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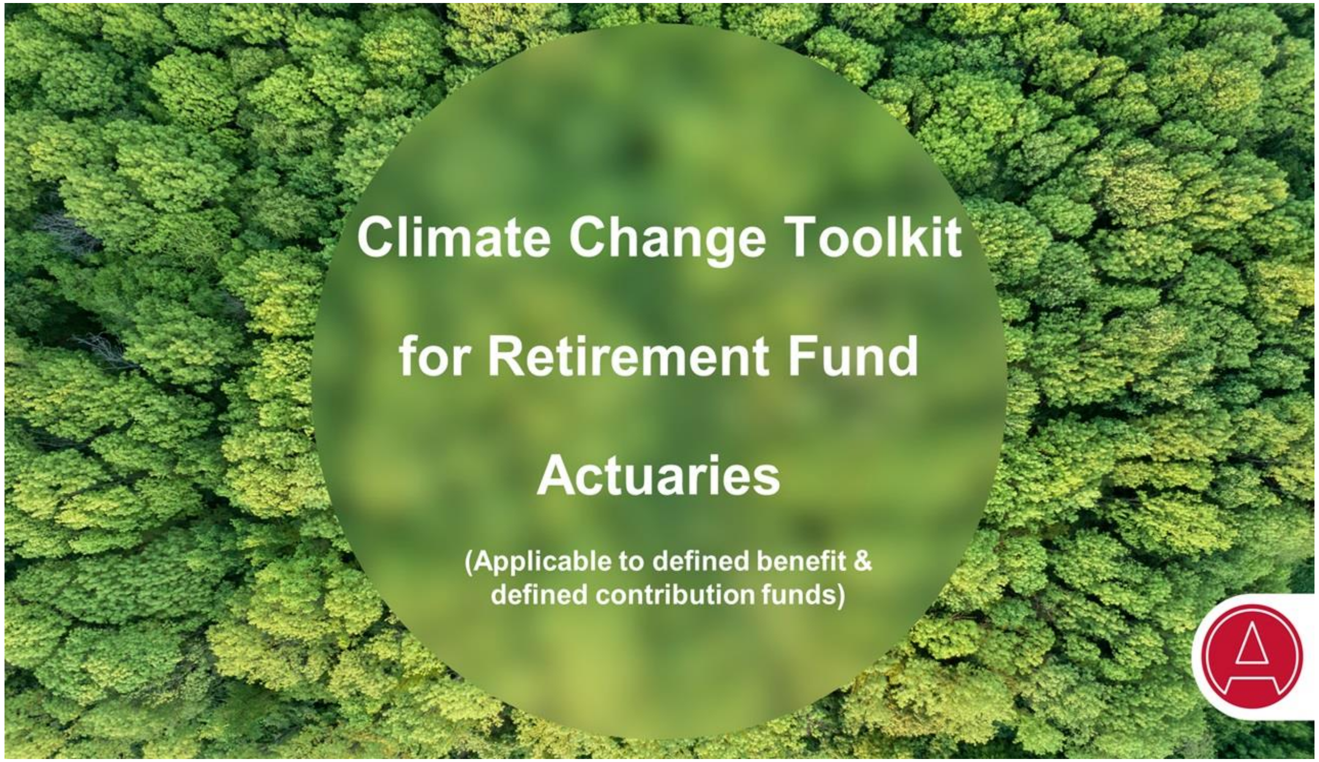

VERSION 1

January 2025

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Executive Summary

In 1987, the United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." In recent years, the sustainability agenda has grown in importance, with many countries, regulators, industries shifting to implement sustainable practices. For retirement funds this means providing a lasting income in retirement for members, whilst ensuring a positive contribution to society and the environment. Retirement funds, with long-term liabilities, are therefore well placed and can play a significant role to contribute to the overall objective.

One of these factors is in relation to climate change. Climate change encompasses shifts in global average temperatures and the associated changes in weather patterns over extended periods.

Science has shown a direct link between human-made green-house gas emissions and global warming. 2024 was the hottest ever recorded in human history, confirmed by the World Meteorological Organization. The average global temperature in 2024 was more than 1.5°C above the pre-industrial (1850 – 1900) baseline for the first time. Global initiatives aim to limit warming to well below 2°C, given the severe implications on global economies and humanity beyond these levels.

Over the short and long-term, there are implications for the funding of defined benefit funds, the outcomes for defined contribution fund members, investment strategies for retirement, the mortality and health of retirement fund members.

To assist retirement fund actuaries and trustees understand the implications and incorporate this into their work, a working group of the ASSA Climate Committee developed this Toolkit on incorporating climate considerations into the running of a retirement fund. It provides an overview of climate change, the relevance for retirement funds and then sets out a framework to use in practice.

Additional papers and resources are set out in Appendix 1.

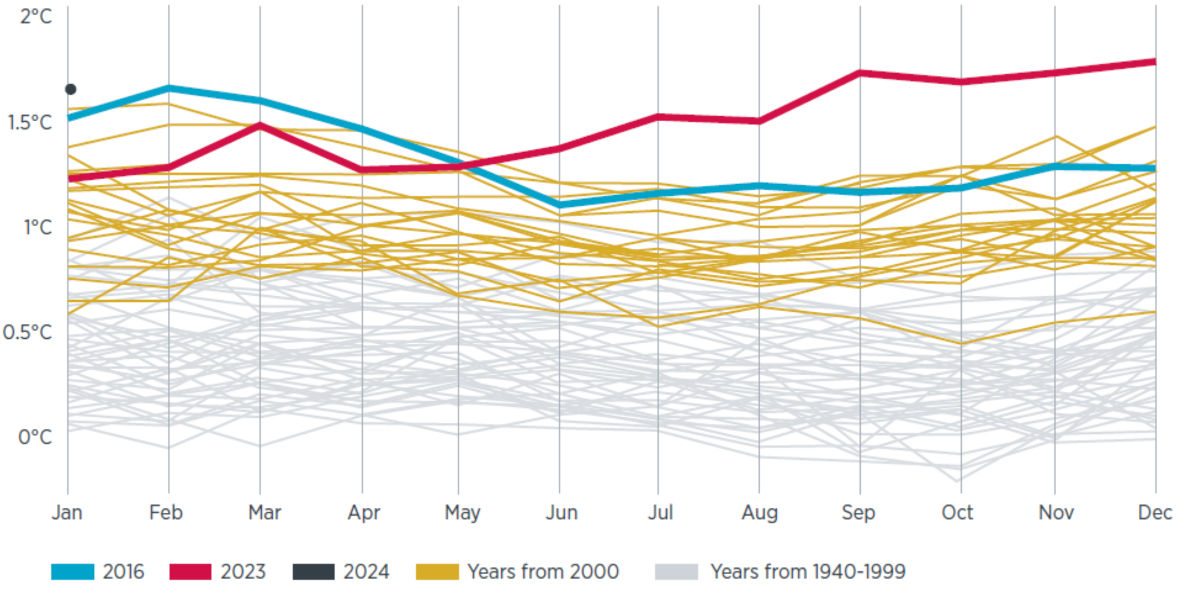
NOTE: Updates on this Toolkit will be issued as the environment changes, more research becomes available, data availability improves and techniques for managing climate matters relevant to retirement funds develops

1. Climate change and climate risk overview

Climate change refers to changes in global temperatures and the associated changes in weather patterns over a long period of time.

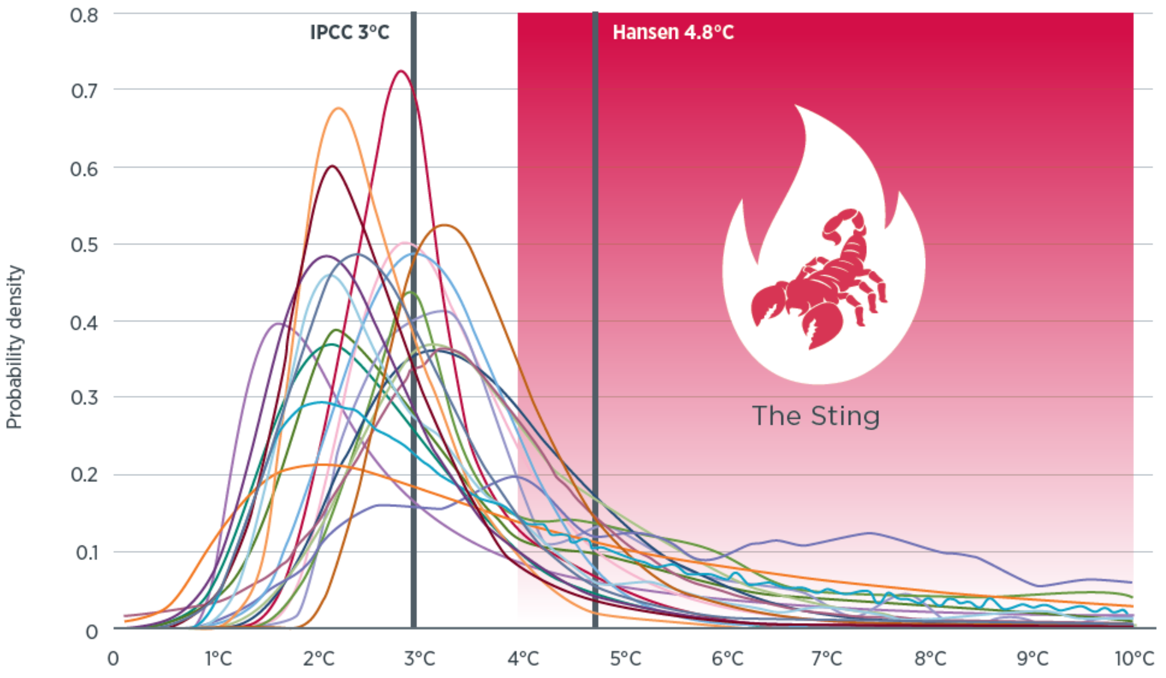
Global surface temperature anomalies

Data ERA5 1940-2024, Reference period: 1850-1900, *Source: climate.copernicus.eu*



Source: IFoA analysis, Copernicus (Diagram was Inspired by the article "Climate records tumbled 'like dominoes' during world's hottest year" by Attracta Mooney, Steven Bernard and Kenza Bryan in the Financial Times, 9th January 2024)

Over the last number of decades, we have seen a consistent increase in global temperatures above pre-industrial levels (driven by the increase in greenhouse gas emissions). The above chart shows the average monthly global temperate in various years compared to the pre-industrial temperatures. The rate of global warming accelerated in 2023 and 2024. There is therefore clear evidence that global warming has been taking place consistently as predicted by scientists, driven by the increase in greenhouse gas emissions into the atmosphere. Ultimately this means we are closer to consistently reaching the 1.5°C to 2°C threshold, beyond which the damage is irreversible.



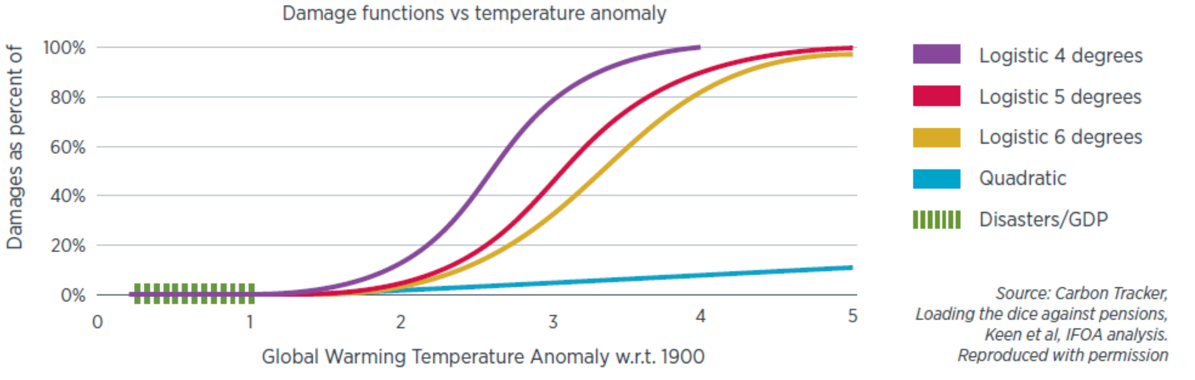
Source: The Economics of the Climate,[33] IFoA Analysis

At this stage it is unclear exactly what level of global warming will be experienced if current carbon emissions are not significantly reduced. There is potential for significant variation in future temperatures as shown by the above distribution function.
Until now, the consensus view from the Intergovernmental Panel on Climate change ("IPCC") is that the temperature rise, without reducing carbon emissions, is expected to be 3 degrees above the pre-industrial period's temperature.
Importantly, this is the "expected value", with much higher levels of warming possible – with a very wide range. However, the earth's climate may be more sensitive than we thought, meaning the planet may warm more quickly than expected for a given level of greenhouse gases. Some research suggests we are already heading for a warming scenario of closer to 5°. The uncertainty due to many factors, including ice melt rate decreasing Earth's albedo, the impact of aerosol cooling, climate tipping points, and the pace of the energy transition.
As the climate continues to warm, we are likely to face increased extreme weather events, changing climatic conditions driving floods and droughts, heat spikes and in the longer-term glacial melt and sea level rise. We also risk triggering multiple climate tipping points which would act to further accelerate climate change or its impacts. These impacts could drive second order events such as shocks to global food supplies or involuntary mass migration.

Climate change: financial and non-financial impact

Until recently, economists have been aiming to quantify the potential impact on global GDP from increased global warming. The estimates range widely, with the Network of Central Banks and Supervisors for Greening the Financial System ("NGFS") estimate being around 18% of global GDP by 2100.

However, recent research has indicated significant shortcomings in the models used be economists to determine the damages expected to be caused by future climate change.



To recognise this, as well as considering the cascading impacts beyond certain temperatures, a risk-based approach put forward by the actuarial profession suggests using a "reverse stress-testing approach", where it is assumed that a total loss is likely at higher levels of global warming (such as 4°C,5°C or 6°C). Under this approach losses to GDP could be between 30% and 80% assuming global warming of 3°C above pre-industrial temperatures.

The latest research released by the Institute and Faculty of Actuaries estimates that the reduction to GDP by 2050 could be as much as 50%.

Climate change will favourably impact some aspects of human health, including likely reductions in cold temperature-related mortality and morbidity in certain regions. In addition, mitigation and adaptation efforts may not only reduce the adverse mortality effects due to climate change but also reduce non-climate-change mortality. The 5th IPCC Assessment Report concludes, however, that the overall impacts on health of more frequent heat extremes greatly outweigh the benefits of fewer cold days, and that the few studies of the large developing country populations in the tropics, point to effects of heat, but not cold, on mortality (Smith et al., 2014).

Research to date (see Appendix I) confirms that:

1. There is significant uncertainty around the impact of climate change on mortality, given that climate change impacts are complex and inter-connected to many aspects that could affect mortality (directly or indirectly).
2. The impact varies by region.
3. A general "U-shaped" relationship exists where extreme heat or cold increases mortality rates, especially at ages 65 and above.
4. The variability of temperature (and changes thereof) within a region impacts mortality.
5. Income and adaptation to climate change is associated with a reduction in impact of climate change on mortality.
6. Generally, today's cold locations can experience an improvement in mortality from climate change whereas today's poor and hot locations can experience large increases in mortality from climate change.
7. A warming climate can substantially change the seasonality of mortality in the future.

8. In south Africa specifically, recent research shows possible evidence of heat-related excess mortality in relation to pensioner mortality and cold-related excess mortality in funeral insurance policies.

In summary, the below range of scenarios illustrates the potential financial and non-financial implications of different levels of global warming based on recent IFoA / University of Exeter research:

Rating	Financial impact	Non-financial impact			
	GDP losses	Human mortality	Climate	Nature	Societal
Extreme	≥50%	≥50% > 4 billion deaths	3°C or more by 2050. Multiple climate tipping points triggered, tipping cascade.	Breakdown of several critical ecosystem services and Earth systems. High level of extinction of higher order life on Earth.	Significant socio-political fragmentation worldwide and/or state failure with rapid, enduring, and significant loss of capital and systems identity. Frequent large scale mortality events.
Catastrophic	≥25%	≥25% >2 billion deaths	2°C or more by 2050. High number of climate tipping points triggered, partial tipping cascade.	Breakdown of some critical ecosystem services and Earth systems. Major extinction events in multiple geographies. Ocean circulation severely impacted.	Severe socio-political fragmentation in many regions, low lying regions lost. Heat and water stress drive involuntary mass migration of billions. Catastrophic mortality events from disease, malnutrition, thirst and conflict.
Decimation	≥10% >$10 trillion annual losses	≥10% > 800 million deaths	Global warming limited to 2°C by 2050. Several climate tipping points triggered.	Severe reduction in several critical ecosystem services. Major extinction events in some geographies. Frequent global food and water crises.	Severe socio-political fragmentation in regions exposed to climate and/or nature impacts. Failure of vulnerable states and mass mortality events in impacted areas.
Severe	≥5% >$5 trillion annual losses	≥5% > 400 million deaths	Global warming limited to 1.5°C by 2050 following overshoot. Some proximate climate tipping points triggered.	Some impacts to critical ecosystem services. Ongoing species extinction. Regular global food and water crises.	Some socio-political fragmentation in most vulnerable states, where adaptation has been limited. Fragile states exposed to climate risks see mass migration and mortality events from heat, water stress and weather events.
Limited	≥1% >$1 trillion annual losses	≥1% > 80 million deaths	Global warming below 1.5°C by 2050, with limited overshoot. Climate tipping points largely avoided.	Mass extinction avoided and ecosystem services largely functional. Occasional global food crisis and widespread water crises.	Ongoing significant climate impacts with many hundreds of billion dollar + loss events annually and associated mortality and socio-political stress.

Source: Planetary Solvency – finding our balance with nature, Global risk management for human prosperity, IFoA / University of Exeter Publications, January 2025

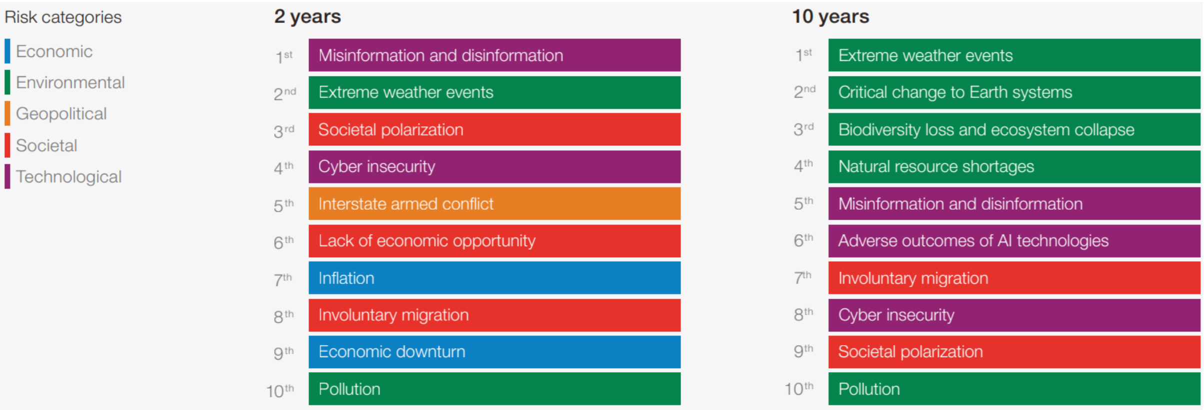
Given the significant uncertainty, the significance of the impacts and the fact that trustees are risk-conscious, it would be advisable for funds to adopt a risk-based approach to determine the resilience of their fund to climate change. At the same time, they can focus on the various opportunities presented by the transition to a low carbon economy.

Recommended actions:
It is important for actuaries to communicate this uncertainty and set out all assumptions in relation to climate work and the sensitivity of the outcomes in relation to the assumptions. As such, a range of assumptions showing various scenarios is encouraged.

Actuaries should point out the limited research around the impact of future climate change on mortality assumptions and that it is a developing area. Given the limitations around research, actuaries are encouraged to illustrate the potential effects of a range of mortality assumptions when performing projections with relevant caveats. An explanation of the extent to which climate change is factored into the best-estimate assumptions and those for purposes of solvency reserves (in the case of defined benefit funds) should be made.

2. Significance of climate risk for retirement funds

According to the World Economic Forum's 2024 global risk report, extreme weather ranks as one of the top risks over the short and long-term as set out in the ranking tables below:



Climate change is a systemic risk, one that can cause a major collapse in the broader economy, market or industry and cannot be reduced through diversification. In other words, it can affect the returns of members of retirement funds in the short and long-term amongst other things. Given the long-term horizon as well as their role in the financial sector, retirement funds should address this risk to ensure that it is appropriately priced into the provision of retirement income. Funds should also identify the opportunities in markets linked to the transition to a low-carbon economy as well as from efforts to adapt to a warner planet.

A 2023 report, "Loading the DICE against pension schemes", shows the growing systemic risks to financial and institutional investment and pension markets from the under-pricing of climate change.

According to The Financial Markets Law Committee (2024), "...with climate-change related risks that are systemic, it is unlikely that diversification alone of a portfolio will be enough to avoid all the risks in the same way that non-systemic risks might be diversified away from".

A 2024 MSCI Research Institute survey highlighted that 48% of market participants believe that the prices of financial assets do not reflect climate risks, compared with 41% who said that financial assets partially reflect such risks, and only 7% who said that prices capture climate risks fully.

Despite the significance, evidence still shows that retirement funds in South Africa have not fully integrated climate risk and opportunities considerations into how they are run. A survey by the FSCA in 2022 also highlighted that:

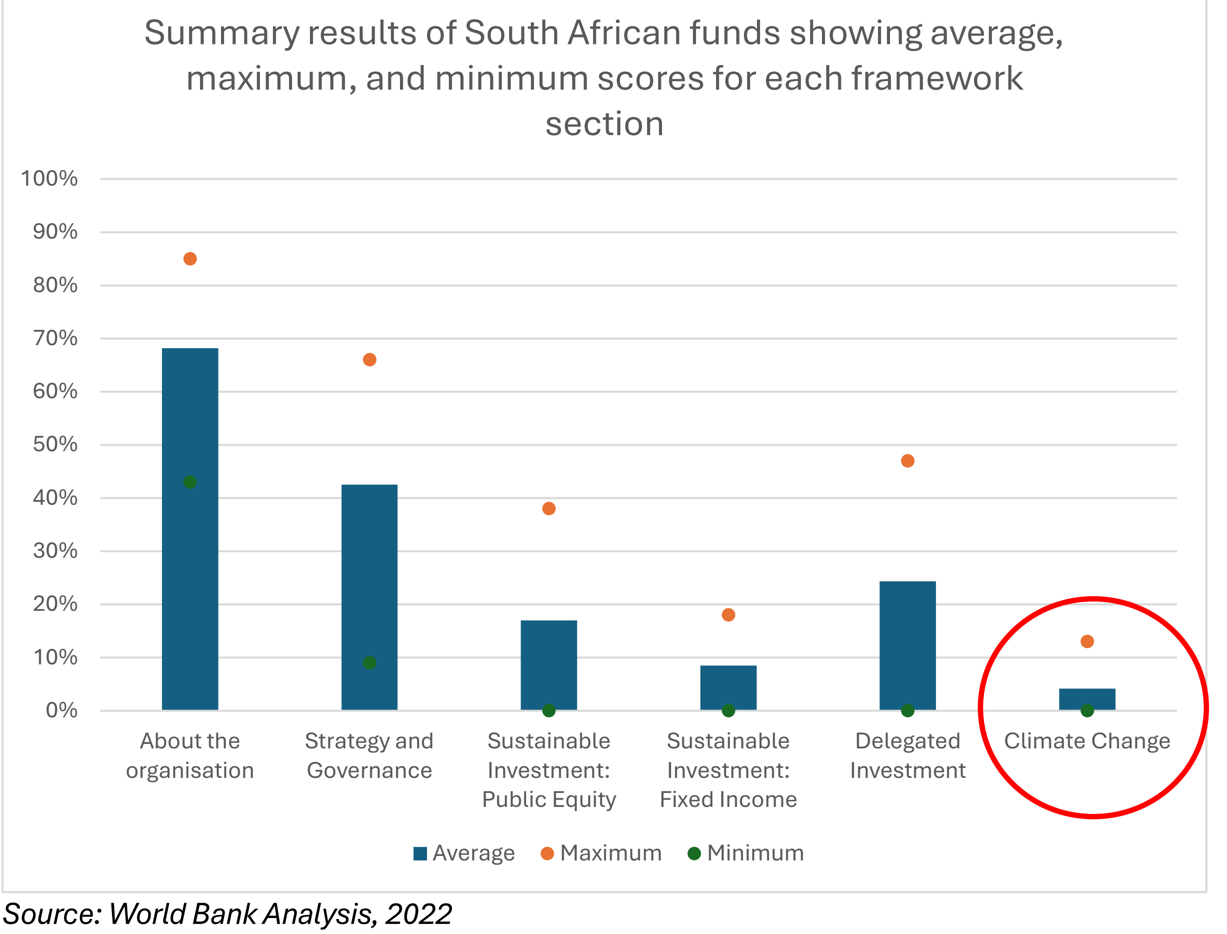
- **99%** of funds have an investment policy statement referring to their ESG philosophy
- **82%** of funds willing to increase allocations to green or climate focussed investments / 18% don't know / 0% unwilling

BUT...

- Only **7%** of SA funds have a climate policy

- Only **2%** of funds have existing commitments to green, climate, social or sustainability focussed investments
- Only **2%** of funds aligned with official social development goals
- **50%** of funds don't set out how they intend to monitor ESG performance
- **95%** of funds have not set out what information and data they require for ESG monitoring
- Only **3%** of funds verify their environmental and social impact

The below analysis done in 2022 (providing a score out of 100%) highlights the gap in how South African retirement funds manage climate change, relative to international best practice.



Source: World Bank Analysis, 2022

A 2024 analysis of the practices of large funds (representing over 60% of the industry by size of assets) in South Africa in relation to the management of climate change was conducted. An extract from this analysis (with is based on a questionnaire consistent with the World Bank analysis above and scores if funds have certain best practices in place) is as follows:

Sustainability criteria	Average sustainability score	Highest score	Lowest score	Std deviation
Actuarial integration	53%	60%	40%	9%
Climate change	11%	44%	0%	15%

Source: *Anderson J, Devlin P, Leicht C et al, Providing a pension income that prices in social and environmental externalities: a reporting framework, JoCo 2024 conference*

Compared to the 2022 World Bank analysis there was a small increase in the climate change score, with many funds still showing 0%. There was also a leading fund with a score of 44% (up from the maximum in the World Bank analysis).

In terms of the "Actuarial integration" factor, which measures the extent to which sustainability issues are incorporated into actuarial assumptions, one of the reasons for the average score being just over 50% is because climate change is not explicitly included in the projections or reserving for any of the funds included in the study. Hence, none of the climate-related impacts have been explicitly quantified in actuarial advice (both in relation to defined benefit fund valuations and projected income from defined contribution funds). This is a significant risk for the actuarial profession and individual actuaries providing advice.

Overall, evidence points to the fact that significant improvements are still required in how retirement funds incorporate climate change into the strategy and running of the fund.

Actuaries therefore have a critical role to play to assist funds in integrating climate considerations into the management of both defined benefit and defined contribution funds. Importantly, there are also various opportunities for funds in relation to investments aimed at the transition to a low-carbon economy and those investments resulting from increased adaption to a warner planet.

Recommended actions:
As the significance of climate change risk continues to escalate, South African retirement funds (both defined benefit and defined contribution funds) should consider its integration into their risk management frameworks.
Specific areas that are affected, and relevant to retirement fund actuaries, include:

1. *Impact on employer covenant*
2. *Impact on future fund membership numbers*
3. *Inflation and real return assumptions across various asset classes*
4. *Salary increase assumptions*
5. *Mortality assumptions*
6. *Ill-health assumptions*
7. *Retirement decrement rates*
8. *Migration rates*
9. *Withdrawal rates*
10. *Assumptions in relation to annuity rates*

In relation to actuarial work, climate change should be included in the various aspects including:

- *Statutory actuarial valuations in relation to defined benefit funds*
- *Projections of expected retirement incomes used for purposes of defined contribution funds*
- *Asset-liability modelling used to determine strategic asset allocations incorporated into investment policies*
- *Monitoring and reporting performed for funds for inclusion in their integrated reports*

Disclosures required in terms of IFRS S1 and S2 in future, as they become relevant to retirement funds

3. Components of climate change risk

Climate-related risk (climate risk) is the potential that changes in climate patterns (temperature, precipitation, sea level rise) from increased emissions of greenhouse gases (GHGs) such as carbon dioxide, methane and nitrous oxide, can cause adverse outcomes in society (economy, health and safety, infrastructure, culture).

There are three main elements of climate change risk, namely:
1. Physical Risk
2. Transition Risk
3. Liability Risk

Physical Risk

A physical climate risk relates to the physical hazards caused by climate change. These hazards can be acute or chronic. Acute hazards consist of severe and extreme events and are location-specific; examples include floods, wildfires and droughts. Chronic hazards relate to long-term incremental changes, such as increased heat, rise of ocean levels, variation in precipitation levels and ocean acidification.

Transition Risk

Transition risks are those associated with the global shift towards a low-carbon economy. The most common transition risks relate to policy and legal actions, technology changes, market responses and reputational considerations.

Liability Risk

Liability risks in relation to climate change are associated with the potential legal responsibilities that individuals, businesses, or governments may face due to their contributions to climate change or their failure to adapt to its impacts.

This risk can affect the underlying investments of a retirement fund or is a risk that the trustees of the retirement fund face. It is identified as a separate risk from physical and transition risk as it arises in both instances.

Relationship between physical risk and transition risk

An interdependence exists between physical risk and transition risk. This interdependence is akin to the equilibrium between two scales on a balance. In this equilibrium, the impact of policy interventions becomes pivotal. Aggressive measures aimed at achieving net zero targets tilt the scale towards transition risk, mitigating the physical effects of climate change. This reduces the likelihood of triggering tipping points. Consequently, the risks associated with physical climate change are significantly reduced. However, transition risks are significantly elevated in this situation due to the policy measures required to achieve this.

Conversely, a delay in policy interventions and the failure to meet net zero targets slows down the transition to a low carbon economy, reducing the effects of transition risk. This shift places greater emphasis on the risks associated with physical climate change, causing the physical risk scale to outweigh the transition risk. Thereafter, depending on the timeframe being considered for the scenarios, more aggressive policy interventions may be introduced to counteract the effects of physical climate change risk. If these interventions however are too delayed for it to have a meaningful impact in reducing the physical climate change risk, the likelihood of tipping points being triggered and the climate system moving into an unpredictable state increases.
It is crucial to consider the interrelationship between these two risk components when formulating scenarios and developing risk management frameworks.

Recommended actions:
Actuaries should consider the physical, transition and liability risks arising from climate change, as well as the relationship between these risks, in their work including the impact on:

(i) assumptions made in arriving at funding levels of defined benefit funds as well as projection illustrations for defined contribution funds
(ii) advice in relation to the setting of investment strategies of defined benefit and defined contribution funds.

Actuaries are encouraged to utilise scenario analysis (covered in a later section) to illustrate the different risks and how they relate to each other.

4. Climate change within the South African context

It is essential for retirement funds to understand the physical and transition risks affecting the country within which they operate as well as how it affects their investment portfolios (depending on which regions they are invested in aligned to Regulation 28).

The following section outlines how transition and physical risks manifest within the South African context and outlines the considerations that retirement funds should give to these risks in South Africa.

4.1 Physical risks

A summary of the current research outlining the impacts of physical risks on the South African climate is presented below. While this section details the specific climate events expected to arise in South Africa due to these physical risks and how they will affect the region, it is crucial to acknowledge that this literature does not account for the breach of tipping points. Ongoing research aims to understand how the climate system will change after these tipping points are triggered and the potential outcomes of this scenario. Nevertheless, the subsequent information aims to provide an understanding of the specific climate events affecting South Africa that could arise with an increase in the global average temperature.

The sub-tropical climate in the southern African region is characterized by warmth and aridity. Climate change is expected to cause an increase in temperatures which is estimated to be twice the rate of increase observed in the global average temperature. This will cause the southern African region to become hotter and drier.[8]

Estimates of the expected increase in temperatures across South Africa vary significantly. Some estimates for the temperature increase range between 2°C and 4°C under a low emissions scenario, with increases ranging between 4°C and 7°C for various regions of the country under a high emissions scenario. Other estimates for the temperature increase remain below 1.5°C under a low emissions scenario, both by 2050 and 2100. In such a scenario, a low likelihood of triggering tipping points exists. Under a high emissions scenario, other estimates of the temperature increases are approximately 2.1°C by 2050 and 5.7°C by 2100.

The number of days which are classified as warm is also expected to increase, with some estimates indicating the number of warm days is projected to increase from 25 to 140 days under a low emissions and high emissions scenario respectively. This is up from 5 warm days in 1990. Other estimates suggest increases of approximately 40 to 80 days, depending on the region of the country, with coastal regions being less affected.

The regional climate warming is anticipated to lead to a surge in the incidence of infectious and vector-borne diseases, such as malaria and dengue fever, attributed to the warmer climate facilitating the spread of these diseases.

These projected increases in warm days are also expected to lead to an increase in the frequency of occurrence of heat waves and an increased threat of fires. The prevalence of heatwaves and wildfires is projected to rise to unprecedented levels during the midterm period, from 2021 to 2050.

Moreover, the southern African region is susceptible to the occurrence of El Niño. El Niño is characterized by the extensive warming of the tropical Pacific Ocean on a large

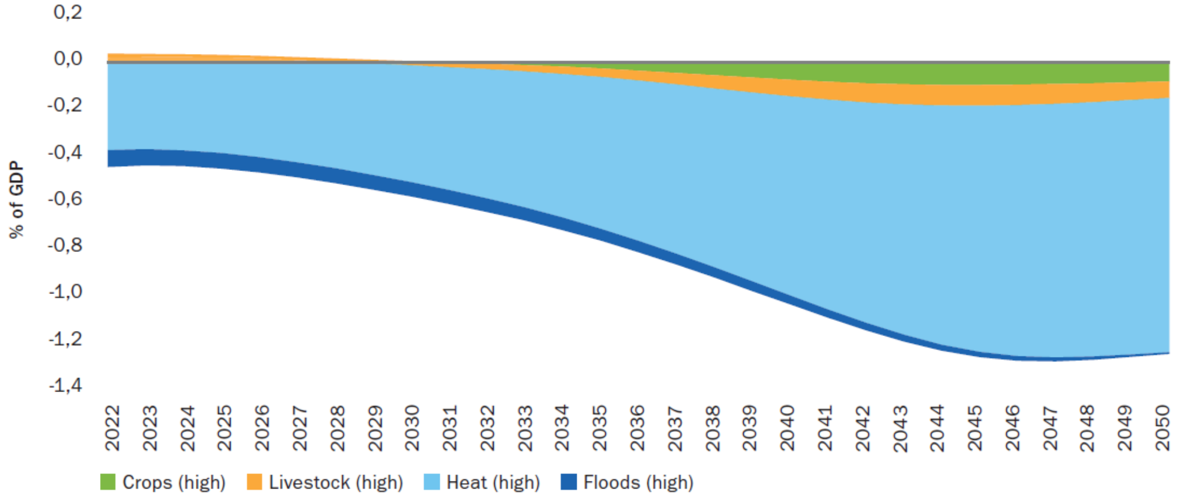
scale and this phenomenon commonly triggers both floods and droughts in the southern African region. With climate change increasing both the intensity and frequency of El Niño events, it is expected that South Africa will observe a rise in droughts and floods over certain regions of the country.
Rainfall is estimated to increase in certain parts of the region and to decrease in other parts if greenhouse gas emissions are not reduced. In the central interior and east coasts, rainfall is expected to increase significantly. However, in the other parts of the country, rainfall is expected to reduce substantially. The number of extreme rainfall events is also estimated to increase in the central interior and east coasts regions. This increase in the number of extreme rainfall events is also expected to lead to an increase in the risk of flooding. With increased flooding risk, there is also an estimated increase in the incidence of water borne diseases.

Projected impact on South Africa
While South Africa may not be among the most vulnerable economies, the long-term cumulative impact of climate change is expected to be significant. Studies vary in their assessments, but the overall annual GDP is expected to reduce by 0.8% on average between now and 2050 if we assume:

- effects in key industries in South Africa
- unsuccessful action to prevent global heating
- an ultimate heating of around 4 degrees above pre-industrial levels (which is also not the most pessimistic outcome)

This impact increases over time and reaches a reduction of 1.2% per year between 2040 and 2050.

Projected economic damages from climate risks from 2022 to 2050



Source: World Bank Group, Country Climate and Development Report, October 2022

Risk associated with triggering Tipping Points

Physical risk is associated with an increased risk in triggering tipping points. Scenarios where tipping points are triggered exhibit more extreme weather events, which are associated with significant financial consequences.

Comprehensive research on tipping points is not readily available, however, one study has examined existing literature on the economic implications of triggering tipping points to assess the Social Cost of Carbon measure (SCC) associated with these occurrences. The SCC is defined as the economic cost linked to emitting an additional ton of carbon dioxide, representing the marginal damage cost.

The approach employed to determine the Social Cost of Carbon (SCC) resulting from the trigger of tipping points includes assessing climate damages at a national level due to increased temperatures and rising sea levels in 180 countries. This model is fine-tuned using extensive econometric evidence and simulation modelling. Employing a meta-analytic Integrated Assessment Model (IAM), the research estimated that exceeding climate tipping points raises the SCC by around 25%, illustrating a positively skewed distribution. Additionally, there is a 10% probability of the SCC doubling. As a result, climate tipping points introduce elevated global economic risk. It is crucial to acknowledge that many of the figures are likely conservative estimates, given the absence of coverage for certain tipping points and the interactions between them in the existing literature.

These findings underscore the substantial impact on economic costs when tipping points are exceeded. Additional research provides further evidence for the economic cost of triggering tipping points by proposing that there is a certain degree of warming and increase in temperatures which would potentially lead to a significant decrease in GDP.

The implications for mortality can potentially be significant in certain instances, however, additional research is necessary to determine the extent of these consequences.

4.2 Transition risks

The global transition to a low carbon economy poses a significant risk to the South African economy. South Africa's economy is characterized by a high level of carbon intensity, ranking within the top 20 countries globally in terms of emissions per GDP. Seven crucial export markets for South Africa, including the EU, China, the United States, the United Kingdom, Japan, and South Korea, have all established net zero targets.

The transition to a low carbon economy is anticipated to result in a substantial reduction in South Africa's exports, specifically coal, platinum, and motor vehicles and parts. Coal and platinum constitute approximately 50% of total mining sales volumes, with the mining sector contributing approximately 7.3% to South Africa's GDP in 2022. Additionally, the automotive industry contributes approximately 6% to the GDP. Collectively, these two sectors contribute just under 15% to South Africa's GDP. Therefore, a significant decrease in these exports due to the shift to a low carbon economy would not only impact the GDP significantly but also the underlying investments of retirement funds and retirement fund membership in certain sectors if they do not adequately adapt to the transition to a low carbon economy. This shift could have significant social and financials consequences for South Africa.

Another aspect to consider regarding transition risk is carbon taxes. Carbon taxes increase energy prices significantly. While this results in a reduction in observed emissions, it also leads to a decrease in output, an increase in consumer prices, and a significant rise in unemployment rates. However, an additional factor to consider is that the decrease in greenhouse gas emissions resulting from the implementation of these carbon taxes contributes to health benefits by reducing deaths caused by local air pollution.

The global shift towards a low carbon economy is expected to result in a decrease in demand for carbon products and commodities. Additionally, it is anticipated to increase reputational risks for countries and businesses operating within them, driven by rising expectations from investors, lenders, and consumers seeking more responsible conduct. South Africa is amongst the countries that have acknowledged the tangible threat of climate change by being one of the 181 nations to sign the 2015 Paris Agreement, aiming to reduce greenhouse gas emissions. This also suggests the presence of increasing policy risk, stemming from government-introduced policies aimed at mitigating the impacts of climate change.

Carbon-border adjustment mechanisms and their impact on South Africa

Another important implication is what actions international trading partners take in the pursuit of mitigating climate change. One such action is the Carbon Border Adjustment Mechanism which the European Union is on track to introduce, effectively introducing tariffs on goods imported from non-EU countries. As a result of South Africa's carbon intensive economy (3.2 times higher than the global average in 2019), the World Bank has estimated that around 50% of South Africa's current exports are at high risk of being penalised by the introduction of this mechanism, losing about 1% of GDP because of this trade exposure.

The UK is also considering a similar mechanism and it is expected that many other countries would similarly follow suit.

The effect of these on South Africa's carbon taxes as well as the response of industries to the international mechanisms will need to be considered.

4.3 South Africa's transition to a low-carbon economy and adaptation to a warmer planet

South Africa's transition plan to a low-carbon economy involves a comprehensive approach that includes policy frameworks, regulatory measures, and strategic initiatives. Key components include:

1. Policy Frameworks
   - National Climate Change Response White Paper (2011): Provides the overarching policy direction for climate change mitigation and adaptation.
   - Integrated Resource Plan (IRP) (2019): Outlines the country's energy mix and emphasizes the role of renewable energy sources.

2. Regulatory Measures
   - Carbon Tax Act (2019): Introduces a carbon tax to incentivize emission reductions.
   - Climate Change Bill (2021): Establishes a legal framework for climate change response, including sectoral emission targets.

3. Renewable Energy Initiatives
   - Renewable Energy Independent Power Producer Procurement Programme (REIPPPP): Encourages private sector investment in renewable energy projects through competitive bidding.
   - Increased Renewable Energy Capacity: Plans to significantly increase the share of renewable energy in the national grid.

4. Energy Efficiency and Conservation
   - Energy Efficiency Strategy: Promotes energy-saving measures across various sectors, including industry, transport, and residential.
   - Building Standards: Implementation of energy-efficient building codes and standards.

5. Green Economy and Sustainable Development
   - Green Economy Strategy: Focuses on sectors such as renewable energy, energy efficiency, waste management, and sustainable agriculture.
   - Job Creation: Emphasizes the creation of green jobs and skills development in sustainable industries.

6. Adaptation and Resilience
   - National Adaptation Strategy: Develops plans to enhance resilience to climate impacts, including water scarcity, food security, and infrastructure resilience.

- Disaster Risk Management: Strengthens disaster risk management systems to cope with extreme weather events.

7. Financial Mechanisms
   - Climate Finance: Mobilizes financial resources to support climate mitigation and adaptation projects.
   - Public-Private Partnerships: Encourages collaboration between the public and private sectors to fund and implement low-carbon initiatives.

8. Public Awareness and Education
   - Awareness Campaigns: Conducts campaigns to raise awareness about climate change and promote sustainable practices.
   - Educational Programs: Integrates climate change education into school curricula and public outreach programs.

These components collectively aim to reduce greenhouse gas emissions, promote sustainable development, and enhance resilience to climate impacts.

Importantly, it is recognised that the pace of the transition must be "just". A "Just Transition" in the context of South Africa refers to the process of transitioning to a low-carbon and climate-resilient economy in a way that is fair and inclusive, ensuring that the social and economic impacts on workers, communities, and vulnerable groups are addressed.

Recommended actions:
Actuaries should consider the specific implications of climate change taking into account South African specific impacts, in addition to the implications in relation to any international exposure.
The implications for return and mortality assumptions should be considered taking regional factors into consideration.
For South Africa specifically, the knock-on effect of carbon border adjustment mechanisms should be taken into account as far as practically possible when consideration the transition risks.

5. Investments and ongoing monitoring of climate risk

Externalities and adopting a Universal ownership approach

The performance of a retirement fund's investments ultimately affects the level and sustainability of a member's income in retirement. Given the long-term nature of retirement savings and decumulation, it is important to consider to what extent externalities (such as those created by climate change because of increased GHG emissions) are priced into the investment portfolios underlying the pension promise.
Externalities are the potential costs or benefits incurred by 3rd parties who were not present in a transaction. The inability of societies to honour property rights even when they can be defined gives rise to externalities, which are the unaccounted-for consequences for others, including future people, of actions taken by one or more persons. The qualifier 'unaccounted-for' means that the consequences in question follow without prior engagement with those who are affected, or without due consideration for future people (DasGupta Review, 2021). Externalities can be positive or negative.
Overall, evidence suggests that externalities are not yet fully priced into global markets. The International Monetary Fund Financial Stability Report (2020) shows that climate risks are not priced into global equity valuations. Whilst there has also been increasing data and reporting of companies around environmental, social and governance risks, the CFA Institute (2021) confirmed that there is a low correlation between the ratings provided by the main ESG rating providers (which investors would use to factor into their assessments of a particular stock). The divergence in correlation of ESG ratings across the main ratings providers was confirmed by Berg, Kolbel, Rogobon (2022), who found the correlation to be between 0.38 and 0.71. Most investment strategies operate within the risk/return paradigm, and systemic risks posed by factors such as climate change are not fully integrated into investors' portfolio models. This creates a potential blind spot when it comes to financial risks and opportunities (Impact Investing Institute, 2021).

The CFA Institute for Policy Research advocates a "Universal Ownership" approach, order to improve the likelihood of retirement fund portfolios having climate change externalities priced in appropriately across the portfolio. This framework emphasises systems thinking, which really means two things: thinking about the whole and its interconnections with the past; and a pattern that is changing all the time. It has a particular application to finance, which both impacts and is impacted by society, technology, the legal system, ethics, politics, consumers and climate.

In this approach there are three principal ways that universal ownership can achieve real-world impacts such as net zero to produce better long-term financial outcomes:

- In listed markets, moving capital away from the backward-facing market cap benchmarks and toward portfolios that face forward and anticipate developments in the transitioning economy
- In unlisted markets, providing primary capital and transition finance to support the climate transition and climate solutions.
- Deepening the stewardship practices with respect to individual investments and industries and in public policy engagement through a systemic approach to stewardship.

A summary applying the "Universal ownership" approach is set out below:

	Shift from: Industry Current Position		Shift to: Industry Desirable Future Position
Portfolio construction	Portfolio creation has gaps in its approach to systemic risk and climate risk Limited appreciation of systemic risks in a market (systematic) risk paradigm	→	Portfolio creation is more robust and adaptable to change Integration of systemic risk into the risk management paradigm
The problems with benchmarks, incentives, and time horizons	Benchmarks and incentives that produce ineffective practice	→	Long-term incentives and actions that are effective and aligned to goals
Universal ownership	Universal ownership is small scale Weakly resourced stewardship	→	Universal ownership becomes large scale Strongly resourced and focused stewardship
Transition finance	Traditional financing models Blended finance early in its maturity	→	Alternative and innovative financing models Blended finance develops in maturity and impact

Source: CFA Research & Policy Institute

Further detail on the approach can be found in the CFA Research & Policy Institute paper called: "Net Zero in the Balance A Guide to Transformative Industry Thinking" issued in June 2024.

Summary of PRI framework: risks and opportunities

The Principles for Responsible Investment (PRI) framework provides a comprehensive approach for investors to incorporate environmental, social, and governance (ESG) factors, including climate change, into their investment strategies. An overview of how the PRI framework addresses climate change and the associated risks and opportunities:

PRI Framework Overview

The PRI framework is based on six principles that guide investors in integrating ESG factors into their investment processes. These principles are:

1. **Incorporate ESG Issues**: Integrate ESG issues into investment analysis and decision-making processes.
2. **Active Ownership**: Be active owners and incorporate ESG issues into ownership policies and practices.
3. **Disclosure**: Seek appropriate disclosure on ESG issues by the entities in which they invest.

4. **Promotion**: Promote acceptance and implementation of the principles within the investment industry.
5. **Collaboration**: Work together to enhance effectiveness in implementing the principles.
6. **Reporting**: Report on activities and progress towards implementing the principles.

Climate Change Risks and Opportunities

Risks

1. **Physical Risks**:
    - **Asset Damage**: Extreme weather events and rising sea levels can damage physical assets and infrastructure.
    - **Operational Disruptions**: Climate impacts can disrupt supply chains and business operations.
2. **Transition Risks**:
    - **Regulatory Changes**: New climate policies and regulations can affect the profitability of certain industries.
    - **Market Shifts**: Changes in consumer preferences towards sustainable products can impact market demand.
3. **Reputational Risks**:
    - **Public Perception**: Companies that fail to address climate risks may face reputational damage, affecting their market value.

Opportunities

1. **Renewable Energy**:
    - **Investment in Clean Energy**: Opportunities to invest in solar, wind, and other renewable energy projects.
    - **Energy Storage**: Advancements in battery technology and energy storage solutions.
2. **Energy Efficiency**:
    - **Green Buildings**: Investing in energy-efficient buildings and retrofitting existing structures.
    - **Smart Technologies**: Development and deployment of smart grid technologies and energy management systems.

3. **Sustainable Agriculture**:
    - **Climate-Resilient Crops**: Investment in agricultural technologies and practices that enhance resilience to climate impacts.
    - **Sustainable Farming**: Supporting organic and conservation agriculture practices.
4. **Water Management**:
    - **Water Recycling and Desalination**: Technologies and infrastructure for water recycling and desalination.
    - **Efficient Irrigation**: Investment in efficient irrigation systems and water-saving technologies.
5. **Green Infrastructure**:
    - **Public Transport**: Expanding and modernizing public transport systems to reduce emissions.
    - **Resilient Infrastructure**: Developing infrastructure that can withstand climate impacts.

Importantly, there are regions, asset classes, sectors and companies that will benefit from the transition and there are those that will be negatively affected. Also, there are regions, asset classes, sectors and companies that will benefit from the adaptation that will be necessary to be resilient on a warmer planet. The key with investment strategies is to identify how best to mitigate the risk and benefit from the opportunities.

Negative screening vs positive engagement

When implementing sustainable investment strategies, funds can make use of either "negative screening: or, as an active investor "positive engagement" depending on their beliefs. Given the structure of the South African economy, being highly dependent on coal-generated power and the implications of excluding certain investments on because of high carbon emissions, the section below summarises the two approaches and some of the pros and cons that funds should consider when deciding on the most appropriate approach.

Negative Screening
Definition: Negative screening involves excluding certain companies, sectors, or industries from an investment portfolio based on specific ESG (Environmental, Social, and Governance) criteria. This approach is often used to avoid investments in companies that do not align with the investor's ethical values or sustainability goals.
Examples:

- Excluding companies involved in fossil fuels, oil or not being sufficiently aligned to the Paris Agreement.

Pros:

- **Ethical Alignment**: Ensures investments align with the investor's values.
- **Risk Mitigation**: Reduces exposure to companies with potential ESG-related risks.
- **Simplicity**: Easier to implement as it involves excluding certain investments based on predefined criteria.

Cons:

- **Limited Investment Universe**: Reduces the pool of potential investments, which may impact diversification and returns.
- **Missed Opportunities**: May exclude companies that are making significant efforts to improve their ESG practices.
- **Impact on Performance**: Potentially lower returns, if excluded sectors or companies perform well financially. Also increases or tracking error of returns relative to benchmark.

Positive Engagement

Definition: Positive engagement involves actively engaging with companies to encourage better ESG practices and drive positive change. This approach focuses on influencing company behaviour through dialogue, voting on shareholder resolutions, and other forms of active ownership.

Examples:

- Engaging with a company to improve its environmental practices, such as reducing carbon emissions or enhancing energy efficiency.

Pros:

- **Influence and Change**: Allows investors to drive positive change and improve ESG practices within companies. In this way funds can make a real change at companies that need to transition or adapt.
- **Enhanced Returns**: Potential for improved financial performance as companies with strong ESG practices may be more resilient and innovative.
- **Comprehensive Approach**: Provides a more holistic view of a company's ESG performance and potential for improvement.

Cons:

- **Resource Intensive**: Requires significant time and resources to engage with companies and monitor their progress.

- **Uncertain Outcomes**: Engagement efforts may not always lead to the desired changes or improvements in ESG practices.
- **Complexity**: More complex to implement compared to negative screening, as it involves ongoing dialogue and assessment.

Both negative screening and positive engagement have their merits and can be effective in promoting sustainable investing. The choice between the two approaches depends on the funs goals, resources, and preferences. It is however important to understand the implications, given the investment universe available to South African retirement funds. A combination of both strategies can be used to achieve a balanced and comprehensive approach to sustainable investing.

Recommended actions:
To increase the chances of externalities being appropriately priced into portfolios delivering retirement incomes, funds could consider moving to a "Universal ownership" approach.
Funds must consider the pros and cons in relation to negative screening compared to positive engagement as an active investor.
In South Africa, a key component of this approach relates to active stewardship and ensuring these activities result in real-world impact and improved outcomes.

Use of climate metrics in monitoring investment portfolios

Another key aspect to support price discovery of climate change, is to have relevant monitoring of investment portfolios in place to support the approach adopted by a retirement fund.
The below section sets out the key monitoring tools, focussing on investment portfolios, that funds can utilise for this purpose.
Per the Principles of Responsible Investing ("PRI), *climate metrics enable investors to:*

- *understand and manage climate-related risks, opportunities and impacts associated with their investments;*
- *track progress against goals, such as reaching* net-zero *greenhouse gas emissions by a specified date;*
- *comply with regulatory reporting requirements;*
- *inform beneficiaries of climate-related risks, opportunities and impacts associated with their investments; and*
- *conduct climate-focused stewardship, either independently or in collaboration.*

Key metrics and uses

The key climate metrics proposed for retirement funds, together with their uses, are set out in the table below.

Metric	Description	Use
Weighted average carbon intensity (WACI)	a portfolio's exposure to carbon-intensive companies, expressed in tons CO2e / USD$M revenue	Measure portfolio's carbon emissions and trends
Carbon footprint	total carbon emissions for a portfolio normalised by the market value of the portfolio, expressed in tons CO2e / USD$M invested	Measure portfolio's carbon emissions and trends
Stranded assets	% of portfolio exposed to risk of being stranded (i.e. premature or unanticipated write-downs, dilutions, or conversion into liabilities because of physical or transition risk)	Assess how a portfolio is impacted by the transition to a low-carbon economy
Physical risk exposure	% of portfolio exposed to issuers with operations located in geographical areas sensitive to physical risks; % of portfolio exposed to issuers in sectors sensitive to physical risks;	provide an insight into if / how investment managers are monitoring and managing the climate-related physical risks associated with their portfolios.
Climate opportunity	% of the portfolio contributing to Sustainable Development Goal (SDG) 7: Affordable and Clean Energy and to SDG 13: Climate Action.	Measure exposure of investments to areas that benefit from the transition to a low-carbon economy.
Climate Value at Risk (VaR)	forward-looking estimates of the loss or gain an asset or portfolio may experience under different climate scenarios, within a given time horizon, at a particular probability (e.g., at a 25% or 50% likelihood). The estimate is based on specific future scenarios of future temperatures and levels of mitigation required, typically including:	To assess the climate-related risks and opportunities facing an asset or portfolio.

	1.5°C (aggressive mitigation), 2°C (strong mitigation) 3°C (some mitigation) 4°C (business as usual)	
Implied temperature rise (ITR)	Extent to which an investment or portfolio is aligned with the Paris Agreement, expressed as a number in degrees Celsius. Implied temperature rise is a forward-looking and attempts to estimate a global temperature rise associated with the GHG emissions of a portfolio.	Used to measure the environmental and social impact resulting from investments and whether engagement efforts are translating to real change in underlying investments. ITR metrics can be useful in communicating a portfolio's exposure to climate-related risks and opportunities.
Stewardship	% of climate-related shareholder proposals supported. % of climate-related shareholder proposals opposed. % of votes against management on the grounds of climate risk concerns; and number of climate-related engagements conducted in the past 12 months as a % of the total. Supplemented with information on the real-world outcomes that result from engagement and voting activities.	Measure stewardship activities to support a transition to a low-carbon economy.

Recommended actions:
Climate-related transition risk metrics are useful to understand and assess how an investment or portfolio is expected to be impacted by the transition to a low-carbon economy.
Actuaries should utilise monitoring metrics that are appropriate and relevant to the purpose, with any limitations in relation to their use being clearly set out.
Importantly, retirement funds should be mindful that GHG emissions metrics are often based on partial data, because not all assets / entities report accurately and consistently on their emissions, and data providers use a range of methodologies to fill in the gaps.
Retirement funds should be aware of methodological differences for the different measures, as well as limited data coverage and data quality issues where relevant.
In some instances, industry classifications of the underlying investments are required for analysis purposes. It is advisable to perform checks on the industry classification to ensure these are appropriate for the climate models utilised.
Another key limitation is that some metrics are highly sensitive to modelling assumptions which should be clearly explained and any limitations set out.
Despite the above challenges, having a monitoring framework in place is encouraged and considered more appropriate than not having anything in place. It is also anticipated that data and modelling techniques will improve over time to address many of the above shortcomings.

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6. Scenario analysis – qualitative and quantitative frameworks

Qualitative framework

Scenario analysis may be qualitative, quantitative, or both. This section sets out guidance in relation to the qualitative assessment.

Scenario analysis is a crucial tool to understand and manage the potential impacts of climate change on retirement schemes, including impacts on & feedback loops from employer/sponsor covenant effects, impacts of assets & investments, and changes in workforce demographics, morbidity and mortality because of climate change.

Actuaries explore different plausible future climate change paths (scenarios which describe future economic and societal conditions) based on climate change models that describe the impact of climate risks (physical and transition risks) as well as of climate adaptation and mitigations.

Currently, future climate change paths are largely based on different levels of GHG emissions which influence long-term equilibrium temperature outcomes, via different transition paths, (mainly categorised as orderly, disorderly or non-existent.)

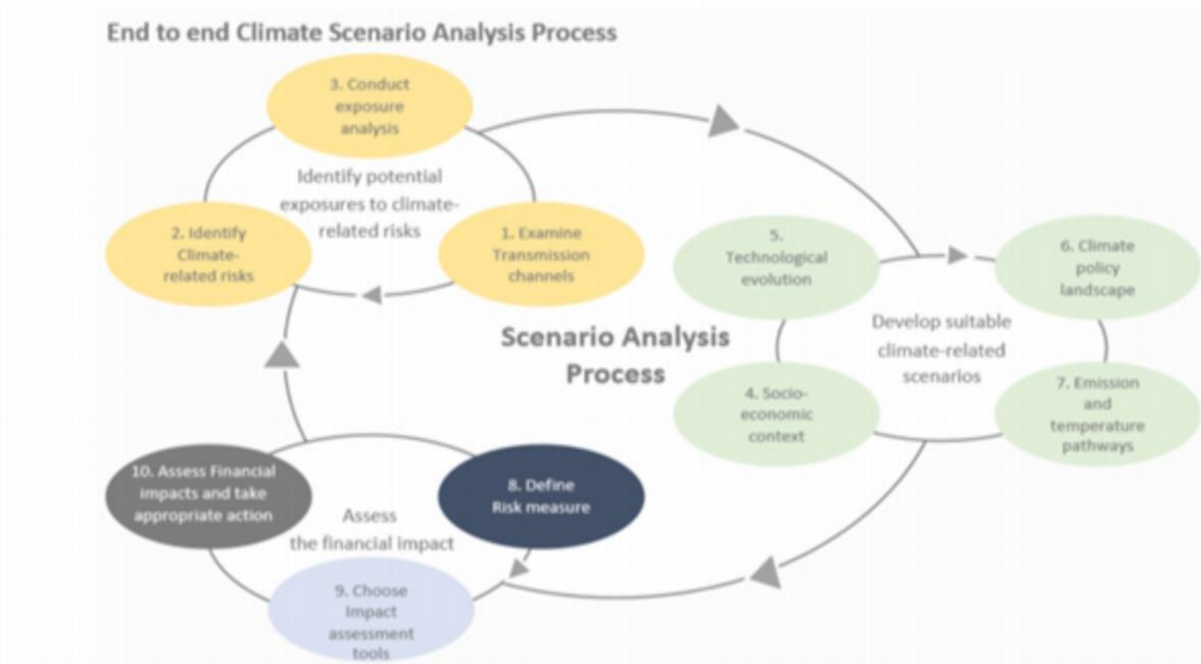
These scenarios are used to feed the impact of climate risks via transmission channels into actuarial financial and liability models, risk assessments, and strategic decision-making processes.

There are a wide range of uncertainties (known unknowns; unknown knowns; unknown unknowns) which actuaries need to incorporate into, and qualify, outcomes.

Scenario analysis should be done within a comprehensive risk management framework, including:

	ERM Framework (Adapted for retirement schemes)
Governance	Refers to the Board's role in determining risk appetite & budget – supported by actuaries & benefit consultants. Qualitatively and quantitatively depends on modelling of complex real world phenomena -including interaction with traditional metrics, financial tools and models
Strategy	Bring the impacts and management of climate change into investment & funding strategy & planning, such as building resilience of employer covenant under distinct climate scenarios (orderly, disorderly, hot-house, too little too late)
Scenario Development	Use of climate models to describe a range of potential future climate pathways and their impacts on both physical and transition risks
Risk Identification and Assessment	Identify climate risk, and their transmission channels into specific risks (likelihood and impact) under different climate scenarios with respect to the fund's operations and strategic objectives. Physical and transition climate risks once identified, need to be linked causally with -macroeconomic risks -investment strategy risks, and market risks -risks that impact sponsor covenant -demographic risks withdrawal, replacement; morbidity; mortality -Political, sovereign risks, such as legislation restricting or changing fund investments -fund specific risks -such as those faced by pensioner only schemes -the risk that diversification capacity in markets is diminished, exhausted, inaccessible Traditional risk categories (market, credit, liquidity etc) should be mapped onto the transmission channels of climate risks
Integration with Risk Management Processes	Integrate into the risk management process, ensuring that it influences risk assessment, mitigation strategies, and decision-making. -funding advice -valuation advice -investment strategy -benefit reviews -asset-liability modelling -incorporating into strategic advice for board governance -risk allocation budgeting

Metrics; Data gathering; Modelling Toolkit	Ensure that metrics/data gathering methods used are fit-for purpose; appropriate to time-horizons; models used for financial impact and projection are consistently used, bearing in mind the nature of the climate models used E.g. where stochastic asset liability models are used, a further level of uncertainty is added, to the existing limitations of the underlying scenario models.
Monitoring and Revision	Regularly update scenarios and risk assessments based on new climate data and scientific predictions, maintaining the relevance and accuracy of the ERM framework.
Strategic Decision Making	Utilise insights from scenario analysis to inform strategic planning, investment and funding strategy, and benefit reviews and structuring, aligning them with the anticipated range of climate change impacts.



Source: IAA, CRTF_Introduction_Climate_Scenarios, Feb 2021

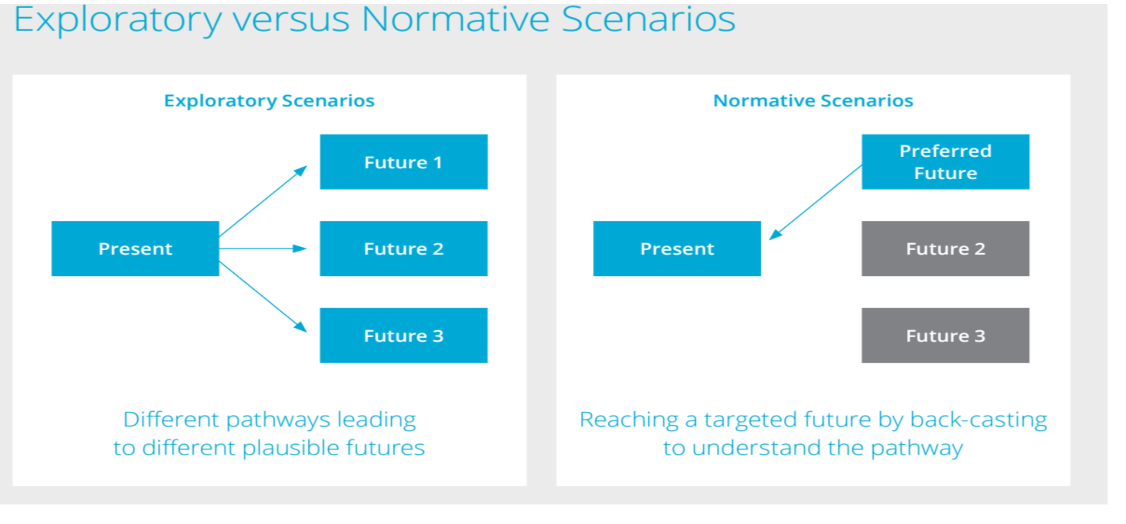
The scenario analysis process draws from several complex domains, so it is critical to develop a high-quality, clearly outlined narrative so that the scenario can be modelled.

	Factors that influence Scenario Narrative Quality
1 Time Horizon	Projects sufficiently in the future (e.g., 2040; 2050, 2100)
2 Focal Question	Has well-formulated and focused objectives/questions to answer
3 Driving Forces	Define a clearly articulated set of underlying causes of change derived from external social, technological, economic, environmental, and policy processes (e.g. current industrial mix, NDCs, current policies and drivers of GHG Warming)
4 Scenario Logic	Develops a clearly stated relationship between various drivers and change, including the causal assumptions underlying the described relationship, and an internal consistency between various statements and assumptions that underpin the scenario storyline
5 Pathways	Clearly described trajectory from now till the future outcome of the scenario that results consistently from the drivers
6 Uncertainties	Explicit description of uncertainties and sources with relation to drivers
7 Storyline	Presents a seamless and integrated narrative describing the causal train of events (pathways) and underlying drivers, assumptions, and affected systems
8 Plausibility	Is possible and credible as to the events it describes
9 Distinctive/ Diverse	Focuses on different assumptions about key driving forces in each scenario, and should have enough scenarios to provide diversity in pathways and outcomes
10 Consistency	Is consistent in the application of the scenario logic between scenarios

11 Relevance	Contributes insight into the futures that relate to the strategic and/or financial decisions facing a company
12 Challenging	Challenges conventional wisdom and simplistic assumptions about the future
13 Granularity	Scenarios with enough regional/sector granularity
14 Downscaling	Most Scenarios are long-term Global; can they be scaled down to apply to smaller systems
15 Tipping points	Scenarios need to allow for, or at least speak to fundamental changes in dynamics due to tipping points (non-linearity, domino effects; 2nd order effects,)
16 Reverse -stress testing	The increasing uncertainty around the actual impacts of lower temperature pathways points to use of reverse testing techniques to interrogate their consistency and sensibleness.

Adapted from A4S Guide to TCFD Climate Scenario Analysis, 2021

Nature of Climate Scenario Pathways



Scenarios could be exploratory which is a "roll forward" approach; or normative, where a future state is targeted or specified, and the pathways to current states are worked back.

The IPCC has developed widely accepted or understood Global Reference Scenarios (baseline) scenarios known as Representative Concentration Pathways or "RCPs", which are normative (plausible emission pathways are worked back from long-term year 2100 temperature outcomes, also quantified as net radiative forcing).
The most widely applied pathways are sumnmarised below:

IPCC Pathway	Emissions Trajectory	Temperature trend by Year 2100
RCP 2.6	Peak by 2020, reducing thereafter in line with Paris Accords, due to drastic sustainability policy impacts	< 2°C rise

RCP 4.5	Peak by 2040, reducing thereafter by 50% by 2080	2.4°C rise
RCP6.0	Peak by 2060, then decline	2.8°C rise
RCP8.5	Business as usual, no change in policy, rising emissions	4.3°C rise

Each of these pathways imply plausible paths via which emissions trajectories can develop, marked by distinct temperature trajectories.
These paths have been developed further into narratives, known as “SSP’s”. or Shared-Socioeconomic pathways, which are similar plausible pathways, this time described in terms of developments economic growth, education, level of globalization, level of urbanization, and the rate of technological development – but not allowing for the climate policy changes implied by the RCPs.
This allows different SSPs to be combined with different RCPs, to enable a much richer, textured scenario architecture. SSP’s are more descriptive of transition and liability risks, and so can be combined with RCPs, in different ways to describe combinations of energy transitions, policy changes, and socio-economic transformation levels (eg. orderly; or disorderly or showing regional conflicts versus global unity), that can lead tomore or less to similar temperature 2100 outcomes.
A limited number of scenarios from organizations beyond the IPCC are used widely enough to be considered reference scenarios. Most significant of these are the IEA (International Energy Agency) two core scenarios, Stated Policies Scenario which is business as usual, and the Sustainable Development Scenario, which reflects transitions limiting global warming to under 2°C, as well as modelling much more ambitious net-zero (2050) scenarios embodying a greater renewable energy focus.
Other organisations which are involved are International Renewable Energy Agency; Greenpeace and the Network for Greening the Financial System (NGFS).

The NGFS scenarios are widely used by financial institutions and service providers. The latest (known as Phase IV) versions are covered below:

- The Low Demand scenario envisions a future where significant climate action is taken to limit global warming to well below 2°C, ideally to 1.5°C, as per the Paris Agreement goals. This scenario assumes rapid technological advancements, behavioural changes, and stringent policy measures that reduce energy demand and carbon emissions.
- Disorderly / Delayed Transition scenarios explore higher transition risk due to policies being delayed or divergent across countries and sectors. climate policies are not significantly strengthened until 2030. This delay results in higher short-term emissions and more severe climate impacts. After 2030, rapid and stringent policy measures are implemented to limit global warming, causing abrupt economic adjustments.
- Hot House world scenarios assume that some climate policies are implemented in some jurisdictions, but global efforts are insufficient to halt significant global warming. Critical temperature thresholds are exceeded, leading to severe physical risks and irreversible impacts like sea-level rise. In the Hot-House World scenario, global efforts to mitigate climate change are insufficient, leading to high emissions and significant global warming beyond 2°C. This scenario results in severe physical risks and limited policy action to transition to a low-carbon economy
- The Current Policies scenario assumes that countries implement only the climate policies that are currently in place. This results in moderate emissions reductions but not enough to limit global warming to well below 2°C.

Scenario analysis should be applied with caution, especially regarding the limitations and uncertainties, uncertainties underpinning global reference climate scenarios:

- There are high levels of uncertainty in climate modelling assumptions, especially in the tails, and around the rapidity & sensitivity of trajectories, for a given level of emission.
- Scenarios usually underestimate economic impact of reference pathways
- The shock impact of climate tipping points (especially multiple tipping points), how they interact, their non-linearity creates potentially cascading effects that are little understood.
- Most global reference scenarios only indirectly model tipping point impacts where the associated damage function outputs, exclude tipping points (multiple, interacting, cascading)
- Equilibrium economic models which underpin many scenario descriptions have too many simplifying assumptions and features- not sensitive or comprehensive enough.
- There is a need to be climate literate alongside narrative scenarios

Climate risk and opportunities assessment

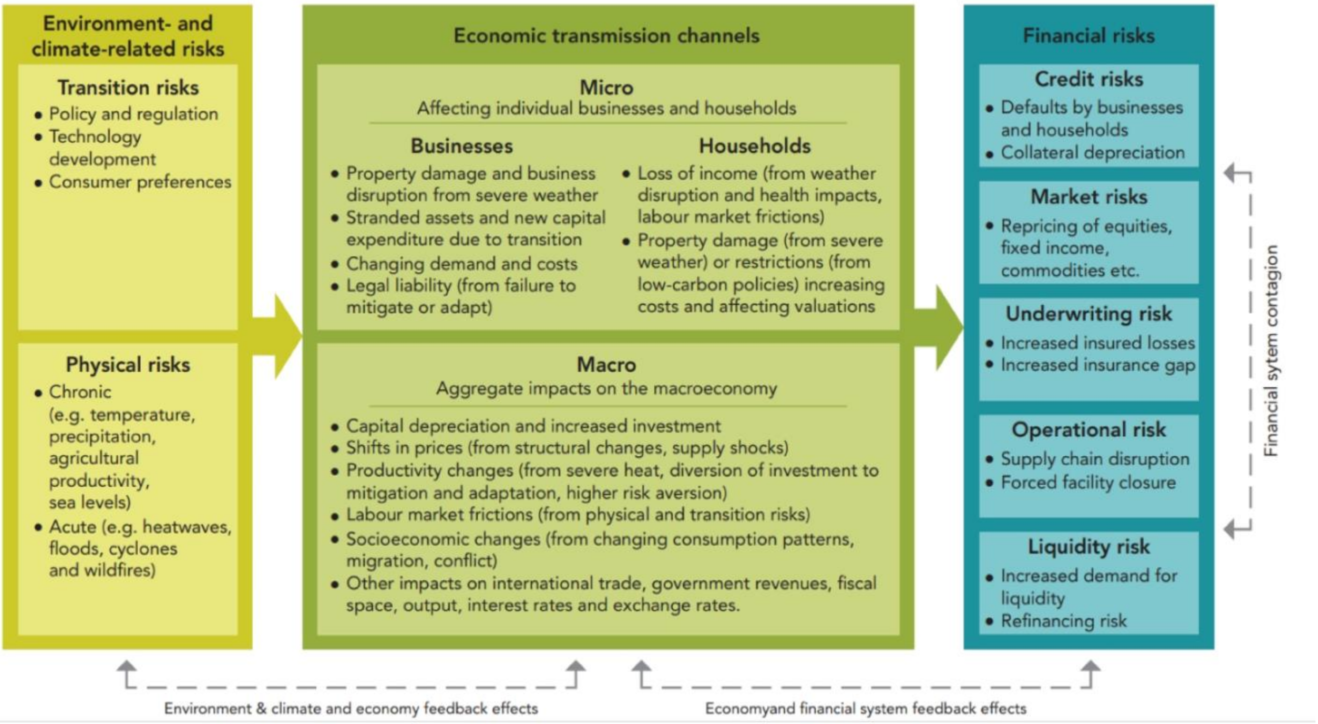
Scenario analysis frameworks are useful in examining climate risk and impacts and the associated opportunities that emerge from managing risk.
The critical properties of the scenario process which feature in the process to qualitatively identify & assess climate risks include:

a) different transitional risk pathways (via complex climate models called Integrated Assessment Models)
b) econometric models which describe how economies change as transition occurs, allowing for risk adaptation and mitigation, as well as focus on changes in energy and emission variables.
c) descriptions of physical risks evolve, via chronic climate impact models (Climate Impact & Earth system models) and natural catastrophe models for acute physical risks.
d) The flow of both physical and transition risks into macro-economic models, in terms of, for example:
    - GDP/Asset damage/ inflation impacts
    - Labour force impacts
    - Macro-variables which can then be applied in other traditional financial models (eg.AP; factor models; Wilkie model with cascading parameters; bond models etc.)
e) allowance for complexity of climate change processes & interactions with expected physical, transition, and traditional risks
f) interaction of acute & chronic hazards
g) adaptation/mitigation subject to synchronised action
h) role of policies and political drivers
i) allow for complexity of drivers such at tipping points such as
    - Cumulative/ jump processes tipping points
    - Cascade effects, ripple effects (across different domains eg CO2 leads to ocean acidification – leads to mass migration)
    - thresholds which lead to big system change
    - feedback loops on initial driver eg permafrost melt links to methane release
j) the magnitude of the inherent uncertainties in the scenarios

The modelled climate Risks can be mapped onto traditional risks which can then be adapted in traditional financial and liability models, via macro-economic & micro-economic transmission channels. These channels are ways in which the actual impact filters in, through pathways of correlation, aggregation, concentration.
Hence, these can be translated into traditional risk category impacts

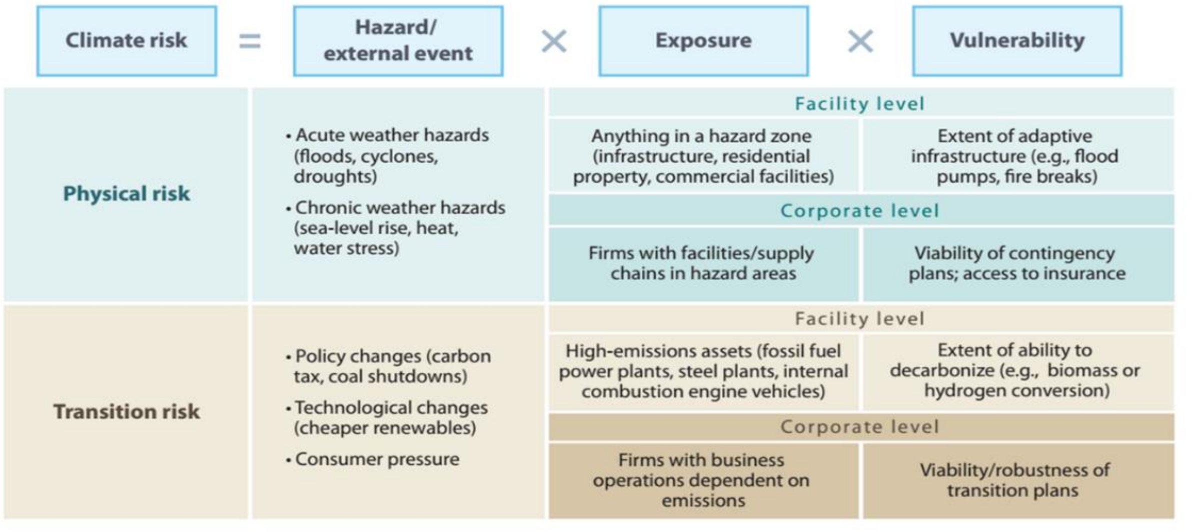
- Credit risks – increased risk of default / business distress, strength of sponsor covenants, home-loans; late payment of contributions
- Market risks, where asset valuations are impacted, influences investment strategies and asset allocations, including to infrastructure, ESG and renewables
- Underwriting risks -increase in morbidity/mortality projections, and impacts on insurance gap
- Operational risks – employer operations; member administration operations, eg member benefit statements available digitally versus on paper
- Liquidity risks because of market and transactional

The types of and levels of uncertainty that surround such mappings, must be communicated, and forms a key component in the effective use of actuarial models using this approach.
Illustration of this:



**NGFS Technical Supplement*

Liability exposures and vulnerability to climate risks
The diagram below illustrates how climate risks can be measured, using a hazard even approach:



**Caldecott 2021*

A key feature is the identification of the hazard event (both acute and chronic, and transitional). The likelihood and occurrence of the hazard event is linked to the Climate model pathways or scenarios selected in the ERM process
The hazard event itself must be linked to scheme vulnerabilities which determine the severity of exposure.
Some examples in the case of retirement scheme and pension funds vulnerabilities and exposure are

- Via employer covenant eg
  - Catastrophic climate event leads to entity failure or distress
  - Impacts workforce, ability to provide adequate contributions on time
  - Morbidity impacts – increased vulnerability of workforce to permanent health impairment/ death
  - Transition risks could impact sponsor in terms of stranded assets/obsolescence effect
  - Or climate destructive sectors- cement and construction
- Via investment strategies
  - Fundamental change in risk-reward features of assets
  - Breakdown in asset class correlations
  - Liquidity, impact of stranded assets on portfolio investments
- Via funding strategies, insurance costs, operational expenses

Conceptually transition risks and physical risks trade-off each other, so there should be awareness of the potential impact of changes in each type of risk on the other.

As always, uncertainties in the model need to be highlighted and range-impact quantified

Choice of Parameters/Assumptions

An example of parameter inputs and analytical tools below, illustrates a few aspects to be borne in mind by the actuary

Parameters/Assumptions	Analytical Choices	Scenario Outputs
• **Discount rates** • **Carbon Price** • **Energy demand and mix** • **Commodity prices** • **Macroeconomic variables**—for example, GDP, employment • **Geographic variation** • **Demographics and employment** • **Technology** • **Policy** • **Climate system sensitivity**—such as the response of climate to given amount of CO_2	• **Quantitative vs qualitative methods** • **Timescale**—2030, 2050, 2100 [2100 only relevant for long-term infrastructure] • **Scope of analysis** • **Data availability** • **Choice of climate hazards**—for example, heat, floods, extreme weather • **Extent of supply chain inclusion** • **Balance of economic, social, and physical analysis**	• **Earnings/profits** • **Revenues** • **Costs** • **Asset valuations**—how badly are assets stranded? • **Investment/capital expenditure** • **Asset allocation** • **Potential impact on productivity** • **Business interruption from physical hazards** *Source*: TCFD Technical Supplement.

The choice of parameters and assumptions are critical to the usefulness of the actuarial modelling results, in an arena where there is already an ecosystem of connected assumptions:

- In the above table the parameter, climate system sensitivity itself impacts on all the other parameters, and is also a link to the climate and scenario models
- The other parameters are linked to macro-economic models, or directly to climate scenario model out puts, which are then themselves linked to the climate scenario models.
- Therefore, a double layer of connectivity exists which the actuary must use with caution

In the pension's environment, caution should be exercised when distinguishing between causal parameters and assumptions, otherwise the actuarial modelling may embed doubling up of impacts from underlying parameters:

- For instance, applying margins to macro-economic variables like real GDP, while at the same time applying margins to employer operations and covenant without applying the distinction between micro-economic effects beyond the systematic impact of national economic performance.

Identify nature of pension arrangement & liabilities

The nature of the pension scheme, out be set out with regards to exposure & vulnerability

It is important to assess and understand the nature of the pension scheme for which climate impacts are being modelled.
One of the key issues is to identify suitable time horizons for the analysis/modelling of impacts. For a pensioner only mature scheme with very aged membership, modelling impacts over a 100-year horizon, may not be suitable. At the same time the impact of tipping points, 2nd order effects and physical catastrophes may have an impact on liquidity of investments; administrative functions that need to be understood over a much shorter time horizon
For instance, the list of features to consider (not exhaustive)

- Type of benefits payable, whether DC vs DB, default channels, or exposed to annuity market, or default in house bpost-retirement benefits
- Self-insured vs reinsured
- Maturity features of the scheme, whether declining or closed membership, or younger growing scheme
- Accumulation phase vs decumulation phase predominance in the fund
- Investment strategies & funding strategies and objectives.
- Member choice or Trustee driven universe of portfolios
- Umbrella (type of umbrella) vs standalone
- Sector/industry /union or negotiated benefit fund, or retirement annuity or preservation scheme
- Homogeneity or heterogeneity of work force
- Suitable time horizons for the analysis for different cohorts
- Workforce morbidity and mortality – for instance, the research here somewhat indicates that seasonal changes may have greater impacts than can be seen through averages; and that geography and location can potentially play an increasing role in differentiating for example, inland vs coastal populations.
- Employer characteristics and covenant – the interplay between
- Regulatory reporting requirements, sustainability regulation; climate policies and evolution
- How is the scheme likely to evolve with regards to scheme profile, investment strategy and funding strategy
- This could include putting in place processes to review opportunities that arise from the transition to a low-carbon economy.
- Employer behaviour and response to climate-change assessments, nature climate risk management in place also has an impact
- The availability of data, for example, increased data availability following the development of their investment managers' climate-related data reporting capability across asset classes.
- Modelling techniques or capabilities, for example, after industry reaches consensus about how some currently challenging asset holdings could be better modelled.

- Global policies or regulations, for example, the introduction of a carbon tax.

While applying a qualitative assessment framework it should be borne in mined that the nature of the schemes assets and liabilities needs to be modelled over relevant future lifetimes, hence model approaches such as Monte-Carlo simulations, and stochastic asset liability modelling may need to be considered, because of the qualitative assessment process.

Integration of Scenario, Climate Risk assessments with the evolution of pensions scheme profile

A heatmap approach is suitable for qualitative assessments which ultimately lead to the choice of a quantitative framework based on the most significant aspects extracted from the qualitative approach.
A heatmap framework should consider:

a) A self-survey approach to identify key scheme profile features, the level and severity of risk associated with the profile, as well as to assess parameters and assumptions, and how they are likely to change under the chosen global reference scenarios; and then
b) Risk assessment of the scheme where the most vulnerable features of the scheme are highlighted.
c) Not only highlight key risks but provide a sense of the plausible correlations and interactions. Further need for stress-testing and reverse stress testing framework in specific areas should be explained
d) Outputs which communicate clearly the need for risk governance, risk allocation and budgeting measures; risk management activities that the Board of the scheme needs to be engaged in.

The qualitative modelling assessment needs to consider the impact on the parameters that are traditionally used over time, for example

- Investment return/discount rate – how likely at the NGFS scenarios to lead to a low-return environment
- Valuation and funding method – the use of AAM versus PUC methods and how they may be appropriate under the different scenario pathways.
- Salary merit scales – how different are merit increases likely to be in Hot-house vs orderly NGFS transitions, and how does the changing skills and expertise of the workforce impact
- Longevity, mortality and morbidity rates – under which scenarios are the membership likely to age, or grow?

The Heatmap approach will lead to:

- Rating of the most significant risks to model, and over what period, given the nature of scheme
- Assessment of the set of scenarios relative to each other to apply the climate modelling

- Provide an understanding of the subsequent modelling required
- Provide an understanding of impact of downscaling to regional levels of Global scenario models
- Clarify the uncertainties, and what further approaches are needed
- Gaps in the analyses which may require quantitative approaches
- Clarify modelling depth and approach needed (eg stochastic vs deterministic, or real-world dynamic models vs equilibrium models)

Guidance:
A worked example of a Heatmap approach is appended Appendix 2.

Quantitative framework

Scenario analysis, and specifically highlighting the impact on the assets and liabilities of a fund, is an area where actuaries can add value to retirement funds. This will assist funds in developing their strategies to climate risk and understanding the implications of the solvency of the fund (in the case of DB funds) as well as the implications of climate change in what members can expect from their DC funds.
The purposed of scenario analysis is to draw attention to important risks and opportunities and to inform trustees' decision making, rather than seeking a precise forecast of the future.
To illustrate the potential impact of climate change under various scenarios, actuaries can provide expected replacement ratio calculations for defined contribution funds. An example of such illustrations is set out in the below table:

XYZ Retirement Fund – Projected Replacement Ratios (for illustration only)

	Base	**Orderly net-zero** 1.5°C warming	**Disorderly net-zero** 1.5°C warming	**Limited Action** 2.0°C - 3.0°C - warming	**High warming** >4.5°C warming	**Planetary solvency (2100)**
Standard mortality assumptions	76%	71%	58%	53%	50%	25%
Reduced mortality improvements	76%	71%	58%	55%	53%	27%
Reduced longevity (low)	76%	71%	58%	56%	56%	43%
Reduced longevity (high)	76%	71%	58%	58%	63%	43%

Source: Alexforbes proprietary calculations for illustration

To illustrate the potential impact of climate change under various scenarios, actuaries can provide funding level calculations for defined benefit funds. An example of such illustrations (for a pensioner-only fund) is set out in the below table:

ABC Pension Fund – funding levels across various climate scenarios (for illustration only)

	Base	Orderly net-zero	Disorderly net-zero	Limited Action	High warming	Planetary solvency
Standard mortality assumptions	100%	96%	91%	87%	82%	58%
Reduced mortality improvements	100%	96%	93%	89%	86%	63%
Reduced longevity (low)	100%	96%	93%	91%	92%	98%
Reduced longevity (high)	100%	96%	100%	104%	123%	98%

Source: Alexforbes proprietary calculations for illustration

Guidance:

In arriving at the assumptions for such illustrations, actuaries should:

1. *Consider the implications of on economic growth, inflation, salary increase assumptions, expected returns, expected mortality. Internal models and research as well as external research should be incorporated and any limitations highlighted.*
2. *Highlight the uncertainty around the implications of climate change.*
3. *Highlight the uncertainty around the impact of adaptation.*

Replacement ratio and funding level scenario analysis should be updated after significant changes in the following areas.

- ***Investment strategy,*** *for example, a higher allocation being made to matching assets following a material deterioration in the employer covenant, which reduces the trustees' risk appetite.*
- ***The availability of data,*** *for example, increased data availability following the development of their investment managers' climate-related data reporting capability across asset classes.*
- ***The way the scheme's investments are invested,*** *for example, a switch from a growth or matching structure to a dedicated cashflow-driven investment portfolio.*
- ***Modelling techniques or capabilities,*** *for example, after industry reaches consensus about how some currently challenging asset holdings could be better modelled, or updated research in relation to the implications of climate change on mortality.*
- ***The scheme's liability profile (for a DB scheme),*** *for example, after a material proportion of the scheme's liabilities is secured under a buy-in policy with an insurance company or the carve-out of some of the liabilities following a corporate transaction.*
- ***The scheme's membership profile (for a DC scheme),*** *for example, after a material changes following a merger or acquisition.*

Global policies or regulations, *for example, the introduction of a carbon tax or changes in relation to carbon-border adjustment mechanisms.*

7. Conclusion

Climate change is expected to have significantly long-term implications for retirement funds.
Current research indicates a significant gap in the integration of climate-related risks in the strategy and management of retirement funds.
This guidance note aims to bridge this gap and encourage the integration of climate change into the actuarial work related to retirement funds.
Overall, actuaries are encouraged to upskill themselves in relation to climate change and its application in their day-to-day work.
This note will be updated over time as additional research and leading practices develop where applicable.

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APPENDIX 1 - REFERENCES

IAA and other publications which provide useful foundations on climate risk include:

- IAA Paper 1: Importance of Climate-Related Risks for Actuaries
- IAA Paper 2: Introduction to Climate-Related Scenarios
- IAA Paper 3: Climate-Related Scenarios Applied to Insurers and Other Financial Institutions
- IAA Paper 4: Application of Climate-Related Risk Scenarios to Asset Portfolios
- IAA Paper 5: Climate-Related Disclosures and Risk Management: Standards and Leading Practices
- IAA Paper 6: The Climate Change Adaptation Gap: An Actuarial Perspective
- IAA Paper 7: Actuarial Considerations Around Climate-Related Risks on Social Security
- Climate Science: A Summary for Actuaries – What the IPCC Climate Change Report 2021 Means for the Actuarial Profession.
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- *NGFS Phase 4 Scenario Explorer https://data.ece.iiasa.ac.at/ngfs/#/login?redirect=%2Fworkspaces*
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- *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115*
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APPENDIX 2 – QUALITATIVE SCENARIOS HEATMAP EXAMPLE

(Please see Excel heat map available for download)

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