It is doubtful that in the next decade, models and observations will allow asset-level climate risk assessments for many types of hazards. This underscores both the importance of granular harvesting of climate-related loss data and the need to increase risk literacy and develop decision-making supporting tools for cities, businesses or citizens.

4.3.3 **Emerging priorities for EU-level action**

To improve support to local climate change risk assessment and adaptation action, it is essential to increase the availability, reliability and accessibility of climate change information with sufficient spatial resolution. This directly relates to improving the downscaling processes applied to climate data under climate change scenarios. Two downscaling methodologies are usually applied: dynamic downscaling, with a huge computational cost, and the much cheaper statistical downscaling, used to improve spatial or temporal distributions from climate models. Against this background, useful and urgent research initiatives should systematically test the performance of statistical versus dynamic downscaling techniques over the whole EU domain to understand when and where the former can be a good substitute for the latter. Investigation should prioritize heat waves, which are projected to be nearly twice as frequent and severe heat waves for which the expected increase is even larger. Another priority is extreme precipitation, which is likely to almost double in occurrence for each degree of further global warming.

Areas where research is particularly lacking are: cost and effectiveness of adaptation in different domains, but in particular health care, cost of farm-level adaptation, cost of adaptation in energy supply, adaptation cost estimates for biodiversity and ecosystem services, and estimation of adaptive capacity. Moreover, when research on adaptation cost is more developed, as for instance in the case of adaptation to sea-level rise or to flood risk, a systematic comparison of results across countries and regions is still missing. Priority sectors and adaptation options could include:

- Tourism. Projected tourist flows and expenditures, possibly at a high geographical resolution and distinguishing domestic and international flows and expenditures, would be ideal in order to capture international dynamics. Local dependency on tourism expenditure (employment and income) and its seasonality should help to recognize socio-economically most vulnerable regions to disruptions;
- Energy sector. A systematic mapping across the EU of the present and future cooling needs of thermal electricity plants and the impact of hydropower production on water availability in European river basins. This research should be developed in a water-energy-food-climate nexus perspective, under present and future climate and social economic development scenarios;
- Interconnected infrastructure (energy, transport, water, ICT): in an increasingly liberalised global economy, society needs are changing, but are still based on the assumption that critical infrastructures are functioning. Critical infrastructures are evolving in environments where continuous delivery of goods and services is required. The demands that regulate their operations constantly evolve and affect critical infrastructures in the execution of their societal missions. Everything is connected to everything, and everything interacts with everything. Connectivity and interdependencies

make infrastructure complex and lead to cascading failures and unpredictable behaviour, while risk situations are growing and do not spare any structure.[196]

- Ecosystem-based adaptation, within the broader context of 'soft' or 'green' adaptation measures, generally considered more flexible, more environmentally sustainable, more community cantered than 'grey' or 'hard' adaptation measures, ecosystem-based adaptation is an emerging area. However, more scientific data and evidence from the field is needed to validate its cost and effectiveness and to improve and standardize methodologies to understand about whether, when and how effective it is. Evidence is still lacking on the ecological, social and economic effectiveness of ecosystem-based adaptation, which prevents comparison with alternative adaptation actions. In this respect, ecosystem accounting provides an internationally agreed statistical framework[197] for a systematic measuring of ecosystem services, including services with a strong link to climate adaptation (e.g. reducing heat island intensities, providing flood protection). Ecosystem accounting allows quantifying the existing role of ecosystem in climate adaptation, the potential to increase their role via ecosystem restoration and valuating it in a consistent way with national accounts, in order to facilitate comparisons with alternative actions.
- Actionability of predictions. Ensuring that models, data and resulting predictions are based on knowledge of sufficiently high quality, as well as ensuring that non-experts can use the knowledge generated from expert models and tools. The Destination Earth (DestinE) initiative[198], with additional research components in Horizon Europe, is putting particular focus on these aspects.

5 Conclusions

The climate protection gap is large and may grow over time unless public authorities, the insurance sector and other stakeholders take steps to reduce it. Cumulative losses from climate-related events were at least EUR 419 billion (inflation adjusted) between 1980 and 2019 in the EU27 and some projections estimate global losses could range from 4% to 18% of GDP depending on the climate scenario. For Europe, this could range from 3% to 11%.[199] While economic loss projections should be interpreted with caution, climate change over the next decades will increase the intensity and frequency of extreme weather events substantially. At the same time, without coverage and accompanying incentives for preventive measures, the costs and protection gap risk becoming even larger. Moreover, the economic effects will be distributed unequally, depending on regions and socio-economic groups – socio-economic status and climate vulnerability are often correlated. These impacts are also expected to affect economic activity and public finance substantially, and to give rise to transition and physical risks in the

[196] See RESIIST project https://anr.fr/fr/projets-finances-et-impact/projets-finances/projet/funded/project/anr-18-ce39-0018/?tx_anrprojects_funded%5Bcontroller%5D=Funded&cHash=678c2b2d5ef0d73920b5b404f145eeba

[197] System of Environmental Economic Accounting – Ecosystem Accounting' – adopted in March 2021 by the United Nations Statistical Commission: https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

[198] Destination Earth | Shaping Europe's digital future (europa.eu)

[199] swiss-re-institute-expertise-publication-economics-of-climate-change.pdf (swissre.com)

financial sector, affecting financial stability. Various EU projects, spending programmes and policy settings seek to reduce existing risks, account for risk before creating new exposure and to manage residual financial risk. But some risks can also be covered through insurance as a risk management tool and through public-private cooperation.

The European Commission has announced measures to reduce the climate protection gap in its 2021 Adaptation Strategy. Beyond the measures taken under the 2013 Strategy, the new Adaptation Strategy plans for the Commission, in the context of the Renewed Sustainable Finance Strategy, to help examine natural disaster insurance penetration in Member States, and promote it, for example through guidelines, and invite EIOPA to develop its natural catastrophe dashboard allowing country level assessments. The Commission will also strengthen dialogue between insurers, policymakers and other stakeholders, identify and promote best practices in financial instruments for risk management, in close cooperation with EIOPA, and explore the wider use of financial instruments and innovative solutions to deal with climate-induced risks. The Commission also plans to promote and support the use of its Risk Data Hub for data on climate-related risk and losses, take measures to improve the collection of uniform and comprehensive insured loss data, and extend the scope of public access to environmental information in the INSPIRE Directive to include data on climate-related risk and losses.

Climate adaptation and the challenge of the climate protection gap concern all of society, and many steps can be taken voluntarily at national, regional, or local level by public authorities, the financial and insurance sector, businesses and individuals. As a public display of the knowledge base underpinning the 2021 EU Climate Adaptation Strategy[200], and some of the measures to close the climate protection gap that will be undertaken in the context of the upcoming Renewed Sustainable Finance Strategy[201], this staff working document has also provided possible solutions for voluntary action by stakeholders of the climate protection gap. For instance:

- At the basis of closing the climate protection gap is the challenge of closing data availability gaps of data existence, collection and access. Insurers and the public sector can come together to build a common understanding and the same definitions on economic loss data. The replication of public-private partnerships such as the Loss Data Knowledge Bank in Norway (Figure 8), or data sharing in Copenhagen, the application of data altruism[202] by insurers and public authorities, and other solutions presented in this staff working document can be taken up by many stakeholders – all of whom would benefit from these actions.
- To close the protection gap itself, the main challenges are to increase the availability of insurance solutions, to increase and improve risk-awareness and risk-transfer solutions and to create the right incentives for risk reduction and transfer. This requires addressing

[200] COM(2021) 82 final.
[201] Building on the 2018 Action Plan on financing sustainable growth, the renewed sustainable finance strategy will provide a roadmap with new actions to increase private investment in sustainable projects and activities to support the different actions set out in the European Green Deal and to manage and integrate climate and environmental risks into our financial system. The initiative will also provide additional enabling frameworks for the European Green Deal Investment Plan. A consultation is currently open on the Renewed Sustainable Finance Strategy.
[202] As contained in the Commission proposal for Regulation on European data governance. COM(2020) 767 final.

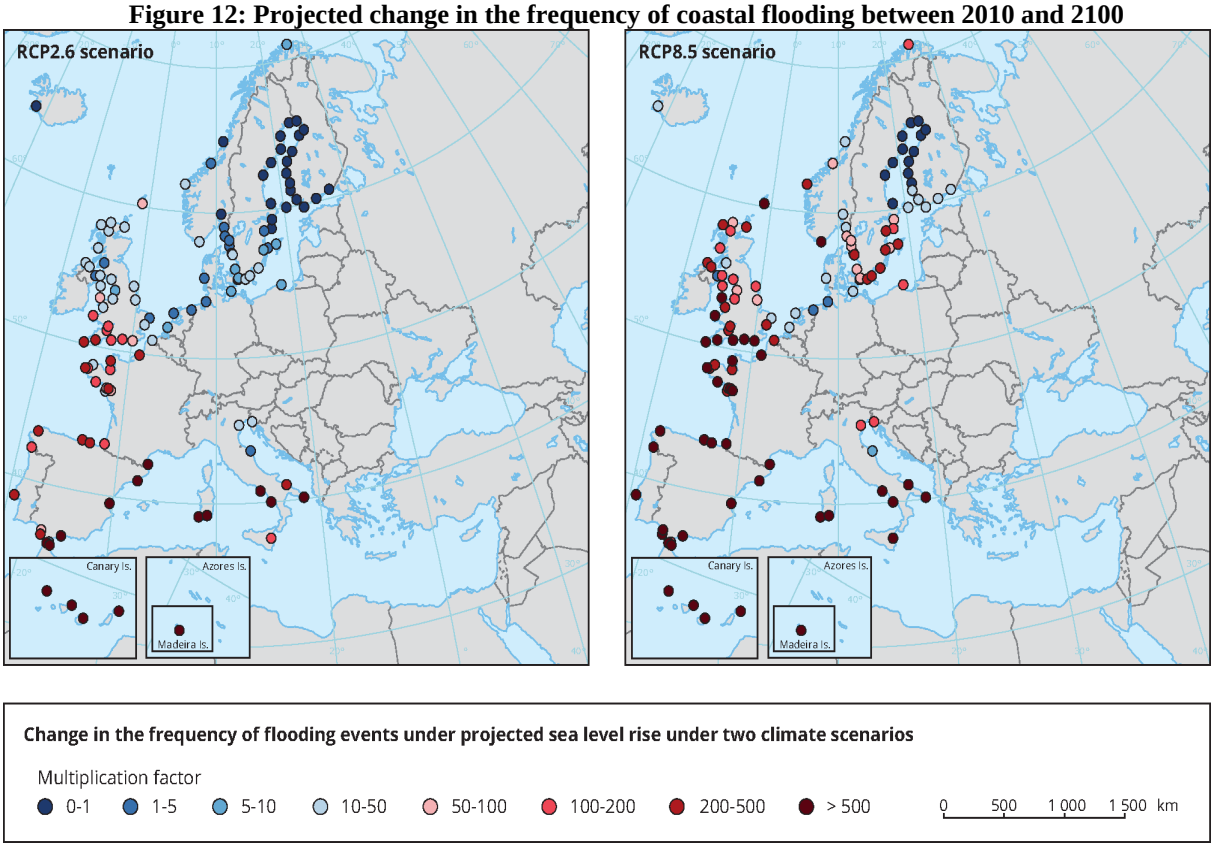
some of the obstacles to insurance coverage - such as a lack of understanding of risks – and could be addressed through data. It requires sharing the burden between the private and public sectors depending on the size of the risk, and some possibilities include partial insurance. It requires exploring innovative financial tools and insurance solutions – for example, exploring solutions such as parametric insurance. It requires applying regulatory tools to increase insurance coverage – for instance, mandatory insurance or bundling across risks. It requires promoting incentives for risk transfer solutions - for example, through pricing and public sector support.

6 Annexes

6.1 Annex I: PESETA projections of climate impacts in Europe

The JRC PESETA IV project results[203] show that ecosystems, people and economies in the EU will face major impacts from climate change in the absence of mitigation or adaptation policies. The burden of climate change shows a clear north-south divide. Southern regions in Europe suffer much larger impacts, through the effects of extreme heat, water scarcity, drought, forest fires and agriculture losses. Limiting global warming to well below 2°C would considerably reduce climate change impacts in Europe. Adaptation to climate change would further minimize unavoidable impacts in a cost-effective manner, with considerable co-benefits from nature-based solutions.

Figure 12: Projected change in the frequency of coastal flooding between 2010 and 2100



Source: EEA, based on IPCC SROCC. (https://www.eea.europa.eu/ds_resolveuid/7EHCXPJ8Z3)

Frequency of coastal floods - The map above from the EEA shows the estimated multiplication factor, by which the frequency of flooding events of a given height changes between 2010 and 2100 due to projected regional sea relative level rise under the RCP2.6 and RCP8.5 scenarios. Values larger than 1 indicate an increase in flooding frequency. Adapted from Figure 4.12 of the IPCC Special Report on the Ocean and Cryosphere (SROCC).

[203] See https://ec.europa.eu/jrc/en/peseta-iv/

Projected cost of coastal flooding - The JRC PESETA IV study[204] projects that extreme sea levels in Europe could rise by one meter or more by the end of this century. Without mitigation and adaptation measures, direct economic losses due to coastal floods could rise by two orders of magnitude, reaching 250 €billion/year in 2100 (which could be much higher under stronger economic development scenarios[205]), with 2.2 million people per year being exposed to coastal inundation, compared to 100,000 at present (see Table 1 below). Without transformational global emissions reductions as is currently the case, the left side of the table below (high emissions columns) presents a higher likelihood than the right hand side (moderate mitigation columns). Also, current adaptation investment trends seem to be inconsistent with an "adaptation" scenario across the EU.

Table 1: Coastal flood impacts projections for Europe

	Today	High emissions		Moderate mitigation	
		No adapt	Adapt	No adapt	Adapt
Damage (€ billion/year)	1.4	239	23	111	12
People exposed (million/year)	0.1	2.2	0.8	1.4	0.6

Source: PESETA IV, p. 38. Available at peseta_iv_summary_final_report.pdf

COACCH provides similar projections while also varying the socio-economic projections which have a major impact on the outcomes. PESETA also varies socio-economic projections based on ageing projections.

Droughts and inland floods - Global warming is also altering the hydrological cycle in Europe, with increasing flood frequency and droughts becoming more damaging. If no mitigation and adaptation measures are taken, economic losses due to river floods could, according to the PESETA IV study, grow to nearly 50 €billion/year on average with 3°C global warming by the end of this century, more than 6 times compared to present. By the end of this century, 3°C global warming would result in drought losses of 45 €billion/year in Europe, 5 times higher compared to today. [206]

[204] Feyen el al. 2020
[205] Vousdoukas, M.I., Mentaschi, L., Hinkel, J., Ward, P.J., Mongelli, I., Ciscar, J.-C., Feyen, L., 2020. Economic motivation for raising coastal flood defences in Europe. Nature Communications 11, 2119.
[206] Naumann, G., Cammalleri, C., Mentaschi,. L., & Feyen, L., 2021. *Increased economic drought impacts in Europe with anthropogenic warming*. Nature Climate Change, in press.

Graph 1: The growth of unaffordability of flood insurance in the period 2010-2080 under existing national insurance systems and different climate and socio-economic scenarios

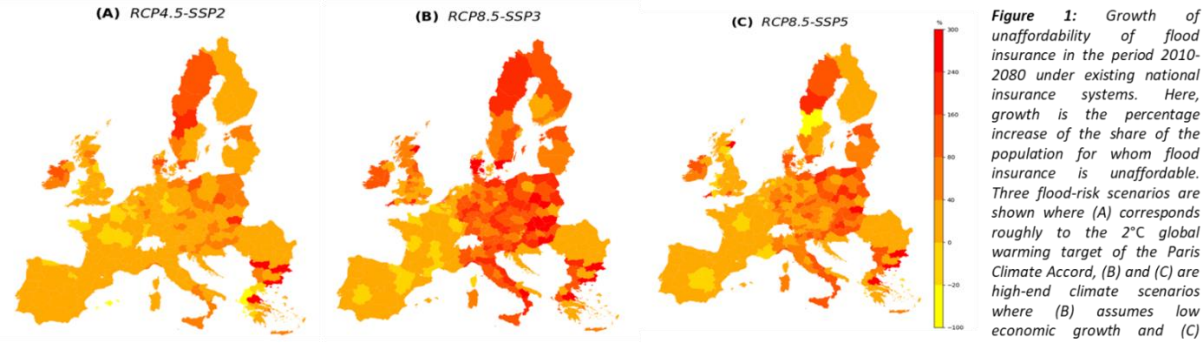


Figure 1: Growth of unaffordability of flood insurance in the period 2010-2080 under existing national insurance systems. Here, growth is the percentage increase of the share of the population for whom flood insurance is unaffordable. Three flood-risk scenarios are shown where (A) corresponds roughly to the 2°C global warming target of the Paris Climate Accord, (B) and (C) are high-end climate scenarios where (B) assumes low economic growth and (C) assumes high economic growth.

Source: COACCH

The increase in flood frequency and related losses may have implication for insurability. COACCH estimates the growth of unaffordability of flood insurance in the period 2010-2080 under existing national insurance systems and different climate and socio-economic scenarios.

6.1.1 Considerations on Economic Impact Modelling approaches

Assessing the economic impacts of climate change is a very challenging problem. First of all, not all possible climate impacts can be covered due to the current data and methodological limitations, as discussed later. Regarding the modelling of the economic climate impacts, there are two main methodologies: process modelling assessments and statistical approaches. Process modelling, or the bottom-up approach, intends to capture in an explicit modelling way the details and mechanisms linking the climate shock to the ultimate estimation of climate impact. Contrary to the statistical approach, they rely explicitly on what is known regarding the processes leading to the specific impact. For the case of floods, this approach would then consider e.g. the soil characteristics of the river basin, the slopes of the terrain, its vegetation, etc.

Statistical approaches, e.g. Burke et al (2018)[207], are essentially an empirical, rear-view approach that attempt to extrapolate to the future, using techniques such as estimating response functions (e.g. relating GDP per capita to average temperature rise). The main strength of the approach is the use of large datasets of observations, hence its sound empirical foundation. However, they also have clear disadvantages because they rely on historical data and then postulate about climate conditions that will be fundamentally different from anything experienced in human history.[208]

[207] https://www.nature.com/articles/s41586-018-0071-9

[208] Alternative approaches are not fully immune to this problem. The historical record remains the only basis for observing how modelled systems actually behave and forms part of a toolkit for model evaluation where the different available approaches all have distinctive strengths and limitations. See Wilson et al (2017) Evaluating Process-Based Integrated Assessment Models of Climate Change Mitigation, http://pure.iiasa.ac.at/view/iiasa/333.html

When it comes to **process modelling**, on one end of the spectrum sit sectoral models, partial equilibrium models and the like, largely used in mitigation studies. "Bottom-up" models, which by definition are useful for studying the impact of a change in one part of the economic system and are deployed in the analysis of climate mitigation policies, de facto hold constant other elements in the system that are not covered by the model. Principally, sectoral models simulate the interactions among the individual energy technologies that make up the energy system of an economy. They are used to investigate the impacts of CO2 emissions constraints on the portfolio of technologies that make up the supply and demand components of the energy system, in order to identify low-cost abatement opportunities or design technology-based subsidies or emission standards. "Top-down" macroeconomic models are used for assessing the macroeconomic costs of CO2 abatement and its economy-wide feedbacks on prices, commodity and factor substitution, income and economic welfare.

Top-down models have historically indicated larger macroeconomic costs as the consequence of a given mitigation policy, with the literature suggesting that the biggest factor may be bottom-up models' relative technological optimism about low-cost abatement potentials[209]. Any interpretation and policy use of results from such models must bear in mind that they do not vary the damage from climate change depending on the mix of mitigation policies. It may therefore be the case that the model projects a higher cost for a given set of policies ceteris paribus, but if these policies are more effective in mitigating climate change than "lower-cost" alternatives, then the overall cost of deploying them could in fact be lower. However**, as the climate change impact is not incorporated endogenously into these models, they are effectively silent on the overall balance of costs of mitigation policies**.

At the other end of the spectrum, the most comprehensive tools are the **integrated assessment models (IAMs)** that are flagship points of reference in policymaking. These integrate climate science models (a description of green-house-gas emissions and their impact on temperature) with economic models (projections of abatement costs and a description of how changes in climate affect key economic variables such as output, consumption etc.). Well known IAMs include the relatively stylised DICE or WITCH models. True IAMs such as the MIT Integrated Global Systems Model (IGSM) or IMAGE from PBL involve endogenous feedback between the economy and the climate modules in a comparatively vast model. In comparison, the climate output from PESETA becomes input into an external CGE model via the calculation of a labour productivity shock.

As with any model, IAMs need to be interpreted and used with key caveats in mind. Some of these caveats, such as the issues around the choice of the discount rate to calculate the social cost of carbon, are relatively better understood by economists and actively debated in the literature. In some important respects, modellers have a great deal of freedom in choosing functional forms, parameter values and inputs. This explains the strikingly different conclusions regarding optimal abatement arrived at by classics in the literature such as Nordhaus (2008) vs. Stern (2007). In the case of the damage function, which is one of the most important parts of an IAM, there is

[209] https://www.sciencedirect.com/science/article/pii/S014098830600079X

currently neither comprehensive theory nor data to comprehensively (across all possible climate impacts, sectors and regions of the world) draw on for its sound specification.[210]

6.1.2 Model inconsistencies, uncertainty, tipping points, and non-linear impacts

Uncertainty is extremely large when modelling the economic impact of climate change, as it compounds the uncertainty of climate models and that of the sector-specific impact models with further uncertainty on the economic impacts, which also depend on the economic and demographic scenarios. Beyond the uncertainty that is considered in the modelling assumptions, certain aspects of climate change are subject to inherent uncertainty and are generally not considered in the models (e.g. tipping points, non-linear impacts). Modellers tend to caution against looking for headline aggregate figures e.g. on the impact of climate change on economic output or financial losses. Yet, the realities of policymaking mean that such figures are often demanded with the footnotes often falling by the wayside by the time they reach decision-makers and media. This section discusses some aspects of climate impact projections that require either methodological improvements or care in communication and interpretation.

Model inconsistencies

The understanding of the climate modelling side is, inevitably, more limited among economists. A recent working paper from Dietz et al (2020)[211] highlights some key **inconsistencies between how leading economic models of climate change represent climate dynamics and how the current generation of climate science models does**. First, the temperature rise in response to a CO2 emission impulse is (much) slower in economic models than in the current crop of climate models. Secondly, Earth system models suggest that terrestrial and ocean carbon sinks exhibit a *diminishing* marginal uptake of atmospheric CO2 as a function of cumulative uptake and of temperature, while most of the economic models investigated exhibit *increasing* marginal uptake. The economic implications of these inconsistencies, leading to carbon prices that are too low and that are too sensitive to the choice of discount rate, is considerable.

Cutting-edge modelling teams, including PESETA and COACCH, work with multi-disciplinary teams of economists and natural scientists. Their authors emphasise that alongside the considerable sophistication of what their models capture, **much is known to be important but currently beyond our modelling capacities**.[212] However, the empirical developments to date and theory alike suggest that the risks are considerable and tilted to the downside.

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[210] See Pindyck (2017) "The Use and Misuse of Models for Climate Policy", Review of Environmental Economics and Policy, volume 11, issue 1, pp. 100–114, http://web.mit.edu/rpindyck/www/Papers/MisuseClimateModelsREEP2017.pdf; Stern (2013) "The Structure of Economic Modelling of the Potential Impacts of Climate Change: Grafting Gross Underestimation of Risk onto Already Narrow Science Models", Journal of Economic Literature, 51(3), 838–859 http://dx.doi.org/10.1257/jel.51.3.838

[211] https://www.cesifo.org/en/publikationen/2020/working-paper/are-economists-getting-climate-dynamics-right-and-does-it-matter

[212] See Ciscar (2019) Ciscar et al (2019) "Assessing future climate change impacts in the EU and the USA: insights and lessons from two continental-scale projects", Environmental Research Letters, Volume 14, Number 8

The current crop of models could at least be partially enhanced with the addition of some of the biophysical trends that are known to be important and are presently excluded, e.g. the impact of climate change and other environmental destruction on biodiversity, and the impact of that in return on the economy[213]. This requires that resources and time are made available. Many aspects of this work are hampered by the patchy data, requiring enhanced resourcing and collection of the necessary data.

Inherent uncertainty

Other biophysical trends are difficult to model because of uncertainty about the timing of their evolution. However, it is known that their impact, if and when materialised, could be devastating, the probability of their materialising is far from negligible, and the plausible time-scales include the near to medium term. Two towering risks in this respect are (i) a stronger than expected temperature response to a given increase in atmospheric GHG concentrations and (ii) crossing tipping points, with properties including abruptness and irreversibility.

Uncertain temperature response to GHG

The concept of "climate sensitivity" has been used for decades to estimate the global average warming at the Earth's surface due to a doubling of atmospheric CO2 from pre-industrial levels. The central estimate for the equilibrium climate sensitivity (ECS) has been considered to be 3°C, with the "likely" range (66% probability) spanning 1.5 to 4.5. Non-modelling studies (observations, paleo data and new techniques, such as emergent constraints) tend to be able to robustly rule out the lower end of the likely ECS distribution, but have trouble bounding the upper end and cannot rule out the possibility of an ECS even as high as 6°C. The climate models whose projections informed the Paris Agreement are being refined and this cycle is at an advanced stage. The initial results indicate that a significant number of models exhibit higher ECS values than before[214], with so far 5 models (which include ones that tend to perform best for the present and past via historical simulations) suggesting an ECS greater than 5°C.

Climate tipping points

The IPCC scenarios on which the advice to policymakers – and the Paris Agreement – are based do not model feedback effects from Earth systems. Tipping points are ecosystems thresholds after which the process is irreversible at the scale of human life: *"A level of change in system properties beyond which a system reorganizes, often abruptly, and does not return to the initial state even if the drivers of the change are abated. For the climate system, it refers to a critical threshold when global or regional climate changes from one stable state to another stable state."* An example that appears perilously close to materialising is the loss of the remaining Arctic sea ice and its ability to reflect incoming solar energy back to space. This would be equivalent to adding one trillion tons of CO2 to the atmosphere, as compared to the 2.4 trillion

[213] More than half of the world's total GDP is moderately or highly dependent on natural capital, according to World Economic Forum (WEF)'s Nature Economy Report.
[214] This is primarily due to an improved modelling of mid-latitude cloud feedback. Source: CRESCENDO brief for policymakers; https://phys.org/news/2019-09-earth-quickly-climate.html

tons emitted since industrialisation.[215] Another example is the capacity of land and the oceans as carbon sinks – these have partially tempered the impact of carbon emissions on global warming, but as the IPCC's latest report on climate change and land emphasises, climate change and environmental degradation itself is making the persistence of the sink uncertain.[216] Yet another case involves the release of carbon dioxide and methane from the melting Arctic permafrost whose estimated impact on the climate in this century varies[217], but where new processes are still being discovered,[218] and where the latest projections include severe changes occurring abruptly[219].

Other tipping points

Not only climate tipping points create important uncertainty around projections. Ecological, socio-economic and policy tipping points cannot easily be modelled either.[220] A lesser known but no less important tail risk relates to the global rate of species extinction, which is by now tens to hundreds of times higher than the average rate over the past 10 million years and is accelerating[221], which in turn impacts the resilience of many remaining species. Most models only consider primary extinction, but taking into account co-extinction (the disappearance of consumers following the depletion of their resources) suggests that when critical environmental conditions are breached, even the most resilient organisms are susceptible to rapid extinction. A prominent model in this regard[222] found that even tardigrade-like extremophiles went extinct close to global biodiversity collapse, which was identified around 5°C heating or cooling, and transition was abrupt.

Non-linear economic impacts

There is a wide variety of non-linear impacts of climate change on economic output and on losses. The charts below provide some illustrative cases where economic impact of climate change either changes signs or is negligible up to a point and then increases dramatically.

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[215] Some research suggests that recent trends could lead to an ice-free Arctic as early as the 2020s and others suggest 2030 or substantially later. Baseline calculations tend to assume that cloud cover would remain constant. In comparison, with a total loss of cloud cover, total added warming could be three times greater. https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GL082914

[216] https://www.ipcc.ch/srccl-report-download-page/

[217] Schaefer et al (2014); https://www.nature.com/articles/s41467-019-09863-x

[218] https://www.yaleclimateconnections.org/2018/02/the-permafrost-bomb-is-ticking/

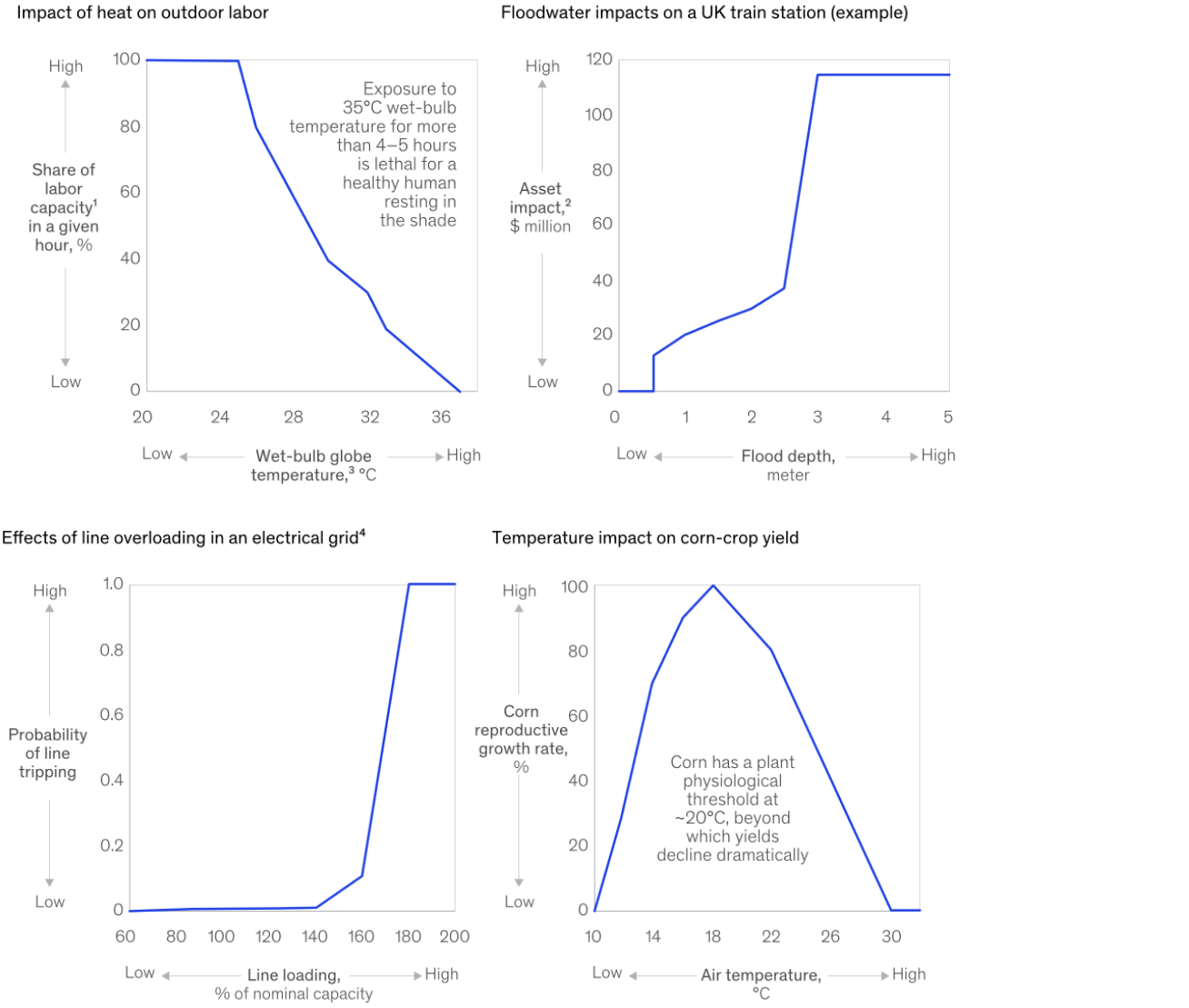
[219] https://www.nature.com/articles/s41558-019-0614-6

[220] Climate tipping point: a critical point at which the future state of a tipping element (a large component of the earth system) is switched into a qualitatively different state by a small perturbation (Lenton et al., 2008). Ecological tipping point: a point indicating a regime shift or critical transition between different stable ecological states of a system. (Scheffer and Carpenter, 2003). Socio-economic tipping point: a climate change induced, abrupt change of an established socio-economic system's functioning into a new functioning of fundamentally different quality. Policy tipping point: a fundamental change in policies or implied actions in response to climate change to continue to achieve societal objectives under changing conditions.

[221] The driving factors range from habitat loss and industrial agricultural methods to climate change (link to IPBES)

[222] https://www.nature.com/articles/s41598-018-35068-1 The paper is so far uncontested in the literature.

Graph 5: Nonlinear impacts on economic output and losses



[1]Immediate effect; longer exposure will cause rapidly worsening health impacts. Humans can survive exposure to 35°C wet-bulb temperature for 4–5 hours, when they can perform a small amount of work, so the working-hours curve does not approach 0 at the 35°C wet-bulb globe temperature (~35°C wet-bulb temperature in the shade).
[2]Average cost of a new-build train station globally used for asset impact/cost on UK train station; salvageable value left in the asset is not factored in.
[3]Based on in-shade wet-bulb globe temperature, defined as a type of apparent temperature that usually takes into account the effect of temperature, humidity, wind speed, and visible and infrared radiation on humans.
[4]Both acute events (eg, flooding, fires, storms) and chronic changes in climatic conditions (eg, sagging because of heat) can damage the grid and may lead to outages.
Source: Upper graphs: CATDAT Database on global historic flooding events, Dunne et al., 2013 (adjusted according to Foster et al., 2018, and McKinsey Global Institute [MGI] analysis), expert engineer interviews on failure thresholds, historical insurance data, Joint Research Centre Damage Functions Database, McKinsey infrastructure benchmark costs, MGI analysis; lower graphs: Henneaux, 2015, Korres et al., 2016

Source: McKinsey & Company 2020

6.1.3 **Existing research projects**

The JRC (as a follow up of the PESETA projects) continues to improve the modelling of climate change impacts in Europe, paying growing attention to pan-European climate risks. This includes gradually expanding the coverage of climate impact categories and going beyond the assessment

of average impacts in order to better understand the range of possible impacts, in particular, high impact-low probability events. The geographical coverage of the analyses is also being extended to global scale in order to understand impacts in the rest of the world, relevant for spillover effects on the EU, international cooperation and development, and climate diplomacy.

In the past the 7TH Research Framework Programme and more recently Horizon 2020 projects (such as HELIX[223], IMPRESSIONS[224], RARE[225], H2020 Insurance[226], NAIAD[227], IMPREX[228] and COACCH[229]) draw on state-of-the-art academic models and expertise to develop knowledge on climate change impacts including on tipping points and adaptation strategies. This work will continue under the Horizon Europe programme with opportunities to improve the understanding of climate related risks, impacts and response options, notably under Cluster 5 (Climate, Energy and Mobility), 3 (Security) and within the Mission on Adaptation to Climate Change and Societal Transformation.

Within the context of a contract with the Commission on the "Economics of Prevention and Preparedness", the World Bank Group will produce a report on *"Financial Risks and Opportunities"* to demonstrate (i) the magnitude of the macro-fiscal risk in EU MS from floods, droughts and earthquakes and how these will change through to 2050 with climate and socio-economic changes. (ii) the typical explicit and implicit contingencies liabilities from natural disasters in, EU MS based on recent disasters, (iii) existing mechanisms in countries to manage the fiscal impacts. The inception report due June 2020 will determine the scope of the exercise, depending on the availability of data and models currently under review.

A major boost towards significantly reducing model uncertainties and identifying tipping points and non-linear impacts with a view to making predictions actionable for practical policy decision support purposes are expected from the Destination Earth (DestinE) initiative[230] and the linked research components in Horizon Europe programme.

[223] Home - HELIX | Building the early life exposome (projecthelix.eu)
[224] Impressions (impressions-project.eu)
[225] https://www.rare2030.eu
[226] Horizon 2020_Insurance (oasishub.co)
[227] NAIAD - NAture Insurance value: Assessment and Demonstration (naiad2020.eu)
[228] Home | IMPREX
[229] COACCH – CO-designing the Assessment of Climate CHange costs
[230] Destination Earth | Shaping Europe's digital future (europa.eu)

6.2 Annex II: Risk management modelling and stress-testing

In December 2017 the Central Banks and Supervisors Network for Greening the Financial System (NGFS) was launched to improve knowledge on the transmission channels between climate-related risks, the financial system, and the macro-economy.[231] The G20 Financial Stability Board has set up a Task Force on Climate-related Financial Disclosures[232] to develop voluntary, consistent climate-related financial risk disclosures, covering physical, liability and transition risks, which companies can use to better inform investors, lenders, insurers, and other stakeholders. A recent survey conducted under its aegis among financial supervisory authorities found that two thirds of the respondents consider climate-related risks as part of their financial stability monitoring. Moreover, those financial authorities considering climate-related risks generally consider the potential for these risks to affect the financial system via similar channels. Most focus on the implications of changes in asset prices and credit quality. Authorities also consider the implications of these risks for financial institutions. Consideration of the implications of credit and market risks faced by banks and insurance firms appears more advanced than that of other risks, or of risks faced by other types of financial institutions. Some respondents have quantified – or have work underway to quantify – climate-related risks. Such work is, however, hindered by a lack of consistent data on financial exposures to climate risks, and difficulties translating climate change outcomes into changes in those exposures. Currently no approach to quantification provides a holistic assessment of climate-related risks to the global financial system. Finally, in some jurisdictions, climate-related risks are being integrated into micro-prudential supervision of banks and insurance firms (including via requirements for firms' stress testing and disclosure).

For the EU, the European Systemic Risk Board (ESRB) has set up a project team on Climate Risk Monitoring to advance towards a stress test methodology for the EU financial sector focusing on climate-related systemic risks, including through a pilot risk-monitoring framework, the identification of relevant data gaps, and the analysis of the relevant transmission channels. The ESRB project team carried out two pilot aggregate top-down stress tests, analysing respectively: (i) a scenario in which climate mitigation actions are delayed and have thus to be taken abruptly; and (ii) a scenario in which a superior more sustainable technology comes along, which renders the existing ones relying on fossil fuels (somewhat) obsolete. Both scenarios therefore capture mostly *transition* risks. Now, this greater focus on *transition* relative to *physical* risks appears quite common. In part, this would seem to reflect the fact that, from a modelling perspective, it is relatively easier to incorporate a change in the carbon pricing, for instance, or a tightening of particular regulations as a shock. For example, restrictions (in the form of higher taxation for instance) on the reliance on fossil fuels are likely to adversely affect the value of certain assets in the energy and fossil fuel sectors, as well as in related sectors such as airlines, airlines, manufacturing, the automotive industry or real estate and ultimately banking and insurance stocks. In contrast, incorporating physical risks such as the impact of a flood over the value of real estate and infrastructure and, in turn, on the financial institutions exposed to

[231] Since June 2019, the network comprises 36 members participating in three different work streams: supervision, macro-financial and mainstreaming green finance. See https://www.mainstreamingclimate.org/ngfs/.
[232] Its 31 members include both users and preparers of disclosures from across the G20's constituency, covering a broad range of economic sectors and financial markets. See https://www.fsb-tcfd.org/.

these, requires granular data, notably geospatial data, which are typically incomplete or altogether not available. An additional challenge is that many climate-related physical risks (e.g., aggregate temperature increase) are *expected* over much longer horizons than the typical stress-test models (2-5 years), though, of course, in practice some of their manifestations can occur any time (and indeed with increasing frequency). Finally, the difficulty in treating physical and transition risk lies in limited cross-disciplinary modelling – and to marry traditional macro-financial approaches with those informed by climate science. The ESRB study found that the direct costs from the materialisation of the two assumed risks for banks and insurances are relatively small and manageable.[233] But it also emphasizes the important shortcomings that need to be addressed to allow for a proper analysis especially of transition risks and, consequently, of the cost of delaying/avoiding adaptation and mitigation policies. These include, in particular, incomplete reporting by financial institutions (which does not include, for example, the carbon intensity of their exposures nor data to assess the vulnerability of the collateral for their loans to climate physical risks, e.g. their exact geospatial location) or the still incomplete models of asset quality, that should either entail variables correlating with climate risks or differ for 'greener' and 'browner' assets.

Lessons from specific analysis conducted by research projects

As pointed out by the NGFS and dedicated projects such as CLIMINVEST,[234] the lack of methods to apprehend uncertainty and related "'materiality concerns", combined with data gaps, are key stumbling blocks to a better assessment of climate physical risks in financial risk assessments.

- The current state of scientific knowledge leaves no doubt about the existence of current and future climate change and the potential for large impacts. However, a certain amount of uncertainty remains when it comes to the possible path of climate in the future – due to its prospective nature, and the way socio-economic systems may contribute to changing climate and adapt to it over the next decades. The likelihood of alternative futures is therefore difficult to estimate. The CLIMINVEST project aims to foster the production of actionable information on physical climate risk for the financial sector thanks to a co-design approach between climate scientists and financial actors with a view to help overcome barriers arising from financial decision-making frameworks. For example, existing literature shows in general that financial actors may perceive some barriers to integrating physical climate risks in decision-making due to lack of "materiality". This may link to focus on short-term horizons and larger impacts; to the prevalence of past events in the analyses; or to specific ways to manage uncertainty (*e.g.* with static probability distributions and trade-offs to account for events with low likelihood and large impacts). To overcome this materiality concerns, it would be important to develop and use new analytical frameworks such as

[233] The scenario with abrupt climate mitigation policy changes results in a sustained impact on banks' capital and thus on their capacity to support lending, whereas that in which a superior technology comes along results more in a reallocation of banks' and insurances' portfolios, after an initial negative impact (see ESRB 2020 for more details).
[234] "*Getting started on Climate Physical Risk Analysis in Finance"* I4CE https://www.i4ce.org/wp-core/wp-content/uploads/2018/12/I4CE-ClimINVEST_2018_Exec-Sum_Getting-started-on-climate-risk-analysis.pdf

robust decision-making, a technique that can help reduce the focus on short-term and likelihood of events.

- Key data gaps still hamper the development of more complete and granular analysis of physical climate risk through the vulnerability module. **Data availability is challenging especially on corporate counterparties**. Information would be needed at macro and sectoral scale on the business environment but also at counterparty or asset scale to define exposure, sensitivity and adaptive capacity to diverse types of impacts. Exposure depends on the location of assets and sales along the value chain of the counterparty and the local characteristics of hazards. The sensitivity may depend on sectoral aspects, such as the dependence on natural resources or the conditions of demand and supply along the value chain and the bargaining power of the company, but also specific characteristics at the asset level (*e.g.* the characteristics of buildings may influence their sensitivity to climate hazards). The capacity of the company to cope with impacts when they arise also depends on multiple aspects. In this frame, the evolution of the insurance cover is also important, and faces many difficulties on the data side. The data gap also affects the capacity to provide monetarized financial estimates of climate impacts to a counterparty. Monetarization techniques use damage functions and data on the cost of past natural catastrophes. These are still limited to some hazards and some geographies, and disseminated in several studies each covering a small but detailed climate change impact.

Ongoing initiatives:

Several elements in the Commission's sustainable finance strategy could help companies strengthen their financial management of physical risks and contribute to the release of crucial vulnerability and exposure data. For example, the **Taxonomy Regulation**[235] introduces an obligation on investee companies to disclose the degree to which their activities comply with a taxonomy of activities pursuing six environmental objectives, including climate change adaptation. This encourages investee companies to take into account existing risks. Moreover, by providing end-investors with the information on how and to what extent a given financial product invests in environmentally sustainable economic activities (including climate adaptation), it promotes investment in activities that reduce risks from climate change. The taxonomy regulation will finally contribute to the release of much needed data/indicators of climate resilience/vulnerability, facilitating the financial sector's analysis of its own exposure and vulnerability to climate physical risk.

The **Revision of the Non-Financial Reporting Directive** (Corporate Sustainability Reporting Directive)[236] would also help ensure that publicly available information about underlying activities' vulnerability to climate physical risk be made more comparable and reliable, so that investors are better informed about the sustainability of their investments. The initiative should lead to more standardised non-financial disclosure requirements across the EU, help reduce the

[235] Regulation(2020) 852.
[236] COM(2021) 189 final

potential for financial instability and contribute to the long-term resilience of the economy, by enabling investors to take greater account of sustainability-related risks.

EIOPA is developing an approach to cover climate-related risks, within the broader methodological improvements to the bottom-up stress testing for insurance sector. The work may cover physical and transition risk stemming from climate change, explicitly excluding legal liabilities and litigation risks. This could serve both micro prudential purposes (e.g. vulnerabilities of insurers, sustainability of the business models) and macro prudential purposes (e.g. resilience of the insurance sector, future insurability of risks and potential protection gap). Methodologies were under consultation throughout 2020 and the development continues.

The Commission already developed a micro simulation model (SYMBOL) to estimate individual banks' economic losses and liquidity shortfalls compatible with the existing bank prudential regulatory framework. It has been widely used to gauge the reduction in the impact of a systemic financial crisis on public finances due to the implementation of various pieces of EU legislation aimed at strengthening the banking sector and the financial safety net. Building on this experience, the Commission has conducted a feasibility study to assess whether a simulation model of financial losses associated to different perils related to extreme weather and climate could be developed, and if so in which form (simulated magnitudes and units, data needs, with our without a climate forcing variable). Such a model would use available estimated or historical data on losses due to natural catastrophes and tools for the assessment of multiple risks to quantify some or all of the following: (1) expected annual loss, (2) probable maximum loss, (3) probability of loss exceedance (4) distribution of contingent liabilities generated by disasters. Conditional upon the availability of relevant data at the level of individual insurance undertakings and on the joint distribution of catastrophic events, a prototype model could be developed in about one year. Annex [1] discusses the steps involved in the elaboration of such model, and the challenges to overcome.

Horizon Europe, the new EU Framework Programme for Research & Innovation, will continue to support projects and initiatives that address the Climate Protection Gap. For instance, in the **Horizon Europe Cluster 3 on Security**, future research priorities may focus amongst others on the mispricing of risk, rethinking insurance payouts, developing innovative risk transfer and financing mechanisms, further expanding risk modelling capacity and promoting public accessibility of fiscal data and information related to disaster risk. In parallel, Cluster 5 on Climate, Energy and Mobility will create new knowledge and build capacity in better understanding of climate change impacts (including extremes), their interaction with decarbonisation pathways and available policy responses while strengthening the synergies with state of art climate science, and will include dedicated efforts to develop cutting-edge modelling tools in support of decision-making.

Moreover, the **Mission on "Adaptation to Climate Change, including Societal Transformation"**—one of Horizon Europe's flagship initiatives— will promote open access to risk data and assist regions and local stakeholders in better understanding, preparing for and managing climate risks. It will support creation of an enabling environment that will help mainstream adaptation considerations into decision and policy-making frameworks, with benefits for closing climate protection gap. The Mission's work could also extend into the development of models with better and more granular resolution of connective events and better capacity and

skills of seasonal to decadal climate prediction; assessment of compound and cascading risk, indirect and intangible losses, spill-over effects and propagation of risks across value chain, social and ecological networks.

Scenario-based analysis will remain critical for financial and non-financial firms aiming to increase their chances of adapting to future risks and their use should be promoted by the European Commission. However, the task of the regulator is made difficult by the potential systemic effect of rational individual hedging strategies of financial institutions. Carney (2015) has noted that insurers' rational responses to physical risks can paradoxically trigger new risks: for instance, storm patterns in the Caribbean have left many households unable to get private cover, prompting "mortgage lending to dry up, values to collapse and neighbourhoods to become abandoned" (Carney (2015, p 6)). Another risk resides in the development of financial products in response to climate-related risks, such as weather derivatives: these may help individual institutions hedge against specific climate-related risks, but they can also amplify systemic risk (NGFS (2019b, p 14)). This poses difficult questions, such as the adequate prudential regulation that should be deployed in response.

More work is therefore still needed on how climate-related asset price shocks (e.g., stranded assets) could trigger other losses within a dynamic financial network, including contagion effects towards non-climate-related sectors. This challenge goes a long way towards explaining the "cognitive dissonance" (Lepetit (2019)) between the increased acceptance of the materiality of climate-related risks by financial institutions, and the relative weakness of their actions in response. In short, accounting for the multiple transmission channels of climate-related risks across firms, sectors and financial contracts while reflecting a structural change of economic structures remains a task filled with uncertainty.

Still, physical impacts from climate change are occurring now and will continue to increase in the near term regardless of GHG emission scenarios. The development and improvement of forward-looking risk assessment and climate-related regulation should be complemented with new approaches to risk management with regard to uncertainty on the physical climate risk side. Faced with these daunting challenges, a key contribution of regulators and supervisors may simply be to develop practical tools and methodologies, leverage best practice, urgently work on data availability and consistently adequately frame the debate.

6.3 Annex III: Insurance penetration

Measuring insurance penetration

The general approach of measuring insurance penetration is to construct ratios where the numerator captures the effect of insurance and the denominator represents a base rate.

$$penetration\ rate = \frac{insurance\ metric}{base\ metric}$$

The split between the numerator and denominator also illustrates that two data sources need to be combined to measure insurance penetration. The data for the insurance-focused numerator will typically stem from the insurance industry, while broader base metric in the denominator will have to rely on other data sources, generally governmental ones. An exception to that would be rates that aim to measure the quality of the insurance coverage in place, i.e. the share of property insurance policies that also cover natural catastrophe risks. The choice of the specific metrics depends on the context it is to be used in. The metric for numerator will usually be a logical consequence of the choice of the base metric.

For instance, macro-economists may be interested in the size of the insurance industry in comparison to the overall economy. A common choice for the base metric is then the GDP. The GDP should be compared with a suitable flow measure that captures the activity of the insurance sector over the relevant period, such as gross written premiums. Indeed, this type of penetration rate is used in many publications in the macro-economic domain[237]. In the context of the climate protection gap, this base metric does however not appear relevant. The table below lists examples for possible alternative insurance penetration rates.

A recent discussion on how to best define insurance penetration in the context of EIOPA's Cat Risk Expert Network (made of insurance industry and catastrophe risk modellers) concluded that:

- the most policy-relevant metric would be to look at the **sum insured versus economic value** (especially for residential/commercial/industrial lines). Obtaining these metrics could be challenging as it would require calculating both the replacement cost and the calculation of the total economic value. Catastrophe model vendors have created related databases but these are proprietary data;
- **premium** based calculations would not necessarily be suitable as these include components other than the pure risk premium (e.g. to cover administrative expenses or the cost of an insurer's capital).

Possible avenues for policy action:

[237] For example, see EIOPA Financial Stability Report December 2019 | Eiopa (europa.eu) (figure 4.2 on page 40).

(1) start with a pragmatic approach to measure the insurance penetration by looking at the number of policyholders with a coverage for a particular peril compared to the total number of inhabitants;

(2) link policyholders with insured objects (i.e. number of houses insured) to derive a metric number of insured houses for a particular peril for example / total number of houses;

(3) work on bridging the data gap for the protection gap with regard to the economic value of assets and replacement cost to compare with the sum insured and finally, including actual limits and deductibles.

Insurance Europe, recently conducted a survey on insurance against flood risk with its members. As part of this, national insurance associations were asked to provide an estimate of the flood insurance penetration for private households. For the survey, insurance penetration was defined as the number of insurance properties over the total number of properties.

Estimated flood insurance penetration level today for private homes as reported by national insurance industry associations (survey 1st quarter 2020 by Insurance Europe) complemented by interviews and literature review[238]						
N/A	<5 %	5-19%	20-39%	40-59%	60-89%	>90%
HR, EE, LT, MT, CY, SI	NL, AT, LU, LV	IT, BG, EL	RO	DE, PL, PT, SK, CZ	HU	BE, IE, FR, SE, FI, DK, ES

Several publications aim to provide an overview of available penetration rates for insurance against natural catastrophes[239] although none provide an overview of the situation in all 27 Member States.

[238] This table hides strong fragmentation in terms of quality of insurance (deductibles, ceilings etc.). For insurance penetration today in many MSs see Flood Insurance Arrangements in the European Union for Future Flood Risk under Climate and Socioeconomic Change, Paul Hudson, 2019; also Policy Issues in Insurance Financial Management of Flood Risk, OECD 2016, and WB Report on Financial and Fiscal Instruments for Catastrophe Risk Management Addressing Losses From Flood Hazards In Central Europe (Poland, Czech Republic, Hungary And Slovakia.

[239] EIOPA (2019): Staff Discussion Paper Protection gap for natural catastrophes (page 7); DG CLIMA (2017). Insurance study of weather and climate-related disaster risk (page 36, Annex II from page 105 to 149); JRC (2012): Natural Catastrophes: Risk Relevance and Insurance Coverage in EU (see flood on page 30, storm on page 36, earthquake on page 40, drought on page 44).

6.4 Annex IV: EU projects and spending programmes with relevance for adaptation policy coherence principles

6.4.1 TEN-E Regulation

The TEN-E Regulation is based on Article 172 of the Treaty on the Functioning of the European Union which provides for the legal base to adopt guidelines covering the objectives, priorities and broad lines of measures envisaged in the sphere of trans-European networks as set out in Article 171. Energy transmission infrastructure has a European added value due to its cross-border nature or impacts and is essential to achieve a climate neutral energy system. Resilient energy transmission infrastructure are of crucial economic importance to the European Union. Modern digital and aspiring low carbon societies are indeed increasingly dependent on a stable energy supply. Even short disruptions in electricity supply can have large economic and social costs, which can be up to one hundred times larger than the direct costs to the energy sector.

The main policy priority of the current TEN-E Regulation has been to improve energy security and interconnectivity of all Member States and regions. The objective to facilitate an accelerated integration of renewable energy into our energy networks will become even more important, in line with the ambitious energy and climate targets. This objective comes with its own challenges with regard to climate resilience given the climate- sensitivity of many renewable energy sources. Building climate resilience in the energy transmission sector includes addressing the impacts of weather hazards on existing energy infrastructure and its operation, as well as considering the impacts of long- term climate change on newly planned infrastructure. The risk is that adaptation could be seen as an additional burden that needs to be managed on top of other challenges related to rapid decarbonisation and changes in the market and regulatory environment. The opportunity is that massive investments made in the energy system should allow climate resilience aspects to be addressed early in the investment cycle to ensure the clean energy transition is also climate- resilient.[240] The Commission proposal to revise the TEN-E Regulation[241] introduces a requirement for projects of common interest to integrate climate adaptation measures and the 'do no significant harm' principle**.**

6.4.2 TEN-T Regulation

TEN-T policy is an integrated policy approach, which combines all transport modes in a single Europe-wide network and includes both physical and smart / innovative components, in line with broader transport policy requirements.

Efficiency enhancement

TEN-T policy is an indispensable basis for the overall EU transport system to enable seamless transport and mobility chains for freight and passengers, thereby ensuring the best possible use

[240] See EEA report Adaptation challenges and opportunities for the European energy system. EEA Report No 01/2019, pp. 82-83 https://www.eea.europa.eu/publications/adaptation-in-energy-system
[241] COM(2020) 824 final

of existing infrastructure capacities. This approach is a strong contribution to enhancing efficiency of the transport system, as one of the pillars towards the achievement of the climate targets.

Enabling clean transport

TEN-T infrastructure shall be equipped with charging and refuelling infrastructure for alternative fuels, in line with the EU legislation concerned. In this respect, TEN-T policy is again an indispensable enabler of decarbonised transport solutions.

Resilient infrastructure, adapted to climate change

TEN-T infrastructure – such as inland waterways or ports, but also vulnerable parts of roads or railway lines – are subject to particular risks in periods of extreme weather events (long drought, floods etc.). Therefore, it is also important to design TEN-T infrastructure in a way that it ensures a high level of climate change resilience.

The TEN-T regulation has specific requirements in terms of considering the vulnerability of transport infrastructure with regard to a changing climate as well as natural or man-made disasters, with a view to addressing those challenges. However, there is no clear or specific reference to reducing risk or promoting residual risk transfer.

6.4.3 **Connecting Europe Facility**

The Connecting Europe Facility (CEF) is a funding programme that supports trans-European networks and infrastructures in the sectors of transport, telecommunications and energy. In June 2018, the European Commission, as part of proposals for the next long-term budget (2021-2027), proposed adapting the CEF programme to support investment in Europe's transport, energy and digital infrastructure networks. A provisional agreement was reached by co-legislators in March 2019[242] and in the context of the MFF. For the period 2021-2027, the CEF 2 Regulation Commission proposal[243] envisages in its Recital 4 the implementation of climate proofing actions to projects supported by the Programme. In addition, climate adaptation would be one criterion considered in the selection of projects, as set out in article 13:

Recital 4

[…]In order to prevent that infrastructure is vulnerable to potential long term climate change impacts and to ensure that the cost of greenhouse gas emissions arising from the project is included in the project's economic evaluation, projects supported by the Programme should be subject to climate proofing in accordance with guidance that should be developed by the

[242] Press release on CEF agreement.
[243] COM(2018)438 final

Commission coherently with the guidance developed for other programmes of the Union where relevant..

Article 13 – Award Criteria

(2) The assessment of proposals against the award criteria shall take into account, where relevant, the resilience to the adverse impacts of climate change through a climate vulnerability and risk assessment including the relevant adaptation measures.

Moreover, for the transport sector, the CEF 2 would be able to support climate adaptation activities: *Article 9 – Eligible actions (eligible to receive Union financial assistance under this Regulation)*

(2)(b)(vii) actions improving transport infrastructure resilience, in particular to climate change and natural disasters and resilience against cyber security threats.

For many energy and transport infrastructure projects, climate proofing (mitigation and adaptation) is foreseen under the Environmental Impact Assessment (EIA) Directive, which Member States have been required to comply with since May 2017.

While the 2021-2027 MFF has been agreed, technical trilogues on the Connecting Europe Facility are ongoing**.**

6.4.4 **Cohesion policy**

The co-legislators reached the political agreement on the Common Provisions Regulation (CPR), which among others applies to the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the Just Transition Fund (JTF) and the Interreg Regulation in the period 2021-2027, in December 2020).

Selecting operations to be co-funded by the ERDF or the Cohesion Fund is a Member State responsibility. The cohesion policy legislative framework for 2021-2027 fixes the climate proofing requirements for the selection of infrastructure projects with an expected lifespan of at least five years. This means that infrastructure would need to be able to better withstand the current and expected future impacts of climate change, including more frequent and extreme weather-events. In this regard, managing authorities would need to detail, in the corresponding calls for projects and corresponding selection criteria, the requirements and methodology, applicable to the types of projects at stake. These would serve as a basis for verifying whether projects are climate-proof when project applications are assessed. This also means that beneficiaries would need to design their projects accordingly. The elements to be taken into consideration may be available in the Member States already through existing national climate adaptation strategies to the extent they contain robust methodology including climate change scenarios, projections and a set-up tailored for the concerned sectors as well as a corresponding set of measures. The Cohesion Policy is one of the main funding sources for climate change adaptation, and risk prevention and management. In the context of shared management, Member States have allocated nearly EUR 8 billion of investments in this area in the 2014-2020 period.

Adding the national co-financing brings the total investment to nearly EUR 10 billion. The majority of these investments goes into the prevention of and preparedness for natural disasters such as floods, forest fires, coastal erosion, earthquakes and drought. It is expected that these investments will bring significant benefits to Europeans. Notably, it is expected that more than 16.5 million people will be protected from flood risks. Similarly, it is expected that more than 16.6 million people will be protected from forest fires.

In this context, cohesion policy contributes to improving cooperation mechanisms among regions facing the same risks, including in a cross-border context, which provides for more effective possibilities, both in terms of prevention and of preparedness. In terms of regional cooperation mechanisms, the EU macro-regional strategies[244] have proved to be an important platform for coordination and cooperation of actions. Moreover, in terms of joint investments, Interreg programmes[245] (co-financed by the ERDF) make a significant contribution, which, in addition to prevention, can include joint reaction capacities, such as shared infrastructures, response vehicles, equipment, shelters, development of early warning systems and training for civil protection units across borders.

In the new programming period of 2021-2027, climate change adaptation and disaster risk management will be key priorities for cohesion policy. Investments in climate change adaptation related areas could increase given that the related specific objective of promoting climate change adaptation, disaster risk prevention and disaster resilience, taking into account eco-system based approaches, is included under the thematic concentration requirements Furthermore, in addition to continued cooperation under Interreg, the possibilities for cooperation between regions and Member States are also facilitated and strengthened within the national and regional cohesion policy programmes in the new period. Interreg programmes also enable cooperation between Member States and neighbouring third countries.[246]

For the 2021-2027 period, enabling conditions have been proposed, linked to Member State disaster risk management planning, in line with the EU Civil Protection Mechanism and linked to existing climate change adaptation strategies. Before Member States can receive reimbursement of investments in climate change adaptation and in disaster risk management measures, Member States have to fulfil the enabling condition on having a national or regional disaster risk management plan, established on the basis of risk assessments, taking account of the likely impacts of climate change and the existing climate adaptation strategies. Member States have to ensure that enabling conditions remain fulfilled and respected throughout the programming period.

[244] Macro-regional strategies.
[245] Interreg.
[246] With regard to disaster risk prevention and preparedness, synergy between Interreg and the UCPM (see Sections 5.4.7 and 5.5.4.2) is important, also as the UCPM legislation requires that Member States report regularly on priority prevention and preparedness measures for key risks having cross-border impacts.

6.4.5 **EU Solidarity Fund**

The EU Solidarity Fund (EUSF) was established in 2002 and subsequently revised several times. Unlike the ERDF and Cohesion Fund, the EUSF operates outside of the MFF and its legal basis is open-ended.

The EUSF was last revised in the framework of the Coronavirus Response Investment Initiative. The purpose of the last revision (applicable as of 1 April 2020) was to extend the scope of the fund to encompass major public health emergencies. Further revision of the instrument is not foreseen in the short-term. The EUSF Regulation foresees an exclusion of the financing of operations going beyond the repair of infrastructure beyond their state before the disaster (Article 3). Nonetheless, reducing existing risks by "building-back-better" is encouraged by covering the additional funding needs from other sources (which may also include the ERDF and Cohesion Fund). The EU Solidarity Fund, is an instrument targeted exclusively at providing financial assistance for public emergency and recovery operations following large natural disasters and major public health emergencies. Prevention and preparedness measures are excluded from the scope of the EUSF. Although ex-post reporting for Member States who benefit from the EUSF typically requires information on prevention measures put in place after the disaster, Member States' ex-post reports often provide incomplete information on prevention measures.

The EUSF Regulation foresees that payments from the Fund are limited to financing measures alleviating non-insurable damage (Article 3.3.). In this regard, insurable damage is excluded from compensation. However, there is no specific method to define "insurability". In practice, under the EUSF, all private assets - residential, businesses, agriculture etc. - are considered insurable and are therefore not eligible for aid. By contrast, all non-insured publicly owned assets are potentially eligible for aid. Given the fragmentation of Member States' national disaster insurance regimes (see Section 2.3.2.), this implies that, in those Member States where publicly-owned assets are insured by design, a narrower set of asset-related losses meet the EUSF eligibility criteria compared to those Member States where penetration of insurance for publicly-owned assets is low.

6.4.6 **InvestEU programme**

The InvestEU Programme builds on the successful model of the Investment Plan for Europe and brings together, under one roof, the European Fund for Strategic Investments and 13 EU financial instruments currently available. The intention is to make EU funding via budgetary guarantees simpler to access and more effective through a more coherent approach, with one set of rules and procedures and one point of contact for technical assistance.

Sustainability is a key aspect of the InvestEU Programme via a bi-dimensional approach:

- Climate target: 30% of the overall envelope is expected to contribute to climate objectives. Additionally, a specific target of 60% of the aggregate volume of financing and investment operations under the Sustainable Infrastructure Window is expected to contribute to climate and environmental objectives;

- Sustainability proofing requirements: According to the InvestEU Regulation[247] *"financing and investment operations shall be screened to determine if they have an environmental, climate or social impact and, if so, shall be subject to climate, environmental and social sustainability proofing with a view to minimise detrimental impacts and maximise benefits on climate, environment and social dimension."*
- Resilience to climate-related risks is part of the screening and proofing process, as relevant for the specific operation. Moreover, the Commission developed a sustainability proofing guidance in cooperation with potential implementing partners.

Through the sustainability proofing process, InvestEU takes into account and manages climate, environmental and social risks prior to creating new exposure. Projects above the established threshold(s) are subject to a screening process, to determine whether they have significant environmental, climate or social impact. If so, they should be subject to sustainability proofing for the identified impacts. This process could lead, whenever necessary and possible, to the adaptation of the project design and the implementation of preventive mitigation and remedial measures. InvestEU expands the utilisation of climate change considerations to more than infrastructure projects, while keeping in mind the proportionality principle.

Climate adaptation is central in both the screening and the assessment of impacts processes. Where applicable, the adaptation to climate change of projects receiving InvestEU support can be done through a climate vulnerability and risk assessment including the identification, appraisal and implementation of relevant adaptation options. The risks of the project are therefore clear in principle to both project promoter and implementing partner, prior to creating new exposure.

Moreover, climate adaptation is eligible for funding under InvestEU. This means that adaptation measures for existing climate risk exposed assets could be financed with InvestEU support. There is also the possibility of using the InvestEU Advisory Hub for the preparation of projects or capacity building for implementing partners or financial intermediaries to integrate considerations related to climate change aspects in their processes.

The InvestEU operates under a fully delegated model, therefore implementing partners will be fully responsible for performing the due diligence of operations they propose for receiving InvestEU support. However, climate proofing will help with reducing the residual risks to an acceptable level for the implementing partner when taking the financing decision. Although insurance is not specifically mentioned in the legislation, going through the proofing process would help with obtaining a good quotation for insurance of the financed assets.

[247] Regulation(2021) 523.

6.4.7 **Union Civil Protection Mechanism – funding aspects**

The Union Civil Protection Mechanism (UCPM) legislation sets the basis for the EU's and Participating States'[248] roles in preventing, preparing for and responding to disasters and offers related technical and financial assistance. In response to the exceptional fire season in 2017, the Commission decided to amend the UCPM legislation in 2019 to: (i) strengthen the EU collective response to disasters, (ii) reinforce prevention and preparedness efforts and (iii) simplify administrative rules to make reaction to emergencies more efficient.

The European Commission also proposed a targeted amendment of the UCPM Decision[249] which was adopted by the Council in May 2021[250].

The UCPM has an annually-determined work programme which sets priorities for activities in the areas of prevention and preparedness. In 2019, a novel tool was introduced to the set of support measures under the UCPM, namely direct grants to Member States' civil protection authorities that would serve as 'seed funds' to leverage larger investments in disaster risk management. In addition, as a result of a revision of the UCPM basic act in March 2019, which strengthened prevention and preparedness to disasters, the UCPM budget was increased.

The UCPM legislation requires Member States to conduct risk assessments at national or appropriate sub-national level every 3 years. Guidelines from 2010 exist for these risk assessments[251] but many Member States have their own, more advanced methodologies. However, while the principle of taking into account risk before creating new exposure is not disputable at the European level, there are no mechanisms in place to ascertain if Member States apply it in practice.[252]

The Commission is requested to establish and regularly update a cross-sectoral overview of natural and man-made risks the Union may face[253], taking into account the impact of climate change on disaster risk. This overview builds on the national risk assessments received but also draws its own assessment of risks at the European level. To further incentivise and strengthen the inclusion of climate risks into disaster risk assessments and disaster risk reduction plans, the Commission proposal for a Common Provisions Regulation[254] foresees an enabling condition requiring Member States to have a disaster risk management plan in place, in line with their national adaptation strategies and plans, and based on the key risks from the national risk assessment (as required under the UCPM) reflecting current and long term threats (25-35 years). The assessment shall build, for climate related risks, on climate change projections and scenarios.

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[248] 27 EU Member States, UK during the transition period, Norway, Iceland, Turkey, Montenegro, Serbia, and North Macedonia.
[249] COM(2020) 220 final.
[250] REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Decision No 1313/2013/EU on a Union Civil Protection Mechanism. Adopted 10 May 2021.
[251] SEC(2010) 626 final: Risk Assessment and Mapping Guidelines for Disaster Management.
[252] The Floods Directive (2007/60/EC) is a notable exception to this rule as it requires MS to carry out preliminary flood risk assessments.
[253] SWD(2020)330 final.
[254] COM/2018/375 final - 2018/0196 (COD).

The EU has played a leading role in the negotiation of the Sendai Framework[255]. One of the underlying principles of the Sendai Framework is: "*Addressing underlying disaster risk factors through disaster risk-informed public and private investments"* as it *"is more cost-effective than primary reliance on post-disaster response and recovery, and contributes to sustainable development".* The UCPM requires Member States to assess existing risk (and most Member States also integrate future risks by considering climate change impacts) but does not directly aim to promote resilience investments by private or public actors. Nevertheless, the Commission has already started incentivising Member States to invest through the aforementioned direct grants as well as by commissioning a World Bank study to illustrate the benefit-cost ratio of prevention investments in Europe.[256]

6.4.8 **Common Agricultural Policy (CAP)**

The Common Agricultural Policy (CAP) has been in place for over 50 years as a common policy at EU level providing financial support for EU agriculture and rural areas. Based on a series of reforms, over time, the CAP has enlarged its scope. It went from addressing economic risks linked to dynamics of (global) markets or agricultural production (plant/animal health, weather events and natural disasters), which have an impact on income, viability and competitiveness of EU farms, to also covering risks linked to functioning eco-systems which are induced by climate change and the sustainability of the use of natural resources in agricultural production (risks in terms of status of soil, water or biodiversity).In 2018, the Commission adopted its most recent proposals for a CAP reform and co-legislators have reached a political agreement[257].

One of the key novelties proposed is that in future the different CAP interventions, chosen and designed by Member States in line with their needs and in respect of a (more flexible) EU framework, will all come together in one, coherent CAP strategic plan at Member State level. In view of the finalisation of the CAP legislative framework, Member States have been preparing these plans for approval by the Commission. The Commission adopted on 20 May 2020 the Farm to Fork Strategy and the Biodiversity Strategy, including a series of Green Deal-relevant targets, and published a Staff Working Document on the link between the Green Deal and the ongoing CAP reform. This analysis concludes that the CAP reform proposal is compatible with the Green Deal, highlighting that the capacity of the future CAP to accommodate the Green Deal's ambitions depends on the final compromise reached and illustrating certain improvements, that could be achieved during the legislative process, without changing the CAP proposals. It also outlines additional practical action the Commission could take to ensure implementation of the future CAP helps to achieve the ambition of the Green Deal (e.g. on targets in the context of the CAP plans).[258]The very aim of the majority of CAP tools is to deal

[255] The Sendai Framework for Disaster Risk Reduction (2015–2030) is a voluntary international agreement adopted by UN member states between 14th and 18th of March 2015 at the World Conference on Disaster Risk Reduction held in Sendai, Japan and endorsed by the UN General Assembly in June 2015. It is the successor agreement to the Hyogo Framework for Action (2005–2015).
[256] [Forthcoming] World Bank Group report on "The economics of prevention and preparedness", 2021.
[257] CAP political agreement.
[258] Farm to fork strategy.

with economic or resource-related risks which endanger agricultural production (either existing or new) and therefore a climate-resilient and resource-friendly production of food and bio-economy input in Europe, which also contributes to the socio-economic-cultural fabric of rural communities. Moreover, the fact that the range of CAP tools covers the full risk spectrum, from normal to catastrophic, implies that combinations of tools into a coherent approach are possible (and even necessary in case of mandatory requirements). While attention to risk is therefore a guiding principle for policy design, the exact mechanism are difficult to generalise given the vast variety of different tools. It is important to note that the Commission proposals for the future CAP contain key elements aimed at enhancing the resilience of EU agriculture and rural areas:

- **Adopt a more strategic approach**: Member States would be required to describe and explain their choice and design of CAP tools on the grounds of a comprehensive and evidence-based problem definition (SWOT/needs assessment) and intervention logic for all nine CAP specific objectives (three economic, three environment-climate, including climate-resilience aspects and three social/territorial ones).
- **Adopt a more integrated approach**: Member States would be required to integrate all CAP interventions into a single strategic programming document at national level (CAP strategic plan) and ensure coherence of the mix of their interventions. For risk management, a targeted assessment of needs in relation to one of the economic CAP specific objectives is required. In addition, in its plan, each Member State has to show how, in pursuing the CAP's objectives, it will also make a specific contribution to achieving the objectives of various pieces of EU environmental, climate and energy legislation. When drawing up its CAP plan each Member State will take into account the analysis and recommendations for action and overall national targets derived from that legislation - for example, through the National Energy and Climate Plans provided for in Regulation (EU) 2018/99 or the integrated reporting on national adaptation actions -reinforcing the tight link between this legislation and CAP implementation.

The Commission's proposals for the new CAP proposes to strengthen various CAP tools which have the potential to increase climate resilience.

A combination of elements, such as interventions, safeguards and principles – so called "new green architecture" – would ensure an increased ambition of the CAP when it comes to caring for the environment and climate:

- The new system of conditionality – linking area-based and animal-based CAP payments to a range of obligations – would draw on the content and strengths of the current cross-compliance and greening systems but would make several improvements, providing a broad and enhanced "foundational" level of environmental care;
- Member States would have to make use of a new means of funding the environment and climate ("**eco-schemes**") from the CAP's direct payments, in order to encourage farmers to adopt or maintain practices that benefit the environment and the climate. These would be voluntary for farmers;
- The **support for rural development (CAP Pillar II)** would continue to offer a wide range of tools such as for example measures 4.4 (support for non-productive investment linked to

the environment and climate objectives), 5.1 (introduction of appropriate prevention), 10 (environmental-climate related measures) and 11(organic) that are beneficial for the environment and climate. Pillar II also supports investments that have a positive effect on climate adaptation, mitigation and resilience for example under measure 4.1 (support for investments in agricultural holdings).

- The requirement for '**ring-fencing**' a certain share of the budget for the environment and climate would be strengthened. In their CAP plan, Member States would remain obliged to earmark at least 30% of their EU Pillar II funding to be spent on the environment and climate. There is no specific earmarking for adaptation related action as it is included in the 30% share and difficult to be distinguished from mitigation.

In addition, the CAP offers tools which, while not directly linked to risk, can make an important contribution when it comes to the enabling environment of risk management, notably by:

- supporting the diffusion of technological solutions, the improvements of skills and awareness and
- complementing risk management tools by investment support for preventive actions to increase resilience or to help adapting to new conditions / environment.

The CAP provides support for various risk transfer/sharing solutions, notably in form of:

- Subsidised insurance premia and mutual funds (production risks only) under the multi-annual programmes for fruit and vegetables and wine sectors;
- Subsidised insurance premia and mutual funds (including for income risks) under the rural development programmes. The EU landscape of availability and coverage of these tools is very diversified (mostly subsidised insurances (originally in particular hail, but more recently enlarged to multi-peril) and few experiences with mutual funds). It is also influenced by a series of factors such as risk awareness (e.g. drought and fire only recently perceived as tangible risks in Central/Northern Member States), distribution of responsibilities between private/public actors and funding tradition (no public support; public support in form of state aid/CAP or ex-post bail out) of Member States.

The Commission proposals for the new CAP include a strengthening of risk management tools, notably via a mandatory requirement for Member States to offer risk management tools under their rural development policy to farmers (no budgetary minimum, flexibility in choice and design of tools).

The CAP also traditionally offers support for agricultural sectors in cases of exceptional events via "crisis management" tools. Financial instruments for working capital loans or capital rebates that are triggered by crisis can help recipients to deal with temporary difficulties.

6.4.9 **European Investment Bank**

The EIB is already one of the biggest investors in climate action and environmental sustainability globally, being the largest Multilateral Development Bank financier of climate action. The Bank has now set itself even more ambitious goals to reinforce its status as the EU climate bank. This includes three key elements:

- The EIB Group will aim to support EUR 1 trillion of investments in climate action and environmental sustainability in the critical decade from 2021 to 2030;
- The EIB will gradually increase the share of its financing dedicated to climate action and environmental sustainability to reach 50% of its operations in 2025 and from then on;
- The EIB Group will align all its financing activities with the principles and goals of the Paris agreement by the end of 2020.

Under its new commitment, the EIB aims to increase the volume of its support for climate action, including building climate resilience. In addition, in order to align with the goals of the Paris Agreement, the EIB will ensure that by the end of 2020 all new investment projects are adapted to the risks from current and future climate change.

This is not a new challenge. Managing physical climate risk and supporting adaptation to climate change is one of the three action areas of the EIB Climate Strategy, which was adopted in 2015.

The EIB's support for measures aimed at reducing physical climate risk span across all sectors and geographies of EIB operations. For example, the EIB worked with the city of Athens to support the implementation of its Resilience Strategy. The EIB provided technical assistance to define adaptation design standards for the refurbishment of public buildings and public open spaces, with the aim of reducing vulnerabilities to increased severity of heat stress and flooding. Additionally, the EIB works with partners such as regional development banks – for example the EIB have funded climate resilience building across the Caribbean for many years together with the Caribbean Development Bank, with a mixture of concessional financing and technical assistance from EU Cotonou funds.

As part of its increased commitments to building climate resilience, the EIB has taken a number of steps to ensure its investments inside and outside Europe are adapted to the adverse effects of climate change, including:

- rolling out a climate risk assessment system;
- carrying out an analysis of hotspots for investment opportunities covering all sectors, geographies and financial products.
- developing a large capacity development programme to enhance the technical skill-set on adaptation of the EIB's loan officers and engineers.

The EIB has rolled out a Climate Risk Assessment (CRA) System in early 2019 to systematically screen operations for physical climate risk. The CRA system is a business process that helps the EIB and its clients understand how climate change may affect projects and identify measures to reduce material risk resulting from sea level rise, extreme heat, heavy rainfall, storms, floods, droughts and other climate-related hazards. The system covers fourteen climate hazards

including both chronic and acute physical climate risk and capturing changes in temperature patterns, wind strength, water and oceans, and land mass.

The system comprises two levels of screening and a more detailed assessment for projects ranked at risk:

- An initial triage carried out when a project is initiated - this screening allows a filtering out of projects that are not likely to be affected by climate change (for example projects with no infrastructure);
- A second screening carried out when more details on the projects are known, mainly location and subsectors - it identifies climate hazards such as sea level rise, heavy rain, floods, droughts and cyclones, which can affect the project's performance.
- A further climate risk assessment for projects ranked *at risk* to determine to what extent the risks posed by climate change have been taken into account by the project promoter and what adaptation measures have been integrated in the project.

At the end of the process, the CRA system estimates the *residual physical climate risk*. This is the risk that a project may still be affected by climate change after adaptation measures have been incorporated. It is a qualitative output metric of the resilience of EIB investments, which allows an estimation of the overall cumulative residual physical climate risk in EIB investment loan portfolio.

This approach allows the EIB to identify risks associated with climate-related hazards at an early stage of project development to enhance the climate resilience of assets it finance.

The EIB requires borrowers to undertake insurance according to market practice. Depending on the type of project and its location, insurance may include the risks faced by a project promoter in relation to climate hazards. For example, the insurance policy of an EIB-funded offshore wind farm may include risk of damage caused by sea storm, as well as other risk such as vessel collision risks, electrical breakdown and defects. However, the EIB does not currently require project promoters to undertake insurance against climate risk beyond current market practice.

At the operational level, the EIB is piloting investments in climate resilience insurance. For example, the EIB has invested in funds aimed at improving access to climate risk insurance in developing countries, such as agricultural insurance to protect poor households and small-hold farmers against weather and climate risks in developing countries. To increase the impact of such efforts the EIB has worked closely with Luxembourg government – providing concessional funding for these funds through the EIB-Luxembourg Climate Finance Platform[259].

5.4.10 **The Next Generation EU and the Recovery and Resilience Facility**

The Recovery and Resilience Facility is part of the Recovery package approved by the Council on 21st July 2020:

[259] https://www.eib.org/en/press/all/2019-308-eib-donors-conference-luxembourg-and-eu-bank-strengthen-their-cooperation-on-microfinance-and-climate-action

- It includes the "Next Generation EU" recovery instrument - €750 billion of financing from the financial markets, €390 billion of which are grants and €360 billion loans;
- It complements a reinforced long-term EU budget for 2021-2027 - €1.074,3 billion;
- The bulk of the money raised for the Next Generation EU recovery instrument will be invested under the Recovery and Resilience Facility (RRF) - €672,5 billion (in 2018 prices), of which €312,5 billion (in 2018 prices) are grants and €360 billion loans (in 2018 prices).

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The Recovery and Resilience Facility envelope will be accessible if a Member State presents a national Recovery and Resilience plan (RRP) with a reform and investment agenda that effectively addresses medium- to long-term structural challenges identified in the relevant Country specific recommendations (CSRs).

The Recovery and Resilience Plans (RRP) have to fulfil several other criteria, including to contribute significantly to the green and digital transitions or to addressing the challenges resulting from them, and to respect the environmental "do no significant harm principle" (which in refers to the Taxonomy regulation) in order to ensure that Member States economies emerge more resilient and sustainable from this crisis.

Overall, RRPs should devote 37% of the total amount of allocated funds foreseen in support of the climate objectives as part of the green transition, and 20% to the digital transformation. Several measures related to adaptation are covered in this description, tagged at 100%, meaning the full cost of the measure can be allocated to this 37%.

6.5 Annex V: EU policy settings with relevance for adaptation

6.5.1 Private finance

6.5.1.1 Sustainable finance action plan

Under the Commission's sustainable finance action plan[260], a number of actions were taken to redirect private capital towards sustainable investment, including to enhance climate change adaptation. The actions concern the various financial services sectors, including banks (credit institutions and investment firms), asset managers, insurance companies and pension funds ("institutions for occupational retirement provision" or "IORPs"). The actions of the plan include:

- The establishment of an EU classification system for sustainable activities ("taxonomy") ;
- The creation of labels and standards for green financial products;
- Clarifications on institutional investors' and asset managers' duties.

The Taxonomy Regulation[261] aims to reduce fragmentation resulting from market-based initiatives and national practices and to reduce "greenwashing", i.e. the practice of marketing financial products as "green" or "sustainable", when in fact they do not meet basic environmental standards. For this purpose, the Taxonomy Regulation defines six environmental objectives, including climate change adaptation. Economic activities can only be deemed "sustainable" according to the EU taxonomy if they provide substantial contribution to at least one of the six environmental objectives without doing significant harm to the five others, while also ensuring compliance with minimum social safeguards. It follows that even if an economic activity does not substantially contribute to climate adaptation, all economic activities deemed "sustainable" according to the EU taxonomy will have to demonstrate a significant degree of resilience to climate-related impacts. The Regulation will thus significantly contribute to mainstreaming "climate-resilience" into broader sustainability practises in the financial and in the business sector.

The Regulation introduces an obligation on certain investee companies (those within scope of the Non-Financial Reporting Directive) to disclose the degree to which their activities comply with the taxonomy. This will encourage[262] investee companies to assess, report and therefore take into account existing or expected adverse impact of climate change.

Likewise, the Taxonomy Regulation will also provide end-investors with information on how and to what extent the investments underlying the financial product are invested in environmentally sustainable economic activities, including climate adaptation as mentioned

[260] COM(2018) 97 final.
[261] Regulation(2020) 852.
[262] Investee companies could simply disclose their alignment with taxonomy as zero, if they do not wish to go through the detailed screening of their activities however.

above. Institutional investors are therefore incentivised to invest in activities that contribute to environmental objectives and to reduce risks from climate change, e.g. by engagement with the investees, refraining from future investments or divesting. It has to be noted that the management of residual financial risk by institutional investors[263] is addressed by prudential regulation which is explained further below. In addition, insurance as tool for the management of individual climate change-related risks by other companies and individuals is explained in this report's section on insurance.

6.5.1.2 **Corporate reporting**

As part of the European Green Deal, the Commission has put forward a proposal to review the Non-Financial Reporting Directive (NFRD), the 21 April proposal for a Corporate Sustainability Reporting Directive (CSRD)[264]. The NFRD currently applies to large listed companies, banks, and insurance undertakings, provided they have more than 500 employees. It is widely recognised that the information currently reported by companies under the scope the Directive does not meet the needs of intended users. Amongst other things, a lot of information considered relevant by users is not reported, and reported information is not sufficiently comparable or reliable. The CSRD would partly address these issues, including by extending the scope of the NFRD in terms of companies reporting, through more detailed reporting requirements and through a requirement to report according to mandatory EU sustainability reporting standards.

6.5.1.3 **Prudential rules**

Prudential rules for institutional investors set restrictions on how those investors can allocate their funds. Under the Action Plan: Financing Sustainable Growth from March 2018, work was launched to clarify the obligations of institutional investors and adopted the resulting delegated acts on 21 April 2021. Further actions on prudential rules are being considered in the preparations for the renewed sustainable finance strategy.

For insurance and reinsurance companies for instance, the Solvency II Directive (Directive 2009/138/EC) achieves a high level of harmonisation of the prudential rules. Quantitative requirements ensure that insurers hold capital to absorb potential losses, among others, from depreciation of the value of their assets. Qualitative requirements ensure, among others, that insurers understand the risk of their investments and are able to manage those risks.

The fact that existing risks have to be taken into account in capital requirements (quantitative requirements) and/or qualitative requirements also incentivises a reduction of risks for insurers, including those related to climate change.

Rules for institutions for occupational retirement provision (IORPs) are set out in the IORP II Directive (Directive (EU) 2016/2341). While quantitative rules are to a large degree set by Member States, qualitative requirements are more harmonised and similar to rules applying to insurers. In particular, IORPs must have an effective system of governance which provides for sound and prudent management of their activities, based on an adequate and transparent

[263] For the purpose of this section, the term "institutional investor" includes credit institutions, investment firms, insurance companies and pension funds (IORPs).
[264] COM(2021) 189 final.

organisational structure, with a clear allocation and appropriate segregation of responsibilities and an effective system for the transmission of information. The Directive requires explicitly that this system has to include consideration of environmental, social and governance factors, including climate-change related aspects, related to investment assets in investment decisions. More specially, IORPs are obliged to invest in accordance with the 'prudent person' rule in the best long-term interest of members and beneficiaries as a whole. The Directive states explicitly that, within the prudent person rule, IORPs are allowed to "take into account the potential long-term impact of investment decisions on environmental, social and governance factors". IORPs also have to document their own-risk assessment regularly, using methods to identify and assess the risks that may have an impact on their ability to meet their obligations. The risk management system and the own-risk assessment should reflect environmental, social and governance (ESG) risks[265].

As for Solvency II, the fact that existing risks have to be taken into account in qualitative requirements incentivises a reduction of risks for pension funds, including those related to climate change.

6.5.1.4 **Product regulation**

Apart from rules concerning the type of institutional investor, there are also examples of **product regulation**, notably the Pan-European Personal Pension Product (PEPP). The PEPP is a voluntary, individual pension product intended to supplement income on retirement. PEPPs can be provided by different groups of financial undertakings, including banks, insurance companies, IORPs, investment firms and investment companies. These providers have to comply with the rules applicable to the product while taking into account the risks that are applicable in their specific sector, notably in terms of risk management and risk reduction as explained above.

PEPP providers are obliged to invest in accordance with the 'prudent person' rule in the best long-term interest of the PEPP savers as a whole. The Regulation states explicitly that, within the prudent person rule, PEPP providers "shall take into account the potential long-term impact of investment decisions on environmental, social and governance factors". The fact that existing risks have to be taken into account in investment decisions also incentivises a reduction of risks for PEPP providers, including those related to climate change.

6.5.2 **Insurance**

6.5.2.1 **Solvency II**

Insurance companies are subject to the **Solvency II Directive**, the main objective of which is the protection of customers (or “policyholders”).

[265] The IORP Directive requires that IORPs identify and assess their ESG risks as part of their risk management system regardless of whether they integrate ESG factors in their investment policy (Art. 25(2)(g). Where ESG factors are considered in the investment decisions, the IORP's own risk assessment must cover ESG risks (Art. 28(2)(h)). See also EIOPA opinions EIOPA-BoS-19-248, EIOPA-BoS-19-245.

To achieve that objective, insurance companies have to be able to meet their obligations to policyholders. They do this by taking into account all relevant risks in their risk management. This would include risks from climate change to which they are or could be exposed, in particular to the degree that they might affect the solvency of the insurance company, as well as interdependencies between those risks.

To safeguard the main objective of Solvency II insurers also have to set and to document the objectives and key principles of their strategy, their risk appetite, i.e. their risk tolerance limits, and the assignment of responsibilities for all their activities. They also need to assess the risks related to new activities, strategies as well as external developments, including those related to climate change or the coverage of risks related to climate change.

Insurance companies have to take into account the already existing risk concentrations (e.g. geographically, regarding the risk type or the value insured) to avoid the underwriting of new risks beyond their risk tolerance.

The Solvency II rules for capital requirements aim to accurately reflect the risks that insurance companies are exposed to. The risk-sensitivity of capital requirements therefore forces insurers to **manage their risks** and it rewards insurers' measures to reduce existing risks.

Insurance companies serve as one source of managing individual risks by individuals and companies. The most important function of insurance companies from the perspective of their customers is the settlement of claims in a timely manner.[266] Insurance companies therefore have to ensure the adequacy of claims management procedures including the extent to which they cover the overall cycle of claims.

In order to ensure the financial capacity to pay claims to customers, insurance companies have to calculate and collect adequate levels of premiums ("pricing") and set aside premiums to cover for estimated future claims ("reserving"), while they face uncertainty as regards the level and timing of future claims ("underwriting risk"). The companies therefore have to assess and manage those risks, ensure sufficiency and quality of relevant data to be considered in the underwriting and reserving processes, and their consistency with the standards of sufficiency and quality.

An important aspect of the functioning of private insurance as risk transfer mechanism is the opportunity for diversification. Insurance works particularly well when the premiums of many customers that represent low or un-correlated risks are pooled to compensate for potentially devastating losses of few customers. Whether or not there is an opportunity for diversification depends both on the characteristics of the assumed risk (taking into accounts deductibles, limits and similar contractual features) generally and on the portfolio of contracts underwritten and not reinsured or passed on to other third parties by a company specifically. The former is outside of the control of an individual insurer. The latter is addressed by Solvency II rules on concentration

[266] Most insurance contracts compensate losses by a payment of cash. However, it has to be noted that some insurance contracts offer "payment in kind", e.g. roadside assistance insurance where benefits are effected by means of the staff and equipment of the person providing them.

risk management, which refers to actions to be taken by the (re)insurance company to identify relevant sources of concentration risk to ensure that risk concentrations remain within established limits and actions to analyse possible risks of contagion between concentrated exposures.

As regards their own risks, insurance companies are allowed to use risk-mitigation techniques (e.g. reinsurance or derivatives) to reduce their capital requirements, provided that those techniques are consistent with their written policies on risk management (including mitigation techniques related to the risks arising from climate change). The rules impose a minimum level of safeguards such as the requirement that the cover provided by the risk-mitigation technique and the transfer of risk should be clearly defined and incontrovertible.

As regards the risk of their customer, Solvency II rules require insurance companies to determine risk-based premiums that reflect the relevant risks ("pricing" as already mentioned above). Actions by policyholders to improve resilience of the insured goods and property against losses will reduce the risk and therefore also the risk-based premium determined by private insurers. The price signal therefore serves as an incentive by insurance companies for customers to take actions to reduce their risks.

Insurance companies, as part of their risk management, can also place contractual obligations/conditions on the policyholder regarding the specificities of the insurance cover. Related to the consequences of climate change, insurers can incentivise an increase in the resilience against losses by making insurance coverage conditional on specific protection or characteristics of the insured good (e.g. drought resistant crops).

EIOPA has delivered advice and an opinion on integrating sustainability in Solvency II.[267]The European Commission's Review of the Solvency II Directive will look, among others, at the contribution of the insurance sector to the European Green Deal and at the strengthening of the single market for insurance[268].

6.5.2.2 **Insurance Distribution Directive**

The Insurance Distribution Directive (IDD; Directive (EU) 2016/97) regulates the sale of insurance products and insurance-based investment products in the EU. The IDD applies to all sellers of insurance products:

- insurance intermediaries, such as agents and brokers, which have to be registered in their home country and meet certain minimum requirements;
- insurance companies that sell directly to consumers; and also to
- so-called "ancillary insurance intermediaries". These are businesses offering insurance as an add-on to products and services proposed by them. Typical examples include travel agencies or airlines offering travel insurance or sellers of electrical appliances proposing insurance against theft and damage.

[267] EIOPA opinion on sustainability within Solvency II. Technical advice on integration of sustainability in Solvency II and IDD.
[268] Solvency II planned proposal for a Directive.

Providers and distributors of insurance products have to operate an adequate product approval process based on the specification of an identified target market for each product (with the exception of the insurance of large risks). They have to ensure that the insurance product is consistent with the relevant risks and the needs of the customers belonging to that target market, that the distribution strategy is consistent with the identified target market and that the insurance product is effectively distributed to the identified target market. The target market might include individuals and companies that wish to transfer or mitigate their financial risks related to climate change.

The insurance company is required to regularly review the insurance products it offers or markets, taking into account any event that could materially affect the potential risk to the identified target market, to assess at least whether the product remains consistent with the demands and needs of the identified target market and whether the intended distribution strategy remains appropriate.

Any insurance product proposed to the customer should always be consistent with the customer's demands and needs, including the potential need to cover effects of climate change. Insurance distributors are obliged, before the sale of an insurance product, to determine the customer's insurance demands and needs (so-called "demands and needs test") and to give the customer objective information about the insurance products available to cover these demands and needs. This means that relevant insurance products proposed to customers who are exposed to specific climate change-related risks and wish to transfer or mitigate these risks must include coverage against these risks. As described above, private insurance providers are able to incentivise preventive action to reduce risk. Insurance distributors can facilitate that process by explaining products, prices and risk coverage and possibly by recommending and incentivising preventive action. Depending on the applicable national law and the wishes expressed by the customer, the insurance distributor may have, in addition to the duty to perform the demands and needs test, an obligation to provide advice in the form of a personalised recommendation explaining why a particular product would best meet the customer's demands and needs.

Insurance distributors can advise their customers on the use of insurance as effective risk management tool for policyholders. The demands and needs test allows the insurance distributor to have a clear picture of the need of their clients in terms of risk transfer and mitigation, to determine gaps in coverage and to look for alternative solutions which could include pooling the risk or covering it through coinsurance.

It has to be noted that IDD rules aim to protect individual customers (i.e. the (prospective) policyholder) and therefore focus on the demands and needs of that customer and not on aspects or objectives of general or third-party interest.

6.5.2.3 **EIOPA activities**

Apart from the EU legislation affecting the insurance sector, the European Insurance and Occupational Pensions Authority (EIOPA) is coordinating activities of insurance supervisors. In accordance with its legal mandate (Regulation (EU) 1094/2010), EIOPA can use non-legal instruments to enhance supervisory convergence such as the adoption of guidelines, opinions, statements and a supervisory handbook. An example is the authority's opinion on the supervision of the management of environmental, social and governance risks faced by IORPs. EIOPA

launched work on integrating climate change risk assessment in its supervisory handbook as part of a step-by-step approach to incorporate climate change risks in the supervisory review process. Furthermore, EIOPA's legal mandate explicitly requires EIOPA to monitor and assess market developments, duly considering developments relating to environmental, social and governance related factors (Art. 8).

As part of its activities on the assessment of market developments, EIOPA has already launched an analysis on the pricing and underwriting practices of insurers in light of climate change. That analysis will support the identification of good practices by insurance companies to enhance adaptation by their policyholders, i.e. the concept of "impact underwriting". Insurance products can be designed to incentivise increased resilience before a disaster and or improvements being made after a disaster (build-back-better, replacement). EIOPA will explore how impact underwriting can become a more wide-spread practice by the insurance industry.[269]

6.5.3 **Public finance**

6.5.3.1 **Public procurement**

Every year, over 250 000 public authorities in the EU spend around 14% of GDP (around €2 trillion per year) on the purchase of services, works and supplies. Public authorities are the principal buyers in sectors which are some of the most adversely affected by the impact of climate change and natural disasters such as energy, transport or social protection and the provision of health. Public authorities are also the principal buyers in sectors that are crucial to increased climate and risk management literacy, such as education.

EU directives on public procurement[270] cover tenders that are expected to be worth more than a given amount. The core principles of these directives are transparency, equal treatment, open competition, and sound procedural management. They are designed to achieve a procurement market that is competitive, open, and well-regulated. Under EU public procurement rules, contracting authorities may take multiple *"quality"* aspects into account when purchasing works, goods or services. Examples include *"protecting the environment, supporting social considerations and fostering innovation'"*. Resilience to climate, environmental or biosafety risks are however not specifically included.

Similarly, there is to date no systematic focus, in the development of Green Public Procurement criteria, to ensure that public buyers take into account climate-related risks in their purchases.

The European Green Deal Investment Plan announced that public investors would profit from tailor-made support on how to implement their projects in practice and flagged a *new 'Sustainable Procurement Screening' instrument* – to be built upon the existing voluntary ex-ante mechanism for large infrastructure projects.

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[269] EIOPA discussion paper on non-life underwriting and pricing in light of climate change.

[270] Directive 2014/24/EU on public procurement; Directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors.

Resilience considerations are essential to ensure that public funds are spent with due regard to safeguarding the value of investments made over time. In particular as to date, despite these "quality aspects" provisions, 55% of procurement procedures use lowest price as the only award criterion for public contracts. This might be an indication that public buyers are not always prioritising quality, sustainability and innovation or resilience at the award stage of public contracts.

6.5.3.2 **State aid**

Article 107(2)(b) of the Treaty on the Functioning of the European Union (TFEU) stipulates that aid to make good the damage caused by natural disasters shall be compatible with the internal market. According to Article 108 TFEU, any intentions from Member States to grant such aid must be notified to the Commission, which is responsible for verifying the occurrence of the natural disaster invoked to justify the granting of aid.

Emergency situations caused by natural disasters require urgent reactions on the side of the granting authorities. It is important to ensure a swift implementation of the envisaged aid measures. The Commission has therefore exempted from notification requirements in its Article 50 (Regulation 651/2014 - General Block Exemption Regulation) aid schemes to make good the damage caused by certain natural disasters (*"earthquakes, avalanches, landslides, floods, tornadoes, hurricanes, volcanic eruptions and wild fires of natural origin")* provided that certain conditions are met. In particular, the competent public authorities of a Member State have formally recognised the character of the event as a natural disaster; and there is a direct causal link between the natural disaster and the damages suffered by the affected undertaking and the aid and any other payments received to compensate for the damage, including payments under insurance policies, shall not exceed 100 % of the eligible costs.

Ex-ante disaster aid schemes have to be notified to the Commission, and an ex-post reporting aid granted as part of ex-ante schemes.

The Commission developed a checklist and a handbook [271] to provide Member States with indicative guidance, based on the Commission relevant case practice, on the information to be submitted to the Commission. Whilst guidelines recommend that Member States explain whether the event qualified as a natural disaster under national law, they also state that this qualification under national law does not bind the Commission for the analysis it will make as this qualification is made by the Commission on the basis of its own practice and in the light of the jurisprudence of the European Court of Justice. The agricultural sector and the fisheries and aquaculture sector are covered by sectoral rules for aid to make good the damage caused by natural disaster.

Typical criteria that the European Commission will check the notification against include:

- The causal link between the loss and the event;

[271] Aid to make good the damage caused by natural disasters (Article 107(2)(b) TFEU) - Checklist for Member States.

- Overcompensation avoidance: aid amount should not exceed the damage suffered, payment made to beneficiaries shall be net of any amount recovered by insurance, litigation, arbitration or other source for the same damage;
- No rewarding of liable/negligent behaviour with regard to event and its related damages: is excluded for any applicant who is responsible for the damage suffered and/or did not conduct his activities with due diligence or in compliance with applicable legislation or did not take any measure to mitigate its damages.

The list of eligible perils for natural disaster aid is a sub-selection of extreme climate and weather related as well as geological events while still leaving some disasters out of the scope of the GBER for example, extra-terrestrial hazards such as meteorites or biological hazards. Storms, or cyclones (there are now extra-tropical cyclones affecting mainland Europe) or glacial lake outbursts are not included either for example.

International organisation guidelines, best practice in disaster risk management policies and literature point to the potential "charity hazard" created by certain types of public natural disaster support schemes. Charity hazard emerges when individuals underinsure, do not insure at all, or do not try to protect themselves against certain losses because of expected governmental aid. This has prompted the OECD Council to issue Recommendation on Disaster Risk Financing Strategies[272] on the implementation of which OECD Member States have to report by 2023.

- These notably provide that:
- "[…] Adherents support the effective management of the financial impacts of disasters by all segments of the population and economy and encourage the development of risk transfer markets for disaster risks, by: […]
- iv) Where necessary, developing public compensation and financial assistance arrangements, co-ordinated across levels of government, to provide timely, targeted, transparent and equitable assistance for uninsurable losses to vulnerable segments of the population and/or economy and financial transfer mechanisms to provide support to sub-national levels of government facing fiscal constraints, with the aim of minimising economic disruptions and facilitating a stable supply of financing to the economy.
- v) Ensuring that disaster insurance and compensation arrangements encourage public and private risk reduction and recognise the benefits of utilising the capacity of national and international (re)insurance and capital markets to absorb disaster losses."

Natural disaster State Aid is essential in many instances to support the economy and vulnerable segments of the population. It should however not provide unintentional disincentives to insurance penetration (or private resilience investments/public resilience investments from other layers of governance).

There are potential disincentives to taking risk into account before creating new exposure in ex-ante schemes/ex-post aid that would not rule-out support to losses arising from claimants that are

[272] OECD recommendation to the Council on disaster risk financing strategies adopted by the OECD Council on 23 February 2017.

responsible for the damage suffered and/or did not conduct their activities with due diligence or in compliance with applicable legislation. The European Commission assessment framework considers this risk.

There are potential disincentives to reducing existing risk in ex-ante schemes and ex-post aid that would not rule-out support to losses arising from claimants that are responsible for the damage suffered and/or did not take any measure to mitigate their damages. The European Commission assessment framework considers this risk.

The framework ensures that the aid is complementary to insurance pay-outs and that the combination of aid and insurance pay-out does not exceed total damage.

6.5.4 Other EU regulatory settings with impact on climate-related risk management

6.5.4.1 Climate adaptation policy

Before the 2021 Adaptation Strategy, the EU was an early actor on adaptation, producing a Green Paper[273] and a White Paper[274] to pave the way for the adoption in 2013 of a first Strategy on adaptation to climate change. This first strategy was welcomed by the Member States and positively evaluated in 2018[275]. That strategy aimed to enhance the preparedness and capacity of all governance levels to respond to the impacts of climate change and make Europe more climate-resilient. Today the speed of adaptation action is varying across the EU but all 27 Member States have adopted national adaptation strategies or plans[276]. In the EU countries, most vulnerability assessments are produced, and adaptation options are identified, for agriculture, health, biodiversity, forestry and energy. The main sectors in which national policy instruments promote adaptation are water, agriculture, biodiversity and forestry, whereas health and energy are lagging behind.

6.5.4.2 Disaster risk reduction, prevention and management

The overall objective of the Union Civil Protection Mechanism (UCPM) is to strengthen cooperation between the EU Member States and six Participating States, in the field of civil protection, with a view to improving prevention, preparedness and response to disasters. When the scale of an emergency overwhelms the response capabilities of a country, it can request assistance via the Mechanism. Through the Mechanism, the European Commission plays a key role in coordinating the response to disasters in Europe and beyond and contributes to at least 75% of the transport and/or operational costs of deployments.

In addition, the 2019 revision of the UCPM established the Union Civil Protection Knowledge Network, to facilitate training and exchange of expertise among civil protection personnel and stimulate research in disaster risk management.

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[273] COM(2007) 354.
[274] COM(2009) 147.
[275] COM(2018)738.
[276] EEA Climate-ADAPT.

The UCPM also foresees a training programme for civil protection and emergency management personnel, but linking climate change adaptation and disaster risk reduction is not yet central, as the trainings are primarily targeting civil protection staff.

The current EU disaster risk management policy framework is a facilitative and encouragement framework, given the support competence designated by the Treaty. The EU collects information on progress in the Member States based on reporting rules initially spelled out in the UCPM legislation.

The UCPM legislation has multiple other tools aimed at stimulating prevention and preparedness actions beyond reporting obligations. These include funding for projects and direct grants, peer reviews, advisory missions and regular expert meetings.

In 2020, the European Commission proposed a revision of the UCPM Decision[277] as result of the COVID-19 pandemic, which has been adopted by the Council of the EU[278], and which defines Union disaster resilience goals in the area of civil protection, and adopts recommendations to define them as non-binding common baseline to support prevention and preparedness actions in face of transboundary disasters.

The UCPM legislation requires Member States to conduct risk assessments at national or appropriate sub-national level and submit a summary report on these every 3 years. Guidelines from 2010 exist for these risk assessments but many Member States have their own, more advanced methodologies. These risk assessments should serve as a basis for making risk-informed decisions. The Guidelines also include guidance on risk mapping, used to visualise areas at risk. However, only some Member States include hazard or risk maps in their risk assessment reports. For those Member States, this wealth of analytical data should be systematically used by other sectors outside of civil protection as well, particularly for spatial planning and land use.

Apart from for floods where the Floods Directive plays an important role, the only case known to the Commission where risk assessments/risk maps translate into spatial planning is in France, where there are local 'Plans de Prévention des Risques Naturels' (climate-related risks covered by these plans are river and coastal flooding, landslides, forest fires, avalanches, storms, cyclones). In the new reporting obligations under the revised UCPM legislation, Member States are explicitly expected to report on whether they develop risk maps. The proposed revision would strengthen the reinforcement of the EU's and its Member States' collective work on disaster resilience and planning.

The UCPM legislation explicitly states as one of its specific objectives that "The Union Mechanism shall support, complement and facilitate coordination of Member States action in pursuit of the following common specific objectives: (a) to achieve a high level of protection against disasters by preventing or reducing their potential effects, by fostering a culture of prevention and by improving cooperation between the civil protection and other relevant

[277] COM(2020) 220 final.
[278] Civil protection: Council adopts new rules to strengthen disaster response - Consilium (europa.eu).

services". Effective risk management is based on an understanding of risk; for this reason Member States are mandated under the UCPM legislation to conduct a national risk assessment every 3 years, followed by an assessment of risk management capabilities.

The revision of the UCPM legislation in 2019 includes a new obligation for Member States to report on prevention and preparedness measures, but focusing on key risks with cross-border impacts. Frequent modifications of investment programmes show that Member States still struggle with implementing viable projects in prevention and risk reduction and sometimes have to resort to just purchasing assets (usually fire trucks) to consume the remaining funds.

However, even though prevention is covered by the UCPM legislation, it is often not in the remit of national civil protection authorities. There is a need to involve a broader range of stakeholders beyond the civil protection remit, including also authorities responsible for climate change, finance and public budget, and spatial planning and land use for instance.

The direct stakeholders of the UCPM are civil protection authorities. As such, the legislation and policy framework has less influence over financial risk management of individuals and corporations. However, these issues are not ignored and have featured as part of the peer reviews of some countries and will also be partially covered under the reporting obligations under the existing UCPM legislation[279], where Member States are asked explicitly *"[…] to what extent disaster funds promote preventive action. Describe the funding sources used (e.g. national, sub-national, public, private, **including insurance**, EU and other international funding) to take priority measures in the field of disaster risk management"* (first reports submitted December 2020).

According to Article 6 of the UCPM, the Commission shall " *establish and regularly update a cross-sectoral overview and map of natural and man-made disaster risks the Union may face, by taking a coherent approach across different policy areas that may address or affect disaster prevention and taking due account of the likely impacts of climate change*". The third edition of the report "Overview of natural and man-made disaster risks the EU may face" was published in November 2020[280]. This report includes an analysis of the national risk assessments that were submitted in 2018.

6.5.4.3 **The Environmental Assessment legislative framework**

The Directives on Environmental Assessment contribute to the integration of environmental considerations into the preparation of projects, plans and programmes[281]. Projects and programmes co-financed by the EU, including some which may not be covered by the climate and sustainability proofing guidelines have to comply with the Environmental Impact

[279] Commission Notice Reporting Guidelines on Disaster Risk Management, Art. 6(1)d of Decision No 1313/2013/EU2019/C 428/07C/2019/8929.
[280] SWD(2020)330.
[281] Environmental assessment for public plans or programmes are undertaken on the basis of the SEA Directive and environmental assessment for individual projects, such as a dam, motorway, airport or factory are undertaken on the basis of the EIA Directive.

Assessment (EIA)[282] and Strategic Environmental Assessment (SEA) Directives[283] to receive approval for financial assistance. They are therefore crucial tools for sustainable development, in which due considerations for climate and environmental risks should be mainstreamed.

The SEA Directive has been in force since 2001 and should have been transposed by July 2004. It covers plans and programmes prepared or adopted by an authority (at national, regional or local level) and required by legislative, regulatory or administrative provisions. An SEA is inter alia mandatory for plans/programmes in the agriculture, forestry, fisheries, energy, industry, transport, waste/ water management, telecommunications, tourism, town & country planning or land use sector.

The EIA Directive applies to a wide range of defined public and private projects, which have may have significant effects on the environment. These projects are defined in its Annexes I and II. Projects listed in Annex I of the Directive always require an EIA (e.g. long-distance railway lines, motorways and express roads, airports with a basic runway length ≥ 2100 m, installations for the disposal of hazardous waste, installations for the disposal of non-hazardous waste > 100 tonnes/day, waste water treatment plants > 150.000 p.e.). For Projects listed in Annex II (e.g. railways, roads, urban development projects, flood-relief works) Member States have to determine if the project is to be made subject to an assessment because of its likely significant effects on the environment taking into account the relevant selection criteria set out in Annex III of the Directive.

The SEA procedure aims to assess a wide range of options but does not include reference to the consideration of climate or environmental risks as it focuses rather on understanding and minimising the impact on the environment of the concerned plans and programmes.

The EIA Directive provides for a need to assess direct and indirect significant effects of each project falling in its scope on climate (among other factors), without establishing a specific methodology. In addition, for projects subject to an EIA a description of the vulnerability of the project to climate change has to be provided.

6.5.4.4 **The EU Floods Directive**

The purpose of the Floods Directive 2007/60/EC (in force since 2007) is to establish a framework for the assessment and management of flood risks, aiming at reducing their adverse consequences for human health, the environment, cultural heritage and economic activity. The Floods Directive takes a three step, 6-yearly, cyclical approach to flood risk management by requiring Member States to (1) undertake preliminary flood risk assessments (PFRA) leading to the identification of areas that are at significant risk of flooding, known as areas of potential significant flood risk (APSFR); (2) prepare flood hazard and risk maps (FHRM) showing how far floods might extend, the depth or level of water and the impacts there might be on human health, the economy, environment and cultural heritage and, finally, (3) prepare Flood Risk Management Plans (FRMP)s.

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[282] Directive 2011/92/EU as amended by Directive 2014/52/EU.
[283] Directive 2001/42/EC 'Strategic Environmental Assessment' – SEA Directive.

The Court of Auditors published a report[284] (based on the survey of 31 projects in 9 countries) pointing out that climate change impacts on flash floods or coastal floods were not fully taken into account in Member States' flood models yet. Following this report, the European Council adopted Conclusions on 5 March 2019[285] which calls upon the Commission to "'*work together with the Member States to reinforce and/or develop appropriate tools that better analyse and forecast these impacts" [the impacts of climate change on floods]".*

The Fitness Check evaluation of the Floods Directive (and other water management related Directives, 10.12.2019 SWD(2019) 439 final) found that it is too early to draw conclusions on its performance, as its first implementation cycle only started in 2016 (after publication of the first ever FRMPs). The evaluation concluded that the Directive had improved flood risk management in the EU.

The Directive, due to its six-yearly cycles, takes a long-term perspective and promotes risk management policies of an iterative nature. It does therefore consider existing risk but does not directly aim to promote resilience investments by private or public actors[286]. It does not mandate specific reporting as to whether the funding of measures foreseen in the FRMPs is public or private nor encourages one particular source of funding over the other.

There is a clear requirement to consider the impacts of climate change in the Member States' PFRAs and FRMPs from the second cycle onwards. Whilst the Directive provides that FRMPs shall take into account relevant aspects to adaptation such as spatial planning and land use, this is however not understood as a hard requirement by Member States. Nevertheless, spatial planning and land use have been elevated in the agenda of EU flood risk managers and this development is supported by the Commission.

FRMPs are required to address all aspects of flood risk management, with a focus on prevention, protection and preparedness. Insurance is not mentioned in the Directive.

The Floods Directive does not cover or prioritise any particular choice of flood financial risk transfer solutions. These exist in various forms in several Member States and some Member States have mentioned these in their FRMPs. Insurance awareness has been rising amongst EU flood risk managers. The Commission encourages this trend.

The Court of Auditors' report mentioned above also recommended that the Member States and the European Commission raise the awareness of the benefits of flood insurance. It specifically tasks the Commission with checking, in its review of the 2nd FRMP cycle by 2024, whether Member States have planned action to a) raise public awareness of the benefits of insurance coverage against flood risks; and to b) increase coverage, e.g. via cooperation between the public and private sectors in relation to flood insurance.

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[284] European Court of Auditor's Special Report 25/2018.
[285] Council conclusions on European Court of Auditors' Special Report No 25/2018 entitled "Floods Directive: progress.
[286] It does so indirectly however by requiring the production of flood hazard and risk maps which show the extend and the depth of flooding.

Following this report, the European Council conclusions mentioned above recognised "the positive role that insurance could have in reinforcing preventive action and improving economic recovery in the wake of a disaster" and called upon "Member States to raise public awareness of the benefits of flood insurance and to explore cooperative measures between the public and private sectors to increase coverage".

6.5.4.5 **Renovation wave/National long-term renovation strategies**

A new Renovation Wave initiative for buildings was announced in the European Green Deal and adopted in October 2020. The building elements of the National Energy and Climate Plans (NECPs) and the national long-term building renovation strategies in line with the Energy Performance of Buildings Directive (2010/31/EU) are the starting point for the policy vision set out in the Communication.

Article 4 of the Energy Performance of Buildings Directive (EPBD) provides that Member States shall take the necessary measures to ensure that minimum energy performance requirements for new buildings and buildings undergoing major renovation are set with a view to achieving cost-optimal levels.

The Renovation Wave does not modify the Energy Performance of Buildings Directive (EPBD). Article 2a of the Energy Performance of Buildings Directive (EPBD) requires each Member State to establish a long-term renovation strategy to support the renovation of the national stock of residential and non- residential buildings, both public and private, into a highly energy efficient and decarbonised building stock by 2050, facilitating the cost-effective transformation of existing buildings into nearly zero- energy buildings.

In its long-term renovation strategy, each Member State shall set out a roadmap with measures and domestically established measurable progress indicators, indicative milestones for 2030, 2040 and 2050, and specify how they contribute to achieving the Union's energy efficiency targets in accordance with Directive 2012/27/EU.

The Renovation Wave will address the main barriers to building renovation and reinforce the pull factors for faster and deeper renovation. The action plan will consider legislative and non-legislative instruments and enabling tools, financing and non-financing aspects, and different levels of action (EU, national and local or regional).

Among other, the Renovation Wave initiative aims to:

- Ensure consistency with the broader principles of sustainability, and circular economy. For example, building renovation in contrast to demolition and new build – lower costs, embedded carbon and re-use of materials.
- Provide an evidence-based estimate of the expected wider benefits of renovating the EU building stock, e.g. health, safety and air quality, in line with the EPBD obligations on long-term renovations strategies.
- Assess how best to combine deep renovation efforts with waste management and circularity principles.
- Make a link to the removal of harmful substances such as asbestos.

- Address the main practical barriers to finance building on the lessons learnt from previous initiatives and projects, such as the Smart Finance for Smart Buildings initiative, and focusing on a more effective use of EU funding, including cohesion policy funds.
- Take into account good practices and stakeholder views.

With their national long-term renovation strategies Member States must support the mobilisation of investments for buildings renovation, and facilitate access to appropriate mechanisms for:

- the aggregation of smaller projects;
- the reduction of the perceived risk of energy efficiency operations for investors and the private sector;
- the more effective use of public funding to leverage additional private-sector investment and to address specific market failures;
- guiding investments into an energy efficient public building stock, in line with Eurostat guidance;
- develop accessible and transparent advisory tools, such as one-stop-shops for consumers and energy advisory services, on relevant energy efficiency renovations and financing instruments.

As energy efficiency expenditures are eligible under multiple EU programmes, climate adaptation aspects are dealt with under the regulatory framework of the respective funds. In the long-term renovation strategies, Member States may also address fire safety and risks related to intense seismic activity affecting energy efficiency renovations and the lifetime of buildings.