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# A Practical Guide to Climate Change for Life Actuaries

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## Introduction

Whilst the scientific consensus is that climate change associated with global warming is in progress ([IPCC, 2014](#)), the scale and timing of its impacts are uncertain. Furthermore, the actions of society in response to this change, and their ultimate effectiveness in mitigating these impacts are also unknown. The effects could include impacts on health and mortality, physical assets, and financial markets. These could therefore have implications for life insurers and actuaries working for them. This guide has been produced to support actuaries working in the field of life insurance both in the UK and overseas.

Life actuaries may find the guide helpful in considering the Institute and Faculty of Actuaries (IFOA) Risk Alert on Climate-Related Risks ([IFOA, 2017a](#)). The Risk Alert states that:

*“Actuaries should ensure they understand, and are clear in communicating, the extent to which they have taken account of climate-related risks in any relevant decisions, calculations or advice.”*

Within the guide we refer to ‘insurers’ to mean both primary insurers and reinsurers. It is one of a number of guides published by the IFOA related to Climate Change and Climate Risk. These other guides also include material which is relevant to life insurance actuaries and we have looked to cross-reference to these where appropriate.

The guide contains the following sections:

- Introduction;
- Executive Summary;
- Life actuaries and climate change: describing the linkages between the roles of life actuaries and the implications of climate change for these roles;
- How can life actuaries allow for climate change in their work? Noting the nature of climate change and the high-level steps that may be practical for life actuaries to carry out at present;
- Regulatory and disclosure aspects of climate change: identifying both existing explicit and implicit requirements and how these may change in future;
- Climate change risk and ERM frameworks: describing a possible approach to linking the climate change risk classifications to those typically included in an Enterprise Risk Management (ERM) framework;
- The role of models in life insurance: considering approaches that are available for climate change modelling and may be appropriate for life actuaries;
- Modelling climate change risk: mortality & morbidity: sets out some specific considerations, and the challenges, specific to linking the implications of climate change to demographic modelling;
- Next Steps: setting out proposals for how life actuaries might consider applying the issues raised in this paper in their work and how they can keep abreast of developments.

Other than for introductory comments, this guide does not aim to cover background information on climate change. A more general introduction to climate change for all actuaries has been published as ‘Climate Change for Actuaries: An Introduction’ ([IFOA, 2019](#)).

The overall state of understanding of climate change is changing rapidly. This includes developments in the understanding of climate change impacts for the world as a whole, but also modelling, regulation and best practice governance for financial institutions. Climate change is also increasingly being seen as important by the general public - with a potential impact for reputational risk. Actuaries may want to use this guide as a starting point for further activity and look to maintain an awareness of ongoing developments.

Nothing in this report should be taken as formal guidance. This report simply seeks to support actuaries in their work and in using their professional judgement when giving advice.

Given that the area of climate change research, awareness and regulation continues to develop it should be noted that the paper only includes consideration of information available to the working party up to June 2019.

## Executive Summary

Climate change is not a new concept. Although this is an established area of scientific research and political debate, it is only in recent years that industries and the wider public are becoming more widely conscious of its important effects.

The effects of climate change present various risks, not limited to those directly attributable to weather or temperature.

**“Physical”** risks describe those risks emerging from climate factors, such as extreme high temperature or rising sea levels,

**“Transition”** risks are those that emerge from a societal shift towards a low-carbon economy, and

**“Liability”** risks are those that arise from parties who have suffered loss and damage from climate change, and seek to recover such losses from others

The IFOA has recognised the emergence of these climate related risks in a Risk Alert, encouraging all actuaries, independent of discipline, to consider the financial risks and implications of climate change. Given the potential for climate change to materially affect future economic and social stability, actuaries may wish to consider how climate change could affect their work.

Whilst there is research and modelling available for the potential impact of climate change on aspects such as changes to global temperatures and sea levels, these do not directly provide inputs to life insurance financial models. In this paper we therefore propose approaches and frameworks to more directly link climate change considerations into typical insurance risk frameworks.

Large, global insurers are making good progress in this space particularly in relation to investment. For smaller firms and across other areas quantitative understanding of the potential impact of climate change is developing, and actuaries should keep aware of developments here. Even where quantification is not yet possible, in order to build an understanding of climate change risks and their impacts, other initial steps can be taken. These involve accepting and recognising climate change as a source of risk and beginning to identify the specific risks that can emerge. Qualitative scenarios can be useful for exploring different possible futures even before there is sufficient data or confidence for quantitative approaches. The range of possible futures is very wide, and some of them could be very difficult for the global economy. Using a range of scenarios will help to inform longer-term business strategy. From here, insurers can develop their approach and include climate change in their Enterprise Risk Management framework.

Globally, regulators and advisory bodies are developing frameworks and regulation aimed at monitoring, measuring, and managing the emerging risks of climate change. In the UK, the Prudential Regulatory Authority (PRA) and Financial Conduct Authority (FCA) are becoming more active in this region; both have published consultation papers with follow up Supervisory Statements and Feedback Statements setting out expectations of firms and planned future engagement. They have created the joint regulatory Climate Financial Risk Forum. Disclosure is emerging as an important component of the response to the risks of climate change, seeking to inform investors and consumers on companies’ approaches to these risks.

Actuaries may therefore want to be aware of the wide-ranging implications of climate change for life insurance and support the developments of insurers in this work.

# 1. Life actuaries and climate change

Whilst the scientific consensus is that climate change is in progress ([IPCC, 2014](#)), the scale and timing of its impacts are uncertain. Furthermore, the actions of society in response to this change, and their ultimate effectiveness in mitigating these effects, are also unknown.

Risk associated with climate change are typically classified according to the following groupings ([Bank of England, 2015](#)):

<b>Risk type</b>	<b>Description</b>
Physical	First-order risks arising from weather-related events, such as floods and storms
Transition	Financial risks arising from the movement to a lower carbon producing economy, this would include the re-pricing of carbon-intensive assets.
Liability	Risks that could arise for corporates or insurance firms from parties who have suffered loss and damage from climate change, and seek to recover such losses from others

Note that in some more recent versions of this classification 'Liability' risks are consolidated into the physical and transition categories. We have retained the 'liability' reference for consistency with other IFOA documentation and given its potential relevance to insurers.

The (non-exhaustive) table below summarises how climate change impacts might relate to the field of life insurance and the particular areas of work for life actuaries:

<b>Impact Area</b>	<b>Areas of Actuarial Work</b>	<b>Examples</b>
Changes to economic growth and performance in wider economies. Effects of these on the demand for insurance products and their pricing	Product Design Reserving Financial / Strategic Planning	Product Pricing Own Risk Solvency Assessment (ORSA)/Longer term financial projections
Changes to investment over or underperformance: whether due to direct climate impacts on specific assets, regulation or restrictions leading to 'stranded assets', longer term investment opportunities in capital intensive climate change mitigation or transitions	Investment advice Product Design Reserving Investment Strategy Investment governance	Product Pricing Environmental, Social and Governance (ESG) investments/ Socially Responsible Investments (SRI) Setting long term economic assumptions Asset Liability Matching Matching Adjustment Strategic and tactical asset allocations Mark to model asset valuation of long-term illiquid investments such as mortgages.
Changes to current mortality and morbidity and uncertainty around future trends	Product Design Reserving	Product Pricing Capital Management Reinsurance Setting long term demographic assumptions Explicit allowances of climate change considerations in mortality and morbidity models
Changes to insurance regulatory environment	Has potential to affect all areas of actuarial work	Risk governance Risk reporting Corporate level disclosures Customer / distributor disclosures Outsourcing arrangements Capital Management

Overall uncertainty around timing, magnitude and response to climate change	Risk Management/ORSA Pricing Reserving	Risk governance Strategic planning Scenario Analysis Risk Appetite Frameworks Capital Management
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***PRACTICAL STEP:** Consider how the impact areas arising from climate relate to your role for example using the table above. What does this mean you should focus on as the key climate change issues relevant to this role?*

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## 2. How can life actuaries allow for climate change in their work?

The implications of climate change are far-reaching. The future financial effects have a number of distinctive, potentially material elements that, when considered together, present further challenges ([Bank of England, 2018](#)):

Element	Description
Far-reaching in breadth and magnitude	The financial risks from physical and transition risk factors are relevant to multiple lines of business, sectors and geographies. Their full impact on the financial system may therefore be larger than for other types of risks and is potentially non-linear, correlated and irreversible
Uncertain and extended time horizons	The time horizons over which financial risks may be realised are uncertain, and their full impact may crystallise outside of many current business planning horizons. Using past data may not be a good predictor of future risks
Foreseeable nature	While the exact outcome is uncertain, there is a high degree of certainty that financial risks from some combination of physical and transition factors will occur
Dependency on short-term actions	The magnitude of the future impact will be determined, in part, by the actions taken today. This includes actions taken by governments, financial market participants and a range of other stakeholders

Note that in particular the reference in the table to ‘Using past data may not be a good predictor of future risks could create a real challenge for actuaries’. In particular, the impact of these future uncertainties and their potential influence on the variability of risks and experience trends that can be derived from past data needs to be considered. Actuarial work relying solely on past data or failing to communicate the limitations of this with respect to climate change, may be problematic.

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**PRACTICAL STEP:** *Recognising the uncertainty surrounding the range of outcomes, life insurers, and actuaries acting on their behalf, need to consider whether or how to include climate change in their risk and business planning. Some likely elements of such reviews are outlined below. Alongside all these steps, actuaries and firms will need to consider, and suitably develop, their firms’ disclosure of approaches to climate change:*

*Awareness and risk identification: obtaining an awareness of climate change and its potential impacts. Ensuring this is logged on a risk register and subsequently picked up in governance and risk assessment work,*

*Qualitative scenario analysis: considering potential future paths for climate change and societal response. Work from high level descriptors of how climate change and the societal responses to it might evolve to describe potential implications for the insurer. It may also be useful to get insight from platforms such as the [CRO Forum](#) on the development of the associated risks and the [TCFD Knowledge Hub](#),*

*Inclusion in strategic decision making: from an understanding of how different future climate change outcomes might affect the insurer, start to incorporate these findings into business strategy,*

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*Embedding in risk frameworks, such as a firm's Own Risk and Solvency Assessment (ORSA): i.e. formalising these strategic considerations and the insurers' ability to cope with potential future outcomes,*

*A quantitative understanding and reflection in modelling: a long-term goal may be sufficiently granular and quantitative modelling of financial and other effects to incorporate into actuarial models.*

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It is the opinion of the working party that with due consideration and commitment of resources, it is possible to at least undertake a qualitative scenario analysis given the current understanding of climate change risks. Further stages, including quantification, may require greater development to ensure the risks arising from climate change are suitably assessed and addressed. Actuaries may wish to monitor and be aware of how best practice and appropriate techniques in these areas evolve over time, noting, for example, that some firms have already begun to quantify and disclose their exposure to climate related risks and opportunities

### 3. Regulatory and disclosure aspects of climate change

Climate change regulation is an increasing area of interest for many regulatory bodies and advisory groups, and formal regulation related to climate change directly applicable to insurance firms is developing. There is a growing focus on company disclosures and the actions that firms are taking to identify, mitigate or manage the effects of climate change. Formal requirements exist for pension funds in this area, as they are required to explicitly disclose the relevance and materiality of any ESG risks. In 2018, the UK Government's Department of Work and Pensions confirmed changes to pension trustee duties and rules, to make it an explicit obligation to consider financially material risks, including climate change in relation to investments for occupational pension schemes ([Department for Work and Pensions 2018](#)) It is increasingly likely that further formalised regulation will be developed for the life insurance sector in the UK and globally, given the recent PRA supervisory statement and FCA activity ([Bank of England 2019a](#)).

As companies have become more conscious of Corporate Social Responsibility and investors have demanded greater disclosure around firms' exposure to climate change, actions and metrics related to climate change are forming a more prevalent component of the disclosures in annual reports, even where there are no formal requirements. Emerging market practice, guided by the framework introduced by the Taskforce for Climate Related Financial Disclosures (TCFD), may drive the foundation of future regulatory frameworks, or simply become a 'must have' expectation. In any case, there is significant regulatory interest in the nature and level of disclosure and formal requirements are likely to increase.

#### Regulatory Authorities

Many national and international regulatory and advisory bodies are considering the impacts of climate change and, to date, the focus has mainly been on the stability and efficiency of domestic economies.

Starting at a global level, the International Association of Insurance Supervisors (IAIS), a voluntary membership organization of insurance supervisors and regulators from more than 200 jurisdictions, is examining the risks from climate change to the insurance sector and offering insight on the current and potential supervisory approaches to the regulation of climate-related risks. A survey across the regulatory bodies of the G20 ([IAIS, 2018](#)) highlights that many countries have developed policy and regulatory approaches towards climate change risks and, although these approaches vary between regulators, the underlying objectives are largely similar. Actuaries may therefore find this of interest in order to understand emerging regulatory thinking.

At a European level, EIOPA has also published a consultation regarding the integration of sustainability risks and factors under both Solvency II and the Insurance Distribution Directive ([EIOPA, 2018](#)). This consultation considers the topics of risk management, organisational requirements, and operational considerations in the context of sustainability risks. The proposals, if adopted, would extend the existing requirements of firms and senior management by including, within the relevant legislation, specific references to (and hence obligations regarding) sustainability or Environmental, Social and Governance considerations.

The UK government recognised the need for an appropriate policy response to climate change in 2008, implementing the Climate Change Act. This year the UK government strengthened its commitment by declaring a climate emergency, a net zero emissions target by 2050 and by launching a Green Finance Strategy and establishing the Green Finance Institute.

Globally, in financial services, the UK government has played a leading policy role by establishing the G20 Green Finance study group in 2016, which the UK continues to co-chair with China. In 2019, HM Treasury became a founding member of the Coalition of Finance Ministers for Climate Action.

Mark Carney, the governor of the Bank of England, chaired the Financial Stability Board (FSB) during the development of the TCFD recommendations and the Bank of England was one of 8 founding members of the Network for Greening the Financial System, which now has membership of nearly 40 central banks and financial services regulators. In 2019, the PRA, the FCA, the TPR and the FRC signed a joint declaration of intent on climate change.

Turning more specifically to UK practice, the PRA published a report on the impact of climate change on the UK insurance sector in 2015 ([Bank of England, 2015](#)). The PRA has built on this earlier publication and senior figures from the PRA and the Bank of England (BoE) have spoken further on the topic of regulation and climate change ([Bank of England, 2019c](#)).

In April 2019, the PRA released a supervisory statement, SS3/19, on the topic of “Banks’ and Insurers’ approaches to managing the financial risks from climate change” ([Bank of England 2019a](#)). This statement includes the PRA’s expectations of firms with respect to governance, risk management, scenario analysis and public disclosure. The statement also provides a background to the regulatory approach to the financial risks of climate change. The PRA has also released a paper relating to the effect of climate change on the banking sector, titled “The impact of climate change on the UK banking sector” ([Bank of England, 2018](#)).

The PRA’s proposed expectations of firms in response to the financial risk of climate change are:

- Governance: encouraging board level engagement and defined responsibilities for individuals within the relevant Senior Management Functions;
- Risk management: firms should incorporate financial risks from climate change into existing risk management frameworks. This could extend to identifying, measuring, monitoring, managing and reporting on such risks;
- Scenario analysis: firms may use scenario analysis to inform risk identification and to estimate the impact of financial risks arising from climate change. These scenarios should include a range of outcomes in the transition to a lower carbon economy, and a range of climate change scenarios to consider physical risks;
- Disclosure: firms should develop and maintain an appropriate approach to disclosure around climate-related financial risks. Such disclosure should allow for interaction with existing risk categories, and allow for the newly introduced, distinct elements of financial risk from climate change.

Subsequently, climate change was included as a scenario in the PRA’s Insurance Stress Test 2019 ([Bank of England, 2019b](#)). In this exploratory exercise, the PRA proposes climate change scenarios involving both physical and transition channels, including shocks to asset values varying by sector. Firms are invited to share the assumptions and parameters derived internally when assessing the likely impacts on climate change.

Further publications from the PRA consider in more detail the BoE’s response to climate change, and the interaction between climate change and the macro-economy. The BoE response to climate change focuses on two core elements: engaging with regulated firms on climate-related risk and enhancing the resilience of the of UK financial system. The PRA is active as a member of other advisory bodies such as the Sustainable Insurance Forum (SIF), where it coordinates with other regulators on regulatory approaches to climate change risk.

## **Developments in disclosure**

Climate change related disclosures can be of relevance to actuaries in two ways:

- Actuaries may need to support (and in any case may need to be aware) of the disclosures being made by the insurers they work for. They will also need to consider this in light of public disclosures from competitors, as well as market expectations and regulatory requirements around disclosure;
- Actuaries may also want to understand the disclosures of other firms and industries which the insurer might want to invest in or have counterparty exposure to.

At an international level, the Financial Stability Board (FSB) has created the Task Force on Climate-related Financial Disclosures (TCFD), on behalf of the G20 and chaired by Michael Bloomberg. Its goal is to promote voluntary, consistent, comparable, reliable, and clear disclosures around climate-related financial risk. Access to better-quality information is intended to allow market participants to better understand and manage these risks, and an early understanding can promote a smooth, orderly market transition to a lower carbon economy.

The final report of the TCFD ([TCFD, 2017](#)) provides a foundation to improve investors' and others' ability to appropriately assess and price climate-related risks through suggesting achievable levels of financial disclosure. This report is not limited to life insurance companies and suggests financial disclosures that could be adopted across a wide range of industries, recognising that reporting will evolve over time as participants contribute to the quality and consistency of the information produced. Supplemental guidance is issued at a more granular level, broadly categorised into financial and non-financial, with the financial sector further sub-categorised into banks, insurance companies, asset owners, and asset managers.

The TCFD report recommended a four-pillar approach to company disclosure around climate change, shown below:

Governance	Strategy	Risk management	Metrics and Targets
Disclose the organisation's governance around climate-related risks and opportunities	Disclose the actual and potential impacts of climate-related risks and opportunities on the strategy and financial planning of the business	Disclose how the organisation identifies, assesses, and manages climate-related risks	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities

The 2018 update ([TCFD, 2018](#)) to this advisory report includes the analysis of a sample group of company reports (250 annual reports were reviewed manually, around 1750 were reviewed by an AI program), to identify which companies' disclosures are consistent with the suggestions of the TCFD. This is not to say that companies have responded to the TCFD recommendations and adapted their disclosure, only that the company disclosure in the relevant report (year-end 2017 if available, otherwise year-end 2016) contained a form of disclosure compliant with TCFD principles. The manual exercise showed a degree of success, albeit variable; of the 13 key objectives across the four pillars of disclosure, the majority of firms are disclosing sufficiently in 11 areas. The AI exercise covering a wider sample group showed a much lower level of disclosure, where the majority of firms' disclosure was insufficient across all 13 key objectives. A key result from this update shows that larger firms (those selected for the manual exercise) have a better level of disclosure than smaller firms, with more granular analysis showing that the areas of Strategy and Metrics and Targets are the pillars with the greatest level of disclosure.

The Asset Owners Disclosure Project (AODP), which has collected important information about the 80 largest global insurers' recognition of and responses to climate-related risk, published a report in May 2018 ([Share Action, 2018](#)). The report is structured around the four pillars outlined in the TCFD report. Some of the key findings include:

- **Geographical differences** - European insurance companies are significantly ahead of their American counterparts in terms of the level of their financial disclosures in the format proposed by the TCFD;

- **Practice area differences** - assessment of climate risk was found to be less common amongst life insurers than general insurers. This may be expected given the latter sector's more immediate exposure to climate-related risks through products such as property and flood insurance;
- **Investment in coal and oil** - a range of approaches of divesting from carbon-intensive assets were identified, including straight divestment of funds, to engagement with asset managers to transition to a low-carbon strategy over time;
- **Scenario analysis** - over 80% of insurers did not consider performing scenario analysis to quantify the impact of climate risk. Of those that did, the most common analysis was how their investment portfolio would be impacted under a 2°C scenario (a climate change modelling scenarios derived from assuming global CO2 emissions are such that global warming is limited to 2°C above pre industrial levels).

The main conclusion from the review of TCFD reports is that firms have made an admirable attempt at the first round of climate-related financial disclosure. However, it is clear there are variations amongst firms and no established market practice, therefore firms should be considering how to improve their disclosure going forward.

There are some voluntary agreements which call for the international participation. In 2012, UN launched its Principles for Sustainable Insurance Initiative (PSI).

*“The Principles for Sustainable Insurance provide a global roadmap to develop and expand the innovative risk management and insurance solutions that we need to promote renewable energy, clean water, food security, sustainable cities and disaster-resilient communities.” Ban Ki-moon, UN Secretary – General*

Since then, PSI has 120 members all over the world. According to Dow Jones Sustainability Indexes (DJSI) in 2017, 11 of the top 12 insurers were PSI members with Swiss Re being the leader. PSI is the largest collaborative initiative between the UN and the insurance industry.

In 2016, UN Environment's Sustainable Insurance Forum for Supervisors (SIF) has been launched. The purpose of SIF is to bring together international network of insurance regulators and supervisors to work together to strengthen their understanding of and response to sustainable issues. SIF members and meeting participants include: regulators of Argentina, Australia, Brazil, Canada, France, Germany, Ghana, Italy, Jamaica, Japan, Malaysia, Mongolia, Morocco, Netherlands, Portugal, Singapore, South Africa, South Korea, Sweden, UAE, UK, USA (California and Washington States), European Insurers and Occupational Pensions Authority and the International Association of Insurance Supervisors (IAIS) ([UNEP FI, 2018](#))

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***PRACTICAL STEP:** Actuaries should keep abreast of local emerging regulatory standards that could affect their work. As noted in the IFoA Climate change report ([IFoA, 2019](#)), it may be useful to research the Corporate Social Responsibility (CSR) initiatives and climate change risk management framework within your organisation, your clients or other stakeholders and look for ways to contribute. Details may be found in the company's accounts, in a separate report or the company's website.*

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## 4. Climate change risk and ERM frameworks

In this section we examine how the consideration of climate change risks could work within a typical Enterprise Risk Management (ERM) framework.

First, we note that the topic of climate change and its impact for institutional investors and for insurers is being considered by other disciplines and bodies. This work can also provide useful information on climate change and on potential approaches to risk assessment and governance. This includes for example work by the CRO Forum ([CRO Forum, 2019](#)) and the Institutional Investors Group on Climate Change ([IIGCC, 2018](#)) ([IIGCC, 2019](#)). Since this is an area of ongoing research and development of best practice, actuaries should remain aware of developments by bodies such as these.

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**PRACTICAL STEP:** *When considering climate change, actuaries may want to:*

*Be aware of how climate change risk is already incorporated into a firm's existing ERM; and*

*Be prepared to challenge and ensure that climate change risk is appropriately and proportionately incorporated within wider ERM, particularly if working within a risk management function.*

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Within an ERM framework ([IAA, 2009](#)) firms integrate risk management into their culture. The table below shows how climate change considerations might influence the key components of such a framework:

<b>ERM Key Feature</b>	<b>Potential Climate Change Considerations</b>
Governance and an Enterprise Risk Management Framework	Governance will cover a wide range of aspects including the management structure associated with risk management, setting an appropriate risk culture and ensuring an appropriate and common risk language across the firm. The framework should enable climate change risk to be appropriately and proportionately assessed and included
Risk Management Policy	The policy needs to outline how the firm manages each relevant and material category of risk and describe how it brings together tolerance limits, capital requirements, processes, and its methods for monitoring and managing the risk. Policies need to be flexible and extensive enough to incorporate climate change risk based on current understanding and as thinking evolves
Risk Tolerance Statement	Appropriately include climate change in the Risk Tolerance Statement, for example considering its impact on product types offered or not offered, the firm's investment strategy for its shareholder investments or on behalf of clients, or climate change implications for its tolerance of demographic exposures
Risk Responsiveness and Feedback Loop	Appropriately include climate change consideration in forward looking emerging risk assessment, current Key Risk Indicator (KRI) assessment and backward looking 'lessons learned' from unexpected losses or control failures
ORSA	See below for how climate change could link to the typical risk classifications used by life insurers in assessing quantifiable capital impacts
Economic and Supervisory Capital	See below for how climate change could link to the typical risk classifications used by life insurers in assessing quantifiable capital impacts

Continuity Analysis	(a) short term potential operational continuity risks caused by extreme climate events, for example closure or reduced working of call centres or operational teams (b) climate change impact on long term viability of the firm's strategy. This may include both consideration of upside and downside effects
Role of Supervision	The firm should be aware of and be able to respond appropriately to current and emerging supervisory thinking and requirements on climate change assessment

Within this ERM framework, the ORSA and any risk-based capital assessment will identify key classes of risk exposure and look to assess the financial impact of risk events within them, e.g. at a 99.5% one-year value at risk ("VaR") level. For a life insurance company, these risk classes can include underwriting, market (with further subdivisions e.g. interest rate risk, equity risk...) or operational risk. By comparison, many frameworks for climate change risk have built on the groupings of Physical, Transition and Liability risk.

Firms and actuaries can therefore use both perspectives in isolating and identifying potential climate change exposures and impacts. Such exposures will be specific to individual firms and situations, however any inclusion would need to be proportionate to the nature, scale and complexity of the firm and the potential climate change risks to which it is, or could be, exposed. An example how such a risk identification grid may be populated is set out below. The examples here of whether particular risk classes are more or less material are purely illustrative. The actual rating for a given firm or set of circumstances needs to be considered case by case.

Risk Class	Physical	Transition	Liability
Market	Yes	Yes	Yes
Longevity	Yes	Less material	No
Mortality/Morbidity	Yes	Less material	No
Lapse	Less material	Yes	No
Counterparty	Yes	Yes	Yes
Operational	Less material	Yes	No
Strategic	Yes	Yes	Yes
Reputational	n/a	Yes	Yes

Exploring this grid and considering what types of climate change impact might fall into each box can provide insights into where the firm might be most exposed and hence where it might want to prioritise further investigation or assessment. Furthermore, it is necessary in this evaluation to distinguish between **shock** (sometimes referred to as 'acute') and **trend** ('chronic') type risks. For example, for some markets there is a risk of a shock in terms of increased mortality or morbidity due to extreme weather events. There may also be longer-term trend risks for mortality due to progressive changes in temperature ([Club Vita, 2018](#)). We present below some of the more tangible examples of risk that may emerge from such a framework.

**Transition** effects on **market** risk may include:

Assets owned by insurers include those with a material dependency on the on-going need for carbon consumption. This could include firms involved in petro-chemical exploration, extraction, refinement or distribution, or firms that generate electricity from fossil fuels or firms that are heavy energy users. In an environment where carbon consumption is expected to fall materially it may be the case that the scale of operation of such firms, or even their existence, may be threatened. Equity and bond holdings in such firms will be affected differently and could manifest in shock or trend impacts on the firms' income

and the firms' balance sheet. The timing and evolution of such outcomes may be influenced by rating agency, regulatory assessments or the actions of investors.

**Physical** effects on **longevity and mortality/morbidity** risk may include:

Temperature related health issues associated with extreme weather, particularly where such extremes may compound pre-existing health conditions or vulnerabilities (i.e. elderly populations) ([IAA, 2017](#)).

**Transition** effects on **Strategic** risk may include:

Even in the absence of climate change effects, companies face strategic risk if management fails to plan adequately for the long-term viability of the company and fails to respond to changes in the market. Additional uncertainty driven by climate change, and the resulting societal responses, may exacerbate this risk. As presented in this paper, there are multiple regulatory and advisory bodies increasing their consideration of climate change and its corresponding risks. Much of this early work was exploratory, investigating firms' existing approaches towards disclosure and risk management, but this is evolving into recommended frameworks within which firms can develop their governance and disclosure of climate-related risk.

**Physical** effects on **Operational** risk:

Operational risk is highly dependent on a firm's prevailing strategy and geographical presence. An increased number of extreme weather events is a likely consequence of climate change; and an increased frequency and greater severity of such events presents a range of operational risks.

Extreme weather events are likely to vary by geography and, as a result, a firm's exposure to such risks is inextricably linked to their geographical presence. Firms that employ a greater degree of outsourcing globally may experience increased exposure to business interruption from extreme weather events, whether within countries which do not have the infrastructure in place to respond to these weather events, or in countries with less developed infrastructure more generally.

## 5. The role of models in life insurance

We believe qualitative scenario analysis is an appropriate way to start understanding an insurer's financial exposures to climate-related risks. In this section, we consider both scenario analysis and other potential modelling approaches, whilst noting some of the main challenges present.

The approach taken by insurance firms and regulators towards cyber risk as an emerging risk presents a useful parallel for the development of approaches to climate change risk. Cyber risk has become an important area of risk management for companies and for insurers, with several highly publicised risk events driving a wider acknowledgement of the need to develop robust risk management processes with regard to cyber risk. Though the underlying risk drivers and resulting risk events are materially different from those of climate change risks, recognising the financial cost and reputational damage of experiencing a cyber risk event for an insurer has led to greater engagement from firms, regulators and other stakeholders.

Where insurance firms have not been able to develop formal models, they have taken a more indicative approach to modelling cyber risk exposure. With insufficient information on trends within cyber risk, or data on the distribution of the frequency and severity of such events, many firms have employed scenario analysis to understand the impacts of a cyber risk event. Firms should consider how previous exercises and existing processes for identifying and exploring emerging risks could be applied to the risks arising due to climate change.

### Scenario Analysis

Climate change modelling, for example that produced by the IPCC ([IPCC, 2014](#)), shows a wide range of potential future outcomes for the global climate over the next century, driven primarily by different potential levels of future greenhouse gas emissions. Individual emissions trends themselves are captured as Representative Concentration Pathways (RCPs). These pathways have also been linked via models to implied levels of global warming and mean sea level rise. Those scenarios linked to the highest level of temperature and sea level rise are ones where greenhouse gas emissions are expected to continue to grow. Those with the lower implied temperature and sea level rise are associated with not just a decline in greenhouse gas emissions but a net position later in the 21<sup>st</sup> century where overall there is a net extraction of greenhouse gases from the atmosphere.

These different types of RCP could therefore lead to a position where:

- There are extensive physical risks, as temperatures and sea levels rise and also the potential for more extreme weather events, but little change in industry types or the economy and hence limited transition risk, or;
- There are lower physical risks but significant (and potentially relatively short term) transition risks as societal / economic change results in significant attempts to reduce overall greenhouse gas emissions and look for their capture.

Actuaries may therefore want consider these different types of future pathways and their implications for physical and transition risk types. These could then form a starting point for understanding the overall possible economic and societal conditions an insurer might be operating in and hence where the insurer might be most exposed. Using a range of scenarios with different characteristics would be helpful. Actuaries would still need to understand and as appropriate challenge the relevance of the models as they ought to do professionally.

Understanding the different potential pathways could enable a degree of qualitative scenario analysis. This might involve both relatively extreme (stress testing) or more moderate scenarios. Beyond these qualitative considerations, techniques are available to link the outcome of climate models to potential future economic outcomes, for example, Integrated Assessment Models (IAM), and the Dynamic

Integrated Model of Climate and the Economy (DICE) ([Nordhaus, 2008](#)). Such models describe how the world economy generates income and output for consumption and investment and as a by-product, releases emissions of greenhouse gases, which lead to climate change and consequently economic losses. They also consider mitigation actions and their contributions to economic cost reductions ([Easton and Repetto, 2014](#)). It should be noted that IAMs have serious structural limitations and as a result are likely to underestimate climate impacts so they should be used with caution ([IFOA, 2018](#)). A deeper critique of the DICE model and potential adaptations of DICE is available at [LSE Grantham Institute, 2019](#).

A report written by the IFoA's Resource and Environment Issues for Pensions Actuaries working party in 2018 discusses some of the issues actuaries need to consider when performing scenario analysis and in particular communicating the results of scenario analysis ([IFOA, 2018](#)). The report is aimed at actuaries who advise UK trust-based defined benefit (DB) pension schemes on funding matters but could potentially provide life actuaries with a useful introduction to climate-related scenario analysis.

Rapid development has been seen in commercial risk quantification tools for investment, particularly in the modelling of asset performance under different climate scenarios that may be useful in strategic asset allocation. Examples include the Paris Agreement Capital Transition Assessment ([PACTA](#)), the climate Value-at-risk tool developed by Carbon Delta ([Carbon Delta](#)), and Climate & ESG Solutions developed by Ortec finance ([ORTEC](#)). Generally, these tools analyse the impact of climate change on a company level and estimate the performance of stocks and bonds of each company for the next 5 to 15 years. The analysis of climate change impact considers both physical and transition risks, allowing for regulatory changes, technology advancement, extreme weather and other factors. Actuaries may therefore wish to understand these models in order to consider whether they are relevant for modelling in their work.

## 6. Modelling climate change risk: mortality & morbidity

There are few research papers that consider the impact of temperature on mortality and morbidity and its implication for life insurance products. In a discussion paper written by IAA in 2017 ([IAA, 2017](#)), both the adverse and favourable impacts of climate change on mortality were considered. A thorough study was performed by the IFoA's Resource and Environment Issues for Pensions Actuaries working party in 2017 ([IFOA, 2017b](#)). Their analysis of existing research concluded that air pollution and temperature increases are both related to mortality and morbidity in the UK, although temperature-related effects on mortality and morbidity are more uncertain than the effects of air pollution. In the UK the number of deaths due to cold-related mortality is expected to reduce due to climate change. However, changes to air quality and temperature are highly uncertain in the future and it is difficult to predict their overall impact on mortality and morbidity.

The World Health Organisation (WHO) ([WHO, 2018](#)) estimated that climate change would lead to around 250,000 additional deaths each year between 2030 and 2050 due to factors such as malnutrition, heat stress and malaria. Another piece of research performed by the European Commission Scientists ([Lancet, 2017](#)) predicts that more than 150,000 people could die as a result of climate change each year in Europe by the end of the century. Their paper cites heatstroke, heart and breathing problems, flash flooding, food shortages and infectious disease as direct and indirect causes of death.

IFOA's risk alert ([IFOA, 2017a](#)) advises actuaries to consider climate change when modelling mortality related liabilities and it is also the view of the Working Party that actuaries should consider the impacts on demographics arising from climate change. In particular they should consider the changes that might emerge due to trends in longevity, mortality and morbidity. Currently, this view does not seem to be particularly widespread and the Working Party takes this opportunity to highlight some of the associated modelling considerations.

The effects described could lead to social unrest, migration and severe measures to reverse the causes of climate change. Increased rates of mortality and morbidity, combined with climactic changes that render parts of the planet less habitable (or even uninhabitable), would represent material changes to economies and societal behaviours.

Climate change can affect demographics in many ways. Some examples are outlined below:

- Air quality: The Lancet Commission ([Lancet, 2018](#)) on Pollution and Health reported that an estimated nine million deaths worldwide - around 16% of the total - were caused by pollution in 2015, including 6.5 million by air pollution. Long-term exposure to air pollution could lead to increased likelihood and prevalence of heart disease, stroke, lung cancer, and other health complications;
- Food and water security: Land and water may be polluted in the process of industrial production. Long-term exposure to the toxic water and food will significantly increase the probability of cancer and other severe health issues;
- Temperature change: taken in isolation increasing mean temperatures are likely to reduce cold-related mortality, however the increased likelihood and severity of heatwaves is likely to increase heat-related mortality. In practice though, technology or healthcare approaches are then likely to change in response. Furthermore, these impacts will depend on factors, such as age. For example, older people may be more vulnerable to extreme temperature change than young people. The exposures of life insurers to the affected population groups may be limited. There are also some indirect impacts on mortality/morbidity arising from temperature change that may be significant in the long run, such as:
  - Extreme weather such as storms and floods leading to deaths and the potential for increased incidence of mental illness as a result of distress caused by the destruction of property;

- Deterioration in nutrition and hygiene conditions caused by food and water scarcity: Crop production may be heavily affected by a change in average temperatures, rainfall, extreme weathers, and many other aspects. Water supply (for drinking and for other usage) may be heavily reduced by drought. These events would result in increases in the probability of disease and a reduction in average life expectancy. Less affluent populations may be heavily affected;
- Infrastructure failure: The operating risk of the healthcare system from severe weather may be highly significant, such as health infrastructure failure driven by flooding and storms, or disruption to transport networks preventing patients from receiving medical assistance from doctors/carers.

In addition, there may also be indirect impacts of climate change on demographics. For example:

- Government funding for healthcare may be reduced due to increases in spending on climate change mitigation or responses. Similarly, economic growth could potentially be slowed by the increased frequency of major physical events arising from climate change, which could reduce the spending power of the Government over the longer term;
- People's lifestyle may change. As extreme weather becomes more frequent, people may choose to stay indoors and be less active, which may lead to poor health;
- The demographic profile of the population may change due to migration from countries more heavily affected by climate change.

Overall, the breadth and severity of the impacts of climate change have the potential to cause widespread effects in society and the economy, many of which may be difficult to capture in a model in a credible manner. As the impact of climate change is likely to vary significantly by location, demographic and socioeconomic profile, amongst other factors, actuaries need to make sure that relevant data is used in assessing the impact.

## Modelling barriers

Incorporating climate change risks and considerations into demographic modelling undoubtedly adds a layer of extreme complexity, predominantly due to the amount of uncertainty involved, which includes but is not limited to:

- Data: there is limited availability of demographic data that would allow any assessment of the impacts of climate change historically, and few established sources of global demographic data that are generally accepted as credible. In any case, the necessary richness of data required to inform sophisticated actuarial models is not widely available. These limitations are true of many emerging fields where it takes time for practitioners to challenge the data and form a view on its reliability;
- Time horizon: there is significant uncertainty related to how the effects of climate change will emerge over time and differing views on how adverse the impact on demographics will be. Therefore, a flexible model that can be applied over different time horizons is needed. However, it is difficult to build a model with parameters and variables that remain suitable and stable over different time horizons;
- The choice of parameters and models: the best models are robust i.e. they react well to new information and have proven predictability power when back-tested over different time periods. If the end goal is to model impacts to morbidity and mortality, there is an intermediate step in interpreting the correlation between parameters derived from observable data collected from the wider environment and parameters concerned with the impacts on health.

Despite the above limitations, life actuaries are encouraged to contribute to research and model climate change risk and its impacts in areas such as demographics, pricing and reserving.

## 7. Next Steps

The recognition and awareness of climate change as a source of risk for life insurers, and the actions required in response to the risks of climate change, to increase.

We encourage life actuaries to consider how the impacts and effects discussed in this document are applicable to their own work, and to the wider work of their employer. This includes their responsibilities in relation to the IFOA Risk Alert on Climate-Related Risks. Recognising the implications of climate change risk in business operations is a key first step. Engaging internally with exercises such as scenario analysis, allowing for its effects in business planning, may provide greater insight into the specific risks a company faces as a result of climate change. Achieving cross-disciplinary and wider firm engagement will be essential in embedding a consideration of climate change in strategic decision making, and, ultimately, including climate change risk in more quantitative and robust risk management processes. Finally, across all of these aspects, actuaries and firms need to reflect on the need for disclosures around climate change related aspects.

Given the engagement and on-going work by national and global regulatory bodies, and voluntary advisory bodies, the approach to climate change is evolving. Actuaries considering climate change in their work should monitor the publications and consultations proposed by these bodies, and we would encourage them to engage in such consultations, as regulation develops in this area.

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