



Institute
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of Actuaries

Climate Change for Actuaries: An Introduction

by the Climate Change Working Party

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Please note that the cut-off date for the original research and content included in this report was November 2018. A light-touch review was carried out in July 2020 to update any broken links and update for key developments in regulation and industry initiatives since November 2018 (see Sections 5.3 and 5.4). Appendix A, which provided links to talks from TED.com and a short reading list has also been removed.

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1. About this report

This report is an introduction to climate change for actuaries in all fields of work.

It provides an overview of some of the differing topics discussed and researched by the Climate Change Working Party over the last few years.

You can read the paper as a whole or skip straight to the section you are most interested in. There are six sections:

“Introduction” summarises the key evidence that shows the climate is warming and outlines the international response and implications for actuaries.

“Impact on natural and human systems” sets out the main effects of climate change and its potential impact on our world.

“Impact on the insurance industry” summarises the key implications of climate change for the insurance industry and provides some examples of how it is responding to protect those most at risk.

“Impact on capital markets” sets out the main implications of climate change for capital markets and how they are responding to help mitigate climate change. It also summarises a number of wider financial initiatives in response to climate change.

“Communicating climate risks” explores the challenges of doing just that and suggests a few ways actuaries could engage others to act.

“Next steps for actuaries” suggests a few practical next steps for actuaries to further their understanding about climate change and help others respond to climate risks.

2. Introduction

This section summarises the key evidence that shows that the climate is warming and that human activity is the primary cause. It also outlines the international response and implications for actuaries.

2.1. Key evidence

The climate is warming at an unprecedented rate Evidence from climate science shows that the climate is warming. Globally, average temperatures have risen by around 1°C since 1901,¹ with all but one of the 18 warmest years having occurred in the 21st century.² The last three years (2015, 2016 and 2017) are the warmest on record.³ Over the last few decades, average temperatures have been higher and risen faster than at any other period in the last 1,700 years.⁴ Temperatures could increase by more than 5°C by the end of this century without major reductions to the emission of greenhouse gases.⁵

Human activity is the primary cause of climate change Climate scientists “overwhelmingly agree that humans are causing recent global warming”⁶ - a consensus view shared by 90%-100% of published climate scientists.⁷ (97% is the figure commonly cited in the media).⁸ One recent report estimates that human activity contributed to 92-123% of the observed change in global temperatures since 1951 (i.e. greater than 100% because temperatures may have decreased during that period, were it not for human actions).⁹ The reality of human-induced climate change and the nature of the risks it poses is now accepted by almost all governments and policy-makers worldwide. This has been reflected in the 2015 Paris Agreement, an international treaty negotiated by 197 parties to deal with climate change and its effects.¹⁰

2.2. International response

International efforts aim to limit increase in global temperatures The Paris Agreement aims to keep the increase in global average temperature “well-below” 2°C above pre-industrial levels, with a further aspiration to limit the temperature increase to 1.5°C, in order to significantly reduce the risk and impact of climate change.¹¹ (Risks for

¹ Donald Wuebbles et al., “Our globally changing climate,” in *Climate Science Special Report: Fourth National Climate Assessment, Volume 1*, ed. D Wuebbles et al. (Washington, DC: U.S. Global Change Research Program, 2017): 39, <http://doi.org/10.7930/J08S4N35>.

² “WMO confirms 2017 among the three warmest years on record,” World Meteorological Organisation, 18 January, 2018, <https://public.wmo.int/en/media/press-release/wmo-confirms-2017-among-three-warmest-years-record>.

³ Ibid.

⁴ Wuebbles, “Our globally changing climate,” 36.

⁵ Wuebbles, “Our globally changing climate,” 35.

⁶ John Cook et al., “Consensus on consensus: a synthesis of consensus estimates on human-caused global warming,” *Environmental Research Letters* 11, 4 (13 April, 2016), <https://doi.org/10.1088/1748-9326/11/4/048002>.

⁷ Ibid.

⁸ Justin Fox, “97 Percent Consensus on Climate Change? It's Complicated,” *Bloomberg*, 15 June, 2017, <https://www.bloomberg.com/view/articles/2017-06-15/97-percent-consensus-on-climate-change-it-s-complicated>.

⁹ Thomas Knutsen et al., “Detection and attribution of climate change,” in *Climate Science Special Report: Fourth National Climate Assessment, Volume 1*, ed. Donald Wuebbles et al. (Washington, DC: U.S. Global Change Research Program, 2017): 114, <https://doi.org/10.7930/J0J964J6>.

¹⁰ “Paris Agreement - Status of Ratification,” United Nations Framework Convention on Climate Change, accessed 2 April, 2018, http://unfccc.int/paris_agreement/items/9444.php.

¹¹ “The Paris Agreement,” United Nations Framework Convention on Climate Change, accessed 1 April, 2018, http://unfccc.int/paris_agreement/items/9485.php.

natural and human systems are significantly lower at global warming of 1.5°C than at 2°C.)¹²

Cutting carbon emissions is a central part of the Agreement – each country has its own goals to reduce emissions and these are expected to be strengthened in the future. The Paris Agreement also aims to help poorer countries mitigate and adapt to climate change through the provision of “climate finance” funded by richer nations.¹³

To date global governance responses have not delivered a step change

The aspiration to keep the increase in global average temperature below 2°C above pre-industrial levels came out of the United Nations Framework Convention on Climate Change (UNFCCC) process which set up a series of Conference of the Parties (COP) events.¹⁴ The Paris Agreement was finalised at the 21st annual COP. Over the two decades since the creation of UNFCCC, efforts to achieve that aspiration have been inadequate. Current pledges under the Paris Agreement also require “substantial enhancement”¹⁵ if the increase in global average temperature is to stay within 2°C. At current rates, global warming is likely to reach 1.5°C between 2030 and 2052.¹⁶ Looking further ahead, estimates of global warming in 2100 range from 3-8°C in the absence of additional mitigation efforts.¹⁷

Achieving the scenario outcomes underpinning the Paris Agreement assumes the removal of carbon dioxide from the atmosphere

Virtually all pathways which show how global warming can be kept “well-below” 2°C assume not only a significant reduction in actual emissions but also the large-scale removal of carbon dioxide from the atmosphere. This has been called the “dirty secret” of the 2015 Agreement.¹⁸ In May 2018 scientists met in Gothenburg for the first scientific conference on this subject.¹⁹ Technology to scrub carbon dioxide out of the air does exist (known as carbon capture and storage or CCS) but financial incentives for developing and enlarging it to the necessary scale are currently weak.²⁰ In February 2018 Nature magazine called the current strategy on negative emissions “magical thinking” and asked scientists to spell out to policymakers “the harsh reality of what this would involve, and in the strongest possible terms”.²¹

¹² Intergovernmental Panel on Climate Change, “Summary for Policymakers” in *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, (IPCC, 2018), SPM-8, http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.

¹³ “Climate Finance,” United Nations Framework Convention on Climate Change, accessed 1 April, 2018, http://unfccc.int/cooperation_and_support/financial_mechanism/items/2807.php.

¹⁴ Samuel Randalls, “History of the 2°C climate target,” *WIREs Climate Change* 1, 4 (14 July, 2010): 598-605, <https://doi.org/10.1002/wcc.62>.

¹⁵ Joeri Rogelj et al., “Paris Agreement climate proposals need a boost to keep warming well below 2°C,” *Nature* 534 (30 June, 2016): 631-639, <http://www.nature.com/articles/nature18307>.

¹⁶ IPCC, “Summary for Policymakers” in *Global Warming of 1.5°C*, SPM-4.

¹⁷ Intergovernmental Panel on Climate Change, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Core Writing Team R.K. Pachauri and L.A. Meyer (eds.), (Geneva: IPCC, 2014), 77, https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf.

¹⁸ The Economist, “Extracting carbon dioxide from the air is possible. But at what cost?,” *The Economist*, 7 June, 2018, <https://www.economist.com/science-and-technology/2018/06/07/extracting-carbon-dioxide-from-the-air-is-possible.-but-at-what-cost>.

¹⁹ See <http://negativeco2emissions2018.com/> for more information.

²⁰ Intergovernmental Panel on Climate Change, “Chapter 4: Strengthening and implementing the global response” in *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, Chapter coordinating lead authors Heleen de Coninck and Aromar Revi, (IPCC, 2018), 4-45, http://report.ipcc.ch/sr15/pdf/sr15_chapter4.pdf.

²¹ Nature (editorial), “Why current negative-emissions strategies remain ‘magical thinking’,” *Nature* 554 (21 February, 2018): 404, <https://www.nature.com/articles/d41586-018-02184-x>.

2.3. Implications for actuaries

Climate change has implications for the work done by actuaries There are a number of implications of climate change, to both human populations and natural systems. The following pages provide an abbreviated summary of the current position in some key areas. Climate change also has wide-reaching implications for the work done by actuaries through its potential to impact human health and mortality, the economy and financial stability, the risks people and businesses face from natural disasters and the value of assets held by insurers and pension schemes.

Actuaries should be mindful of transition risks as well as other risks When considering the financial implications of climate change, it is important to consider transition risks and liability risks as well as the physical risks of climate change.²² Physical risks are the risks arising from the impact of climate change, e.g. more frequent damage to property due to flooding resulting in higher number of insurance claims. Transition risks are risks related to transitioning to a lower-carbon economy or to helping the world adapt to or mitigate the effects of climate change. These could include impacts arising from changes to government policies, reputational risks, changes in consumer demand, disruptive technologies, the need to significantly update global infrastructure or a rapid reduction in the value of certain assets (“stranded assets”). Finally, liability risks are risks from third parties seeking compensation from the effects of climate change, e.g. companies being sued because of the impact of their greenhouse gas emissions.

²² “Risk Alert: Climate-Related Risks,” Institute and Faculty of Actuaries, 12 May, 2017, accessed via <https://www.actuaries.org.uk/news-and-insights/media-centre/media-releases-and-statements/foa-warns-climate-change-financial-risks>.

3. Impact on natural and human systems

This section sets out the main effects of climate change and impact on natural and human systems. It is largely based on the body work by the Intergovernmental Panel on Climate Change (IPCC) who provide reports on the state of knowledge on climate change at regular intervals. The latest report is the Fifth Assessment Report published in 2014. (The next report is not due to be published until 2022.)²³

3.1. Main effects of climate change

Rising surface temperatures	The last three decades have been successively warmer than any decade since 1850 and are likely to have been the warmest 30 year period of the last 1,400 years. ²⁴ Models suggest that the average surface temperature is likely to increase between 0.3°C and 0.7°C further over the period from 2016 to 2035. Temperature changes beyond mid-21 st century are highly dependent on the level of future emissions. ²⁵
Warming of the oceans and acidification	Over the 30 year period to 2010, the surface of the oceans has warmed by 0.1°C per decade on average. Absorption of CO ₂ has led to acidification of the oceans – the pH of the ocean surface has decreased by 0.1 since the beginning of the industrial era. ²⁶ Oceans will continue to warm and acidify through the 21 st century. ²⁷ This has implications for coral and marine life, and for all parts of the economy that rely on the ocean for their livelihood.
Reduction in land and sea ice	Since 2002, the land ice sheets in Greenland and Antarctica have lost over 400 gigatonnes of ice mass each year. ²⁸ Climate change has been linked to the collapse of Antarctica’s Larson A and B ice shelves in 1995 and 2002 respectively. (In 2017 an iceberg twice the size of Luxemburg broke off Antarctica’s Larsen C but no direct connection with climate change has been determined.) ²⁹ The Arctic Ocean is predicted to become ice free during summer by the middle of this century. ³⁰ Glaciers are shrinking around the world and permafrost is thawing. This increases the risk of further substantial carbon and methane emissions, ³¹ creating a positive feedback loop that could accelerate climate change.
Rising sea levels	Sea levels are rising as a result of melting land ice and higher ocean temperatures (sea water expands as it warms). Sea levels rose by around 20cm between 1901-2010. ³² Relative to the year 2000, sea levels are predicted to rise by 30cm to 130cm by 2100 depending on the level of

²³ “IPCC holds meeting in Addis Ababa to draft Sixth Assessment Report outline,” IPCC, 28 April 2017, https://archive.ipcc.ch/news_and_events/PR092017_AR6_Scoping.shtml.

²⁴ IPCC, *Climate Change 2014: Synthesis Report*, 40.

²⁵ IPCC, *Climate Change 2014: Synthesis Report*, 58-59.

²⁶ IPCC, *Climate Change 2014: Synthesis Report*, 40-41.

²⁷ IPCC, *Climate Change 2014: Synthesis Report*, 62.

²⁸ “Vital Signs: Ice Sheets,” NASA, accessed 25 March, 2018, <https://climate.nasa.gov/vital-signs/land-ice/>.

²⁹ Nicola Davies, “Iceberg twice size of Luxembourg breaks off Antarctic ice shelf,” *The Guardian*, 12 July, 2017, <https://www.theguardian.com/world/2017/jul/12/giant-antarctic-iceberg-breaks-free-of-larsen-c-ice-shelf>.

³⁰ “The Effects of Climate Change”, NASA, accessed 25 March, 2018, <https://climate.nasa.gov/effects/>.

³¹ IPCC, *Climate Change 2014: Synthesis Report*, 67.

³² IPCC, *Climate Change 2014: Synthesis Report*, 42.

future emissions.³³

Changes to precipitation patterns and seasons Some areas in the world are projected to experience higher levels of precipitation, whereas in others precipitation is projected to decrease.³⁴ Seasons are also changing, with several studies showing spring is arriving earlier across the Northern Hemisphere.³⁵

3.2. Impact of climate change on natural and human systems

Greater risks of extreme events and disasters Climate change is expected to increase the risk of extreme events and disasters such as cyclones, floods, droughts and wildfires.³⁶ Heat waves and extreme precipitation events are likely to become more frequent, intense and/or last longer in some regions of the world.³⁷

Irreversible damage to ecosystems and loss of biodiversity Many species are at risk of becoming extinct over the 21st century through a combination of climate change and other environmental stressors such as pollution and loss of habitat.³⁸ Climate change is already impacting fragile ecosystems, some of which may never recover, e.g. major Great Barrier Reef coral bleaching event in 2017 as a result of ocean acidification.³⁹

Disruption to the economy and livelihoods Risks from climate change include disruption to the economy as a result of extreme events and loss of livelihoods from industries like agriculture, fishing and tourism.⁴⁰ People already living in poverty are particularly vulnerable to disruption to their livelihoods.⁴¹

Food insecurity Climate change, coupled with increased demand from growing populations, threatens food security for millions of people. It has repercussions for the availability, access, use and stability of food sources.⁴² Without adaptation, climate change is projected to have a negative impact on crop yields globally. (Climate change may have a positive impact on crop yields in some high-latitude regions. The balance of positive and negative impacts from climate change in these regions is not yet known.)⁴³ Indirectly, food insecurity may also lead to political instability or violent conflict in some regions.

Negative impact on human health and mortality The impact of climate change on human health includes an increase in injury and deaths from heat waves and extreme events (e.g. fires), under-nutrition and increased risks from changes in the distribution and season of infectious diseases. There may be some positive impacts, for example a reduction in cold-related deaths in some areas. However, climate change is

³³ William Sweet et al., "Sea level rise," in *Climate Science Special Report: Fourth National Climate Assessment, Volume 1*, ed. Donald Wuebbles et al. (Washington, DC: U.S. Global Change Research Program, 2017): 333, <https://doi.org/10.7930/J0VM49F2>.

³⁴ IPCC, *Climate Change 2014: Synthesis Report*, 60.

³⁵ Cheryl Katz, "Summer in March? Warming Climate Alters Europe's Seasons," *National Geographic*, 4 April, 2016, <https://news.nationalgeographic.com/2016/04/160404-climate-change-Europe-early-summer/>.

³⁶ IPCC, *Climate Change 2014: Synthesis Report*, 72.na

³⁷ IPCC, *Climate Change 2014: Synthesis Report*, 58 - 60.

³⁸ IPCC, *Climate Change 2014: Synthesis Report*, 67.

³⁹ Craig Welch, "Warming Bleaches Two-Thirds of Great Barrier Reef," *National Geographic*, 9 April, 2017, <http://news.nationalgeographic.com/2017/04/great-barrier-reef-climate-change-coral-bleaching/>.

⁴⁰ IPCC, *Climate Change 2014: Synthesis Report*, 65 -67.

⁴¹ IPCC, *Climate Change 2014: Synthesis Report*, 54.

⁴² "Impacts on food security", Met Office, last updated: 16 December, 2013, <http://www.metoffice.gov.uk/climate-guide/climate-change/impacts/food>.

⁴³ IPCC, *Climate Change 2014: Synthesis Report*, 51.

expected to have a detrimental impact on human health and mortality overall, with those living in poorer regions most likely to be affected.⁴⁴

Water scarcity Growing numbers of people are expected to experience water scarcity over the 21st century as a result of changes to the quantity and quality of water resources caused by the effect of climate change on hydrological systems.⁴⁵ This might contribute to mass population migrations with inherent consequences of political instability and/or violent conflict in some regions.⁴⁶

⁴⁴ IPCC, *Climate Change 2014: Synthesis Report*, 69.

⁴⁵ IPCC, *Climate Change 2014: Synthesis Report*, 67 - 69.

⁴⁶ For example see J.A.Duran-Encalada et al., "The impact of global climate change on water quantity and quality: A system dynamics approach to the US–Mexican transborder region," *European Journal of Operational Research* 256, 2 (16 January, 2017): 567-581, <https://doi.org/10.1016/j.ejor.2016.06.016>.

4. Impact on the insurance industry

This section summarises the key implications of climate change for the insurance industry. It also provides some examples of how the insurance industry is responding to protect those most at risk from climate change.

4.1. Key implications of climate change for the insurance industry

Changes in climate related risks	Changing weather patterns and a changing climate will impact property- and agriculture-related losses through changes in frequency and severity of flood, wind, drought, hail and other climate-related events. These changes will need to be modelled and allowed for in all aspects of the business i.e. pricing, reserving and capital modelling.
Some types of insurance may become less affordable	Insurers typically charge higher prices for risks where there is greater uncertainty around their scale, nature and frequency. For some types of insurance, the uncertainty around climate risks could lead to prices that few customers or businesses could afford and lower rates of insurance penetration. It could also widen the protection gap i.e. between those who can afford protection and those who cannot.
Diminishing markets	Exposed coastal properties and coal-related activities are examples of risks that might soon become uninsurable. To support the Paris Agreement commitment to keep climate change below 2°C, some insurers and reinsurers have divested from coal companies while others refuse to underwrite new coal projects. ⁴⁷ Insurers and reinsurers face the risk of a shrinking market for certain products.
Greater accumulation of risks	The risk of over-exposure to a single (climate-related) event may increase as significant climate events become more common and/or more severe, e.g. increased frequency of tropical cyclones, tornado, hail, drought, flood, famine, etc. Insurers and reinsurers should ensure that accumulations are managed in areas that become more susceptible to these developing risks, e.g. increased density of coastal property coverage as sea levels rise.
Increased correlation of events	Events that are usually uncorrelated may become more correlated because of climate change, e.g. correlation of political risk with droughts or floods. These correlated risks are difficult to quantify and manage and contribute to a greater accumulation of risks.
Latent claims	At some point in the future, liability claims relating to climate change could emerge with some latency. There are already many examples of legal proceedings relating to climate-change both inside and outside of the US. ⁴⁸ Lawsuits where the negative impact of carbon emissions is central to the claim are increasing. ⁴⁹ Examples of legal action include local governments in the US seeking a contribution to the costs of adapting to rising sea levels

⁴⁷ Unfriend Coal, *Insuring Coal No More: An Insurance Scorecard on Coal and Climate Change*, by Casey Harrell and Peter Bosshard, (Unfriend Coal, 2017), 3, <https://unfriendcoal.com/wp-content/uploads/2017/11/UnfriendCoal-Insurance-Scorecard.pdf>.

⁴⁸ See <http://climatecasechart.com/> for examples

⁴⁹ The Economist, "Climate-change lawsuits," *The Economist*, 2 November, 2017, <https://www.economist.com/news/international/21730881-global-warming-increasingly-being-fought-courtroom-climate-change-lawsuits>

from fossil fuel companies⁵⁰ and the Ugandan government being sued for failing to protect people from the dangers of climate change.⁵¹

Model Risk	Actuaries should be mindful of the huge uncertainty surrounding climate change and its future impact on the world. There is a risk that the different models used by actuaries to calculate premiums, reserves and capital do not adequately represent the reality of a world impacted by climate change (and if they do now, they may not in the future). In particular, actuaries should consider how sensitive their models are to assumptions and data that could be impacted by climate change.
Adverse selection against insurers	Those insurers who do not adequately account for climate risks in their pricing models may be more susceptible to adverse selection by policyholders, e.g. because they unwittingly offer cheaper premiums to customers than competitors who have adequately accounted for climate risks.
Changing mortality / morbidity risks	A changing climate may alter the distribution or prevalence of both infectious and non-infectious diseases like malaria ⁵² and asthma ⁵³ in insured populations. Equally a changing climate could increase the number of deaths linked to extreme temperatures. ⁵⁴ It is worth noting that the relationship between disease and climate change is complex - for some populations, mortality and morbidity may fall. ⁵⁵
Changes in population	Climate change could lead to rapid changes in the population of different geographic areas, e.g. due to mass migration because of water shortages or floods. Populations that have either shrunk or increased dramatically because of migration could have very different risk profiles than before, e.g. different demographic profile, socio-economic status, education, etc.
Greater capital requirements	Climate change could lead to greater capital requirements for insurance companies because of the increased frequency and severity of extreme events combined with the risk climate change poses to assets (see the next section for more details). There is a move towards standardised reporting requirements, e.g. recommendations for climate change reporting published by the Financial Stability Board Task Force on Climate-related Financial Disclosures (TCFD) in 2017 ⁵⁶ and a growing number of jurisdictions have introduced requirements for insurance companies. ⁵⁷ Rating agencies have also flagged that climate risks need to be incorporated in credit ratings. ⁵⁸

⁵⁰ "Carbon Majors to face court over rising sea levels in California", ClientEarth, 18 July, 2017, <https://www.clientearth.org/carbon-majors-face-court-rising-sea-levels-california/>.

⁵¹ "Ugandan government to face court in the country's first climate change case", ClientEarth, 27 June, 2018 <https://www.clientearth.org/ugandan-government-to-face-court-in-the-countrys-first-climate-change-case/>.

⁵² Noriko Endo, Teresa Yamana, Elfatih A B Eltahir, "Impact of climate change on malaria in Africa: a combined modelling and observational study," *The Lancet*, 389, no. S7 (April 2017): 7, [https://doi.org/10.1016/S0140-6736\(17\)31119-4](https://doi.org/10.1016/S0140-6736(17)31119-4).

⁵³ Brittany Patterson, Manon Verchot and ClimateWire, "Climate Change May Speed Asthma Spread," *Scientific American*, 30 April, 2017, <https://www.scientificamerican.com/article/climate-change-may-speed-asthma-spread/>.

⁵⁴ IPCC, *Climate Change 2014: Synthesis Report*, 69.

⁵⁵ *Ibid*, 69.

⁵⁶ "Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures (June 2017)," TCFD, accessed 25 March, 2018, <https://www.fsb-tcfd.org/publications/final-recommendations-report/>.

⁵⁷ United Nations Environment Programme, *Sustainable Insurance: The Emerging Agenda for Supervisors and Regulators*, by Jeremy McDaniels, Nick Robins and Butch Bacani, (UNEP, 2017), 13, http://www.unepfi.org/psi/wp-content/uploads/2017/08/Sustainable_Insurance_The_Emerging_Agenda.pdf.

⁵⁸ Christopher Flavelle, "Moody's Warns Cities to Address Climate Risks or Face Downgrades," *Bloomberg*, 29 November, 2017, <https://www.bloomberg.com/news/articles/2017-11-29/moody-s-warns-cities-to-address-climate-risks-or-face-downgrades>.

4.2. Examples of how the insurance industry is responding to climate change

- Microinsurance** Low income populations are particularly vulnerable to climate change risks. They often live in more severely impacted regions and may lack the resources to recover from significant fluctuations in income and / or displacements as a result of floods, droughts or famines. Microinsurance provides insurance coverage to low income populations. It typically covers lower valued assets but may also provide compensation, e.g. for illness or death. Premiums are considerably lower than mainstream insurance plans due to the lower sums assured and customers may be offered innovative ways to pay premiums and make claims (e.g. through mobile phones).⁵⁹ In the past, microinsurance initiatives were typically funded by charities or NGOs but increasingly commercial insurers are moving into this market, e.g. the Blue Marble Consortium, a consortium of nine international insurers.⁶⁰
- Weather-based index insurance** Weather-based index insurance takes advantage of developing technology to provide insurance to subsistence farmers who are more likely to be affected by changing climatic conditions.⁶¹ Claim payments are linked to parametric triggers or a “weather-index” which uses technology such as satellite imaging to estimate rainfall or vegetation coverage. Claim payments are made automatically, e.g. once rainfall reaches a certain level, without the need for claims adjusters to assess crop damage on the ground. While this increases basis risk (i.e. caused by the difference between experienced losses and the value of the payment),⁶² improvements in technology, modelling techniques and policy design are helping to mitigate this risk. Examples of weather-based index insurance products include the index-based flood insurance (IBFI) scheme piloted in India and Bangladesh⁶³ and the Kenya Livestock Insurance Programme.⁶⁴
- Government-backed insurance schemes and international risk pooling** In developed countries some risks have become uninsurable. Several governments have set up state-backed organisations to pool risk and provide coverage to those exposed. Examples include the National Flood Insurance Programme (NFIP) in the US,⁶⁵ Texas Windstorm Insurance Association,⁶⁶ Florida Hurricane Catastrophe Fund⁶⁷ and Flood Re⁶⁸ in the UK. Similarly, in emerging economies, schemes have been set up to provide coverage to vulnerable populations without insurance to help them

⁵⁹ Kelvin Chamunorwa, “In search of that elusive scale,” *The Actuary*, 13 July, 2017, <http://www.theactuary.com/features/2017/07/in-search-of-that-elusive-scale/>.

⁶⁰ See <http://bluemarblemicro.com/> for more information.

⁶¹ Nicholas Bell, “Satellites in agricultural insurance”, *Actuarial Post*, accessed 26 March, 2018, <http://www.actuarialpost.co.uk/news/satellites-in-agricultural-insurance-5038.htm>.

⁶² “Index Insurance - Frequently Asked Questions”, International Finance Corporation, accessed 1 June, 2020, https://www.ifc.org/wps/wcm/connect/industry_ext_content/ifc_external_corporate_site/financial+institutions/priorities/access_essential+financial+services/qiif+frequently-asked-questions .

⁶³ See <https://ibfi.iwmi.org/> for more information.

⁶⁴ Sophie Eastaugh, “Satellite images trigger payouts for Kenyan farmers in grip of drought,” *The Guardian*, 25 April, 2017, <https://www.theguardian.com/global-development/2017/apr/25/satellite-images-trigger-payouts-for-kenya-farmers-in-grip-of-drought>.

⁶⁵ See <https://www.fema.gov/national-flood-insurance-program> for more information.

⁶⁶ See <https://www.twia.org/> for more information.

⁶⁷ See <https://www.sbafla.com/fhcf/> for more information.

⁶⁸ See <https://www.floodre.co.uk/> for more information.

recover quickly after an event, e.g. World Bank pandemic bond,⁶⁹ Africa Risk Capacity,⁷⁰ Caribbean Catastrophe Risk Insurance Facility⁷¹ and the InsuResilience Global Partnership.⁷² The use of state-backed finance can efficiently increase coverage when the pooling of risk brings the average risk in the pool to a level that is insurable. However, such schemes can also be used to ensure insurance is still provided in areas where, even through pooling, the risks remain too high. These schemes could represent a systemic risk to the public sector over the medium to long-term.

Systems thinking

Understanding the impact of climate change is a difficult challenge for insurance companies. The short time horizon on which insurers report and issue policies makes incorporating climate change into their models particularly difficult. Systems thinking is increasingly seen as an approach to tackling some of these problems. This involves modelling the environment as a complex adaptive system, in which the components of the system interact with and are impacted by other parts of the system. The system is treated as a whole rather than in its separate component parts.

⁶⁹ "World Bank Launches First-Ever Pandemic Bonds to Support \$500 Million Pandemic Emergency Financing Facility," The World Bank, 28 June, 2017, <https://www.worldbank.org/en/news/press-release/2017/06/28/world-bank-launches-first-ever-pandemic-bonds-to-support-500-million-pandemic-emergency-financing-facility> .

⁷⁰ See <http://www.africanriskcapacity.org/> for more information.

⁷¹ See <http://www.ccrif.org/> for more information.

⁷² See <http://www.insuresilience.org/> for more information.

5. Impact on capital markets

This section sets out the main implications of climate change for capital markets and how capital markets are responding to help mitigate climate change. It also summarises a number of wider financial initiatives that aim to help investors (and businesses) to understand the risks of climate change and the transition to a lower carbon economy.

5.1. Implications of climate change for capital markets

Stranded assets	Reducing global carbon emissions to meet the UNFCCC goal of limiting climate warming to 2°C above pre-industrial global average temperatures requires keeping significant fossil fuel reserves in the ground – or at the very least they cannot be burned without carbon capture and storage. This will impact the cash flows, future values and share prices of companies whose businesses rely on the extraction and consumption of fossil fuels. ⁷³ These fossil fuel assets may effectively become “stranded”. The International Energy Agency estimates that over \$1trillion oil and natural gas assets could be abandoned by 2050. ⁷⁴
Business model redundancy	Demand for, and cost of, production of most goods and services could be significantly altered as a result of either climate change or efforts to transition to a lower carbon economy. For example, energy, water and food might comprise a higher proportion of most consumers’ spending. Many business models may be rendered obsolete or non-viable as a consequence, with resultant collapses in share prices and debt defaults becoming more frequent events. ⁷⁵ On the other hand, new business models and opportunities may emerge, leading to improved prospects for some sub-sectors of the economy.
Market volatility and economic shocks	In addition to the above, future uncertainty around climate change and the implications for society are likely to increase market volatility, for example, through political instability as a result of water or food shortages. In the near future, shifts in market sentiment caused by (currently unrealised) awareness of the future impact of climate change could lead to economic “shocks” and substantial losses. ⁷⁶ Triggers for these shocks could include new scientific evidence, policy change or legal developments.
Changes in saving patterns	Higher energy, water and food costs may reduce savings by families and investment by businesses, lowering the level of capital formation and deployment in the global economy at a time when new infrastructure investment is critical to meet the challenges posed by climate change.
Intergenerational issues	Another consequence is intergenerational transfer of risk, from current to future generations who will be more directly impacted by climate change.

⁷³ Sini Matikainen, “What are stranded assets?” London School of Economics, 23 January, 2018, <http://www.lse.ac.uk/GranthamInstitute/faqs/what-are-stranded-assets/>.

⁷⁴ Jillian Ambrose, “IEA warns \$1.3 trillion of oil and gas could be left stranded,” *The Telegraph*, 20 March, 2017, <https://www.telegraph.co.uk/business/2017/03/20/iea-warns-13-trillion-oil-gas-could-left-stranded/>.

⁷⁵ Carbon Tracker & The Grantham Research Institute, LSE, *Unburnable Carbon 2013: Wasted capital and stranded assets*, (Carbon Tracker & The Grantham Research Institute, LSE, 2013), <https://carbontracker.org/reports/unburnable-carbon-wasted-capital-and-stranded-assets/>.

⁷⁶ University of Cambridge Institute for Sustainability Leadership, *Unhedgeable risk: How climate change sentiment impacts investment*, (Cambridge: CISL, 2015), 5, <https://www.cisl.cam.ac.uk/publications/publication-pdfs/unhedgeable-risk.pdf/view>.

5.2. Examples of how capital markets are responding to climate change

Capital markets play an important role	Capital markets have an important role to play in terms of allocating capital towards alternative fuels and green technology to help the world transition to a low carbon economy. Of the countries that have ratified the Paris Agreement, around 60 have estimated how much they would need to spend to meet their commitments over the period 2015-2030 – this stands at approximately \$5.3 trillion, much of which will need to be financed by private investors. ⁷⁷ Initiatives include new types of bonds, carbon trading, impact investing and the creation of sustainability indices, as described below.
Climate / green bonds	These are financial instruments that have their income stream related to a climate change solution or other projects with an environmental benefit (e.g. infrastructure investment, clean energy development, green innovation). They can be issued by governments, multi-nationals or corporations. Most climate bonds have ring-fenced proceeds or are asset-backed. This form of investment has shown large growth over the past few years, reaching a record \$150bn new bonds issued in 2017. ⁷⁸ Further work needs to be done to help investors separate those projects that will have a positive impact on the environment from those which are merely “greenwashing”. Currently there is no universal certification system. ⁷⁹ Examples of climate / green bonds include The European Investment Bank’s Climate Awareness Bonds ⁸⁰ and the green bond issued by the Government of Fiji in 2017. ⁸¹
Catastrophe bonds	Catastrophe bonds are financial instruments which transfer a specific set of risks linked to a catastrophic event to investors. The bondholder receives a coupon payment from the bond issuer, with the principal payment under the bond lost in the event of a catastrophic event and the money instead used to remediate the damage. For example, in 2017 the World Bank issued a catastrophe bond to Mexico to protect the country against losses of \$360m in the event of a natural disaster. ⁸² An increasing number of catastrophes and the increase of an investment market in reinsurance means that this investment class is growing steadily over time.
Carbon trading	Carbon emissions trading is founded on a permit system that sets the maximum amount of carbon emissions that countries may produce. The caps on carbon emissions are then notionally split between companies operating within a country by issuing permits for their share of emissions. This is one approach to getting companies to reduce their emissions although companies may trade carbon permits as a means of increasing

⁷⁷ Standard & Poor’s, *RatingsDirect: COP23: Two Degrees, With Separation*, by Noemie De La Gorce (primary credit analyst), (Standard & Poor’s, 2017), 2, <https://www.spratings.com/documents/20184/1634005/COP23+Two+Degrees+With+Separation/a5807259-f7dd-45b9-8753-0b1836b1ac93>.

⁷⁸ Nina Chestney, “Global green bond issuance hit record \$155.5 billion in 2017,” *Reuters*, 10 January, 2018, <https://www.reuters.com/article/greenbonds-issuance/global-green-bond-issuance-hit-record-155-5-billion-in-2017-data-idUSL8N1P5335>.

⁷⁹ Kate Allen, “Sellers of green bond face a buyer’s test of their credentials”, *The Financial Times*, 25 May, 2017, <https://www.ft.com/content/467b5778-3fd7-11e7-82b6-896b95f30f58>.

⁸⁰ See http://www.eib.org/investor_relations/ for more information.

⁸¹ “Fiji Issues First Developing Country Green Bond, Raising \$50 Million for Climate Resilience”, The World Bank, 17 October, 2017, <http://www.worldbank.org/en/news/press-release/2017/10/17/fiji-issues-first-developing-country-green-bond-raising-50-million-for-climate-resilience>

⁸² Sophie Christie, “World Bank Group issues the world’s largest ever ‘catastrophe bond’ to Mexico,” *The Telegraph*, 8 August, 2017, <https://www.telegraph.co.uk/business/2017/08/08/worlds-largest-ever-catastrophe-bond-issued-mexico/>.

their permissible carbon emissions or being paid for carbon reduction methods. Note that this approach has had some problems in the past due to flawed pricing and / or oversupply of carbon permits.⁸³ Many prefer the application of a carbon tax instead of, or in conjunction with, carbon trading.

Impact investing A more general option is to evolve the understanding of an investment to consider not only its financial risk and return but also its social and environmental impact. “Impact” in this sense is very broad, although there is a sub-sector of impact investing that seeks to invest in entities whose activities have a positive impact on climate change. Impact is an increasingly important area for investors.⁸⁴ There is a potential role for actuaries to promote economic cost analysis above pure financial analysis as this asset class begins to gain greater traction in institutional investing.

Sustainability indices Numerous global indices have been created which include or weight companies based on their ESG (Environment, Social and Governance) practices, e.g. FTSE4Good,⁸⁵ FTSE Climate Balanced Factor Index,⁸⁶ FTSE/JSE Responsible Investment Index.⁸⁷ Although not all of these are specifically climate-related, climatic impact is invariably a significant factor in the environmental component of the index weighting. These indices can help investors identify sustainable companies and benchmark the performance of investment portfolios. They may also be used by investors as a basis for tilting their portfolios towards climate change mitigating activities and away from carbon emitting (climate change inducing) activities.

5.3. Examples of regulatory initiatives to help the financial sector understand and respond to climate risks

Emerging regulatory environment In April 2019, the UK Prudential Regulation Authority (PRA) published its Supervisory Statement setting out how it expects banks and insurers to manage the financial risks from climate change (known as SS3/19).⁸⁸ Firms are expected to adopt a strategic approach to managing climate risk, including the use of scenario analysis to inform strategy setting and risk assessment. The regulator also expects board-level engagement and for firms to allocate responsibility for identifying and managing climate risks to an appropriate Senior Management Function(s).

The PRA’s Dear CEO letter, published in July 2020, includes observations from its thematic review of firms’ plans in response to SS3/19.⁸⁹ The PRA also states that it expects firms to have fully embedded their approaches to managing climate risks by the end of 2021.

In October 2019, the UK Financial Conduct Authority (FCA) published its

⁸³ Daniel Boffey, “Reform of EU carbon trading scheme agreed”, *The Guardian*, 28 February, 2017, <https://www.theguardian.com/environment/2017/feb/28/reform-of-eu-carbon-trading-scheme-agreed>.

⁸⁴ Owen Walker, “Impact investment universe grows to \$502bn”, *The Financial Times*, 1 April, 2019, <https://www.ft.com/content/83814145-2166-3ef3-9bdb-3d4f6fa8c987>.

⁸⁵ See <http://www.ftse.com/products/indices/FTSE4Good> for more information.

⁸⁶ See <http://www.ftse.com/products/downloads/climate-balanced-factor-overview.pdf> for more information.

⁸⁷ See <https://www.jse.co.za/services/market-data/indices/ftse-jse-africa-index-series/responsible-investment-index> for more information.

⁸⁸ See <https://www.bankofengland.co.uk/prudential-regulation/publication/2019/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change-ss> for more information.

⁸⁹ See <https://www.bankofengland.co.uk/-/media/boe/files/prudential-regulation/letter/2020/managing-the-financial-risks-from-climate-change.pdf> for more information.

supervisory expectations following an earlier discussion paper on climate change and green finance. While the FCA has not yet finalised rules and guidance in this area, it has published a consultation on its proposals to improve climate disclosures by listed issuers.⁹⁰

Climate regulation aimed at the financial sector is expected to develop globally over the next few years. The Network for Greening the Financial System is global regulatory forum of 66 central banks and supervisors that aims to strengthen “the global response required to meet the goals of the Paris agreement and to enhance the role of the financial system to manage risks and to mobilize capital for green and low-carbon investments in the broader context of environmentally sustainable development”.⁹¹ It has published a number of guides to help central banks and supervisors integrate climate risks into prudential supervision.⁹²

Climate stress tests and vulnerability assessments

A number of central banks and national regulators are planning, or have signalled their intent, to introduce climate stress tests or vulnerability assessments for the financial sector (some of these have now been postponed due to the COVID-19 pandemic). These include the Bank of England,⁹³ France’s Autorité de Contrôle Prudentiel et de Résolution,⁹⁴ the Monetary Authority of Singapore,⁹⁵ the Australian Prudential Regulation Authority,⁹⁶ and the Bank of Canada.⁹⁷

The European Insurance and Occupational Pensions Authority also plans to carry out an analysis of the sensitivity of insurers’ balance sheet to climate risks.⁹⁸

Regulators that have already published details of their assessments typically include at least three scenarios covering: a business as usual scenario where no further action is taken to limit climate change and physical risks are higher, a smooth and orderly transition scenario where countries act quickly to limit global warming to 2°C by 2100 and a disorderly transition scenario where climate action is delayed initially leading to abrupt and severe action at a later date to limit global warming to 2°C.

The Bank of England,⁹⁹ De Nederlandsche Bank¹⁰⁰, the California Insurance Commissioner¹⁰¹ and the Swiss Federal Office for the Environment and the State Secretariat for International Financial Matters¹⁰²

⁹⁰ See <https://www.fca.org.uk/publication/discussion/dp18-08.pdf>, <https://www.fca.org.uk/publications/feedback-statements/fs19-6-climate-change-and-green-finance> and <https://www.fca.org.uk/publications/consultation-papers/cp20-3-proposals-enhance-climate-related-disclosures-listed-issuers-and-clarification-existing> for more information.

⁹¹ “Origin and Purpose”, NGFS, accessed 5 July, 2020, <https://www.ngfs.net/en/about-us/governance/origin-and-purpose>.

⁹² See <https://www.ngfs.net/en/liste-chronologique/ngfs-publications> for more information.

⁹³ See <https://www.bankofengland.co.uk/-/media/boe/files/paper/2019/the-2021-biennial-exploratory-scenario-on-the-financial-risks-from-climate-change.pdf> for more information.

⁹⁴ See <https://acpr.banque-france.fr/lacpr-publie-les-hypotheses-provisoires-de-son-exercice-pilote-et-incite-une-meilleure-gouvernance> for more information (in French).

⁹⁵ See <https://www.mas.gov.sg/news/parliamentary-replies/2020/reply-to-parliamentary-question-on-including-climate-change-related-risk-in-mas-annual-iwst> for more information.

⁹⁶ See <https://www.apra.gov.au/understanding-and-managing-financial-risks-of-climate-change> for more information.

⁹⁷ See <https://www.bankofcanada.ca/2020/05/staff-discussion-paper-2020-3/> for more information.

⁹⁸ See https://www.eiopa.europa.eu/content/workshop-climate-change-related-risks_en?source=search for more information.

⁹⁹ See <https://www.bankofengland.co.uk/prudential-regulation/letter/2019/insurance-stress-test-2019> for more information.

¹⁰⁰ See https://www.dnb.nl/binaries/OS_Transition%20risk%20stress%20test%20versie_web_tcm46-379397.pdf for more information.

¹⁰¹ See <https://www.insurance.ca.gov/01-consumers/180-climate-change/ScenarioAnalysis.cfm> for more information.

¹⁰² See https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/fachinfo-daten/klimavertraeglichkeitsanalyse.pdf.download.pdf/EN_2ii_Out_of_the_fog_v0_full_report_October_2017.pdf for more information.

have already published results of initial or pilot assessments relating to the financial sector.

Wider sustainable finance regulation

A wider sustainable finance agenda is also being promoted by regulation across the world.

For example, the High-level Expert Group on Sustainable Finance was established by the European Commission to investigate ways in which sustainability considerations, including climate change mitigation, could be included in its policy framework. The group published a report in January 2018 that looked into ways of mobilising finance to support the transition to a low-carbon, more resource-efficient and sustainable economy.¹⁰³ This was followed by an action plan from the European Commission (EC) in March 2018.¹⁰⁴ The action plan includes a number of measures, including establishing a taxonomy to define sustainable activities, regulation on disclosures relating to sustainable investment and sustainability risks, the creation of a new category of low-carbon benchmarks, and the requirement for firms to consider the ESG preferences of their clients.

In April 2020, the EC launched a consultation on a renewed sustainable finance strategy which aims to increase private investment in sustainable projects and activities to support the objectives of the European Green Deal. (The Green Deal is a roadmap for making the EU's economy sustainable, including measures to make the EU climate neutral by 2050.)¹⁰⁵ Other jurisdictions that have developed wide reaching sustainable or green finance plans include the UK and Singapore.¹⁰⁶

Pension specific regulation

The European IORP II directive requires pension schemes to consider and report on their approach to ESG factors and risks.¹⁰⁷ The directive refers explicitly to the consideration of climate-related risks. EU countries were given until 13 January 2019 to transpose the new rules into national law.

In 2018, the UK Government published a consultation setting out its proposals to clarify trustee ESG duties.¹⁰⁸ This was followed by new regulations, effective from October 2019, requiring trustees to set out their policies on ESG, climate change and stewardship activities, in their scheme's Statement of Investment Principles.¹⁰⁹ Investment guidance from the UK Pensions Regulator, issued for defined contribution and defined benefit schemes, also states that trustees should take ESG factors into account in investment decisions if they believe they are financially significant.¹¹⁰

¹⁰³ EU High-Level Expert Group on Sustainable Finance, *Financing a sustainable European economy*, (HLEG, 2018), https://ec.europa.eu/info/sites/info/files/180131-sustainable-finance-final-report_en.pdf.

¹⁰⁴ See https://ec.europa.eu/info/publications/180308-action-plan-sustainable-growth_en for more information.

¹⁰⁵ See https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en for more information.

¹⁰⁶ See <https://www.gov.uk/government/publications/green-finance-strategy> and <https://www.mas.gov.sg/development/sustainable-finance> for more information.

¹⁰⁷ Directive (EU) 2016/2341 of the European Parliament and of the Council of 14 December 2016 on the activities and supervision of institutions for occupational retirement provision (IORPs), accessed 1 April, 2018, <http://data.europa.eu/eli/dir/2016/2341/oj>.

¹⁰⁸ See <https://www.gov.uk/government/consultations/pension-trustees-clarifying-and-strengthening-investment-duties> for more information.

¹⁰⁹ See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/739331/response-clarifying-and-strengthening-trustees-investment-duties.pdf for more information

¹¹⁰ The Pensions Regulator, *A guide to Investment governance*, (The Pensions Regulator, 2018), 7, <https://www.thepensionsregulator.gov.uk/-/media/thepensionsregulator/files/import/pdf/dc-investment-guide.ashx> and The Pensions Regulator, *Investment guidance for defined benefit pension schemes*, (The Pensions Regulator, 2018), 22, <https://www.thepensionsregulator.gov.uk/-/media/thepensionsregulator/files/import/pdf/db-investment-guidance.ashx>.

Further changes are planned. The UK's Pension Schemes Bill 2020, still going through Parliament at the time of writing, will allow the Government to impose new duties on trustees and pension scheme managers, including a requirement to assess pension scheme exposure to climate change risk.¹¹¹ Additionally, the DWP has recently closed (as of July 2020) a consultation on non-statutory guidance for pension scheme trustees on assessing, managing and reporting climate risks in line with the Task Force on Climate-related Financial Disclosures (TCFD) framework (see Section 5.4 for more details).¹¹²

Pension fund fiduciary duties and ESG issues

The fiduciary responsibilities of pension fund trustees are evolving to place a greater emphasis on ESG risk analysis and reporting. In 2014, the Law Commission (UK) published *Fiduciary Duties of Investment Intermediaries* which clarified that pension trustees should take into account factors which are financially material to the performance of an investment, including financially material risks to the long-term sustainability of a company's performance from ESG factors.¹¹³

Fiduciary Duty in the 21st Century, a partnership initiative between PRI, UNEP FI and the Generation Foundation, has argued that failure to consider ESG issues as a component of long-term determinants of value is a breach of fiduciary duty. It is working with investors, governments and intergovernmental organisations to promote more widespread integration of environmental risks (among others) into the scope of fiduciary duty.¹¹⁴

5.4. Examples of wider financial initiatives to help the financial sector understand and respond to climate risks

Task force on Climate-related Financial Disclosures

The aim of the TCFD is to increase transparency and disclosure around climate risks.¹¹⁵ It has developed a voluntary framework to help companies provide information on climate risks to investors, lenders, insurers and other stakeholders in a way that is consistent and comparable across sectors and jurisdictions. In turn, these financial institutions will be better placed to provide disclosures to their stakeholders of how climate risks may impact their business. As of February 2020, over 1,000 large companies have expressed their support for the TCFD since its final recommendations were published in June 2017.¹¹⁶

The TCFD is increasingly being adopted by regulators and supervisors as the preferred framework for climate risk disclosures. For example, in its Green Finance Strategy, the UK Government set out its expectation for all listed companies and large asset owners to disclose in line with the TCFD recommendations by 2022.¹¹⁷ The International Association of Insurance

¹¹¹ Daniel Brooksbank, "UK quietly presses ahead with climate change rules for pension assets", *Responsible Investor*, 23 June, 2020, <https://www.responsible-investor.com/articles/uk-quietly-presses-ahead-with-climate-change-rules-for-pension-assets>.

¹¹² See <https://www.gov.uk/government/consultations/aligning-your-pension-scheme-with-the-tcfd-recommendations> for more information.

¹¹³ "Fiduciary Duties of Investment Intermediaries," Law Commission, accessed 1 April, 2018, <https://www.lawcom.gov.uk/project/fiduciary-duties-of-investment-intermediaries/>.

¹¹⁴ See <https://www.fiduciaryduty21.org/> for more information.

¹¹⁵ See <https://www.fsb-tcfd.org/> for more information.

¹¹⁶ "TCFD Supporters", TCFD, accessed 5 July, 2018, <https://www.fsb-tcfd.org/tcfd-supporters/>.

¹¹⁷ HM Treasury and Department for Business, Energy & Industrial Strategy, *Green Finance Strategy*, (HM Government, 2019), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820284/190716_BEIS_Green_Finance_Strategy_Accessible_Final.pdf.

Supervisors and Sustainable Insurance Forum have jointly published a paper on TCFD implementation as part of a wider objective to support supervisors in their efforts to assess climate risks.¹¹⁸

An analysis of disclosures across different sectors published in the TCFD's latest Status Report shows that disclosure of climate-related financial information has increased since 2016 but is still insufficient for investors.¹¹⁹

United Nations Principles for Responsible Investment (PRI) and Sustainable Insurance (PSI)

The Principles for Responsible Investment (PRI) is an initiative supported by the United Nations that encourages investors to adopt responsible investment as a way of enhancing returns and managing risks.¹²⁰ Signatories commit to six voluntary principles, which set out ways investors can incorporate ESG issues into their investment practices and contribute to a more sustainable financial system. Helping asset managers and asset owners take into account factors relating to climate change in their investment decisions is currently a key focus for the PRI.¹²¹

TCFD-based reporting is now mandatory for PRI signatories.¹²²

The PRI are paralleled by the United Nations Environment Programme Finance Initiative (UNEP FI) Principles for Sustainable Insurance – also known as the PSI Initiative.¹²³ This initiative aims, through better understanding, to prevent and reduce environmental, social and governance risks in the insurance sector.

Actuarial initiatives

In 2017, the Institute and Faculty of Actuaries (IFoA) issued a risk alert to its members in relation to the financial risks posed by climate change. It states that actuaries “should ensure that 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.”¹²⁴

The IFoA has also published a number of practical guides to help actuaries examine the main implications of climate change for different practice areas and identify the best ways to manage those implications.¹²⁵

The Actuaries Climate Index was set up to monitor climate-related extreme events in North America and provide information to those working in the insurance industry and the general public.¹²⁶ It aims to provide an objective indication of how the climate is changing based on observed data. Six components make up the index – high temperatures, low temperatures, heavy rainfall, drought (consecutive dry days), high wind and sea level. An Australian version of the index was launched in November 2018.¹²⁷

¹¹⁸ See https://b9ea8c1e-dc19-4d5f-b149-9b1ea4b8d050.filesusr.com/ugd/eb1f0b_365cc83062254d509c20d79313143868.pdf for more information.

¹¹⁹ TCFD, *Task Force on Climate-related Financial Disclosures: Status Report*, (TCFD, 2019), iv, <https://www.fsb-tcfid.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf>.

¹²⁰ See <https://www.unpri.org/> for more information.

¹²¹ “The 2018 investor climate calendar”, PRI, 19 February, 2018, <https://www.unpri.org/news-and-press/the-2018-investor-climate-calendar/2891.article>.

¹²² “TCFD-based reporting to become mandatory for PRI signatories in 2020”, PRI, 18 February, 2019, <https://www.unpri.org/news-and-press/tcfid-based-reporting-to-become-mandatory-for-pri-signatories-in-2020/4116.article>.

¹²³ See <http://www.unepfi.org/psi/> for more information.

¹²⁴ Institute and Faculty of Actuaries, “Risk Alert: Climate-Related Risks.”

¹²⁵ See <https://www.actuaries.org.uk/practice-areas/resource-and-environment/resource-and-environment-practice-area-practical-guides> to access these guides.

¹²⁶ See <http://actuariesclimateindex.org/home/> for more information.

¹²⁷ See <https://www.actuaries.asn.au/microsites/climate-index> for more information.

Investor- and industry-led initiatives ClimateWise is an initiative that aims to help the insurance industry improve its communication and response to risks and opportunities relating to the climate-risk protection gap (i.e. the growing divide between total economic and insured losses attributed to climate change).¹²⁸ The ClimateWise Principles provide a framework for the insurance industry to disclose climate risks and opportunities, and is aligned with the TCFD.

Over 450 investors with over \$40 trillion in assets collectively under management are signatories of Climate Action 100+, an investor initiative that aims to drive corporate action on climate change from the world's largest corporate greenhouse gas emitters.¹²⁹

The Institutional Investors Group on Climate Change (IIGCC) is a European membership body for investors to collaborate on climate change with over 240 members, mainly pension funds and asset managers.¹³⁰ It aims to bring investors together to influence policymakers and companies to adopt policies and practices which accelerate the shift to a low-carbon economy.¹³¹

A number of asset owners are involved in initiatives that aim to align investment portfolios or business activities with the goals the Paris Agreement – these include Science Based Targets, the UN-Convened Net-Zero Asset Owner Alliance, and the IIGCC Paris Aligned Investment Initiative.¹³²

Activism Insurers, asset managers, large pension funds and banks are under greater pressure from activist and campaign groups like ShareAction and Insure our Future (formerly Unfriend Coal).¹³³ Both these groups publish rankings of financial institutions based on their response to climate risks, and involvement in fossil fuel financing or investment activities.

Companies are also under pressure to take climate change into account in their business planning and strategy. Shareholder support for climate change resolutions at annual meetings is growing.¹³⁴ For example, analysis of data on climate change resolutions up to May 2020 shows that these had received average shareholder support of 23%, compared with 16% during all of the previous year.¹³⁵

Financial institutions have also been subject to more direct forms of activism. For example, Extinction Rebellion's protest at a 2019 Pensions and Lifetime Savings Association conference.¹³⁶

Legal challenges Between 1986 and the end of May 2020, a total of 1,587 cases of climate litigation have been identified – over three-quarters of these in the United

¹²⁸ See <https://www.cisl.cam.ac.uk/business-action/sustainable-finance/climatewise> for more information.

¹²⁹ See <https://climateaction100.wordpress.com/> for more information.

¹³⁰ See <https://www.iigcc.org/> for more information.

¹³¹ See <https://climateaction100.wordpress.com/> for more information.

¹³² See <https://sciencebasedtargets.org/>, <https://www.unepfi.org/net-zero-alliance/> and <https://www.iigcc.org/resource/iigcc-paris-aligned-investment-initiative/> for more information.

¹³³ See <https://shareaction.org/> and <https://insureourfuture.co/> for more information.

¹³⁴ Cydney Posner, "Are Shareholder Proposals on Climate Change Becoming a Thing?" Harvard Law School Forum on Corporate Governance and Financial Regulation, 21 June, 2017, <https://corpgov.law.harvard.edu/2017/06/21/are-shareholder-proposals-on-climate-change-becoming-a-thing/>.

¹³⁵ Attracta Mooney, "Shareholder climate rebellions surge despite coronavirus crisis", *The Financial Times*, 30 May, 2020, <https://www.ft.com/content/c10056af-306f-4d9d-8e97-5ffa112ddf49>.

¹³⁶ Nick Reeve, "Climate change protesters disrupt pensions conference", *IPE*, 14 May, 2019, <https://www.ipe.com/climate-change-protesters-disrupt-pensions-conference/10031170.article>.

States with the remaining spread across 36 other countries and eight regional or international jurisdictions.¹³⁷

Climate litigation affecting the financial sector is increasing - with more cases filed in 2019 than in any previous year.¹³⁸ Some of these cases focus on fossil fuel investments while others relate to shareholders' claims against banks, pension funds and investment funds for failing to incorporate climate risk into their decision-making and disclosures to beneficiaries. For example, an Australian pension scheme member has filed a suit against the Retail Employees Superannuation Trust (REST) for failing to provide information on climate risks (trial due to take place in July 2020).¹³⁹

ClientEarth, an environmental legal group, is currently running a campaign to help pension fund members challenge their pension providers to fulfil their legal duties relating to climate change.¹⁴⁰

Transition readiness comparison tools The Transition Pathway Initiative assesses how companies are preparing for the transition to a low carbon economy.¹⁴¹ It provides an online toolkit which compares different companies within the same sector on two dimensions – management quality and carbon performance (different sectors are being added over time).

The Paris Agreement Capital Transition Assessment (PACTA) tool, devised by the 2° Investing Initiative, is an open-sourced tool that allows financial institutions to carry out climate scenario analysis for listed equity and corporate bonds portfolios.¹⁴²

Separately, users of Bloomberg terminals can access an app developed by the Carbon Tracker Initiative that shows which oil and gas producers are most exposed to transition risks under a 2°C scenario.¹⁴³

¹³⁷ Ibid.

¹³⁸ Joana Setzer and Rebecca Byrnes, *Global trends in climate change litigation: 2020 snapshot*, (London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science, 2020), http://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2020/07/Global-trends-in-climate-change-litigation_2020-snapshot.pdf.

¹³⁹ "McVeigh v. Retail Employees Superannuation Trust", Grantham Research Institute on Climate Change, accessed 5 July, 2020, https://climate-laws.org/cclow/geographies/australia/litigation_cases/mcveigh-v-retail-employees-superannuation-trust.

¹⁴⁰ See <https://www.clientearth.org/pensions-and-climate-change-2/> for more information.

¹⁴¹ See <https://www.transitionpathwayinitiative.org/> for more information.

¹⁴² See <https://2degrees-investing.org/resource/pacta/> for more information.

¹⁴³ Deirdre Fretz, "How to Compare Climate Risk Across the Biggest Oil Companies," Bloomberg, 24 March, 2018, <https://www.bloomberg.com/news/articles/2018-03-24/how-to-compare-climate-risk-across-the-biggest-oil-companies>.

6. Communicating climate risks

This section explores the challenges of communicating climate change. It also sets out some potential ways to engage others to act on climate change.

6.1. Why is communicating climate change so difficult?

Climate change is a “wicked problem” There are particular aspects of climate change that make the communication of its risks particularly difficult. Communicating risk is simple if you understand what the risk is. However, climate change is a “wicked problem”.

A wicked problem “is a problem that is difficult or impossible to solve because of incomplete, contradictory and changing requirements that are often difficult to recognise. Moreover, because of interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems.”¹⁴⁴

Stakeholders may have hugely different views of the problem, meaning that they will think of different issues and solutions. The problem may never be solved definitively and may require changing resources through time to address the issue. This makes it harder to define, understand and predict the risks before suggesting possible solutions. These solutions are then unlikely to last forever – at some point new solutions may need to be found.

6.2. Five inner defences that stop people from engaging with climate change

The five Ds Per Espen Stoknes discusses the challenges of communicating climate change in his TED Talk “How to transform apocalypse fatigue into action on global warming”.¹⁴⁵

He identifies five inner defences that people put up when they hear about climate change. These five inner defences are five “Ds”: Distance, Doom, Dissonance, Denial & iDentity.

Distance “Climate change is not now!” This can be in terms of both time and place. We have a natural tendency to focus on the immediate and places near to home. Therefore, we feel that climate change is outside our sphere of influence making us feel helpless meaning that “the urgent ends up driving out the important”.

Even in a general insurance context, threats with long and indeterminate time lags rarely challenge existing business models (or so it seems). Actions taken now will only have a significant or discernible influence after many years or even several decades. Even then it will be difficult or impossible to construct the counterfactual and demonstrate the exact effect of actions taken now.

If an event occurs in 20 years’ time, and can be clearly attributed to anthropogenic climate change, this cannot be pinned on a particular person or action. This contrasts with (say) a nuclear accident, like Fukushima, or

¹⁴⁴ “Wicked Problem”, Wikipedia, accessed 2 April, 2018, https://en.wikipedia.org/wiki/Wicked_problem.

¹⁴⁵ Per Espen Stoknes, “How to transform apocalypse fatigue into action on global warming,” filmed September 2017 at TEDGlobal NYC, New York, video, 15:00, https://www.ted.com/talks/per_espen_stoknes_how_to_transform_apocalypse_fatigue_into_action_on_global_warming.

an air crash, where usually a specific cause can be found.

Doom “The world is going to end!” The media often associates the impact of climate change with doomsday scenarios. The overuse of which leads us to become desensitised about the issue of climate change and our brain becomes “numb” to these problems. This is especially the case when problems and consequences are harder to conceptualise.

Dissonance “I won’t make a difference!” This makes us feel better but it dismisses the truth that we know. It may appear that no action at individual, or even national level, is worthwhile unless everyone else takes action too. Behaviour drives actions.

We are not very good at assessing and comparing risks in different fields in a consistent way. In our minds we exaggerate some risks (e.g. crime, shark attacks) and downplay others, especially when inconvenient (e.g. health related effects of lifestyle). Even in the energy sector we overstate certain kinds of risk, e.g. radiation from nuclear or from unknown technologies like CCS, and ignore direct health risks from fossil fuel burning. As a result, we often justify our actions to cover up the inner discomfort we feel about contributing to this problem.

Denial “It’s not my problem.” We bury ourselves in our inner refuge away from truth and our troubles and live life normally.

The climate change threat is closely linked to current energy use, which is intimately bound into every aspect of our way of life, and most of our assets. We all have a built-in vested interest in hoping the problem will go away without having to take any action.

iDentity “My identity trumps truth!” Our beliefs sometimes overpower truths. People who believe in a smaller government with little intervention in markets are less likely to support governments increasing their powers and intervening in the market, which is likely to be the case for climate change policy.

The issue of climate change has become politicised, mainly as it represents a threat to ideological as well as commercial vested interest while, for others, it is part of an anti-capitalist agenda. Neither makes for rational discussion on which debate should be based.

6.3. How do we engage people to act on climate change?

The five Ss To help overcome the five defences, Per Espen Stoknes identifies five potential solutions.¹⁴⁶ We have added some thoughts on how actuaries may apply each of them in their work.

Social Make climate change a positive social force by speaking to your neighbours, friends and colleagues about your positive response to climate change, e.g. installing solar panels, eating less meat. This helps reduce the distance of climate change and makes it part of daily life.

To help engage our clients or employers, this could translate to sharing examples and case studies of what other insurance companies, pension funds, risk functions, etc. are doing in response to climate change.

¹⁴⁶ Ibid.

- Supportive** Reframe climate change as being about opportunities, e.g. for human health or new technology. For example, the electricity savings on your new solar panel roof, saving money and getting fit by cycling to work or eating delicious plant based “beef” to reduce the amount of red meat in your diet. This removes doom from the conversation and turns it into small positive actions.
- In our role as actuaries, this could mean exploring new investment or business opportunities that have emerged as a result of climate change.
- Simple** Nudging and simple actions can help change behaviours and drive attitudes. Simple “nudges” like having a smaller plate at dinner to help reduce food waste or turning the heating down by a couple of degrees can really help drive behaviour and make a difference.
- For our clients and employers, this could mean breaking down the actions they need to take to respond to climate change into simple steps – for example, a simple training session is a potential starting point for further action – or “nudging” them by creating standardised reports that include climate risks.
- Actuaries can also play a role in creating appropriate default products and services that take into account climate risks. This is perhaps best demonstrated by HSBC’s defined contribution equity default fund, which has been designed to improve risk-adjusted returns and protect members from climate risk.¹⁴⁷
- Signal** Many people like to visualise their progress and compete with others – there are even apps which help you track your carbon footprint.¹⁴⁸ Engagement and competition can help drive further positive behavioural changes.
- As actuaries, we need to be able to illustrate how actions taken by clients or employers have reduced climate risks or improved performance – this could be an absolute measure or relative to peers / competitors.
- Story** Human brains love stories - we buy into these stories and find them easier to believe than facts and figures. Telling positive stories about climate change can help engage more and more people into making positive changes.
- This can be a challenge for actuaries as our discussions are often based around calculations, modelling and quantitative analysis. But we can still talk about the impact our work has on individuals, e.g. the young pension savers we want to protect from climate shocks to their retirement funds, the families we want to help renovate their houses after flooding.

¹⁴⁷ Mark Thompson, “Climate risk: rain or shine,” *The Actuary*, 9 February, 2017, <http://www.theactuary.com/features/2017/02/climate-risk-rain-or-shine/>.

¹⁴⁸ See <https://www.thecapture.club> for an example.

Communicating uncertainty around climate change

Like many risks, the uncertainty around future climate projections and outcomes is difficult to communicate, particularly to people who do not have a science or actuarial background.

The “Uncertainty Handbook” released by the University of Bristol and Climate Outreach sets out 12 practical principles for communication around climate change uncertainty.¹⁴⁹ This is a good checklist to use when communicating or delivering a message on climate change to various stakeholders.

¹⁴⁹ Adam Corner et al., *The Uncertainty Handbook*, (Bristol: University of Bristol, 2015), <https://climateoutreach.org/resources/uncertainty-handbook/>.

7. Next steps for actuaries

This section sets out a few practical next steps for actuaries to further their understanding about climate change and help their employers and clients respond to climate risks.

7.1. Some practical next steps

- Engage** Climate change is an actuarial problem and an issue that should be proactively raised with clients and stakeholders. Communicate with colleagues, clients and other stakeholders about climate change and the risks they may face in relation to climate change to spark interest in the subject. Find out how clients, stakeholders and competitors are addressing their climate change risks.
- Collaborate** Work with other disciplines such as asset managers, investment consultants and lawyers when discussing climate change risks with clients or stakeholders. When possible put climate change on the agenda in meetings, both internal and external. This will bring different perspectives to the table and help to form a more collective view.
- Improve governance** Help clients and stakeholders improve their governance and set up a framework where decisions can be made quickly and effectively (whether relating to climate change or not).
- Educate** Attend seminars and training sessions on climate change risks along with reading and researching the topic further. Invite colleagues and clients to join you where useful or relevant.
- Research CSR initiatives** Find out where the accountability for Corporate Social Responsibility (CSR) and climate change risk management reside within your organisation, your clients or other stakeholders. Research CSR initiatives in your organisation, and for your clients and 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.
- Monitor** Investigate which climate change issues are particularly relevant to clients and stakeholders, given their business sector. Add climate change risks to risk registers, risk matrices and other risk management systems in place and continue to monitor, mitigate and update these risks. The same actuarial risk management approach applies to climate change risks as with the other actuarial risks that we are involved in.
- Quantify** Help clients and stakeholders quantify qualitative climate change risks to improve understanding; using tools such as scenario analysis. Get insight from platforms such as the CRO Forum on the development of the associated risks¹⁵⁰ and the TCFD Knowledge Hub.¹⁵¹
- Understand materiality** Understand the materiality of climate change risks in clients' and other stakeholders' business models and prioritise actions relating to these risks accordingly.

¹⁵⁰ See <https://www.thecroforum.org/> for more information.

¹⁵¹ See <https://www.tcfdhub.org/> for more information.

Understand timelines Understand the timeline that you are advising on in order to concentrate on the relevant climate change risks i.e. short-term or long-term risks, and prioritise these accordingly.



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