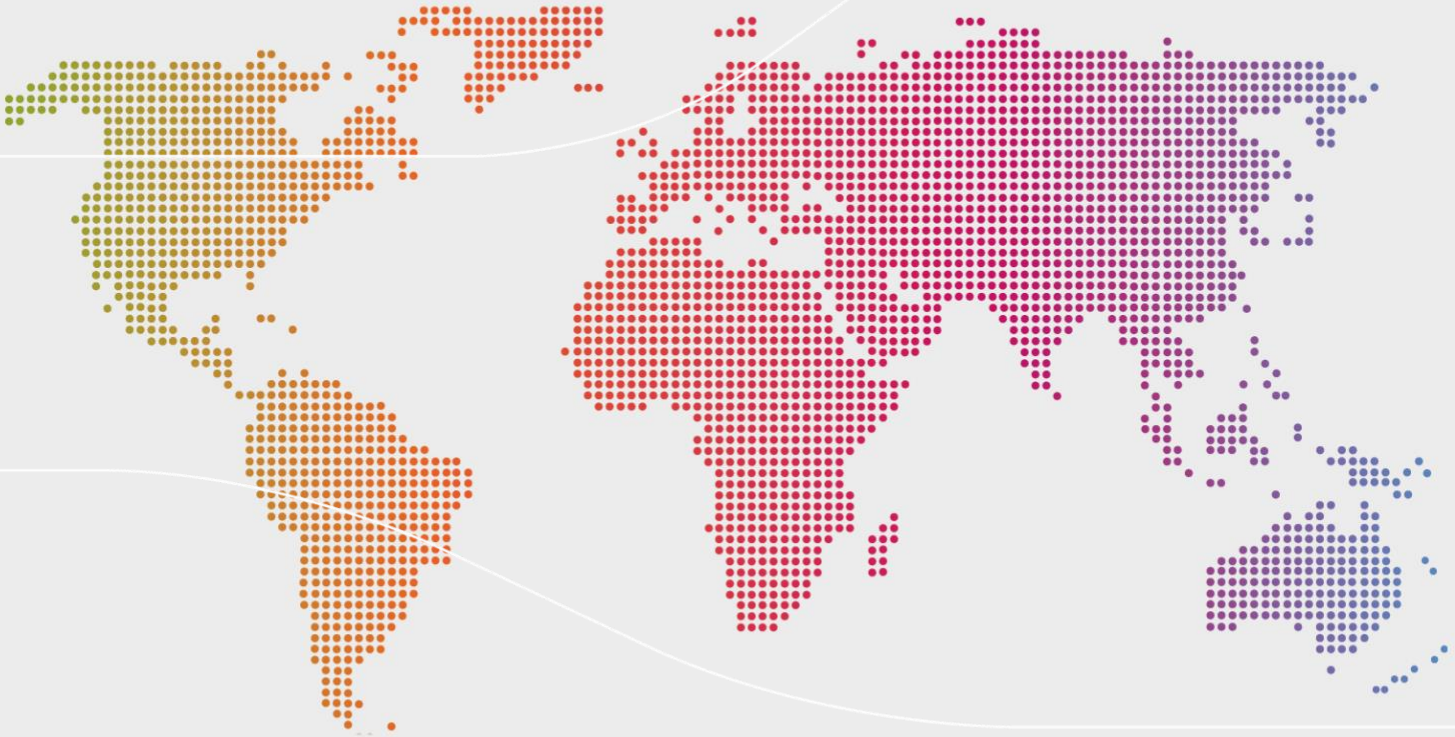
ClimateWise
Insuring a sustainable future



The coming deluge: Scenario analysis for underwriting in a changing climate

UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

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The University of Cambridge Institute for Sustainability Leadership partners with business and governments to develop leadership and solutions for a sustainable economy. We aim to achieve net zero, protect and restore nature, and build inclusive and resilient societies. For over three decades we have built the leadership capacity and capabilities of individuals and organisations, and created industry-leading collaborations, to catalyse change and accelerate the path to a sustainable economy. Our interdisciplinary research engagement builds the evidence base for practical action

ClimateWise

ClimateWise supports the insurance industry to better communicate, disclose and respond to the risks and opportunities associated with the climate-risk protection gap. This is the growing divide between total economic and insured losses attributed to climate change.

Representing a growing global network of leading insurance industry organisations, ClimateWise helps to align its members' expertise to directly support society as it responds to the risks and opportunities of climate change.

Authors and acknowledgements

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Executive summary

Recent market and regulatory activities in the UK and globally have highlighted the important role of scenario analysis for risk assessment and communication to regulators, investors and clients.[1,2] The key risk from climate change in Europe identified in the most recent IPCC scenarios is 'to people, economics and infrastructure due to coastal and inland flooding'.[3] Scenario analysis by insurers of the wider impact from flooding as well as the estimated losses for individuals, businesses and communities provides valuable insights for risk management, mitigation and adaptation by insurers themselves, but also for policy makers and society at large.

This white paper considers the options, implications and communication of scenario analysis for underwriting non-life insurance. It raises awareness of different natural catastrophe modelling approaches and highlights the valuable insights that can be generated across the insurance business. This further shows the unique opportunity for business and society to engage with such analysis and better understand the benefit of managing physical risks in a changing climate. As an example, we present the outputs of UK flooding from two different multi-flood-type quantification approaches. The methodology used/explored by Ambiental Risk Analytics (Ambiental) is deterministic, meaning the output of the model is determined by the parameter and initial values, while JBA Risk Management (JBA) uses a probabilistic (or stochastic) methodology, which incorporates randomness. Scenario analysis by Ambiental and JBA shows the variation of results for the impact of climate change on UK flood risk and losses (Figure 1).

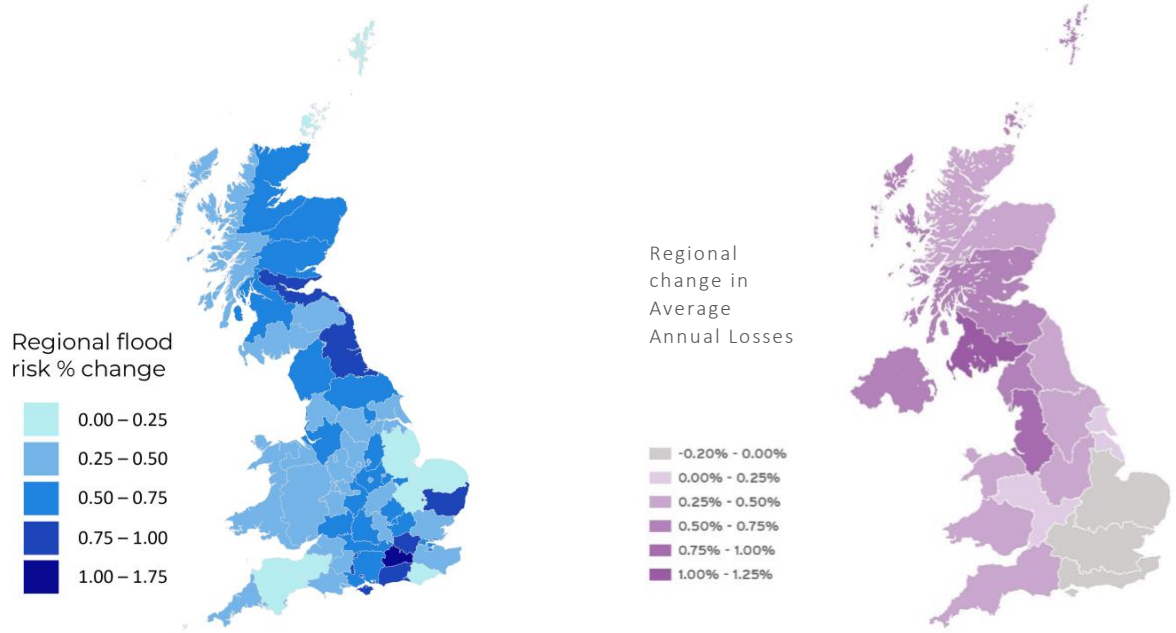


Figure 1 Left Ambiental's percentage change in regional flood risk (2060 2°C scenario) and right JBA's change in regional flood average annual losses (2040 2.2°C scenario) when compared with present day estimates.

Given the data available, modelling expertise and regulatory momentum for scenario analysis in the UK, this white paper focuses on flooding to demonstrate impacts of climate change on one peril. The recommendations are then drawn more widely to reflect the ClimateWise membership, the insurance industry and its global scope and remit. The paper aims to explain how we use climate-conditioned catastrophe models to undertake scenario analysis. Using this methodology, we can understand how climate risk propagates through different areas of the insurance underwriting process and the relevant considerations and implications for insurance firms, the insurance industry and society.

Following this research, we make recommendations on how to progress scenario analysis in underwriting for broader use.

For scenario analysis in insurance underwriting:

- When undertaking scenario analysis and using the output of climate-conditioned catastrophe modelling, **outlining what the outputs represent and communicating limitations transparently are of equal importance** to avoid misinterpretation in decision-making.
- As primary hazards can trigger secondary physical ramifications, **these climatic interdependencies and their associated correlations need to be integrated into scenario analysis**. This makes it easier for the relevant stakeholders to understand accumulated and aggregated risks, which means they can be managed more effectively.

For the insurance industry and society:

- **Insurers need to undertake scenario analysis to understand their role in helping develop viable insurance markets in the long term,** so they can strategically assess their business models and manage risk.
- **The insurance industry needs to assess how risk is passed on (or retained) by different industry actors.** It also needs to co-ordinate actions so that nations and regions highly exposed to flood risk can remain financially resilient, while also managing flood risk more effectively.
- **An insurance sector cannot retain its resilience and relevance if its data and products are out of step with the real world.** A predictive data-driven warning system focused on mitigating and adapting to the risk rather than (ex post) risk transfers might be a preferable approach from a long-term societal perspective.

For scenario improvement:

- **A cross-disciplinary and evidence-based approach is necessary to manage flood risk,** which is a complex challenge with profound effects on individuals, businesses, communities and the economy. Taking this approach could help manage flood risk to tolerable levels in economically viable, sustainable and socially acceptable ways.
- **It is critical for scenario planners to consider the interconnectivity of risks and the challenges to possible futures so they can set priorities for investing in resilience.** The likely scenarios described by the Intergovernmental Panel on Climate Change (IPCC) or others can be used to develop a storyline approach for assessing the impact of different climate projections.[4]

- Insurers should be mindful of how they use scenarios, including the timeliness, completeness and accuracy of data they draw on in developing their scenarios or the standard scenarios they draw on, given that climate science itself is a dynamic and developing field. Although scenario analysis itself is not a new management analysis tool, many organisations are yet to use scenario analysis effectively, as evidenced by the Task Force on Climate-related Financial Disclosures' (TCFD) Status reports[5].

ClimateWise members are committed to understanding and managing the physical impacts of climate change within their own business as well as promoting wider financial sector, policy and societal resilience to climate change. Our further research will build on this white paper with a project focused on the definition and modelling of secondary perils, being both secondary events of primary perils and non-peak perils. Additional research will also examine wider elements of the risk equation, particularly scenario insights from the individual property and portfolio's exposure and vulnerability to a hazard, to enable insurers to understand and provide more detailed guidance on adaptation measures to planners, developers and infrastructure managers and owners.

1. Introduction

The IPCC assesses climate change impacts and risks as well as adaptation measures across the globe. Recognising the interdependence of climate, ecosystems and biodiversity, the IPCC notes that for Europe, the current 1.1°C warmer world is already affecting natural and human systems with losses and damages to people, ecosystems, food systems, infrastructure, energy and water availability, public health, and the economy.[3]

The insurance industry and the society they underwrite depend on an accurate understanding of the possible future risks to manage and prepare for climate change. In addition to their action on climate mitigation, insurers have significant opportunities to support climate resilience across the broader financial markets through three distinct areas of activity:[6]

1. Considering resilience within insurers' own operational, underwriting and investment activities,
2. Promoting resilience indirectly across the broader financial markets; and
3. Promoting societal resilience to climate risk in general.

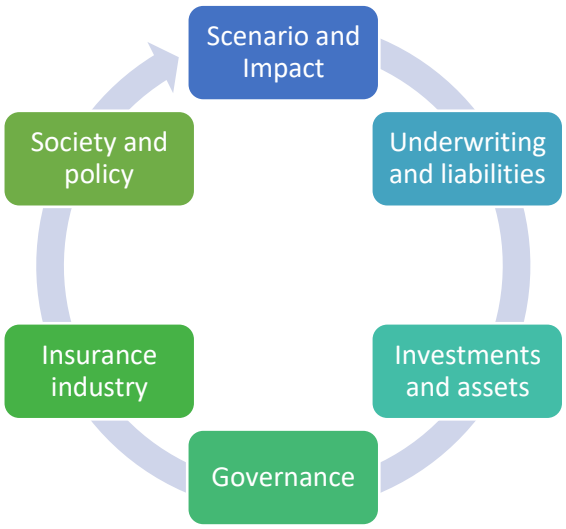
Climate risk scenarios inherently suggest a future-focused posture for an organisation: a posture that asks how the organisation may be impacted by climate risk, but also asks what kind of world a given organisation is co-creating with its business activities. For insurers, this strategic question is tightly linked to risk appetite as, in essence, what is underwritten is tacitly approved and enabled.

Scenario analysis is a key mechanism for the insurance industry to understand climate change, integrate mitigation and adaptation into their business and inform the wider customer and policy response to climate change. Scenario development starts with the purpose and audience of the analysis - from a one-time activity for strategy development or an ongoing learning activity or for regulatory reporting. The scenario scope can be either broad or narrow in geography, time and outputs. Providing the right guiderails to a scenario and understanding its limitations enable the insights drawn to be presented and acted upon.

Current frameworks are available to assist the development of a climate scenario by the insurance industry. The ClimateWise Physical risk framework outlines steps to incorporate climate change into natural catastrophe models of the insurance industry and applies this to infrastructure assets.[7] The Geneva Association's *Climate Change Risk Assessment for the Insurance Industry* is noteworthy for the holistic approach to transition and physical climate risk over the short, medium and long term, giving key considerations for both sides of the balance sheet.[8] The Cambridge Centre for Risk Studies' *Developing Scenarios for the Insurance Industry* provides details on steps for an insurance firm to develop a scenario.[9] The UN Principle for Sustainable Insurance's *Insuring the climate transition* links scenario development to TCFD -aligned reporting.[10]

This report builds on the generalised frameworks available by working through a specific example of scenario outputs and how these then impact the insurer, insurance industry and society. Research on UK flooding to date has provided a strong background context[11] and example segments of the market such as new housing developments.[12] We built on earlier work by collaborating with private modelling companies and insurance industry members to give specific examples of implications for insurance firms and wider industry.

The report follows a guiding logic or sequence, setting the scene with a climate scenario of a single peril (UK flood) to investigate the impact of climate change on an insurance company, the insurance industry overall and society in the following steps.



- Defining the scenario (Chapter 2): the output from a hypothetical insurance portfolio is presented from two different data modelling vendors, Ambiental and JBA. Building on the assessment of the impact of climate change on the hazard, further scenario analysis could give insights to the exposure and vulnerability of properties within the insurance portfolio, to highlight the benefits of mitigation and adaptation measures.
- Physical impacts (Chapter 3): the impacts are outlined to broaden the analysis to secondary effects of primary perils, which are often not captured in the models but require a scenario expansion exercise. The insurance industry needs to model secondary events, non-peak perils and climatic dependencies using sophisticated statistical methodologies to manage the aggregation and accumulation of risk more effectively.
- Underwriting and liability impacts (Chapter 4): the impact on underwriting and liabilities is addressed through claims, looking at how quickly the insurance industry would reprice risk while being aware of the "new norm" versus a cyclical increase in claims (i.e. human induced climate trend impacts on losses versus natural climate variability influencing losses). Additionally, the report looks at how quickly flood models should be revised and at new dynamic flood maps. It goes on to investigate how price increases are passed on to customers or reinsurers, to understand whether other firms react as quickly to re-price the risk and whether they would choose not to reprice to keep that business on their books.
- Investment and asset impacts (Chapter 5): the report considers which assets and companies might be most affected, such as government bonds due to increased debt to fund retreat, adaptation and migration. The wider industry impacts are considered, particularly focusing on the implications for data

and modelling for reserving and premium pricing. The report extends the analysis to the solvency implications for insurers.

- Governance of insurance (Chapter 6): how the insurance industry, and firms operating within it, can think about industry leadership in managing these risks. The governance and leadership of insurance firms is particularly important as it defines the role and strategy of insurance in building resilience in our society.
- Insurance industry implications (Chapter 7): the impact is considered at a macro level, highlighting how scenario analysis provides an opportunity for the industry to revisit their product offerings and envision how these might change. It allows insurers to investigate whether there are markets, products or policies they will want to review and monitor regularly. Another consideration that is highlighted, is what would happen if all insurers retreated from these products and the implications this might have on the insurability of invested physical assets, leading to lack of insurance coverage and potentially financing, creating stranded assets for companies slow to adapt.

- Societal impacts (Chapter 8): the report looks at assessing societal change and the impact climate risk has on broader society, answering questions such as whether the government will step in to defend all – or some – coastal towns, how those decisions might be made in terms of resource allocation and what impact that would have on the creation of further pockets of uninsurable risks arising under a given time horizon. Finally, it considers potential coastal defence strategies and the impact on society as a whole, such as the need for managed retreat from certain areas.

The ClimateWise Principles provide a foundational framework for a robust insurance industry response to climate change.[13] Scenario analysis is utilised across the Principles as it guides firms' governance, strategy, risk management and metrics and targets, as well as engagement with customers and policy makers. In break out boxes throughout the report, where discussion cross references the ClimateWise Principles Independent Review, we will mention the relevant Principles and specific member reports for further details and examples of insurance industry use of scenario analysis in practice.

This report was developed and drafted by a task group of the ClimateWise membership with additional input from consultation with a broad range of stakeholders across insurance industry firms and academics. The concept for the report evolved over a series of meetings with the task group which explored industry expertise and potential barriers to effective scenario analysis for physical risks and the implications to the insurance industry.

2. Defining the scenario

In this section we define a scenario and give a view of how it is modelled and therefore how it can be used for the purposes of scenario analysis. As an illustrative example for this report, we focus on the UK and look at flood risk as a primary peril, defined as pluvial (rainfall, surface water), fluvial (river flow) and coastal (surge) flooding. This also includes the impacts from sea level rise, resulting in secondary event or additional climate risk considerations (refer to Report terminology section for definition of key terms). The UK is chosen due to availability of both the data and modelling tools to provide illustrative results and the regulatory use of scenario analysis in stress testing exercises.

ClimateWise Principles and industry examples of risks analysis

The ClimateWise Principles provide a foundational framework for a robust insurance industry response to climate change.[12] Throughout the report, break out boxes explain the relevant Principles and examples of insurance industry use of scenario analysis in practice. ClimateWise Principle 3 is to lead in the identification, understanding and management of climate risk.[13] ClimateWise members commonly have working groups to bring together the expertise across the business in identifying and assessing risks as well as conducting or commissioning research. This includes research on integrating physical and transition risks assessments and temperature score methodologies for underwriting portfolios.

'Flood Re's Transition Team commissioned research that analysed over 700 insurance claims for flooding over six years to understand the key factors that influence the cost and duration of flood damage claims. The work aims to establish an evidence-based approach to broader take-up of resilience measures. As with the 2019 Bank of England's General Insurance Stress Test (GIST), the Flood Re ORSA Report containing the results of the scenario analysis has been shared with a range of stakeholders, including the PRA and rating agencies. A summary of the ORSA stress and scenario testing is included in Flood Re's Solvency and Financial Conditions Reports and has been made publicly available.'[13]

Quantification approaches and methodology

As our atmosphere warms, its capacity to hold water vapour increases, by the rate of ~7 per cent per degree Celsius (°C). Due to the atmosphere carrying more water, there is increased risk of flooding in certain regions of the world due to climate change, particularly the UK. The temperature rise due to climate change is discussed in reference to the IPCC Representative Concentration Pathway (RCP) of Figure 2 below.

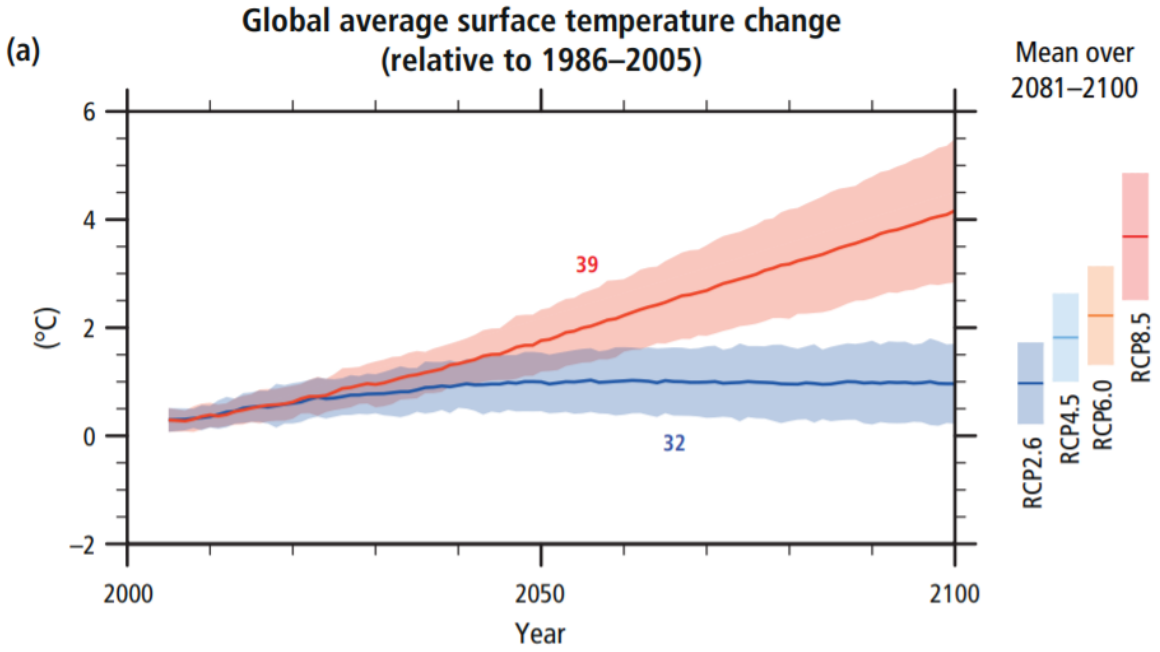


Figure 2: Global average surface temperature change from 2006 to 2100 as determined by multi-model simulations. All changes are relative to 1986–2005. Time series of projections and a measure of uncertainty (shading) are shown for scenarios RCP2.6 (blue) and RCP8.5 (red). The mean and associated uncertainties averaged over 2081–2100 are given for all RCP scenarios as coloured vertical bars at the right hand side of each panel. The number of Coupled Model Intercomparison Project Phase 5 (CMIP5) models used to calculate the multi-model mean is indicated.[14]

Several analytical approaches are available when quantifying the impact of climate change on precipitation and flooding, and the consequences for an insurance portfolio. The most common currently employed within the insurance industry is the use of catastrophe modelling capabilities to undertake scenario analysis. This requires the assumptions underlying the scenario to be defined, which is considered a 'climate change stress test' under a consistent climate change scenario. We have increasingly seen catastrophe models being conditioned or updated to incorporate forward looking climate model inputs, to simulate future, not just present, loss scenarios.[15]

The IPCC sets high to very high confidence on elements or summaries of climate scenarios, however other aspects continue to have low certainty - these include tipping points, the risk exposure and mitigation measures taken. Therefore, the outputs used in these forms of scenario analysis require the limitations and uncertainties to be indicated so that the output is not misinterpreted. Scenarios can take many forms; they are projections based on a variety of assumptions following a 'what-if' modelling approach, which can be exploratory or normative, providing a stress test view.

Approaches used in the study

For this study, we used the outputs of two multi-flood-type quantification approaches from two leading vendors, whose approaches are slightly different. The Ambiental methodology is deterministic, meaning the output of the model is determined by the parameter and initial values, while JBA uses a probabilistic (or stochastic) methodology which contains a probabilistic event set consisting of hundreds of thousands of simulated events. It is important to mention that both methodologies are based on a projected warming scenario, developed using government-led climate change assumptions.[Error! Bookmark not defined.] These models

do not consider mitigation measures. Therefore, to avoid misinterpretation, we encourage practitioners using the output of these models to inform decision-making always to seek a full understanding of what the output means (and considers), and the associated limitations.

Catastrophe modelling begins with the generation of a stochastic event set, which is a database of scenario events. Each event is defined by a specific strength or size, location or path, and probability of occurring or event rate. Thousands of possible event scenarios are simulated based on realistic parameters and historical data to probabilistically model what could happen over time. The Geneva Association's report *Flood Risk Management in England: Building flood resilience in a changing climate* provides additional details on drivers of UK flooding and flood risk management.[11]

Ambiental Risk Analytics model

Ambiental's predictive climate change model, FloodFutures, is a deterministic hazard mapping tool that shows how a 1 in 100-year return period flood event will change in the future under a range of scenarios. Sea level rise for the present day and three future points (2020s, 2050s and 2080s) under three climate change scenarios (Low, Medium and High emissions as defined below) are presented using geospatial hazard layers representing flooding depths and extents are provided for all major flood sources (fluvial, pluvial and tidal).

FloodFutures was built using Ambiental's proprietary modelling software to simulate flooding for all climate change scenarios at five-metre cell resolution across Great Britain. The software uses a 2-dimensional hydraulic modelling solver (shallow water wave) to model the flow of water over land and has been highly optimised for national scale applications. It can accurately handle high-density urban environments and is parameterised to account for drainage, ground roughness and infiltration. FloodFutures represents an undefended scenario, providing a worst-case flood hazard narrative that is independent of current or future flood defence infrastructure decisions.

Climate change adjustments were derived from a combination of direct climate model outputs (such as UK Climate Projections (UKCP09/18)[16]) and government policy (derived from climate science) such as from UK Water Industry Research (UKWIR) and the Environment Agency. The 'Low Emissions' scenarios are based on the 10th percentile of IPCC Representative Concentration Pathway (RCP) 4.5 and anticipated temperature rise of 1.5°C as per Figure 1 above.[14] The 'Medium Emissions' scenario is based on the 50th percentile of RCP 6.0 and temperature rise of 2.2°C and the 'High Emissions' scenario is based on the 90th percentile of RCP 8.5 and temperature rise of 4°C. Adjustments for each scenario were applied to the input peak flows, rainfall intensities, storm surge and tidal levels of flood simulations.

Figure 3. Extract of Ambiental's FloodFutures in Bristol showing pluvial flooding in the 2080s under the High Emissions scenarios

JBA Risk Management model

JBA's UK Climate Change Flood Model was their first probabilistic climate change model developed for the UK. The model is market-leading with a ground elevation resolution of five metres and reflects potential UK flooding by the end of 2040 under a realistic 2°C warming scenario. The model considers fluvial, pluvial and coastal flood risk and was developed using peer-reviewed climate change adjustments to rainfall amounts, river flows and sea levels. In particular, UKCP09 data was used to incorporate projected changes in UK rainfall, while the UK Climate Change Risk Assessment (CCRA) 2017 allowances, provided peak river flows and relative sea level rise.[17] These allowances were used to adjust the frequency distribution of event severities in the UK Flood Event Set for implementation within the climate change model. Overall, the model suggests that flooding under this warming scenario increases, with higher return periods having larger increases than lower return periods.

UKCP09 is a set of climate projections released by the UK government and was developed by over 30 contributing organisations. It features the most comprehensive climate projections ever produced for the

UK, with the projections having been used in several studies, including the underlying data in Environment Agency research and the UK CCRA 2017. In addition, UKCP09 is used by local authorities for planning purposes to assess risk in the utilities, construction and environmental/civil engineering sectors.

Hypothetical insurance portfolio

A hypothetical portfolio with insurance risks has been created across the study region for the purpose of this analysis. The aim is not to quantify climate change but rather to show the scenario analysis process and how it might be used in an analytical framework. Our research focuses on the hazard within the risk equation, additional research on wider elements, particularly the individual property and portfolio's exposure and vulnerability to the hazard, would enable insurers to further understand and provide more detailed guidance on adaptation measures.

The portfolio includes residential and commercial policies with risks defined at the centre of each UK full postcode level. Total insurable values (TIV) were calculated as a proxy from population count in each postcode.[18] Proxy assumptions do not vary by region, thus, two postcodes with the same population count in any region around the UK will see the same exposure values. The hypothetical portfolio contains approximately 1.8 million locations for each class of business.

The other important assumption of this hypothetical portfolio is that we are using the last UK Census from 2011. Therefore, the resulting exposures are not a reflection of what the exposures will be by 2040, 2050 or 2100 where demographic changes due to climate change (sea level rise in particular) will likely affect the relative inter and intra-regional distributions.

A summary describing the relative weights of exposures by region can be seen in Table 1 below. The difference across regions is driven by population count and postcode boundaries.

REGION	AGGREGATE EXPOSURES (% OF TOTAL)		
	RESIDENTIAL	COMMERCIAL	COMBINED
All Regions	100%	100%	100%
Southeast	36%	42%	38%
Southwest	9%	8%	8%
Midlands & Wales	21%	19%	20%
North	23%	22%	23%
Scotland	8%	8%	8%
Northern Ireland	3%	2%	3%

Table 1: The hypothetical portfolio exposure distribution for Ambiental and JBA modelling

Results

The hypothetical insurance portfolio outlined above was fed into the Ambiental and JBA models to estimate the impact of climate change. For each of the vendors, the portfolio was analysed twice. The first

was under their UK Flood Model with current climate conditions; the second was under the same version of the tool with climate change conditions.

Ambiental Risk Analytics results

Ambiental's future flood risk data has been compared to the present-day view of flood risk to produce a map displaying regional percentage change and a chart to display how wider regions are likely to be affected by flood risk across four time periods under one emissions scenario. Ambiental's data reports several emissions scenarios, in the case of Figure 4, analysis was performed on RCP 6.0 or 2.2°C scenario.

Figure 5 shows the percentage change of regional flood risk when the present-day risk is compared to the modelled 2060 risk relating to the RCP 6.0 or 2.2°C warming scenario. The map shows an overall increase in the amount of flood risk at a regional scale with the highest increase being seen in the South East of England. Additionally, Central Scotland and North East England feature an increase in regional flood risk when compared to the rest of the country, this is likely due to potential for increasingly intense rainfall events and the presence of urban settlements.

Figure 5 displays the wider regions relative flood risk score (0 – 100) for four time periods: the present day, the 2030s, the 2060s and the 2090s. The trend shows all regions increasing in flood risk with Greater London featuring the greatest increase in flood risk relative to the present day. The increase in London is partly explained by the larger density of properties and an increase in the intensity of pluvial flood events.

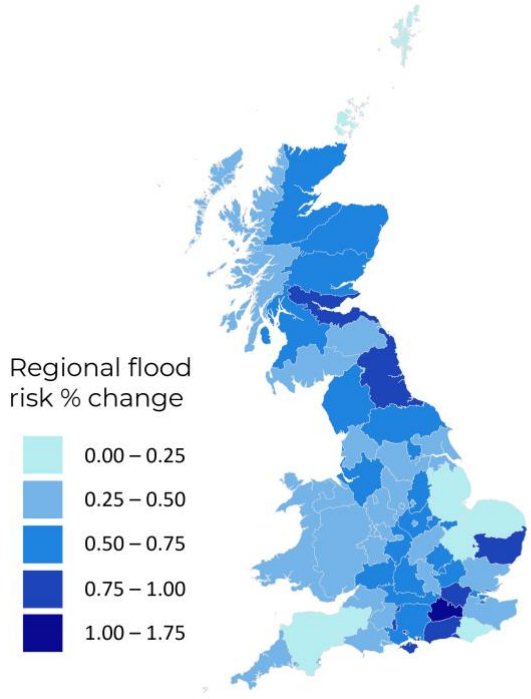


Figure 4. Percentage change in the 2060 RCP 6.0 (2.2°C scenario) regional flood risk when compared to Ambiental's present-day flood risk data

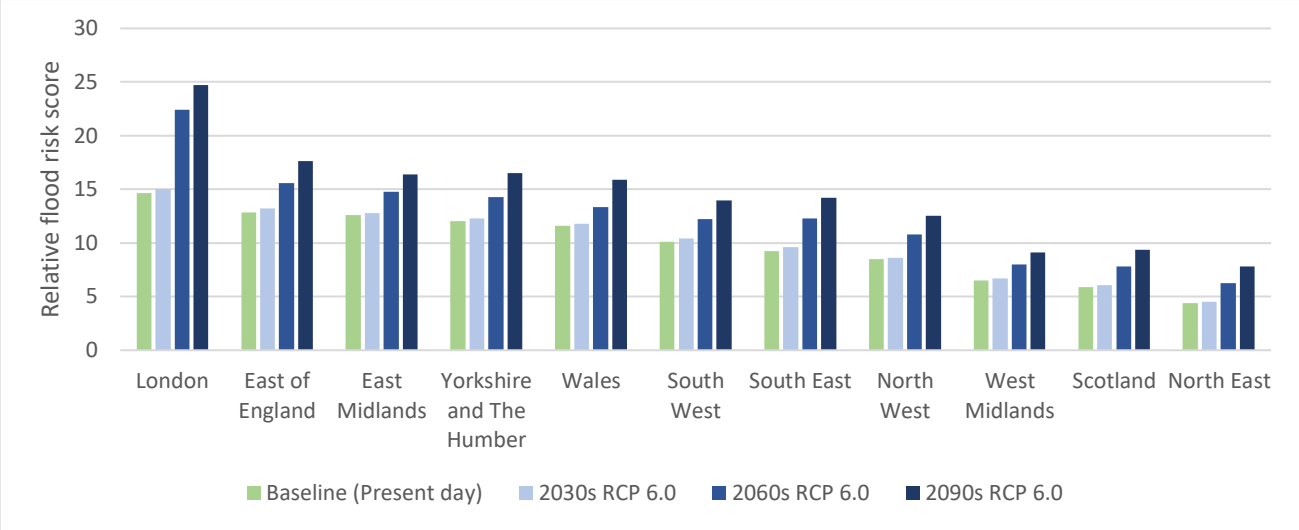


Figure 5. Regional change in relative flood risk for all flood sources, comparing four time points for RCP 6.0 (2.2C scenario)

JBA Risk Management results

Regional Average Annual Losses (AAL) produced by JBA's UK Flood Model and UK Climate Change Flood Model are presented together to enable direct comparisons between the baseline and 2°C warming scenarios. The regional ratios of AAL to Total Insured Value (TIV) across both scenarios reveal the ranking of regions by AAL as a proportion of total UK insured value.

The maps in Figure 6 both show the London and Home Counties region as producing the largest AALs for the baseline (£158 million AAL, 0.0020 per cent AAL ratio of TIV) and 2°C warming scenario (£149 million AAL, 0.0019 per cent AAL ratio of TIV). This is, however, a 5 per cent decrease in AAL. The region with the greatest increase in AAL is southern Scotland with an increase of 105 per cent, followed closely by north-west England with an increase of 97 per cent.

Overall, the UK displays a trend where the most significant flood loss increases between the baseline and 2°C warming scenarios are expected to occur in the North West, while the South East experiences negligible to small decreases in flood loss. As Figure 7 highlights, the differential pattern of change observed in the AAL to flood is consistent with the future climate change projections of rainfall in the UK – a pattern that foresees wetter winters in the North West and dryer/warmer summers in the South East regions. The lower overall AAL under a future climate is accounted for by the higher concentration of exposure in the more heavily populated London and the South East.

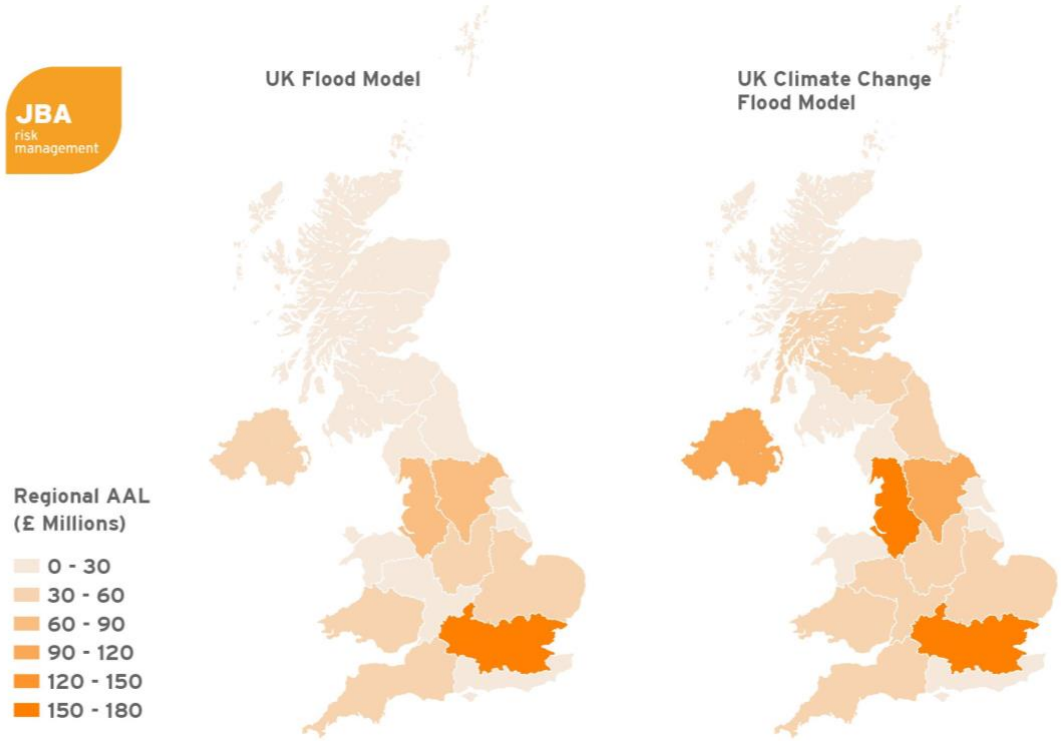


Figure 6 (left) UK Flood Model regional Average Annual Loss (AAL) (right) UK Climate Change Flood Model regional AAL (2°C scenario).

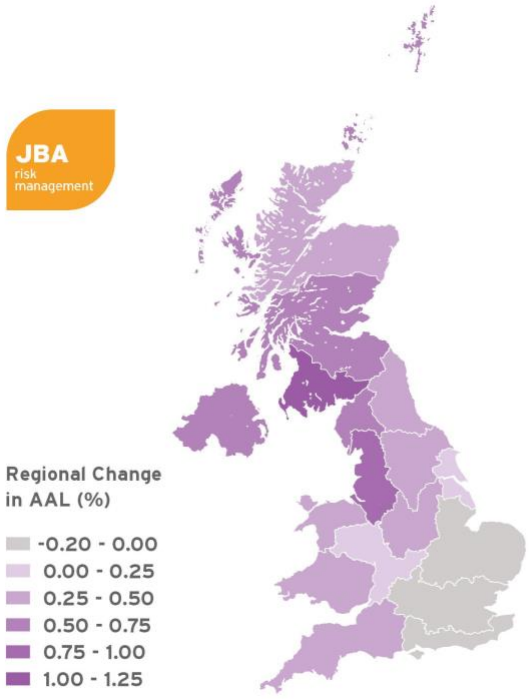


Figure 7: Regional change in flood AAL based on results from the UK Flood Model and UK Climate Change Flood Model

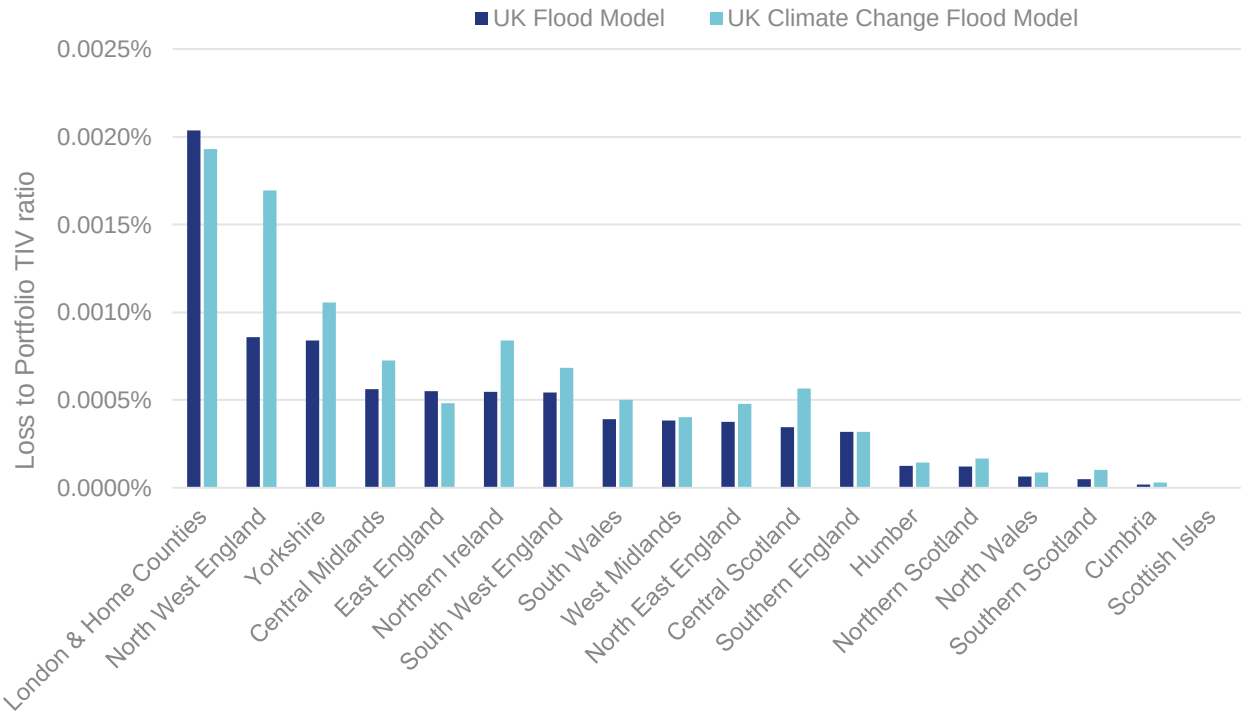


Figure 8: UK Flood Model and UK Climate Change Flood Model regional average annual loss for all flood sources as a proportion of the portfolio Total Insured Value (TIV).

The following sections outline how the information from the scenario analysis gives insights to the specific impacts on a firm and the insurance industry.

3. Physical impacts

The previous section looks at how flooding events are modelled and how we understand these risks change in a warming climate. This scenario is from the perspective of a primary disaster peril but can have indirect, secondary physical ramifications (secondary events) such as hurricane-induced flooding (refer to Report terminology section for definition of these and other key terms). Recently, secondary perils are starting to also refer to independent events that generate small to mid-sized losses, such as coastal flooding (non-peak perils). These secondary hazard impacts and non-peak perils are exacerbated by climate change and have the potential to drive insurance losses in certain regions, for certain hazard perils. Models are often unable to capture the correlation between these hazard interlinkages in different region/peril combinations.

ClimateWise Principles and industry examples

ClimateWise Principle 4 focuses on how an insurer uses their operations to support mitigation and adaptation in preventing the worst impacts of climate change.[13]Error! Bookmark not defined. ClimateWise members commonly have sustainable procurement policies, track their GHG emissions with targets for reduction and engaging with employees to play their own part.

'Some [members] are requiring suppliers to align with sustainability standards such as the UN Global Compact (including Munich Re and Swiss Re); others, such as Allianz, are also developing bespoke in-house procurement standards that include carbon footprint data. Allianz's carbon footprint data requirement is integrated in the screening progress alongside questions related to environmental management.'[13]

Accumulation and aggregation risk

The accumulation of losses from secondary and non-peak perils accounted for more than 50 per cent of insured losses between 2016 and 2020.[19] This means that the insurance industry needs to model secondary perils, non-peak perils and climatic dependencies using sophisticated statistical methodologies to manage the aggregation and accumulation of risk more effectively. Accumulation and aggregation risk refers to the potential loss exposure of one event spreading to multiple lines of business and to an insurer's portfolio or to a large number of claims being generated by the same (or related) risk by an event or in a specified contract period. In this case, the dependency between primary and secondary perils, and potentially increased correlation among the losses, are a driver for further concern. These interdependencies may change in a warmer climate.

Impact across the global economy

Australia suffers the most significant secondary effect and non-peak peril losses, even beyond the United States, where roughly 75 per cent of aggregate losses in recent decades have come from severe convective storms, inland flooding, bushfires and extra-tropical cyclones. The 1999 Sydney hailstorms remain as Australia's most expensive event for the insurance industry. The southern hemisphere summer

of 2019–20 resulted in the costliest bushfire season in Australia's history after 25 million acres of land, equal to 8 per cent of the country's total vegetation, were damaged. This shows that even if the risk is considered as secondary, there are regions of strategic priority when managing climate risk associated with these perils.

Another example is when Hurricane Harvey hit Texas. It was not the wind damage that drove losses (for which more homeowners were insured) but the secondary effect flooding, for which more than 70 per cent of homeowners were not insured. This is another reason why scenario analysis needs to take these correlated primary and secondary impacts into account, going beyond traditional catastrophe modelling outputs, so that it can inform decision-makers.

Climate hazard interlinkages

Different hazard groups such as geophysical, hydrological, shallow earth processes, atmospheric and biophysical can have different primary and secondary impact linkages. Primary hazards that have the highest influence over the greatest number of secondary hazards are geophysical hazards (volcanic eruptions and earthquakes). The two highest ranking natural hazards influenced by primary perils are forest fires and avalanches. Landslide, volcanic eruptions and floods are the secondary effect peril or events with the closest link to primary perils. Geophysical and atmospheric hazards are the predominant triggers of other hazardous phenomena. Geophysical and hydrological hazards, and shallow earth processes are identified as being the most triggered.[19]

The existence of hazard interactions needs to be acknowledged when undertaking scenario analysis. However, we also need to know the extent to which each secondary events can be forecast, for which spatial location, timing and the magnitude of the hazard are important factors. For example, a place where subsidence (a sudden sinking or gradual downward setting of the ground surface with little or no horizontal motion) can be 'forecast' and give information about locations with an increased susceptibility to flooding; the location, timing and magnitude of an earthquake's epicentre can estimate the likely path and speed of a tsunami. The relationship between these primary and secondary hazards can help us plan and forecast (through different probabilistic scenarios) how the secondary impact might play out.

Other conditions can impact the likelihood of a secondary hazard occurring, consisting of a spatial overlap of each hazard combination and the temporal likelihood (where the spatial overlap occurs) of all necessary environmental conditions coinciding for the secondary hazard to occur. This is another criterion which should be considered when conducting scenario analysis and investigating the secondary impacts to understand how this might influence strategic action.

As primary hazards can trigger secondary impacts, these climatic interdependencies, and their associated correlations, need to be integrated into scenario analysis. The models in section 2 above include this by integrating fluvial, pluvial and tidal flooding. This makes it easier for the relevant stakeholders to understand accumulation and aggregation risks, which means they can be managed more effectively.

4. Underwriting and liabilities

In this section we highlight the implications for underwriting of the changes in flood risk associated with scenarios and hazard linkages outlined earlier. Changes in flood risk naturally do not impact the UK housing stock uniformly: for example, flood risk will rise most in areas that are already experiencing it. Images of flooded towns will increasingly become the norm if we fail to mitigate and adapt. Many coastal communities are already dealing with impacts of flooding. For instance, Boston (in Lincolnshire, England) is spending £100 million building a new tidal defence (for an extra 1.5 metres of sea level rise) but smaller towns are unlikely to see equivalent spending. [20] Local and national government will not be able to fund flood defences everywhere. At some point the cost of building ever greater defences outweighs the cost and/or value of an area being defended. Fairbourne in Wales has already been earmarked as the first community in the UK to retreat inland and the town has been effectively given back to the sea (see box overleaf).[21]

ClimateWise Principles and industry examples

ClimateWise Principle 2 focuses on incorporating climate-related issues into business and investment strategies, covering evaluation, measurement and disclosure of the implications of climate change for business performance and key stakeholders, as well as the incorporation of these material outcomes into business decision making.[13]
ClimateWise members are developing ways to manage climate risk identified through scenario analysis by adapting underwriting, pricing or reinsurance strategies.

'Zurich undertook a comprehensive analysis of its business performance to understand the implications of climate-related risks on its strategy in line with the TCFD framework. Zurich has outlined the potential impact of climate change across both physical and transition risks on the investment and insurance sides of the business and developed a clear business strategy to target resilience to climate change and decarbonisation. For example, Zurich is targeting net zero GHG emissions from its investment portfolio by 2050.

Tokio Marine Kiln has evaluated each risk category identified within climate risks (Physical, Transition, Reputational, Strategic and Litigation) and assessed the materiality of each risk across the business planning horizon and for the longer term. Tokio Marine Kiln has considered the potential impact of physical and transition risks that are likely to affect the investment portfolio and has approved an investment asset allocation strategy as a result.'[13]

To address gaps within insurance coverage, governments have already taken active steps such as establishing of UK's Flood Re. Flood Re is a reinsurance scheme that makes flood coverage more widely available and affordable as part of UK home insurance,[22] helping households at the highest risk of flooding. Flood Re also provides information about taking action to reduce flood risk to incentivise adaptation. However, in the UK Flood Re is due to end in 2039, precisely when it may be needed most.

CASE STUDY: FAIRBOURNE

Fairbourne, a village in northern Wales, is facing serious challenges due to climate change. By the 2050s sea defences will no longer be maintained, and the local council is advocating that people will need to move out long before that. Since 2013, several public bodies and other partner agencies have been working with the local community to identify how the village can be sustained and the flood and storm risks it faces managed up to 2054. A few years ago, Fairbourne completed a £6.8 million scheme to help protect the village but defending Fairbourne is a constant challenge. The council is working against nature to try to reduce the risks at a time when the climate is changing and sea levels are rising.

Uneven claims will increase

A pattern emerges of some regions being less impacted and others more so. The impact and recovery of society to natural disaster reflects the individual, business and government preparedness and response.[15] This variety of impacts has created increased uncertainty for insurers and their business models, particularly in their pricing and management of flood risk into the future.

Flood damage will rise in many areas due to the increased frequency of flooding, but also its increased severity. For direct property insurance, more frequent and extreme flooding events mean not only a higher volume of claims, but also the potential for more costly claims. There is also the potential for more claims related to a single large and severe flood.

While Excess of Loss reinsurance will help in the most severe cases, reinsurers themselves are not blind to the impact of climate change and will naturally adjust their prices (and their risk appetite), which may lead to reduced capacity and potentially uninsurability as they update their models. There is a risk that these models continue to rely upon data that represents cooler climate conditions, which could continue to mask the 'true' risk. We estimate that the flood loading for UK home insurance is relatively small, with fire, theft and accidental damage all significantly more material. Increased flood risk is a higher cost that may need to be borne by the insurer, the reinsurer or customer and society in general.

In addition, other products outside of physical damage insurance will also be exposed to increased claims:

- Business interruption policies cover loss of profits or revenue due to an insured event. More frequent and extreme flooding will increase business interruption claims. Claims will result not simply from closures due to damaged sites but also from supply chain disruption, also known as non-damage business interruption. The Climate Change Commission estimates 7,500 km of roads, 520 km of railway lines, 205,000 ha of agricultural land and 3,400 ha of potentially toxic historic landfill sites are currently at 0.1 per cent or greater risk of coastal flooding in any given year.[23] The impact of extreme flooding on infrastructure could result in material increases to business interruption claims.
- The various forms of liability risk cover are all exposed to potential increasing claims. The industry is exposed if it has provided liability cover when/if a coastal defence fails, floodplains are poorly designed, or dams fail. Insurers will look to include within scenario analysis the liabilities associated with exposure and responsibility for managing physical climate risk with predictable legal

outcomes. Professional indemnity and Directors and Officers policies may be relied on following significant insured events.

The above is not an exhaustive list of considerations but aims to highlight how there are likely further areas where increased extreme flooding may impact existing policies.

Cost to (re)insurers, customers or government

As stated above, significantly increasing flood risk will result in increased costs. The key uncertainty is around who ends up bearing these costs. Is it the insurer, reinsurer, customer or potentially the government?

General insurers typically sell annual products. This offers them the opportunity to reprice as new information comes to light. Annual repricing and solvency requirements for capital holdings, means that non-life insurance has limited exposure to climate risk in the short-term. However, in the medium to longer-term the ability to reprice depends on several factors including the continued accurate prediction of expected losses each year, diversity in the pool of risks insured, and whether customers accept the increased premiums.

Predicting expected losses each year – Calculating the expected flood loading and how this evolves over time involves incorporating the academic modelling of climate change into insurance modelling. The altered flood risk from climate change drivers and/or random fluctuations by science is converted into risk for specific properties via revised flood models and maps with higher climate model resolution. This is a far from straightforward set of calculations and each major insurer (and reinsurer) will make different modelling assumptions, as there is no standard methodology or reference framework for this kind of work. There is also a time factor to this. To be useful, the modelling needs to be ahead of the actual events. Climate risk is already changing faster than what is being modelled within the insurance industry. The external rate of change is faster than the internal rate, so risk models are potentially not capturing the true risk.

Will customers accept increased premiums? – Conditional on accurately modelling physical risk in a changing climate, the customer may or may not be willing to absorb the cost. Each insurer will need to estimate the price sensitivity of their customer base and find ways to provide access to products at an acceptable market rate. This may be a bigger driver for inertia in repricing than any hazard changes, given that increased loadings are likely to vary significantly depending on whether a property is considered a flood risk. This assessment is potentially an extremely granular undertaking.

INSURANCE PRICE ELASCTICITY

Price elasticity is an area that insurers have spent a lot of time analysing, in the context of understanding customer lifetime value and ensuring that customers deliver acceptable returns through a sufficiently long tenure. When deciding if customers will accept a policy renewal, several issues are considered. Whether the customer made a claim on the policy, whether they are motivated by paying the lowest price and whether they care about the quality of service are examples of factors that would impact insurance price elasticity.

How will other firms react? – Each insurer (and reinsurer) is not pricing in a vacuum. As well as modelling differences, different insurers may have different strategic priorities - from growth in revenue to cross-selling. Firms could make a conscious decision *not* to reprice to maintain a customer base. Alternatively, they can offer price discounts for customers who proactively take adaptation measures and incentives to undertake reinstatement works that reduce risk of future impacts. Another extreme would be an insurer or reinsurer deciding to exit a particular market (or a segment of a market). In addition, insurers with less modelling expertise may not adjust for increased climate-related flooding and inadvertently offer more attractive pricing. All these will lead to different insurers pricing differently. It will also make it even more challenging to predict how competitors price.

How will the regulator react? – Coastal areas may be disproportionately home to elderly (and potentially vulnerable) customers.[24] Increases in price for the customers need to take account of the social aspects (even if the price increase is statistically and scientifically valid).

At the extreme end of an insurance market scenario, certain policies may become too expensive and result in pockets of uninsurable risks. Similarly, increased use of exclusions may exacerbate the problem of insurable risks where the price the insurers set is higher than that which a customer is willing to pay for the reduced coverage. At this stage, when policies become too expensive, the 'insurer of the last resort' has typically been seen as the government.

All the above factors point to the fact that annual repricing in the context of climate change will become increasingly challenging for the non-life insurance industry. Insurers there have a role in foreseeing shifts in risk and risk sharing to build resilience within their own business model as well as wider financial services and society.

5. Investments and assets

In this section, we focus on the impact on insurers' assets and investments resulting from increased flood risk associated with the scenario outlined. Increased flooding will impact specific areas more noticeably, such as coastal communities where the cost of building better flood defences may be less than the value of the property or cost of relocating communities. Nevertheless, flood risk as demonstrated by storms in recent years, as opposed to wider climate risk, is unlikely to pose a systemic threat to the UK economy and hence wider diversified assets. However, on a localised level, investment impacts could be significant.[25]

Reserving and Solvency II

General insurance reserves include an allowance for cash flows related to future claims payments for in-force policies. Increased claims should be offset by increased premiums (provided this is possible) or effectively reduced profit margins, if the cost increase is not passed on to the customer. A potential hit to reserves could come from liability-related insurance, where class actions or case law could result in insurers needing to add reserves for risks that they have not anticipated.

Apart from the abovementioned underwriting process, these issues are also relevant to the calculation of the level of capital. Changes in hazard caused by changes in climate create additional uncertainty, which will manifest itself in higher rates of capital being required to support flood-related risk. The natural catastrophe component of general insurance solvency calculations will need to be re-calibrated to reflect the increased frequency and severity of flooding.

While this is likely to be relatively small in the context of a firm's overall capital, from an economic value-added perspective, property insurance becomes potentially less profitable when a higher capital charge is associated with it. As confidence in the quantification of contingent climate liabilities grows, this will provide a foundation to inform the treatment of regulatory capital.[15] The recent announcements in the UK of support for adjustments to Solvency II for green financing reflect the steps possible for regulation of capital.[26]

Scenario analysis, such as presented in Chapter 2, focuses on the total losses for an event of a given insured portfolio or identified area. While this gives insights for an individual firm or for a government, neither the additional stages of customer willingness to pay a premium to cover the increased losses, nor market and government responses, are modelled.

Localised and systemic flood risk

Based on the analysis presented in Chapter 2, it is not apparent that the individual properties and bearers of flood risk are interconnected and pose a systemic risk to the UK market. The most directly impacted individuals and businesses are homeowners and local business owners in poorly defended towns. For most individuals, homes are their main exposed asset. Nevertheless, on a local level, the impact of significant sea level rise and flood risk could be devastating on communities. While homes that fall into the sea due to erosion are hugely symbolic, stranded local assets (homes that become both uninsurable and un-mortgageable) are a more silent and undocumented loss. The individuals who own these homes will bear the brunt of this and will face the stark choice of either living in a devalued home or moving and absorbing

the loss. For the younger population with significant future earnings potential, the latter is a real option, but the older population could be effectively trapped in their homes.

Similarly, local businesses that serve the local community will be impacted severely. Villages and towns that are deemed not worth protecting will slowly shrink due to the population impact highlighted above. Keeping current local businesses profitable will become more difficult and encouraging new businesses or new investment even more so. The decision to not protect coastal train routes and road infrastructure could further impact these towns, making it more difficult to bring in goods and services (or tourists). Additionally, it will be difficult for locals to travel to out-of-town jobs. Vanishing infrastructure, declining local businesses and shrinking communities could lead to ghost towns, especially if the retreat is not managed (this socio-economic impact is discussed more broadly in the latter sections).

The vast bulk of the above losses will be borne by individuals (either as homeowners or local business owners) and, despite the potential for devastating impacts at a local level, there will be limited impact on the wider economy. Only where the loss is unexpected and these events become widespread or significant to infrastructure that supports the wider economy, such as key port infrastructure or the Thames flood barrier, could the event trigger a systemic loss.

As noted in the earlier chapter, the impact of events on the economy through private and business activities and investments is generally not modelled. Providing broader implications on macroeconomic variables of losses due to events is an important next iteration of scenario analysis for natural catastrophes. As insights on expected losses are the basis for commercial pricing of insurers, it requires innovation and collaboration by the insurance industry generally only seen in limited circumstances.

Limited losses for insurers

Homeowners have insurance to cover the cost of damage to their homes. As set out in the liability section, we do not expect insurers/reinsurers to bear the brunt of this due to the impact of increased flooding being relatively predictable. Therefore, it can be priced into insurance contracts. The insurance policy may become unaffordable for the homeowners or business prior to the risk being uninsurable.

Increased losses on insured property in badly hit coastal towns will not necessarily result in losses to the insurer if the increased losses are expected. Unlike homeowners, insurers may choose to walk away from a policy, or set of policies, if the premiums paid are no longer seen as viable. Accurate scenario analysis incorporating climate change over the period of the insurance policy is required for viable pricing now and estimates for future by the insurer.

However, for financial markets and society, it is clearly undesirable for insurers to cease offering affordable cover as this widens the protection gap and reliance on government and community networks for recovery. Society and the insurance industry need to be engaged in understanding the changing risk profile of exposures from climate change to avoid dramatic shifts in risk sharing and management. We explore the role of insurance in society in the next chapter.

Impacts on the market

If we are in a 2+ metre sea level rise world at 5°C temperature rise, then climate risk more broadly will have had dramatic impacts on the market.[27] Flood risk will be one component of this (and, as highlighted

above, unlikely to be a key driver of the losses). For completeness, we set out the high-level potential impacts for several asset classes as examples.

The impact on government bonds, given that the UK is an island with a large amount of coastline, would be severe. The cost of improving coastal defences, managing the impact of flash flooding, as well as rebuilding roads and railways at threat from coastal flooding will all need to be funded. The UK government will be responsible for funding retreat, adaptation and migration strategies to meet the challenge of rising sea levels. Insurers may have indirect exposure to coastal towns via equity release books and the losses on homes with equity release. There could be a boom in green-infrastructure assets, either to fund and build better coastal defences or to rebuild road and rail links. From the perspective of equity and corporate bonds, as discussed above, we do not believe that flood risk in isolation will spill over significantly into the wider economy. That said, specific sectors which could be impacted include transportation and shipping, due to disruption to the supply chain and shipping ports for example. In addition, businesses that rely on 'Just-In-Time' manufacturing, such as the car manufacturing industry or indeed the food industry, would be highly impacted, with the COVID-19 Pandemic highlighting the fragility of many supply chains and potential for economic disruption.

6. The governance of (re)insurance organisations

Best practice recommends climate risk scenarios

The role and responsibility of (re)insurers as the risk managers of society is led by the governance of firms. In the UK, Solvency II came into effect in 2016 and sets out regulatory requirements for insurance firms and groups, covering financial resources, governance and accountability, risk assessment and management, supervision, reporting and public disclosure. Compliance is overseen by the Bank of England's Prudential Regulation Authority (PRA), which also issues stress testing guidance to check the health of insurers and other financial institutions.[28] It does this to ensure financial stability and protect financial services customers and the public at large.

The UK's corporate governance mirrors that of other global financial markets and places a responsibility on insurers to take their own risk management seriously and to conduct their own stress tests with relevant analysis, equal to the nature, scale and complexity of their businesses. In addition, they are required to continuously assess their overall solvency needs for their insurance-specific risk profile.

This framing clearly includes emerging issues such as cyber underwriting and climate change. The PRA's 2019 stress test guidance specifically referred to a set of climate scenarios exploring impacts on both firms' liabilities and investments stemming from physical and transition climate risks. In this way, the PRA's guidance lines up with the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) recommendations that climate-related risk and opportunity are considered as part of the overall management structure of an organisation – its governance, strategy and risk management, plus its metrics and targets, given the pressing need to address this material global risk.[29]

ClimateWise Principles and industry examples

ClimateWise Principle 1 highlights that the organisation's board should be working to incorporate the Principles into business strategy and has oversight of climate risks and opportunities, as well as management's role in assessing and managing climate risks and opportunities.[13] ClimateWise members particular show strong board-level oversight of climate risks and opportunities, with evidence of discussing climate-related issues at board level or at board-level committee meetings and the processes by and frequency with which the board and committees were informed.

'Santam has a Group Investment Committee and Group Risk Committee that are specifically responsible for integrating climate risk into investment and risk management, respectively. This year, Santam's Group Strategy team provided a TCFD workshop for the board and Executive Committee, following which a resolution was raised for TCFD disclosure across all entities in the Group.

'Argo Group's board is supported by the Risk and Capital Committee to meet oversight responsibilities in relation to climate issues. At a management level, the Chief Risk and Sustainability Officer is responsible for implementing sustainability and ESG strategy and is supported by a Sustainability Working Group, responsible for managing climate-related and broader sustainability issues. The Working Group reports directly, to the Enterprise Risk Management Steering Committee and through the Chief Risk Officer to the Risk and Capital Committee.'

Climate-related risk impacts all aspects of the insurance business across the value chain – from treating customers fairly, through the underwriting and claims processes, as well as the use of up-to-date risk data in internal capital modelling. It is therefore essential that, in addition to solvency-related stress testing, underwriting-related stress testing and scenario analysis is conducted. As the important impacts of flooding shown in Chapter 2 are seen to permeate other aspects of the insurance business and industry, the analysis should understand the implications and responsibilities of the insurance organisation from an income statement, cash flow and balance sheet point of view.

Such climate risk analysis and scenario modelling should include broader and longer-term stakeholder implications and related societal impacts as explained above. In addition, the corporate governance infrastructure of insurers should be reviewed and updated to include climate change-related risks and opportunities, where it is found that policies, position statements, executive and director mandates do not reflect material and relevant climate issues appropriate to the nature, scale and complexity of the business.

Future strategy practice should be science-based, contextually situated and on the 'right side of history' where stakeholders are concerned. The key questions that should be considered are:

- Are we tracking our climate action progress with appropriate science-based metrics and targets? (TCFD Metrics and Targets, ClimateWise Principle 4)

- Are our scenario analyses based on up-to-date climate science and contextually relevant? (TCFD Risk Management, ClimateWise Principle 3)
- How do our scenario analyses and governance frameworks inform each other? (TCFD Governance, ClimateWise Principle 1)
- How are we supporting the organisation's strategic decision-making for the current and longer-term planning horizon? (TCFD Strategy, ClimateWise Principle 2)

The TCFD's recommendations place strategy firmly within the context of an organisation's broader governance climate.[30] In turn, strategy encircles risk management, metrics and targets.

Two further TCFD 'circles' can be added, with the organisation contained in society which is in turn contained within the natural environment. It is increasingly accepted that business is embedded in a socio-ecological context, which it impacts and is shaped by. This realisation, named by the World Economic Forum (WEF) as stakeholder capitalism, calls for conscious and responsible participation in the global marketplace and global commons.[31] Many organisations, including insurers, are coming to terms with and accepting their responsibility in this regard by making decarbonisation commitments, setting science-based targets and joining climate action networks. However, if public claims are not founded on science or embedded in the governance structure of an organisation, it can lead to reputation risk and accusation of greenwashing. (For more information see Embedding Project at Simon Fraser University.[32])

The use of business-based and pragmatic climate risk scenarios can help insurers unpack their impact on stakeholders, as well as the impact of external forces on the firm and its business model. Scenarios can also be instrumental in setting science-based metrics and targets by helping organisations draw appropriate baselines and then tracking progress against stated baseline metrics and targets for a given business line or portfolio.[33]

Although scenario analysis itself is not a new management analysis tool, many organisations are yet to use it effectively, as evidenced by the TCFD's Status reports.[5] Insurers should be mindful of how they use scenarios, including the data they draw on in developing their scenarios, given that climate science itself is a dynamic and developing field, where the data and insights are far from static. This is a different 'world' from the one that insurers are used to – where data is based on the past and where past loss experiences can be used to help inform quantification of expectations for future losses with some certainty.

The United Nations Environment Programme Finance Initiative's (UNEP FI) Principles for Sustainable Insurance (PSI) guide on environmental, social and governance (ESG) issues in non-life insurance underwriting provides helpful guidance on this topic.[34] At the core of the insurance organisation's underwriting decisions over time is a broader strategic question about the impact of its risk appetite and how it builds or retracts from broader societal resilience in what it chooses to underwrite, or not, and under what conditions. Furthermore, scenario thinking is also about preparing for a range of possible futures, which are inherently uncertain. Well-thought-thorough scenarios can explore the long-term resilience of the business and be instructive about the desired future of the organisation.

Using a strategic scenario approach to help explore and make sense of future possibilities, imagining alternative futures and the multiple 'stories of the future' can help an organisation navigate the complexity and uncertainty inherent to the current global business landscape. A broader approach and understanding that there are explorative and normative scenario approaches – in addition to the predictive portfolio

scenario analysis and more quantitative and data-driven approach outlined above – may be very useful to inform organisations' choices about the longer-term strategic horizon. It may also help executives and responsible managers test the future fitness of strategy and risk appetite for climate risk and opportunities.

A scenario team usually comprises an internal team from the firm supported by external experts. These are experienced climate scenario experts who provide new ideas and who design and facilitate the process. Using tools such as those described in this paper, experts provide information which is then interpreted by insurer scenario team. First, the starting points for a particular management decision, issue or general concern are identified, followed by the key driving forces. Defining the scenario logically against organisational themes and principles, and continuing this into the output of the scenario exercise, helps improve the practitioners' understanding of the importance of such an exercise. This could be a qualitative set of equally plausible scenarios in narrative form with strategic options, implications and early warning signals. Not all scenarios are equally probable, therefore uncertainties and limitations will be outlined.

7. Industry impacts

Climate change represents a significant threat and opportunity for the insurance industry, that can be better understood and managed through climate scenario analysis. Backward-looking data will need to be supplemented by forward-looking insights for the insurance industry to be able to assess exposure and plan ahead without using an outdated understanding of hazards and exposure. Forward-looking forms of scenario analysis can also highlight possible opportunities for insurers, where these risks may be managed through new products or business models.

ClimateWise Principles and industry examples

ClimateWise Principle 6 highlights how the industry as a whole is to support climate awareness amongst customers/clients.[13] With many having client engagement plans on climate change, but others members have limited quantitative tracking of engagement activities or feedback mechanisms.

'RSA published its Climate Change and Low Carbon Policy, clearly setting out its stance on climate change and how it will impact the insurance industry through changing weather patterns and increased frequency and severity of events. RSA also promoted campaigns, and shared tools and advice that encourage personal and commercial customers to adapt to climate change and reduce their energy use and associated GHG emissions, such as their 'repair over waste' campaign on waste reduction and sustainable claims handling.'

Micro-level impacts

Climate change and the potential for heightened frequency and severity of hazards may severely impact claims volumes on lines of business written by insurers. Increased flooding will particularly affect property and casualty lines, where techniques are improving to quantitatively model a scenario such as shown in Chapter 2.

This raises the question of how climate litigation may impact direct insurance classes, which remains largely untested. The subsequent impact on (re)insurer asset values and share prices, and implications for new classes of business or new product offerings, are largely unknown. Based on the flooding example, this could be procurement procedures, incentives for policy holders or new products that either insure resilience measures rather than the property itself or create warning systems that reduce client and insurer risk exposure.

Systemic implications

Climate change alters the insurance industry's resilience - solvency, operational stability and overall strength. There are opportunities for industry co-ordination, which may need to dramatically improve to meet the level required for global standards to address climate change. Ultimately, if the sector fails to

adapt and become more dynamic, the insurance market could become smaller and very expensive, and therefore less relevant in improving societal resilience to climate risk.

Financial market risk also needs to be more effectively managed, to ensure the impact on the banking sector does not materially affect the solvency of all insurers at the same time, for example where large movements in bond/equity prices impact every (re)insurer's asset portfolio. Equally, in reverse, if affordable insurance becomes unavailable due to increase risks such as flooding, it will inhibit the flow of capital from banks and investors who cannot rely on the backstop of insurance.

If the insurance industry fails to become more dynamic its viability and reputation could be threatened, as recently seen in class actions over a Florida tropical cyclone[35] and availability of affordable insurance following California wildfires[36]. The cost of capital may be heightened as a result of a shortage of capital supply, which impacts the insurance cycle. The impact on terms and conditions in some regions and different asset classes becoming uninsurable will make exceptions to coverage much more frequent. This might lead to increased use of alternative risk transfer mechanisms with differing regulation allowing the industry to be more innovative. The entire industry structure may change if it fails to adapt risk pools and pricing to the dynamism of climate risk. Policies may include high-tech early warning systems, shifting the focus from mitigating risk or ex-post risk transfers for acute risks - chronic perils that might require more systemic adaptation measures.

8. Role of insurance in society

Insurance, both as an institution and a risk transfer mechanism, plays a key role in society.[15] Insurance is a key pillar of risk sharing along with tax-based protection, such as government welfare and emergency response, and the informal protection of savings and community networks. Insurance plays a pivotal role in providing risk protection to complement governments and community support. For example, in response to a flooding event in the UK, insurers may support the recovery cost for losses to personal and corporate assets (such as cars, buildings and infrastructure), liability if goods and services did not perform as expected during a flood, business interruption (for example, from road closures), and health impacts of injury, sickness and disability.

ClimateWise Principles and industry examples

The majority of ClimateWise members demonstrate they promote and actively engage in public debate on climate-related issues and the need for action (Principle 5).[13] However, knowledge exchange and engagement with policy needs to become consistent across the ClimateWise membership and wider industry.

'QBE has been active in supporting the Climate Measurement Standards Initiative (CMSI), which has developed standards for assessing climate physical risk projections of damage to property in Australia. The CMSI delivered a report with recommendations on disclosure and a report by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Bureau of Meteorology and University of New South Wales on the expected impact of climate change on cyclones, storms, floods, sea-level rise and bushfires in Australia. The conclusions from this work have been referenced within QBE's internal assessments of exposure and modelling.'

Insurers support society before, during and following natural disasters. Insurance companies work with their policyholders for both parties to understand the risk exposures and appropriate risk management and transfer. The design of insurance can incentivise risk reduction by policyholders, such as flood doors or flood resistant building materials, and reduce the likelihood of the risk occurring overall as well as the impact when an event does occur.

Insurance fundamentally shifts the management of risks for personal and corporate assets from a government balance-sheet responsibility to the private sector. This works well, except in extreme cases where unforeseen systemic losses occur. An example of this would be the Covid-19 pandemic. The UK government-imposed lockdown and consequent claims on business interruption policies highlighted potential under-insurance issues and required some level of government funding and/or intervention.

Both general and life insurances offer protection to stabilise financial positions and enable recovery by society, from property losses to loss of human health, and in turn, help manage inflationary pressures – through the redistribution of funds over time and through pooling risk. The stability and certainty provided by the insurance industry encourages economic security. As a risk transfer mechanism, insurance specifically supports individuals and businesses to manage their exposures: by reducing the uncertainty of

losses, ensuring business continuity, enhancing the ability to secure credit and generally improving the welfare of the beneficiaries of the insurance cover.

Specific to this study, flood risk has become an exposure subject to under-insurance and/or becoming uninsurable in certain geographical areas driven by housebuilding in increasingly flood-prone areas as the climate changes. As stated above, insurance companies play a principal role in identifying and assessing the most effective ways to manage risks for policyholders. They will use their expertise and modelling capabilities to determine the premium based on the residual risk profile. In the case of a natural catastrophe peril such as UK flooding and climate-related perils more generally, however, this has limited capabilities. More lateral actions need to be considered, including how the industry might contribute to addressing national or regional protection measures as well as the root causes of climate change with the insights from scenario analysis.

Being responsible for providing appropriate coverage but also taking the opportunity to influence stakeholders to address climate change, insurance companies are refocusing aspects of their business and investment portfolios away from carbon intensive lines of business to progressively 'greener' enterprises and initiatives. Supporting corporate initiatives to adopt environmental and social responsibility is an important development for insurance companies that will increase with the growth in net zero commitments. Though this process is underway, more action and faster pace is needed for the industry to play an active role in promoting the green transition and avoiding the worst potential outcomes of climate change.

How decisions from climate risk scenarios impact society

Flooding is a complex challenge with profound effects on individuals, businesses, communities and the UK economy. A cross-disciplinary, evidence-based approach is necessary to manage this risk in economically viable, sustainable and socially acceptable ways. Insurance is a common thread linking infrastructure/development, risk management and post-event costs at policyholder level, from individuals, SMEs, corporate firms and government.

The scientific community has provided the fundamental understanding and methodological approach to make projections about future nature-related events. However, individuals, business and government need to quantify how these possible futures will affect them and determine their preferred approach based on their risk appetite, capability, capacity and ambition. These choices are not simple: maintaining financial stability and responding to disasters to protect lives, livelihoods and businesses will involve risks; but with risks come opportunities.[37]

The effects of climate change must be acknowledged in developing flood risk management policy; this is an imperative given the scientific evidence for climate change. While we know that climate change will increase the probability and consequences of flooding in many areas, flood modelling is also a statistical science with inherent uncertainty. While Chapter 2 presents estimated losses due to climate change in the UK given a specific scenario, it is essential to understand, communicate and accept the impact and likelihood is uncertainty, and work with it.

Decisions on investment in adapting to future flood risk or insurance coverage must first consider what level of risk we, as a society, are willing to tolerate. This discussion needs to include the costs, benefits,

uncertainties and residual risks of various options. Discussion of societal risk tolerance needs to consider all hazards, not only flooding. Building in societal resilience has benefits during shock events.

Scenario planning to inform societal action

It is critical for practitioners of scenario analysis to consider the interconnectivity of risks and the challenges to possible futures so they can set priorities for investing in resilience. Public and policymaker understanding of risk is critical and governments, insurers and other stakeholders should work together. This will ensure there is a greater understanding of the role of all parties in the economic and social consequences of poor risk management and allow the development of appropriate solutions.

Modelling risks and their impact alone is not sufficient to build resilience. Scenarios that tell a story are one way to bring risks and challenges to life by creating shared understanding. Managing climate risks requires solutions that establish a baseline level of tolerable risks to benchmark future events against and then drive asset-level and systems-level resilience. Maps like those found in Chapter 2 are a useful way to explore potential flood risk futures and to make decisions around what is and is not acceptable, and how to avoid risks to society.

The narratives associated with the IPCC, CCRA or other scenarios can be used to develop a storyline approach for assessing the impact of different climate projections.[14, 17] They are a useful resource to prepare for policy decisions and discussions with industries or regions that are potentially uninsurable or unattractive to investment in adaptation. For example, increasing flood risk from climate change may encourage public sector risk mitigation strategies that include expanding areas identified as flood plains or, conversely, building extra defences that improve or decrease an asset's value.

Larger scale flood mitigation measures require government support given the size, planning and cost involved. Such schemes are likely to deliver the most significant return on investment and provide the most efficient way of protecting many properties. This investment must be evidence-based and affordable and must recognise future uncertainties in climate, funding and land use.

Alterative measures by government to address gaps within insurance coverage include the UK's Flood Re (discussed in Chapter 4). All UK home insurers pay into the Flood Re Scheme to cover the flood risks in home insurance policies. Insurers can then choose to pass the flood risk element of a policy to Flood Re and, if a policyholder makes a claim, Flood Re will reimburse the insurer from the pooled fund.[38]

Modelling to provide more robust adaptation and resilience

Robust spatial planning is an essential component of a national flood risk strategy. Risk management tools can support public strategies and policy with inputs from probabilistic models and lessons from other disaster response contexts.

Spatial planning is essential to reduce or avoid placing new property development in areas at risk of flooding now or in the future, and to ensure that development does not increase flood risk in other locations due to altered water flows. The Netherlands' Delta Plan on Spatial Adaptation maps out climate change and water-resilient vulnerabilities. Local governments were required to conduct an initial stress test by 2019 and every six years thereafter that centred on those weather-related threats.[39] Municipalities,

district water boards, provinces and central government conducted a stress test in collaboration with stakeholders in urban as well as in rural areas to gain insight into the vulnerability to climate extremes.

Where investment in larger schemes cannot be justified, flood risk management at the individual property level may be appropriate. There is also an opportunity for wider use of scenarios and probabilistic models to stress test the impact of property-level flood protection and 'Build Back Better' to support these measures. 'Build Back Better refers to the process of carrying out a more resistant and/or resilient repair to flooded homes'.[38] Depending on the economics of such schemes, 'Build Back Better' would be the natural step to improve risk resilience, as it is in both insurers' and policyholders' interests.

The insurance industry is uniquely positioned to support sustainable flood risk management and investment, and to co-ordinate a step change in the national approach to mitigating flood risk. Supporting a granular view of flood risk enables accumulations to be identified that either increase the risk or diversify it. It further ensures a consistent approach, from the establishment of a risk-reflective tariff through to reinsurance and capital modelling. From a reinsurance perspective, increased volatility may lead to higher reinsurance premiums, which could dissuade insurers from assuming such risks in the first place, especially during the Flood Re transition period. To ensure that the most appropriate reinsurance can be designed, the industry will require a better understanding of modelling the impacts, benefits and challenges.

Integrating climate considerations into mainstream financial decision-making

A robust and resilient response to adapting and mitigating the impact of climate change on UK flood risk also requires climate-related considerations to be integrated into public and private sector financial decision-making. Policies and proposals within the UK's Green Finance Strategy and the leadership being demonstrated by the UK's financial regulators, include, for example, the Bank of England's work on climate stress tests.

It will be important to maintain a high level of ambition in this area to ensure current and future climate-related risks are effectively managed. For example, ensuring expectations set for climate-related financial disclosure by listed companies and large asset owners are fully met, and that government also leads by example – such as fully integrating climate risk and resilience into the spending review process.

Without committed and engaged multi-stakeholder collaboration, effective long-term strategic planning proves challenging. Strong cross-sector collaboration will be important to developing a consistent approach, and institutions that help flows of financial and human capital can play a particularly valuable role in ensuring an effective market-wide response.

9. Conclusion

This white paper considers the options, implications and communication of scenario analysis for underwriting non-life insurance. It raises awareness of the different natural catastrophe modelling approaches and highlights the valuable insights that can be provided across the insurance business and wider society for physical risk management in a changing climate.

There are industry challenges associated with undertaking scenario analysis, and even more so in interpreting and strategically tackling the outcomes presented. As climate change increasingly impacts the insurance industry, it might present challenges of unaffordable insurance, which may then pose a threat to the business model and stability of the insurance industry, as well as have undesirable effects on society. Consequently, this raises the important role of industry regulation and increasing the need for collaboration to address challenges which need collective action.

As mentioned above, the data used within the insurance industry might be compared to driving forward using rear-view mirrors. To increase visibility, the need for the insurance industry to share claims data in a dynamic and more open manner is key. The industry also needs to question the model of proprietary data and how we might move forward with more open-source platforms.

Recommendations are made below on how to progress scenario analysis in underwriting for firms, the industry and society.

For scenario analysis in underwriting

- When undertaking scenario analysis and using the output of climate-conditioned catastrophe modelling, outlining what the outputs represent and communicating limitations transparently are of equal importance to avoid misinterpretation in decision-making.
- As primary hazards can trigger secondary physical ramifications, these climatic interdependencies and their associated correlations need to be integrated into scenario analysis so that those accumulated and aggregated risks can be better understood by the relevant stakeholders and therefore be managed more effectively.

For the insurance industry and society

- Insurers need to undertake scenario analysis to understand their role in helping develop long-term, viable insurance markets, so they can strategically assess their business models and manage risk.
- The insurance industry needs to assess how risk is passed on (or retained) by different actors and how it can develop coordination, so that highly exposed regions to flood risk can remain financially resilient, while also managing flood risk more effectively.
- An insurance sector is not resilient if its data is out of step with the real world. Therefore, a predictive data driven warning system focused on mitigating risk rather than (ex-post) risk transfers might be an alternative business model.

For scenario improvement

- Flooding is a complex challenge with profound effects on individuals, businesses, communities, and the UK economy. A cross-disciplinary, evidence-based approach is necessary to manage this risk in economically viable, sustainable and socially acceptable ways.
- It is critical for scenario planners to consider the interconnectivity of risks and the challenges to possible futures so they can set priorities for investing in resilience. The qualitative descriptions within the IPCC or other scenarios can be used to develop a storyline approach that broader society can understand and connect with for assessing and responding to the impact of different climate projections.[14]
- Although scenario analysis itself is not a new management analysis tool, many organisations are yet to use it effectively, as evidenced by the TCFD's own progress reports. Insurers should recognise its importance, whilst also being mindful of how they use scenarios, including the data they draw on in developing their scenarios, given that climate science itself is a dynamic and developing field, where the data and insights are far from static.

With increasing data availability, modelling expertise and regulatory momentum for scenario analysis in the UK, this white paper focusses on the impacts of climate change on flooding. The recommendations are then drawn wider reflecting the global membership of ClimateWise. The research shows how we can use climate-conditioned catastrophe models to undertake scenario analysis in order to understand how climate risk propagates through the different areas of the insurance underwriting process as well as how it can inform action by wider finance, regulators and society for mitigation and adaptation.

The scale of the challenges requires collective action across the insurance industry but also for insurance to play a leading role in informing and driving societal responses. ClimateWise Principles reporting highlights the progress made and the greater action needed by insurers. Scenario analysis is a key tool to enable insurance to leverage its insights and expertise to help society respond to physical climate risks. We look forward to the insurance industry building on the insights included in this paper and continuing to accelerate their response to climate change.

Glossary

Accumulation/Aggregation risk or total combined risk is the potential loss exposure of one event that can spread to multiple lines of business in an insurer's portfolio.

General insurance refers to coverage of loss or damage to an asset or assets, and loss or damage due to their loss, such as business disruption

Primary perils are events that may damage or inhibit assets, activities or life. Primary perils have the highest loss potential, are well monitored and usually covered by catastrophe models, for example earthquakes and tropical cyclones.

Secondary perils are two categories of events that have historically been localised, less significant in physical impact and loss, and less well modelled. Traditionally, these perils are the secondary effects of primary or peak perils, such as hurricane-induced flooding, coastal storm surges, tsunamis and earthquake-induced wildfires (secondary effect perils). More recently secondary perils also refer to independent events that generate small to mid-sized losses, such as hail, flood or wildfire (non-peak perils).

Scenario analysis assesses the impact over time of changes in key variables on a firm's financial position or portfolio, allowing firms to understand the potential outcomes and prepare or plan.

Stress testing analyses the impact of a particular scenario on a firm's financial position or portfolio, allowing firms to assess the security of their position.

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