Actuarial adaptation: exploring new roles for actuaries in response to climate change

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ABSTRACT

This paper explores new practice areas for actuaries in the context of climate change. It aims to provide a broad overview of areas where actuaries can apply their skills and expertise to assist with climate change risks and opportunities, and thereby support the transition to a low-carbon economy, whilst also helping to manage the risks associated with such a transition (including not transitioning). The paper will draw on current literature, case studies, industry practice and stakeholder interviews.

The paper covers current and potential areas of practice relating to climate risk management, risk and emissions modelling, insurance, finance and investments, strategy setting, governance, reporting and regulation, government, and other areas of corporate support. The paper also addresses, at a high level, areas in which actuaries will be required to enhance their technical climate knowledge to enable actuarial practice.

KEYWORDS

Climate change, sustainability, new practice areas

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1. INTRODUCTION

1.1 Background

1.1.1 The state of the global climate crisis continues along a concerning trajectory with the latest report by the World Meteorological Organization (WMO) published in March 2024 indicating that 2023 observed the highest readings to date across all global climate indicators including:

— concentration of atmospheric greenhouse gases (carbon dioxide, methane and nitrous oxide);
— global mean temperature increase of approximately 1.45°C in a 174-year observational record;
— ocean heat content (energy absorbed and stored by oceans) in a 65-year observational record;
— record low reading of Arctic sea-ice extent (i.e. surface area of the ocean covered by sea ice);
— loss of glacier ice across a global set of reference glaciers;
— reduction in snow cover in the northern hemisphere; and
— global mean sea level reflective of ocean warming and melting of glaciers and ice sheets (WMO, 2024a).

1.1.2 The Global Annual to Decadal Climate Update also published by the WMO provides a summary of predictions for climate indicators. The latest report covering the period 2024–2028 suggests that:

— it is likely that the global mean near-surface temperature will exceed 1.5°C for at least one year between 2024 to 2028 and that at least one year will be the warmest year on record (exceeding the 1.5°C threshold specified in the Paris Agreement);
— Arctic warming is expected to be more than three times as high as the increase in global mean temperature;
— there will be further reductions in sea-ice concentrations;
— there is a reduced chance of precipitation in north-east Brazil and increased chance of wet conditions in the African Sahel; and
— there is above average expected tropical cyclone activity in the North Atlantic. (WMO, 2024b; UNFCCC (United Nations Framework Convention on Climate Change), 2015)

1.1.3 Extreme weather and climate events continued to lead to severe socio-economic impacts globally. Storm Daniel, Cyclones Freddy, Mocha, Gabrielle and Hurricane Otis in 2023 resulted in flooding, infrastructure damage, forced relocation, loss of food security, casualties and fatalities. Many significant heatwaves and wildfires were experienced globally with long-term persistent drought experienced across Africa, Asia, Americas and the Iberian Peninsula (WMO, 2024a).

1.1.4 The socioeconomic impacts of climate change include reduced food security where higher temperatures, changing precipitation patterns and more extreme events negatively affect the four pillars of food security, i.e., availability, access, utilisation and stability (FAO (Food and Agricultural Organisation of the United Nations) et al., 2019). The proportion of the world facing chronic hunger was 9.2% in 2022 impacting between 691–783 million people (up from 7.2% before the pandemic in 2019). While some recovery has been noted since the pandemic, extreme weather-related events have been noted as a key disruptor (FAO et al., 2023).

1.1.5 Globally, extreme weather events continue to trigger displacement, forcing individuals to leave their homes and communities to cope with the implications of climate events on their safety and livelihoods (WMO, 2024a). Between 2008 to 2023, 70 disaster events were reported in South Africa resulting in the internal displacement of 232 000 people, mainly driven by flood events. Globally, 26.4 million people have been displaced by approximately 3900 natural disasters during the same period.[1]

1.1.6 To help mitigate these developments, as part of decarbonisation efforts to reach 11 000 GW of renewable energy by 2030,[2] additions to global renewable energy

1 https://www.internal-displacement.org/countries/south-africa/
2 https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge

capacity increased by 50% in 2023 (i.e., an addition of 510 GW) driven by increases in renewable capacity in China, US, Europe, and Brazil. However, the International Energy Agency (IEA) expects global renewable capacity to reach 7300 GW only by 2028 – key challenges include policy uncertainty, insufficient investment in grid infrastructure, cumbersome administrative barriers and insufficient financing in developing economies (IEA, 2024).

1.2. Considerations for the actuarial profession

1.2.1 The previous section highlights the urgency and far-reaching transition that is required across society to meet our collective goal to limit the impacts of climate change, a key component to achieving sustainability for people and the planet.[3] As climate indicators continue to worsen, the extent of change required and period within which this needs to be achieved presents an urgent societal challenge, exposing different groups within society to varying levels of risk. The International Labour Organization (ILO) defines the "Just Transition" as "Greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind".4

1.2.2 As part of its Just Transition Policy Brief, the ILO recognises that the availability of the right skills paves the way for transition to an economy that is carbon neutral, environmentally sustainable as well as inclusive and provides decent work. This is seen to require education and training for all individuals at all stages of their lives (ILO, 2022). Project Drawdown, a non-profit organisation providing thought leadership on climate change, highlights the importance of harnessing employee influence in addressing climate change, encouraging employees to work climate issues into their own job responsibilities, viewing every job as a climate job.[5]

1.2.3 In considering the role of actuaries in combating climate change and contributing to a just transition, reference is made to the Code of Conduct governing professional members of the Actuarial Society of South Africa (ASSA) – with similar principles applicable to other professional actuarial bodies globally) – which requires that members maintain up-to-date knowledge of all actuarial practices, professional standards as well as the legal and business environment. Additionally, members are required to serve the public interest through its actuarial education, continuing professional development programmes, and in rendering actuarial services.[6]

1.2.4 These principles highlight a professional responsibility as actuaries to:

— participate in and contribute towards upskilling programmes and initiatives to deepen our understanding of climate change and related areas of specialism (e.g., environment, social and governance (ESG) and sustainability);

3 https://sdgs.un.org/goals
4 https://www.unglobalaccelerator.org/themes/jobs-and-just-transitions
5 https://drawdown.org/publications/climate-solutions-at-work/
6 https://www.actuarialsociety.org.za/professional-resources-structure/professional-conduct/

— expand the scope of actuarial services that we provide within and outside of traditional areas of practice in a responsible manner (ensuring sufficient and appropriate expertise) to further societal and institutional progress towards decarbonisation and a just transition; and
— proactively engage with other key stakeholders and/or professions (e.g. government, financial institutions, energy suppliers, climate scientists etc.) that have the relevant expertise and qualifications to ensure that the wide-ranging implications of climate change are taken into consideration in any decision-making processes.

1.2.5 Taylor (2023) notes that the profession has begun to articulate the role that actuaries could play in the response to climate change and managing its risks and opportunities since 2010. However, he highlights that many actuaries remain unclear on how climate change may practically be integrated into their work. The Institute and Faculty of Actuaries (IFoA) has additionally issued numerous risk alerts to its members highlighting the need to appropriately consider climate-related issues in their actuarial work.[7]

1.2.6 This paper aims to provide a non-exhaustive overview of existing and potential areas to which actuaries can apply their skillset to aspects of climate change within traditional and non-traditional areas of practic e. We draw on current literature, case studies and interviews with actuaries actively incorporating climate change within their current roles and/or contributing to thought leadership in this area. Further work will have to be performed to expand on "how" actuaries would execute on their roles in these areas. It is, however, recognised that work is already being done in this space. For example, the IFoA in the United Kingdom (UK) has issued several practical guides on how actuaries should be incorporating climate change into their specialist areas such as risk management, life insurance, general insurance and pension schemes.[8]

1.2.7 Consideration is given to the skillset of actuaries when identifying potential new practice areas. In defining an actuary, the IFoA fundamentally recognises the core actuarial skillset of problem-solving and strategic thinking and the use of mathematical skills to measure probability and risk of future events. Consequently, actuaries possess a unique mix of mathematical, analytical, communication and management skills.[9]

1.2.8 More specifically key technical and soft skills include:[10, 11, 12]

— technical skills and expertise:
  – mathematics and statistics,
  – financial theory and economics,

7 https://actuaries.org.uk/standards/risk-alerts/
8 https://www.actuaries.org.uk/practice-areas/sustainability/sustainability-practice-area-practical-guides
9 https://actuaries.org.uk/qualify/become-an-actuary/what-is-an-actuary/
10 https://www.actuarialsociety.org.za/becoming-an-actuary-2/
11 https://blog.actuaries.org.uk/actuaries-skills-for-the-future/
12 https://www.coursera.org/articles/actuary

  - financial modelling and management,
  - data analysis and management,
  - data science and machine learning,
  - programming,
  - risk analysis and management,
  - sensitivity testing and scenario modelling, and
  - cost-benefit analyses.

— Soft skills and expertise include:
  - critical thinking,
  - problem-solving/use of first principles,
  - attention to detail,
  - ability to balance short- and long-term needs,
  - communication of complex concepts in understandable terms
  - leadership skills, and
  - ability to collaborate and work within and across teams.

1.2.9 Furthermore, actuaries are equipped with the conceptual framework of the "actuarial control cycle" which allows for the application of actuarial science to any complex and real-world problems, involving three key steps of problem identification, solution design and result monitoring (Espinosa & Zarruk, 2021).

1.2.10 The following excerpts from our interviewees further highlight an important ability of actuaries to obtain a broad understanding of and to solve complex problems:

> We have excellent analytical skills and the ability to view processes end-to-end bring it all together along with understanding what a client is looking for and being creative on how we achieve that. (John Anderson)

> You will be working with other professionals like economists and engineers. We need to position ourselves as the kind of professional that can bring all the pieces of the process together at the right level of detail. (Lusani Mulaudzi)

> Looking at forecasts, bringing it all together, it is definitely an area where an actuary could provide generic help across any industry. (Christopher Sterley)

1.3 Summary of current and potential areas of involvement

1.3.1 The paper identifies several key areas where actuaries currently and could potentially contribute to addressing climate change and supporting a transition to a low-carbon economy:

— **Climate risk management** Actuaries can contribute to identifying, measuring, and managing climate-related risks, which include both physical risks (e.g., damage to

assets from extreme weather events) and transition risks (e.g., regulatory or market changes related to transitioning to a low-carbon economy). Their role involves integrating climate risks into risk management frameworks, governance structures, and organisations' risk appetite statements.

- **Climate risk measurement and modelling** Actuaries can use their expertise in data analytics, scenario modelling, and risk assessment to quantify climate risks and greenhouse gas (GHG) emissions. This involves leveraging mathematical, statistical, and actuarial techniques to measure the impact of climate change on physical assets and financial outcomes, as well as modelling the financial implications of transitioning to a low-carbon economy.
- **Insurance** Actuaries can enhance existing practices in insurance areas such as pricing, underwriting, reserving, capital management, and product development to incorporate climate-related risks. They can also contribute to developing innovative insurance products like parametric insurance, which offers rapid pay-outs based on predefined climate event triggers.
- **Finance and investments** In finance, actuaries can integrate climate risk assessments into investment decision-making processes, help adjust valuations of financial instruments to reflect climate risks, design metrics for monitoring climate-related risks, and align investment strategies with climate goals. Their skills in scenario analysis and stress testing are particularly valuable for assessing climate risk impacts on investment portfolios.
- **Climate strategy** Actuaries can play a role in setting and embedding climate strategies within organisations. This includes assessing climate risk exposures, identifying climate-related opportunities, and integrating these factors into broader business strategies. Their ability to communicate complex risk assessments can help develop effective climate strategies that align with an organisation's overall mission.
- **Corporate governance** Actuaries can support boards in establishing effective climate governance by leveraging their risk management and governance expertise. They can ensure that climate considerations are integrated into strategic decision-making, reporting, and disclosure processes.
- **Regulation and reporting** Actuaries can assist with compliance by conducting gap analyses against reporting frameworks (e.g. Task Force on Climate-related Financial Disclosures (TCFD) and International Financial Reporting Standards (IFRS) S2), advising companies on compliance roadmaps and ongoing regulatory requirements, producing the required quantifications and supporting qualitative disclosures, and providing assurance on climate risk integration and emissions quantification.
- **Government** Actuaries can assist governments with climate policy by conducting risk evaluations, modelling long-term impacts of policy decisions, and advising policymakers on climate adaptation strategies, energy supply modelling, and cost-benefit analyses.

— **Other areas** of corporate support have also been identified such as evaluation of climate risks in mergers and acquisition (M&A) engagements, facilitating insurance cost optimisation, and assistance with financial instrument issuance by quantifying climate performance for corporate bond purchases and credit ratings.

1.3.2 Each of the following sections explore these areas of practice in further detail providing an overview of the current and emerging landscape with consideration to actuarial involvement. It should be noted that this paper does not aim to provide the reader with a comprehensive understanding of climate risk and related concepts. Rather, it aims to equip the reader with a broad understanding of the context.

1.3.3 Nick Spencer, previous chair of the IFoA Sustainability Board highlights that climate change is just one aspect of sustainability, pointing out the interconnectedness of climate, nature and social issues. He stresses that solving climate change will also require addressing the nature crisis as a net-zero and nature-positive world requires the existence of both. John Anderson, Executive: Solutions and Enablement at Alexander Forbes similarly encourages actuaries to start incorporating nature and social issues into existing roles, allowing time to develop capabilities in this area, noting the longer we wait, the more difficult it is to implement effective change quickly. Broader sustainability considerations are noted to be outside of the scope of this paper.

2. CLIMATE RISK MANAGEMENT

2.1. Overview of climate risk management

2.1.1 The IFoA notes risk management as necessary in avoiding, reducing and minimising the likelihood of or minimising the impacts of events that might cause significant harm to an organisation. It is an important tool to reduce losses, build resilience against uncertainty and optimise decision-making to improve performance (IFoA, 2017).

2.1.2 The IFoA (2022) notes that sustained action across all aspects of the economy is required on an unprecedented scale given the size of disruption required to curb global temperatures. Consequently, the potential impacts of climate change are global and systemic, presenting ecological, social, economic and financial risks which may impact on firms' risk profiles. Risk management plays a key role in developing a response to climate change, building carbon literacy, enhancing climate resilience and creating a better understanding of the risks and opportunities. This results in the creation of leading indicators for monitoring trends, allowing for the placement of climate-related risks and uncertainties within existing risk appetites and helping businesses understand the impact on short- and long-term business strategy.

2.1.3 The TCFD divides climate-related risks, (interchangeably referred to as climate risks throughout this paper) into two major categories, i.e., risks related to the transition to a lower-carbon economy (transition risks) and risks related to the physical impacts of climate (physical risks). In expanding on these risks the TCFD (2017) notes:

Transition Risks Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organisations.

Physical Risks Physical risks resulting from climate change can be event driven (acute) or longer-term shifts in climate patterns (chronic). Physical risks may have financial implications for organisations, such as direct damage to assets and indirect impacts from supply chain disruption. Organisations' financial performance may also be affected by changes in water availability, sourcing, and quality; food security; and extreme temperature changes affecting organisations' premises, operations, supply chain, transport needs, and employee safety.

2.1.4 The Global Association of Risk Professionals (GARP) describes climate risks as "transverse" risks, in that they manifest themselves through existing channels of risk or magnification of existing risk types.[13] Commonly, physical risk incidences increase operational risk through damage to physical assets and interruption to operations for all types of organisations. Specific to the industries in which actuaries are commonly employed, namely insurance, banking and investment industries (i.e., financial industries), climate risks can increase underwriting risks (e.g., through increased mortality or morbidity due to acute and chronic physical hazards), credit risk (e.g., through physical damage to operations and/or investment assets) and market risk (e.g., increases in demand for certain products due to increased risk of adverse weather events). Transition risk may manifest itself within such industries through heightened credit risk (e.g., increased default of fossil fuel intensive investment assets), market risk (e.g., through changes in consumer demand to more climate-friendly products and services) and policy risk (e.g., failing to comply with reporting or carbon tax requirements). Figure 1 from the Network for Greening the Financial System (NGFS) shows how climate risks can translate into financial risks.

2.1.5 The following components of the enterprise risk management framework (ERM) for organisations are therefore expected to be impacted:

— Incorporation of climate-related risks and opportunities into existing risk management frameworks and governance structures covering the responsibilities of the board, oversight committees, senior management, and individuals across an organisation
— Risk strategy and appetite statements will need to be reviewed to include climate-related risk covering organisations' long-term strategic objectives, limits and tolerances. Consideration needs to be given to the longer-term considerations required for climate-related risk.

13 https://www.garp.org/garp-risk-institute/climate-risk-management-guide

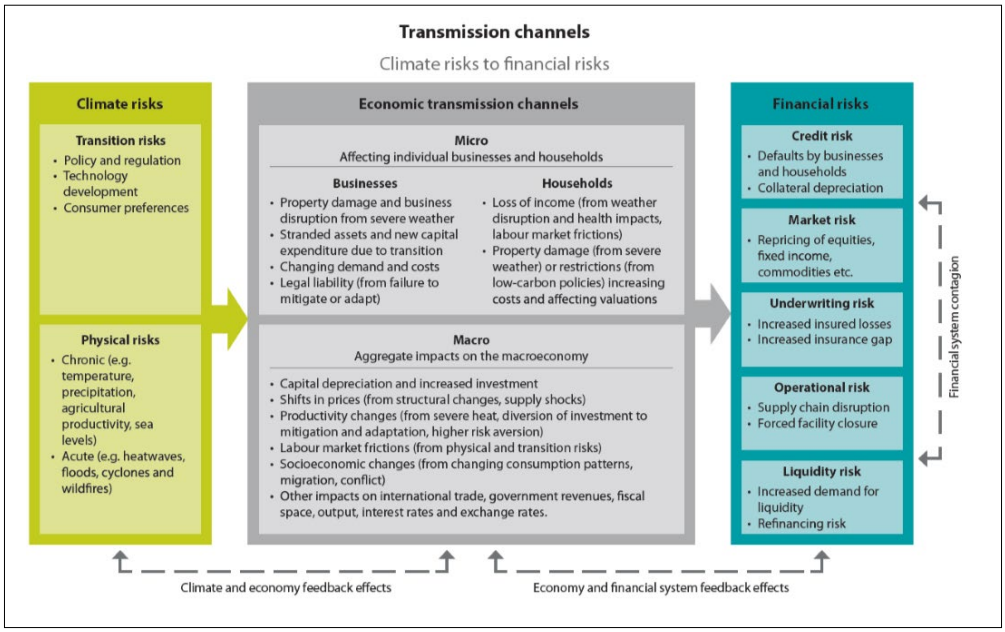

FIGURE 1. Transmission channels of climate risks to financial risks (NGFS, 2020)

— Incorporation of climate-related risks into the risk identification process including the impact on the full business value chain, current and future, and existing risk categories. This would be expected to include updates to risk taxonomies.
— Conducting risk assessments on newly identified risks which would involve determining appropriate risk measures and approaches (e.g., metrics and scenario testing), reappraising tools and modelling required and quantifying the required impacts.
— Design and implementation of appropriate risk responses to newly identified and new emerging risks (e.g., actions for mitigation, transfer of risks).
— Determination of appropriate measures or metrics, limits and thresholds that will be regularly monitored to identify triggers in both internal and external environments, prompting review of the organisation's risks.

2.1.6 The above is not only consistent with the actuarial approach to risk management (IFoA, 2017) but also in line with climate change risk frameworks discussed globally, including that proposed by the Institute of Risk Management (IRM) (2021) illustrated in Figure 2.

2.1.7 The IFoA (2022) notes the key challenges with managing climate-related risk includes its systemic nature (i.e., affecting all components of a system and not just a particular entity, industry, component), interconnectedness with financial, economic, and planetary systems and the influence of how other organisations manage and govern climate risks.

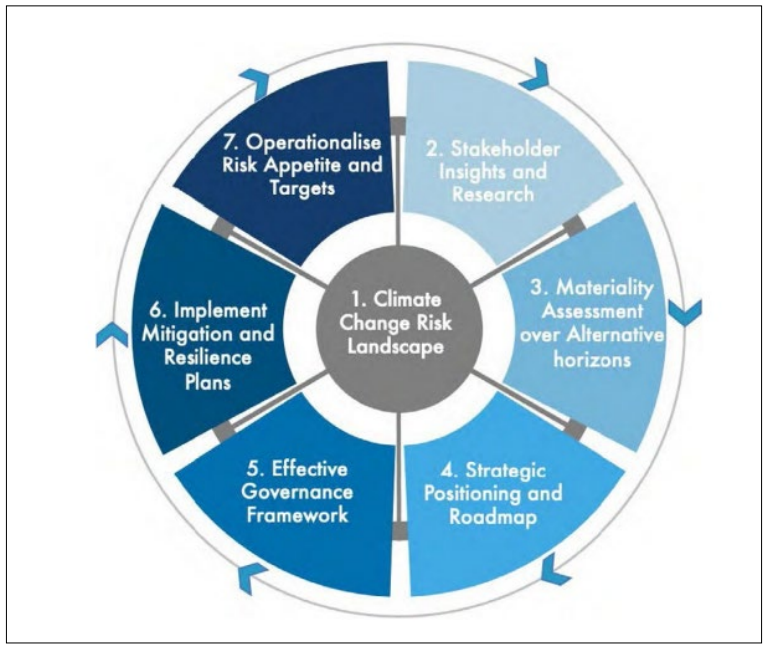

FIGURE 2. Climate Change Risk Framework (IRM, 2021)

2.1.8 Additionally, organisations should judge materiality of risks and opportunities from two perspectives. The concept of double materiality is defined by the European Financial Reporting Advisory Group (EFRAG) as "financial materiality" and "impact materiality" where impact materiality involves:

> Identifying sustainability matters that are material in terms of the impacts of the reporting entity's own operations and its values chain (impact materiality), based on:
>
> (i) the severity (scale, scope and remediability) and, when appropriate, likelihood of actual and potential negative impacts on people and the environment;
>
> (ii) the scale, scope and likelihood of actual positive impacts on people and the environment connected with companies' operations and value chains;
>
> (iii) the urgency derived from social or environmental public policy goals and planetary boundaries.

2.1.9 Roelof Coertze, Head of Enterprise Risk Management for Prudential Africa offers a practical approach for how organisations can apply double materiality utilising the matrix illustrated in Figure 3 in order to determine the climate risk impacts on and from the company on its key stakeholders. Furthermore, such an assessment should ideally be performed over short-, medium- and long-term horizons under different potential climate scenarios: an orderly transition, a disorderly transition and a hot house scenario.

Direction of Impact	Climate Risk	The Company's Stakeholders (Illustrative)						
		Customers	Employees	Distribution	Shareholders	Society	Regulator and Government	Rating Agencies
Impact on the company	Transition Risk							
	Physical Risk							
Impact from the company	Transition Risk							
	Physical Risk							

Figure 3. Illustrative double materiality assessment framework (Roelof Coertze, Prudential Plc)

2.1.10 While core activities of risk managers remain largely consistent with past practices, climate change has significantly shifted the importance of certain skills:

— **Communication** In some organisations there may still be an ongoing necessity to educate key stakeholders about the unique risks associated with climate change.[14] This could include engaging in high-level discussions with senior management about emerging and correlated risks that are not as prominent in traditional risk categories where the risks are typically more comprehensively understood. Furthermore, there is an increased need to articulate these climate-related risks in an accessible and relevant way to individuals in varying roles across the organisation. In some cases, it may be sufficient to translate climate-related risks into business metrics, such as the impact on capital or profitability, to demonstrate the potential risks and opportunities arising from a changing climate. In other instances, it may involve challenging existing mental models around the long-term and complex societal problem that is climate change (Shome et al., 2009).

— **Regulation** The increasing landscape of climate-related regulations and new compliance requirements necessitates that risk managers keep abreast of these developments. While climate regulations are not mandatory across the globe at the time of writing, staying up to date with international regulations could benefit local actuaries by providing insights into best practices for managing climate-related risks and identifying related opportunities. This involves not only understanding emerging regulatory frameworks but also mastering approaches to risk management that align with these standards (e.g. scenario modelling).

— **Collaboration** A wider range of stakeholders need to be engaged across the business value chain, including additional external stakeholders such as climate scientists and industry experts. This requires active collaboration with various stakeholders within and beyond the company to assess the overall impact of climate change on the organisation.

— **Data** The lack of historical data with regards to climate change poses a challenge for understanding future experience (IRM, 2021). However, actuaries operating in the ERM space should be familiar with such challenges in dealing with operational

14 https://sustainabilitymag.com/sustainability/climate-literacy-why-esg-training-for-employees-matters

and emerging risks. What may be new to actuaries is the scale, complexity, and interconnection of climate risks with other risk categories, as well as the significant reliance on local and global government policies that will influence how climate change evolves. At the same time, there are different types of data that needs to be considered (e.g. global climate data, climate scenarios, geospatial information) that will require an understanding of and revised/new models to translate this to business impacts.

— **Approach** A more holistic approach is needed to manage climate-related risks which requires consideration of the organisation's full capital and operational landscape (IRM, 2021). While similar considerations have been applied in the past in managing operational risks, climate change requires more detailed consideration on how systemic risks transmit and impact organisations.

— **Staff resources** In some organisations, the role of managing climate-related risks is part of the responsibilities of the ERM function. However, with the evolving nature of managing climate risks as described above, the actuaries interviewed by the authors found that their role in managing climate-related risks moved from being part of their job to a full-time role. It is anticipated that this should eventually scale back again once organisations become more climate-literate, and the risks are well understood and integrated.

2.2 Areas of actuarial involvement

2.2.1 The International Actuarial Association (IAA) states in its 2023 paper on the climate change adaptation gap:

> Collectively, the actuarial profession has a role to play in helping stakeholders better understand the consequences and uncertainties of their decisions on implementing actions or not acting at all on climate adaptation. The actuarial profession can add value to these decisions by leveraging actuarial experience in risk management practices and, in particular, managing uncertainty over long time horizons.

2.2.2 The usefulness of the actuarial skillset is further highlighted in the report "Climate Scorpion – the sting is in the tail" where the authors introduce the concept of "planetary solvency", and compare climate risks to the extreme risks typically managed by actuaries (such as financial ruin or catastrophic losses), suggesting a similar actuarial approach is necessary for global climate risk management (IFoA, 2024)

2.2.3 The IFoA (2017) note that actuaries undergo comprehensive training which includes the use of statistical analysis to understand risks and uncertainties, making actuaries well-placed to support organisations' risk management efforts. Furthermore, the actuarial approach to risk management places additional focus on measurement of risk, understanding the impact of risks on the outcomes experienced (both positive

and negative), the evolution of risks (extending to decades in the future if required), understanding interactions between risks, and the ability to translate risks into financial values, all of which are critical to managing climate-related risks.

2.2.4 Therefore, risk management actuaries need to be aware of and able to integrate climate risk into their existing roles and the organisation's risk management framework. This is typically found to be within financial services. However, the actuarial risk management approach and skillset can be extended to other industries and other entities (e.g. government departments, regulators, non-profit organisations interested in community impact) that are interested in understanding the impact of climate risk. The actuarial skillset can be used to design a framework for measuring, monitoring and managing climate risks e.g., understanding the impact of extreme weather events on a food manufacturer's supply chain (for example, impact of crop failures on production costs, impact on logistics and transport routes etc.)

2.2.5 Actuaries can therefore contribute to each step of the organisation's risk management framework which would include:

— Redesigning governance structures and policies to incorporate climate-related risks. This would be expected to include updates to terms of references of existing governance structures, designs of new oversight committees (e.g., climate risk committee, revisions to existing risk management policies, drafting of new focused policies covering climate risks, facilitating discussion on and setting risk appetite as it relates to climate risk).
— Direct contribution to the risk identification process for business units where actuaries are already involved (e.g., insurance underwriting, insurance product development, financial reporting, etc). For areas where actuaries may not be directly involved, they are able to facilitate discussions with the relevant stakeholders to enable the transfer of climate risk literacy across the business and equip business owners to contribute to the risk identification process.
— Measurement of risks and the translation of risk quantification into financial impacts. Further detail on climate risk measurement and modelling is covered in the following section. Actuaries can therefore utilise the measurement to understand the risks (and relay understanding to business), translate this into business impacts for risk owners, and work alongside risk owners to design metrics, limits, and thresholds consistent with the organisation's risk appetite.
— Design of (and assessing the impact of) risk mitigation strategies: Some examples include (re)insurance, adaptation measures and diversification. This includes collaboration with business owners to understand possible options, feasibility, and operational impacts of various mitigation strategies.
— Design of new products in response to any opportunities identified: Specific examples of refinements to insurance and investment products are discussed further in Sections 6 and 8. This can further be extended to any product base

where actuaries can assist in the refinement to product design based on emission modelling performed (see Section 13 for further information)

— Training and communication: business owners and personnel, responsible for governance structures can be kept up to date on the nature of the climate risks, impacts on business, results of quantification, in easy-to-understand language.
— Assistance in the reporting on risks which would include internal reporting (e.g. risk monitoring dashboard/reports), external reporting for financial or regulatory reporting purposes (details on risk management approach, quantification methodology, areas of uncertainty, results of scenario modelling). This would also include reporting across the organisation through activities such as building process workflows and dashboards to monitoring key metrics.
— Review, validation and/or assurance on the climate risk management process, including models built and associated reporting.

2.2.6. The IAA and IFoA provide more practical guidance on how actuaries can incorporate climate risks into the risk management process (IAA, 2023; IFoA, 2022).

3. CLIMATE RISK MEASUREMENT AND MODELLING

3.1 Overview of climate risk measurement and modelling

3.1.1 The IRM (2021) succinctly highlights the main objectives of quantifying the impacts of climate change, which include improving operational resilience (i.e., enabling management to understand and rank risks, better react to occurring risks, and implement plans to manage and/or mitigate risks), supporting business decisions and long-term strategic planning (e.g., understanding vulnerabilities of business plans, supplementing Own Risk and Solvency Assessment (ORSA) reporting, providing external stakeholders with a forward-looking view of climate-related risks), and complying with growing regulatory expectations (e.g., climate disclosures such as the TCFD recommendations and the International Sustainability Standards Board (ISSB) requirements for meeting decarbonisation targets).

3.1.2 Physical risk

3.1.2.1 Physical risk modelling involves assessing the potential impacts of acute and chronic climate perils on the assets and operations of an entity. Modelling approaches may vary in terms of complexity and granularity (Deloitte, 2023). The ClimateWise Physical risk framework (Cambridge Institute for Sustainability Leadership, 2019) summarises the physical risk modelling process into the following key steps:

— Collection of physical asset exposure data, including geographic location data and asset characteristics,
— Selection of a natural catastrophe or climate model, including selection of perils to model, which may be in-house or outsourced,

— Selection of climate scenarios to model, including specifying how these may affect the probability and severity of extreme weather events, such as those produced by the Intergovernmental Panel on Climate Change (IPCC), and
— Model execution and results interpretation, which may include a range of outputs, including financial loss impacts.

3.1.2.2 The ClimateWise Physical risk framework further summarises the input data and the model components as follows (also depicted in Figure 4).

— **The hazard component** involves assessing the extent and intensity of certain weather perils on defined assets or locations, using a combination of historic event data and modification for future occurrence.
— **The vulnerability component** involves estimating the physical harm or damage caused to a specific asset or location by an extreme weather event and may involve the use of damage curves. Impacts of adaptation measures may be included in this component.
— **The financial component** aims to translate damage to assets caused by perils to a relevant economic loss or financial impact. This may include allowance for insurance or reinsurance contracts and information on replacement costs.

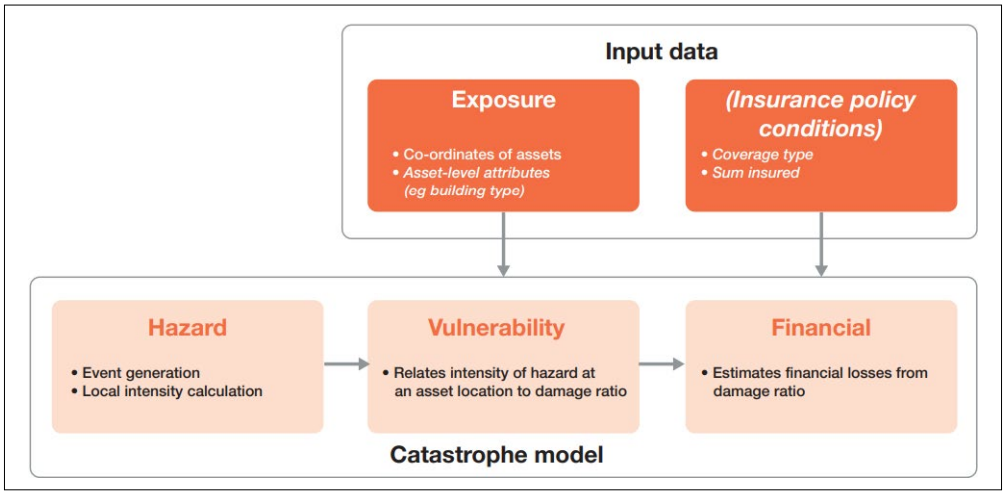

FIGURE 4. ClimateWise Physical risk framework input and model components (Cambridge Institute for Sustainability Leadership, 2019)

3.1.2.3 It is worth noting that physical risk may leverage traditional catastrophe (Cat) modelling, a tool that has been used by (re)insurers for several years and understood by some actuaries. In a series of recommendations by The Geneva Association regarding leveraging catastrophe models to aid in the modelling of physical climate risk, it is suggested to "further leverage and enhance current Cat modelling methodologies and

tools" and to "embed latest climate science in Cat models and explore opportunities for improving modelling of physical climate risk with a forward-looking approach, taking into consideration the climate change scenarios" (The Geneva Association, 2018). Graham Hall, Director of the Climate Change and Actuarial team at PwC United States, has however highlighted some potential difference between catastrophe models and physical risk models, which include the scope of the model, time horizon, assumptions regarding underlying portfolios and use of output.

3.1.3 Transition risk

Given the wide range of transition risks, it is expected that transition risk models may vary widely depending on the industry and scope of transition risks assessed. However, more robust models aim to assess the potential financial or economic impact of transition under various transition pathways or scenarios (PwC, 2023b). This is typically expected to involve the identification of exposed assets, including infrastructure and other assets, defining the impact of transition risks on such assets, and analysing the potential financial impacts, possibly catering for resilience actions (Cambridge Institute for Sustainability Leadership, 2020). Some transition risks, such as changing consumer sentiment and reputational risk, are more difficult to quantify, according to Adam Kallin, Director within PwC United States' Risk Modelling Services. Depending on the scope of the exercise, a range of data and assumptions may be required in addition to transition scenario data. Such data may include regulatory data, financial and market data, physical asset data, and technological data.

3.1.4 Greenhouse gas emissions

3.1.4.1 While the risk measurements referred to above deal largely with the impact that climate change has on an organisation, entities may also consider their impact on the climate or environment through their operations, referred to as assessing "double materiality". This is typically done through an entity's GHG emissions, which are emissions produced through an organisation's operations, including up and down the value chain, often measured in carbon dioxide equivalent. GHG emissions can be broken down into scopes 1, 2 and 3 (WRI & WBCSD (World Resources Institute & World Business Council for Sustainable Development), 2004). Scope 1 relates to direct emissions stemming from activities owned or controlled by an organisation, while scope 2 relates to indirect emissions from purchase of energy consumed by an organisation. Scope 3 emissions relate to all other indirect emissions that stem from activities occurring within an entity's value chain (WRI & WBCSD, 2004)

3.1.4.2 Financial institutions play important roles in supporting the global transition to a low-emission economy. Being institutional investors, insurers, banks and asset managers can demand and invest in low-emissions assets and technologies, and actively engage with investee institutions to decarbonise operations (Partnership

for Carbon Accounting Financials (PCAF), 2022). Such organisations can also work to decarbonise their own operations and product offerings, having the ability to incentivise consumer behaviour through underwriting and product development (e.g., offering more affordable insurance for electric or hybrid vehicles, offering better mortgage rates on energy-efficient buildings), as discussed further in later sections. With entities progressively setting decarbonisation targets aligned with global or national decarbonisation goals, the measurement, ongoing monitoring and performance of GHG emissions under various scenarios is a growing area of importance.

3.1.4.3 The quantification of an entity's GHG emissions involves the sourcing and integration of various types of data across the value chain, which may include physical and/or economic activity data, emissions intensity factors, internal financial data and other external data, in order to quantify current emissions at a baseline level (Partnership on Transparency in the Paris Agreement (PATPA), 2021). Additionally, entities may attempt to project their baseline emissions into the future under various future scenarios. Such modelling may aim to assess the effects of entity-specific actions, such as the effect of changing power sources, development of new products or changes in supply chains, or be used to determine and/or track progress against reduction targets and strategies based on global transition pathways.

3.1.4.4 Although models to project emissions may vary, a basic approach to the projections of GHG emissions, showing the inputs required, is shown in Figure 5. While the modelling itself may not be overly complex, various challenges may be experienced relating to data quality and completeness, meaning that proxy data or data gap filling methods may be required (PATPA, 2021). Additionally, to project emissions, determination and understanding of variables and assumptions will be required (PATPA, 2021). For example, future assumptions relating to changes in value chain activities, technological changes and activity drivers or growth rates may be required.

3.1.4.5 According to the PCAF, scope 3 emissions can be divided into financed

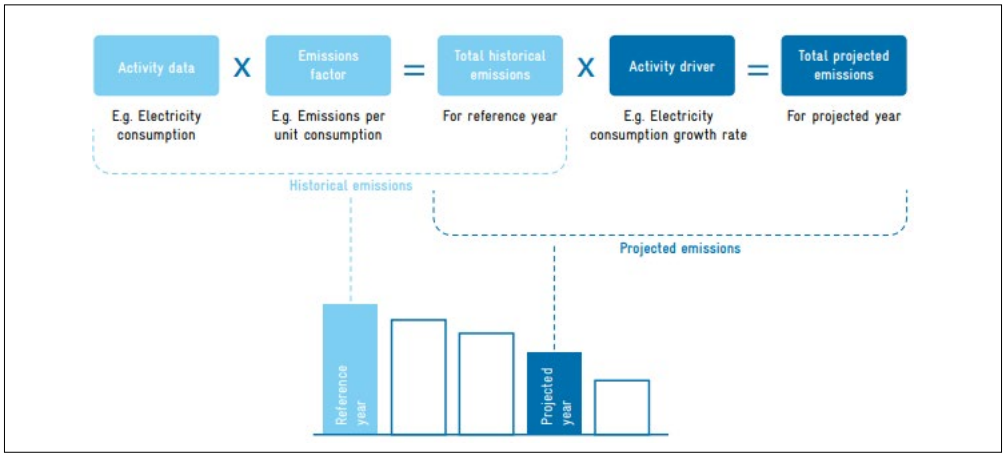

Figure 5. Approach to estimating emissions (PATPA, 2021)

emissions, insured emissions, and facilitated emissions (PCAF, 2020). These commonly make up the largest portion of emissions for a financial services company, with scope 3 emissions estimated to make up between 65 to 95% of an average company's total emissions (PwC, 2023a). Specifically, for a typical insurer, financed and insured emissions are likely to make up over 95% of all emissions (Boston Consulting Group, 2022). The quantification and projection of scope 3 emissions can pose added complexity due to data requirements and calculation methodologies (e.g., determination of attribution factors). A key challenge is the sourcing of robust data and dealing with availability, granularity, and quality gaps (PwC, 2024).

3.1.4.6 It should be noted that the generation and measurement of GHG emissions may be considered as a sub-component of transition risk to the extent that such emissions impact regulatory compliance, consumer preferences, carbon taxes, stakeholder reporting and other aspects of transition to a low-carbon economy. Results of emissions modelling may therefore link into broader transition modelling discussed above.

3.1.5. Scenario analysis

3.1.5.1 Uncertainty, interconnectedness and spanning varied timescales are noted as three key characteristics of climate risks that contribute to the complexity of modelling such risks (Cambridge Institute for Sustainability Leadership (CISL), 2022). Scenario analysis or modelling is therefore a key mechanism used to fully understand the materiality of climate-related risks and opportunities; it is also a tool recommended by climate disclosure frameworks such as the TCFD. Scenario analysis is not a concept to be viewed separately to the sections above pertaining to climate risk and emissions modelling, but as an overarching tool that can be used within each of these areas. The IRM (2021) sets out a climate scenario analysis framework depicted by Figure 6, which involves the following key steps:

— **Identify business decisions** This step involves linking climate issues to specific organisational threats and opportunities by identifying and understanding the key drivers of business performance that should be built into the scenarios.
— **Define scope** This involves specifying which components of the organisation are included within the scope of the analysis (e.g., legal entities, geographic locations, assets, nature of operations, customers, and key stakeholders).
— **Conduct background research** This step involves the design of specific scenarios, which includes research into previous climate-related losses and extrapolation of known trends, determining the base scenario, deciding on the inclusion of other climate pathways or representative concentration pathways, and assessing data sources and availability .
— **Assess available tools** This component includes the selection of tools and techniques to assess physical and transition risks, but also emissions where relevant. Examples may include the use of qualitative scenario analysis based on expert judgement,

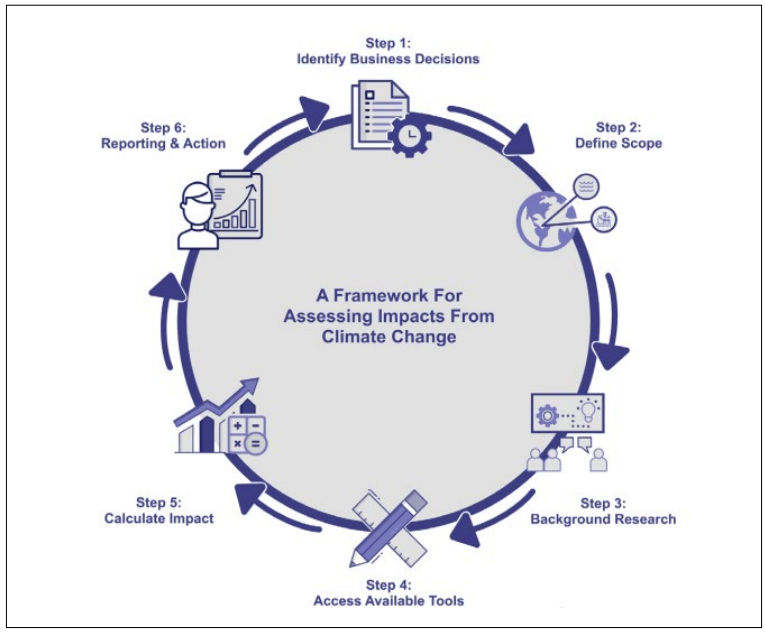

FIGURE 6. Climate change risk assessment process to aid scenario modelling (IRM, 2021)

hazard maps and footprints, and probabilistic modelling such as catastrophe models and economic scenario generators using econometric modelling techniques.

— **Calculate the impact** This step involves using the abovementioned data and tools to measure the aggregate impact of climate scenarios on the organisation, possibly on the income statement, balance sheet and other key financial metrics (e.g., regulatory capital buffers, size of relevant tail events, emissions and/or carbon tax costs under each of the chosen scenarios). Understanding key areas of risk under plausible scenarios enables a company to think through their likely business response and develop, test and implement management or mitigation measures.

— **Reporting and action** Reporting may include a description of the scenarios, assumptions, key judgements and corresponding rationale, and the organisation's expected response. A useful approach would include mapping business decisions to climate-related risks and opportunities, and assigning a materiality assessment that can be used to inform strategic decision-making and the allocation of resources within an organisation. Examples of strategic decisions may include the introduction of new products based on new consumer needs identified, amendments to or discontinuance of current products or investments that may no longer be financially viable in their current state, or changes to marketing approaches.

3.1.5.2 In practice, organisations typically make use of standardised scenarios that capture potential global emission, economic and social trajectories in order to assess

the risk and opportunities impact over time. A number of organisations have developed scenarios including the IPCC[15] and IEA.[16] The IPCC scenarios referred to as shared socioeconomic pathways (SSPs) incorporate various potential demographic, social, economic, technological and environmental developments with each scenario associated with a corresponding emission level and temperature warming (IPCC, 2023).

3.1.5.3 Widely adopted scenarios in the financial industry include those provided by the NGFS (who have partnered with climate scientists and economists) to determine a set of hypothetical scenarios with the aim of providing a common reference point on how climate change (physical risks) and climate policy and technology trends (transition risks) could evolve in the future.[17] To illustrate, a total of seven scenarios are provided, split across the following categories, which represent varying intensities of physical and transition risks (NGFS, 2023):

— **Orderly scenarios** which assume climate policies are introduced early and become gradually more stringent. Both physical and transition risks are subdued relative to their other scenarios.
— **Disorderly scenarios** which explore higher transition risks due to policies being delayed or divergent across countries and sectors. For example, carbon prices are typically higher for a given temperature outcome.
— **Hot house world scenarios** which assume that some climate policies are implemented in some jurisdictions, but globally efforts are insufficient to halt significant global warming. The scenarios result in severe physical risk including irreversible impacts like sea-level rise.
— **Too-little-too-late scenarios** which assume that a late and uncoordinated transition fails to limit physical risks. This quadrant is explored for the first time in this vintage.

3.1.5.4 The NGFS scenarios are designed to explore potential futures with regard to physical and transition risk. They, by design, do not aim to give a best estimate view of how governments' climate policies are expected to be implemented. For uses where a best estimate of such policy introductions, such as setting central market assumptions, are needed, the United Nations Principles for Responsible Investment's Inevitable Policy Response scenario can be used.[18]

3.1.5.5 Additionally, work is being done to better understand and highlight key challenges and limitations underpinning current climate-scenarios in the financial services context. An IFoA report highlights the risks underpinning models used in

15 https://www.ipcc.ch/report/emissions-scenarios/
16 https://www.iea.org/reports/global-energy-and-climate-model/understanding-gec-model-scenarios
17 https://www.ngfs.net/ngfs-scenarios-portal/
18 https://www.unpri.org/sustainability-issues/climate-change/inevitable-policy-response

financial services, some of which include: underestimation of climate risks, not accurately accounting for the full economic impacts, underestimation of carbon budgets (tolerable quantity of GHG) and encouraging herd mentality instead of developing an appropriate understanding of climate change (IFoA, 2023a).

3.2 Areas of actuarial involvement

3.2.1 There is significant scope for actuarial involvement in the measurement and modelling of physical risks, transition risks and GHG emissions. The areas of actuarial involvement are similar across these areas, and involve leveraging and building on key traditional skills actuaries typically possess, such as data analytics, model building, scenario analysis, risk assessment, and interpretation and presentation of results.

3.2.2 Climate risk and emissions modelling are dependent on a range of data and assumptions. As such, the following non-exhaustive list of actuarial skills may be applied to the data and assumption components within the broader modelling process:

— data validation and interpretation techniques, including the use of statistical analysis and visualisation techniques;
— data manipulation techniques (e.g., to deal with data completeness, quality and granularity issues);
— application of statistical or machine learning techniques (e.g., to perform predictive modelling, determine and test proxies);
— understanding of data flow processes between models or systems;
— application of professional judgement and robust techniques in the setting and testing of long-term and often complex assumptions used within projections;
— understanding of complex value chains, specifically within industries such as insurance, banking and asset management, to aid in sourcing of data and setting of assumptions; and
— specific understanding of financial datasets that may be used within physical and transition risk impact and exposure modelling, as well as in emissions modelling (e.g., calculation of Scope 3 attribution factors based on annualised premium, equity, debt or revenue data).

3.2.3 Vinay Sewraz, Director of Risk Modelling Services for PwC UK with a focus on emissions modelling within the banking industry, highlighted that all models have similar principles that need to be adhered to, and noted that "a key skill that tends to be appreciated by clients is the modelling capabilities that we have developed", emphasising the merits of actuarial modelling capabilities.

3.2.4 Actuaries can therefore leverage their existing coding and software skills to contribute to climate risk and emissions modelling. In order to facilitate these processes, actuaries can apply their knowledge of data management and manipulation software (e.g., SQL). Depending on the type and extent, modelling may be performed using programs

such as Python or R, with possible further integration of outputs into other industry-specific software, such as SAS or Prophet. Visualisations may be required as part of interpretation and reporting of results, which may be performed using software such as Power BI or other visualisation tools. Actuaries would benefit from developing familiarity with geospatial analysis in software such as ArcGIS or use of additional functionality such as geospatial overlays within tools such as Power BI. Here, working with geospatial engineers or similar experts may be beneficial, depending on the scope of modelling.

3.2.5 Mathematical and statistical methodologies and techniques commonly used by actuaries in traditional modelling areas may be leveraged in this space, leading to more complex, dynamic and robust models. A non-exhaustive list of examples suggested by Adam Kallin and Graham Hall is shown below:

— application of discounted cashflow modelling techniques;
— use of Monte Carlo simulations;
— application of scenario analysis;
— use of stochastic modelling techniques;
— application of relationship modelling techniques to cater for complex inter-dependencies, non-linearity and reliances, further emphasised by Christopher Sterley based on his involvement in physical and transition risk modelling;
— application of techniques such as regression and clustering; and
— use of catastrophe modelling techniques in physical risk modelling, including the use of damage functions.

3.2.6 Climate risk modelling involves the projection of impacts, including underlying cashflows and assumptions, over long-term time horizons (McKinsey & Company, 2023). Graham Hall suggested that life insurance actuaries may be particularly well suited to contributing to understanding and modelling from this perspective given the long-term nature of life insurance products.

3.2.7 Actuaries are adept in allowing for uncertainty within modelling processes and results. As previously noted, climate risks are complex, and past climate and event data are not likely to be a reliable predictor of the future. Additionally, emissions results may be based on varied qualities of data and proxied data (PwC, 2024). Therefore, allowing for and understanding uncertainty around results is important if we are to produce realistic and robust measurements and models that aid in decision-making. For example, this may involve performing sensitivity analysis, adding credibility weightings to inputs and/or outputs, use of stochastic modelling techniques or adding ranges or confidence levels to presented output.

3.2.8 A crucial aspect to the measurement and modelling of climate risks and GHG emissions is the inclusion of relevant and industry-specific impact assessments, as well as the translation of results into meaningful business impacts. The following points summarise the value that actuaries add in this space:

- As mentioned in paragraph 2.1.4, climate risks are transverse risks, and this is reiterated by Christopher Sterley, stating that "climate risk accelerates other risk types". Given that actuaries typically have a sound understanding of traditional risk types and the application of these in modelling, they are likely well-placed to understand and assess the financial and business impacts of changes to or increases in such risks (i.e., once climate risks have been converted into these).
- Actuaries may therefore add value through using results and insights from modelling within existing processes used by banks, insurers and asset managers, such as product development, pricing, reserving, investment strategy and capital management, as discussed further within later sections of this paper.
- With financial impacts likely being the most valuable form of modelling output to companies, the ability of actuaries to understand balance sheets, income statements and wider economic impacts is beneficial.
- A key step of the modelling process is to translate climate risks into traditional risk types and/or relevant business impacts. In order to do so, knowledge and understanding of the relevant organisation and industry is required. Given that actuaries typically have a thorough understanding of complex financial organisations such as banks and insurers, they are well-suited to collaborating in this space.
- However, a more comprehensive understanding of the full value chain, including the supply chain and post-sale product life cycle, is required for comprehensive assessments, which may expose a gap in traditional actuarial knowledge. It is therefore crucial to work with industry specialists and subject matter experts (SMEs) in order for actuaries to ensure the relevance and accuracy of modelling performed (as well as the interpretation thereof). As Vinay Sewraz noted:

  > To make a decision or do an assessment, (…) you will definitely need (…) industry experts.

3.2.9 Additionally, the following broad aspects relating to climate risk and emissions modelling have been identified as areas that actuaries can contribute towards:

- Actuaries can ensure that any model enhancements or new models built include the relevant model controls, governance, audit trails and documentation which are traditionally incorporated in the current model practice.
- Consistency of methodology, data and assumptions used across models is a pivotal aspect within any modelling exercise. As reporting and disclosure is often performed at a group level, this is specifically important for organisations or groups with several subsidiaries or business areas that have implemented such models. Actuaries can play a valuable role in this activity given that some are likely to have played similar roles in alignment of valuation, pricing or credit models and processes across and within organisations. Understanding the input, process and output flow of models can also add value in the context of climate risk and emissions models.

— Many companies performing climate risk and/or emissions modelling are likely to use externally available models and/or data produced by specialist organisations (Deloitte, 2023). A level of due diligence of such external models and/or data is required, which may involve analysis of relevant model documentation and/or correspondence with experts within the organisation from which the external model or data is obtained. A base level of model understanding, including data flows and assumptions, is required, which actuaries are typically well-equipped for. Also, integration between output of external models and in-house models is required.

3.2.10 Given that the principles of measuring and modelling of climate risks and GHG emissions are likely to be similar across various organisations, there is opportunity for actuaries to have broader industry involvement in measurement and modelling beyond just financial services, within industries such as retail, mining, manufacturing, and agriculture. Working closely with industry specialists and SMEs is beneficial to enhancing the actuarial role in other industries. We are already seeing actuaries progressively being involved in such areas, specifically within the consulting space, as emphasised by Graham Hall stating, "We now work across all sorts of industries".

4. INSURANCE

4.1 Role of and impact on the insurance industry

4.1.1 The European Insurance and Occupational Pensions Authority (EIOPA) notes that insurance has a unique role to play in tackling climate change, with a key role of contributing to a more resilient society. The Munich Climate Insurance Initiative provides some examples:[19]

— By assessing risks and potential losses, insurance can support climate risk management for their clients;
— By reducing vulnerability and incentivising risk-reducing behaviour, insurers can contribute towards increasing resilience;
— By creating a space of certainty for investment and planning to be undertaken e.g. enabling the financing of sectors that are exposed to climate change risks; and
— By providing reliable and timely financial relief to recover livelihoods and assist reconstruction post-disaster.

4.1.2 However, increasing insurance costs impact the insurability and pricing of climate-related risks, and hinder the ability of insurers to contribute towards a more resilient society.

4.1.3 The latest report on natural catastrophe losses by the Swiss Re Institute notes that 2023 experienced USD108 billion of insured losses relative to total economic

19 https://climate-insurance.org/the-role-of-climate-risk-insurance-in-adaptation/

losses from natural catastrophes of USD280 billion (i.e., 62% of global losses were uninsured with 95% uninsured in emerging economies). The report further notes that natural catastrophe insurance claims have outpaced GDP growth over many years, increasing the loss burden to society and contributing to the rising challenge of insurance affordability. Insurance premiums are trying to keep up with increasing loss trends, inflation effects, economic and population growth, but reduced affordability and a narrowing protection gap is expected on the current trajectory. More structural changes are required to reduce exposure and vulnerability of the built environment to hazards. Some of these measures include reduction in GHG emissions, increased uptake in the latest building codes, renovating existing buildings, changes in land use, adequate infrastructure, early warning systems and, growth in the non-life insurance industry capacity (Swiss Re Institute, 2024).

4.1.4 Insurers are responding in numerous ways to the risks and opportunities brought about by climate change, such as:

— Incorporating climate-related risks as part of insurers' risk management processes[20, 21]
— Revising catastrophe models to allow for increased frequency and severity associated with climate-related events.[22] These model enhancements are used for more accurate pricing, and risk and capital management. While some insurers are choosing to increase premiums, others are declining insurance. [23]
— Adjusting reserving processes and models for uncertainty and changing patterns in the emergence of climate risks (physical, transition and legal risks) (IFoA, 2019; 2023b)
— Using geospatial data to understand their exposure to various hazards to inform more accurate pricing of insurance contracts, determination of appropriate policy conditions and working with policyholders and government to inform adaptation decisions and spatial planning.[24]
— Reviewing the skills of advisors and non-executive directors to ensure that appropriate expertise is brought onboard to inform decision-making.25 Similarly, insurers are building and/or acquiring renewable energy underwriting expertise.26
— Refining existing/developing new insurance solutions to offer sustainable products which cover the design, production and use of sustainable products or where certain features promote sustainable behaviour (Zona et al., 2014).

20 https://reports.swissre.com/media/3l4ftzxl/ar22_financial_report_tcfd.pdf
21 https://www.munichre.com/content/dam/munichre/contentlounge/website-pieces/documents/MunichRe-Sustainability-Report_2023.pdf/_jcr_content/renditions/original./MunichRe-Sustainability-Report_2023.pdf
22 https://www.hlb.global/how-the-insurance-industry-is-responding-to-climate-change
23 https://www.cfr.org/article/climate-change-and-us-property-insurance-stormy-mix
24 https://www.santam.co.za/about-us/media-centre/corporate-news/how-geospatial-data-is-being-used-to-manage-the-effects-of-natural-hazards-and-climate-change/
25 https://www.hlb.global/how-the-insurance-industry-is-responding-to-climate-change
26 https://www.aon.com/en/insights/articles/how-insurers-can-capture-climate-opportunities

— Some examples include:
  - Property insurance, covering the use of environmentally friendly or energy-efficient materials when making repairs and/or offering discounts where policyholders are already green or have mitigation devices in place (e.g., use of energy efficient heating, solar power, have installed window shutters for storm protection). Other examples include reimbursements to policyholders for loss of income from selling surplus energy generated by alternative-energy systems and for extra costs of purchasing replacement electricity. (Zona et al., 2014)
  - Motor insurance, where discounts are provided for the use of hybrid or electrical vehicles, pay-as-you-drive benefits incentivising policyholders to drive less, options to upgrade vehicles or commercial fleets to hybrid or electrical vehicles on replacement. (Zona et al., 2014)
  - Insuring resilient infrastructure development, electrification or renewable energy projects (such as solar, wind or hydro power), carbon capture and storage, and decommissioning of carbon-intensive assets.[27]
  - Insurance solutions for new and emerging liabilities (e.g., Directors & Officers liability as it relates to climate risk disclosure, manufacturer labelling claims, workmen's compensation resulting from extreme heat, architects and engineering professional liability insurance for building commissioning, etc).[28]
  - Political risk insurance arising from governmental interference, war and political violence, licence cancellation interrupting the production, certification and delivery of carbon credits. (Zona et al., 2014)
  - Health insurance plans covering hospitalisation and other medical costs for conditions caused by exposure to heat and sun or products offering health product premium waivers during national disasters.[29]
  - Life investment products that offer ESG investment fund options which incorporate detailed due diligence criteria for investments.[30]
  - Customer education and partnering on risks presented by climate change. Some examples include working with customers to ensure that an appropriate cover or product mix is provided, incentivising adaptation measures, informing property placement at project planning phase and implementing early warning systems for weather events like heatwaves.[31, 32]
  - Alignment of investment portfolios with climate goals such as divesting from

27 https://www.aon.com/en/insights/articles/how-insurers-can-capture-climate-opportunities
28 https://www.aon.com/en/insights/articles/how-insurers-can-capture-climate-opportunities
29 https://www.bcg.com/publications/2024/how-insurers-can-take-on-the-climate-driven-health-crisis
30 https://kpmg.com/xx/en/blogs/home/posts/2023/04/esg-in-insurance-creating-a-sustainable-product-and-investment-portfolio.html
31 https://www.hlb.global/how-the-insurance-industry-is-responding-to-climate-change
32 https://www.aon.com/en/insights/articles/how-insurers-can-capture-climate-opportunities

carbon-intensive industries and increasing investment in renewable energy and other sustainable projects.[33]

- Adopting more sustainable practices in their own insurance operations such as reducing energy consumption, minimising waste, promoting remote work to reduce emissions with many insurers setting ambitious targets to achieve net-zero within their operations.[34]
- Advocacy and collaboration with different stakeholders: Some examples include working with regulators to understand the impact of insurance and build wider acceptance of regulatory action while balancing costs of regulations and disclosures; working with lenders to incorporate resilient property incentives; and working with government to determine policy relating to funding and tax concessions on adaptation, emission-lowering initiatives and national insurance requirements.[35, 36]

4.2 Areas of actuarial involvement

4.2.1 Actuaries are already widely involved in the insurance response to climate change. This has been mostly an expansion in existing roles in traditional areas of insurance practice. Actuaries can continue to build on these roles, which include:

— **Risk identification, assessment and management** The role of actuaries in the risk management process and risk quantification is also discussed in Sections 3.2 and 5.2.

— **Pricing, underwriting and product development** This includes enhancing risk models to better incorporate climate change risks, thereby refining pricing, revising underwriting guidelines to reflect high-risk areas and setting appropriate limits and exclusions, and designing incentives and changes in coverage as part of product development. Professional bodies such as the IFoA and Actuaries Institute of Australia (AIA) have issued guidance for practitioners in these areas. (IFoA, 2019; AIA, 2023)

— **Reserving** This includes enhancing risk models, revising reserving processes and judgements where climate change is expected to affect the value of future claim costs. Guidance from the IFoA is similarly available for reserving actuaries. (IFoA, 2019; 2023b)

— **Capital management** This includes incorporation of non-modelled and emerging climate risks as part of capital modelling, estimation, and solvency management.

33 https://www.zurich.com/knowledge/topics/climate-change/three-ways-insurers-can-support-business-in-their-climate-change-strategies

34 https://www.zurich.com/knowledge/topics/climate-change/three-ways-insurers-can-support-business-in-their-climate-change-strategies

35 https://www.pwc.com/us/en/industries/financial-services/library/climate-risk-and-insurance.html

36 https://www.skadden.com/insights/publications/2023/12/2024-insights/corporate-trends/climate-change-and-its-undeniable-impact

IFoA (2019) and AIA (2023) provide supporting guidance for capital management actuaries including specific considerations for enhancing natural hazards catastrophe modelling.

— **Investment** Oversight, advice and design of investment strategy with better alignment to ESG criteria. The role of actuaries in finance and investments is discussed further in Section 11.

— **Reporting and regulation** Assistance with compliance and reporting required for regulatory and financial reporting, which includes supporting the development of appropriate and new climate products and related investments The roles of actuaries in this area is discussed further in Section 9.

— **Strategy** Actuarial involvement in the above areas lends itself to contributing towards business and risk strategy. Sharanjit Paddam, Principal at Finity Consulting, notes that the actuarial work typically begins with identifying and managing risks; this progresses to the management of risk becoming more strategic, particularly given our broader understanding of the business and policyholder and/or membership base. Actuarial involvement relating to climate strategy is explored further in Section 13.

5. PARAMETRIC INSURANCE

5.1 Overview of parametric insurance and market practice

5.1.1 Parametric insurance is a risk transfer solution that facilitates rapid payout to support relief either directly before or after a climate disaster. Parametric or index-based types of products are relevant for situations in which the insured is not looking for payment for reconstruction of a specified asset, but rather for funds to respond to a catastrophic event (Jarzabkowski et al., 2019). This is unlike traditional indemnity insurance which indemnifies policyholders based on the actual losses suffered.

5.1.2 With parametric products, a predetermined amount is paid out when a specific trigger event occurs and meets or exceeds a predefined threshold, measured by an objective model-based index of catastrophic events. Many types of indices are possible, but for managing climate-related risks, three types are most relevant:

— **Weather indices** These can be rainfall-related to cover droughts and floods, wind speed-related to cover tropical cyclones or temperature-related to cover extreme heat.

— **Weather proxy indices** These measure the effects of weather on vegetation health for example, and can serve as a trigger for when an extreme weather event has occurred (e.g., a Normalised Difference Vegetation Index (NDVI) measures green vegetation levels and is used for agricultural drought insurance).

— **Area yield indices** These are based on the average historical crop yield in a specific geographic area. Area yield indices are used for agricultural insurance and the trigger is when the actual yield falls below the threshold.

5.1.3 It is important that the indices used are strongly correlated to the potential loss, objectively based on measurable data and verifiable by independent sources. Once the predefined trigger is met, a predetermined pay-out is made to the policyholder. This pay-out is fixed and does not require the insurer to assess the actual loss or damage suffered by the insured party.

5.1.4 Parametric insurance dates to the 1800s, but it wasn't until the late 1990s that it was adopted by mainstream global insurers. The birth of modern parametric insurance was largely driven by a demand from larger clients for a faster claims processing time, more flexible protection and greater certainty around pay-outs.[37] The global parametric insurance market size is now valued at USD14.8 billion (2023) and is estimated to register a compound annual growth rate (CAGR) of over 11.5% between 2024 and 2032.[38] Natural catastrophe cover is a common use case for parametric insurance, but as the sophistication of data analytics and recording has increased, there are a large number of other applications, such as non-damage business interruption, construction delays and loss of tourism revenue.

5.1.5 Parametric insurance adoption in Africa is steadily growing, driven by the continent's vulnerability to climate change and natural disasters, as well as the need for new risk management solutions. A key player is the African Risk Capacity (ARC), a specialised agency of the African Union which has been a pioneer in parametric insurance in Africa.[39] ARC provides disaster risk insurance to member states, helping them manage financial risks associated with drought, flood and tropical cyclones. As of 2023, ARC had paid out over $170 million in claims through its parametric insurance policies.[40]

5.1.6 In addition, several global and domestic insurance companies are increasingly offering parametric insurance products to individuals, businesses, and governments in Africa, supported by specialist brokers such as Pula and ACRE Africa amongst others. Several industry initiatives are also driving private sector adoption:

— The Nairobi Declaration on Sustainable Insurance (NDSI) is a collaborative platform of over 200 African insurance industry players who have committed to working towards achievement of the UN's Sustainable Development Goals. At COP27 the NDSI signatories committed to cumulatively underwrite $14 bn worth of climate risk cover by 2030.[41]
— An African Development Bank initiative, the Africa Climate Risk Insurance Facility

37 https://corporatesolutions.swissre.com/dam/jcr:0cd24f12-ebfb-425a-ab42-0187c241bf4a/2023-01-corso-guide-of-parametric-insurance.pdf
38 Global Market Insights, 2024
39 https://www.arc.int/news/african-risk-capacity-launches-its-first-parametric-insurance-product-against-high-impact
40 https://www.artemis.bm/news/african-risk-capacity-makes-over-170m-of-parametric-payouts-in-first-10-years/
41 UNFCC, Summary of Global Climate Action at COP 27, https://unfccc.int/sites/default/files/resource/GCA_COP27_Summary_of_Global_Climate_Action_at_COP_27_1711.pdf

for Adaptation (ACRIFA) is working to demonstrate and develop insurance as a vital tool to foster climate adaptation, resilience, and sustainable development within Africa's agricultural sector with parametric insurance being a key solution.[42]

5.1.7 In South Africa, the regulatory status of parametric insurance is currently evolving and, at the time of this paper, is not explicitly recognised as a separate insurance category under the South African Insurance Act. This means it is somewhat of a grey area, often treated as a non-insurance product or a derivative. In Kenya, the insurance regulator defined micro-insurance and index-based insurance in its primary legislation on insurance services and this has led to strong uptake of parametric insurance in the country.

5.1.8 As it relates to climate risk, parametric (or index-based insurance) currently has the following main uses:

— **Agriculture insurance** Parametric insurance is increasingly being used to protect farmers in Africa against weather-related crop and livestock losses. For example, in Kenya, smallholder farmers and pastoralists are covered by government-subsidised parametric insurance programmes for drought risk.[43]
— **Disaster risk management** Providing financial protection to governments and communities against natural disasters.
— **Humanitarian aid** Parametric insurance is being integrated into humanitarian aid programmes to provide faster and more efficient relief after disasters. For example, the Start Network has used parametric insurance to deliver aid in Senegal ahead of a severe food insecurity situation caused by drought.[44]

Additionally, parametric insurance provides an alternative to traditional insurance, enabling more customers access to some coverage following an extreme weather event, allowing uninsurable exposures to become insurable with a parametric trigger.[45] Parametric insurance can therefore be used as a mechanism to reduce the protection gap particularly in relation to the most vulnerable communities.

5.2 Areas of actuarial involvement

This section expands on areas of actuarial involvement noted under the Insurance section of this paper with specific considerations to parametric insurance products.

42 https://www.afdb.org/en/documents/africa-climate-risk-insurance-facility-adaptation-acrifa
43 https://www.swissre.com/our-business/public-sector-solutions/thought-leadership/successful-kenya-livestock-insurance-program-scheme
44 https://startnetwork.org/funds/disaster-risk-financing/arc-replica
45 https://www.aon.com/en/insights/articles/parametric-insurance-a-complement-to-traditional-property-coverage

5.2.1 Pricing

5.2.1.1 Historical burn analysis is a fundamental method used for pricing index-based insurance contracts. This technique relies on the empirical distribution of pay-outs derived from a sample of historical data (Omondi, 2015). Actuaries are crucial in this process as they are able to calculate the mean of historical index values, which serves as an estimate of the actual expected index. This estimated index is then used to determine the expected pay-out for the insurance contract. By applying statistical methods to historical data, actuaries ensure that the pricing of index-based contracts reflects historical trends and patterns accurately.

5.2.1.2 However, the use of historical data introduces various uncertainties, particularly when the data sample is limited, requires cleaning, or is not expected to be an accurate predictor of future experience. Actuaries must investigate how these uncertainties impact the estimated expected index, the expected pay-out, and the overall pay-out distribution. Their role involves assessing the robustness of the historical burn analysis method and refining pricing models to account for data variability and potential inaccuracies. By addressing these uncertainties, actuaries help improve the reliability and precision of index-based insurance pricing.

5.2.2 Data

5.2.2.1 Data are essential for pricing any insurance products. Actuaries play a key role in ensuring that these data utilised to price index insurance products are both adequate and of high quality. Actuaries are involved in analysing historical weather and catastrophe data (e.g. from meteorological stations) to inform the pricing of catastrophe-based index insurance. By scrutinising variables such as temperature, rainfall, precipitation, and snowfall, actuaries help ensure that index-based contracts are priced accurately and appropriately. Their expertise in interpreting this historical data is essential for developing reliable pricing models and managing risk effectively.

5.2.2.2 Additional data-related skills, as mentioned in Section 3.2, can also be applied to this area. For example, actuaries can use techniques to assess correlations between indices and potential losses and can assist in the validation of data.

5.2.3 Product development

5.2.3.1 Actuaries are important in the development of index insurance products by guiding the selection and design of the indices that underpin these products. Index insurance products generally fall into two categories (Omondi, 2015): those based on total losses (e.g., area yield indices) and those based on specific events (e.g., weather indices). Actuaries are involved in evaluating the appropriateness of different indices for these product types, ensuring that the chosen indices accurately reflect the risks covered and meet the needs of both insurers and policyholders.

5.2.3.2 Actuaries contribute to designing and analysing indices that align with the

insurer's strategic objectives and risk management goals during the product development phase. For products based on total losses, actuaries assess comprehensive loss data to construct indices that reliably capture the full extent of potential losses. For event-based products, they evaluate the frequency and severity of specific events to develop indices that trigger pay-outs in response to predefined occurrences such as temperature, rainfall, etc. Actuaries use their expertise to model potential outcomes, conduct sensitivity analyses, and refine the indices to ensure they are both effective and fair.

6. FINANCE AND INVESTMENTS

6.1 Overview of climate finance and investments

6.1.1 Average annual finance flows reached almost USD1.3 trillion in 2021–2022, nearly doubling from 2019–2020 levels. Most of this amount relates to mitigation finance with the largest growth in the renewable energy and transport sectors, concentrated in China, the USA, Europe, Brazil, Japan and India. Annual finance flows of approximately USD8.1–9 trillion will be required each year until 2030, highlighting a significant gap that needs to be filled to avoid the worst impact of climate change. (CPI, 2023)

6.1.2 The United Nations Development Programme (UNDP) defines climate finance as "financial resources and instruments used to support action on climate change" where funds are used to invest in projects that reduce, absorb, or prevent GHG emissions (mitigation) or projects that build resilience to climate change (adaptation). Multiple types of climate finance instruments exist, including grants, bonds, equities, debt swaps, guarantees and concessional loans.[46]

6.1.3 The United Nations Principle for Responsible Investing (UNPRI) (2020) states in order for investors to play a role in mitigating climate change risk (for clients, beneficiaries and societies), leading investors (particularly long-term investors such as pension funds and other financial institutions) will be expected to increase allocation of assets to climate change mitigation and adaptation projects, build climate change into investment processes, including pricing climate risk, and utilise shareholder leadership to drive corporate climate change activity (Mackenzie et al., 2009).

6.1.4 According to the 2024 Global Climate Investing Survey conducted by Robeco, 62% of the 300 global institutional and wholesale investors (totalling USD28 trillion assets under management) surveyed describe climate change as a significant or central factor in their investment policy. Other key observations from the survey include (Robeco, 2024):

— Investors are typically adopting active equity trading strategies in transition-oriented companies (45%), followed by green and sustainability bonds (43%).
— Key challenges include finding suitable investment data, research, and ratings (to

46 https://climatepromise.undp.org/news-and-stories/what-climate-finance-and-why-do-we-need-more-it

tackle greenwashing) and decreased demand from end–users expected to be due to a rise in risk versus return considerations.
— The need to build up additional technical expertise in investment teams to adequately assess investment opportunities and credibility of company's transition plans.

6.1.5 Research provided by the CFA Institute summarises some of the key sources of climate-related information collected and analysed by investors, which includes (Vinelli et al., 2024):
— Credit rating agencies, which incorporate climate risk exposure into credit ratings;
— Index providers, which provide climate-themed indexes;
— Valuation service providers, which may incorporate climate considerations when valuing private assets;
— ESG rating providers;
— Sell-side research providers, some of which integrate climate-related information; and
— Climate-related data and research providers, which produce a wide range of company and sector-specific climate-related information, including market research, market intelligence, and thought leadership on climate-related topics.

6.1.6 Vinelli et al. (2024) also highlight the multiple challenges faced with sourcing and using climate-related information, including inconsistent disclosure obligations, the nature of voluntary disclosures (variability in quality and extent of information disclosed), clarity in methodology and processing underlying the data, lack of consistency and comparability across data providers, different standards and regulations, and resource and skills constraints when collecting, analysing and reporting on data. Consequently, investors are required to use judgement to ensure the effective use of the data that is available and to be cognisant of the limitations underlying the data.

6.1.7 Investors can adopt multiple methods of analysis in the investment decision-making process. In addition to qualitative analysis of the data acquired, this can also include analysis and monitoring of the following quantitative measures (Wagstaf, 2022):
— Scenario analysis to project potential future climate conditions and the impact on investments which can be used to calculate climate value at risk (VaR) metrics. Such scenarios would be expected to encompass physical and transition risks.
— Physical risk metrics (e.g., proportion of portfolio located in vulnerable geographical areas)
— Transition risk metrics (e.g., NAV exposure to various energy sources);
— GHG emissions metrics (e.g., carbon intensity, weighted average carbon intensity per portfolio); and
— Portfolio alignment metrics (e.g., implied temperature rise associated with a portfolio).

6.2 Areas of actuarial involvement

6.2.1 As noted in Section 4, actuaries would be able to apply their risk assessment and financial modelling skillset to the quantification of transition risks, physical risks and GHG emissions, as well as the performance of scenario analysis and stress testing. Additionally, actuaries would be able to contribute in the areas where climate risks are incorporated into investment design and decision-making. These areas comprise an expansion of existing roles held by actuaries across retirement funds, insurance companies, investment managers and banks.

6.2.2 Actuaries can play an important role in effectively sourcing data to develop an investment decision-making framework that incorporates climate change factors. John Anderson highlighted several ways in which actuaries can contribute, including:

— Defining specific data needed for various analyses including the necessary ESG metrics and climate data required for assessing investment portfolios. This includes providing guidance to data providers on what specific information is needed and why ensuring that the data collected is relevant and useful.
— Evaluation of the quality of data, the methodologies used to collect it and its limitations. Actuaries can assess whether data sources are reliable, the methodologies used to gather and classify data are fit for purpose, and whether the data are sensible.
— The data landscape in respect of climate and other ESG-related elements is still developing (in terms of consistency and availability of data). Development of a data strategy and framework for data collection and validation, and actions for filling any data gaps commensurate with the business and market risks faced by the asset owner or manager are needed. Where data gaps exist, actuaries can determine alternative metrics and/or proxy information that can be used for the intended modelling.

6.2.3 Other areas include:

— Adjusting the valuation of financial instruments or assets to reflect higher inherent risks due to climate change. The nature of the adjustments would depend on the method of valuation adopted with the paper by Feltmate et al. (2020) providing insights into the various considerations that could be applied. For example, reviewing key assumptions underlying the discounted cashflow model, such as the discount rates (and assessing whether this appropriately reflects the risk of return), and determining whether future cashflow projections would be expected to be impacted by extreme weather events.
— Valuation of climate-related instruments such as sustainability, green, climate resilience bonds, environmental impact, green securitisation and parametric bonds.[47]

47 https://napglobalnetwork.org/innovative-financing/

— Revisions to investment policy (Gordon, 2021) for investing entities to specify revised strategic asset allocations, qualifying criteria for investment incorporating climate-risk indicators, interim and long-term targets for portion of investments in low-emitting companies and industries, and principles for balancing climate criteria and risks versus returns (e.g. for a life insurer, setting investment carbon reductions while balancing against meeting policyholders' reasonable expectations).
— Enhancing existing or developing dynamic asset allocation strategies (Mercer, 2023) that respond to climate risk assessments and indicators.
— Design and implementation of additional KPIs or metrics to enable reporting to manage and monitor climate-related risks (Gordon, 2021) for asset managers and investors.
— Design and implementation of a decision-making framework for the selection of investment and funds (or fund managers) that incorporate various quantitative and qualitative analyses. This will allow for the standardisation of information used within the business in making investment-related decisions in order to mitigate against climate-related information that may be inconsistent or lack transparency (e.g., ESG ratings)
— Update/review calibration of economic capital models (used for capital determination and management) to include the amplifying effects of climate-risk.
— Training decision-makers (Gordon, 2021) such as trustees, investment committees and board of directors on the impacts of climate risk on investment policy, strategy, and decisions, including outcomes of results of quantitative analyses performed (e.g., scenario modelling, stress testing, valuation impacts, etc).
— Involvement in stewardship activities (whether as an asset manager, investor, or company) such as discussing the nature of material climate-change risks involved (supported with quantitative analysis), understanding the extent of climate strategy and risk management processes in place at companies (to factor into investor decision-making), and discussing the impact of mitigation and adaptation measures on climate change risk measures.

7. CLIMATE STRATEGY

7.1 Setting a climate strategy

7.1.1 As with general business strategies, approaches to developing climate strategies will vary by organisation. Key steps that represent current common practice in developing a comprehensive climate strategy to address both climate risks and opportunities are outlined below.

7.1.2 These steps represent a "bottom-up" approach to determining the climate goals or commitments which the strategy needs to deliver. This involves understanding an organisation's baseline climate risk exposure and internal capabilities and allowing that to inform the targets that are set. However, some organisations follow a more "top-down"

approach of making public climate commitments and work backwards to understand their status quo and what needs to be done to achieve the targets committed to.

7.1.3 **Step 1: Assess climate risk exposure** The initial risk assessment often takes the form of a high-level heat map that qualitatively rates physical (both acute and chronic) and transition risks (including carbon footprint) on the institution's assets, liabilities and operations. However, a more advanced quantitative assessment may also be performed.

— Further detail on how climate risks translate into financial risks are covered in Section 3. In addition to considering the impact of climate on the company, the risk assessment should importantly apply double materiality by also considering the impact of the company on the climate (i.e., through its GHG emissions). See Section 4 on the measurement and modelling of climate risks and GHG emissions.
— In terms of approach, the organisation can choose to map the physical and transition risks by economic sector, stakeholder type, business line, or by all of these. Overlaying the organisation's approximate portfolio exposure may then produce a heatmap which will give an initial indication of the most material climate-related risks and emission-intensive areas.

7.1.4 **Step 2: Assess climate-related opportunities** The transition to a low carbon economy also presents numerous opportunities for financial and other institutions which should be assessed as part of the strategy process. Examples of opportunities include:

— **Green finance** Opportunities to finance and invest in renewable energy, energy efficiency, sustainable agriculture, and other green projects.
— **Product innovation** Develop new financial products and services that cater to the growing demand for climate-friendly solutions, such as green bonds, sustainability-linked loans and climate insurance.
— **Reputation and brand enhancement** Demonstrate leadership in addressing climate change, which can attract customers and investors who prioritise sustainability.

7.1.5 **Step 3: Baseline capability assessment** This step involves assessing the current level of maturity of the organisation in each of the enabling activity areas for the climate transition of the organisation. There are many possible frameworks for assessing capability. To illustrate, the framework set out in Figure 7 uses the four pillars of the TCFD, namely governance, strategy, risk management, and metrics and targets, and adds related supporting functions. Within each of these areas the organisation can further break down the necessary capabilities and assess the level of maturity on a scale they determine.

7.1.6 **Step 4: Define ambition** Each organisation needs to set clear climate objectives, ideally aligned with the global Paris Agreement goal of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C".

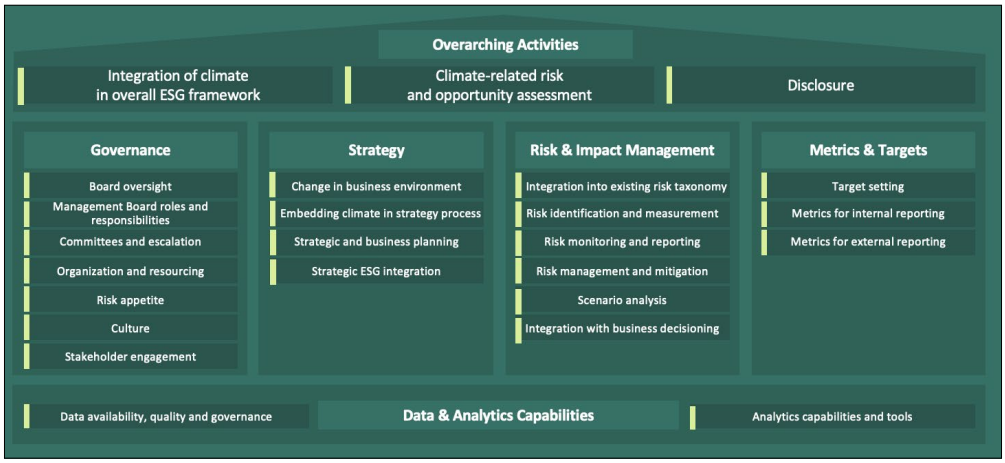

FIGURE 7. Capabilities within TCFD pillars (Developed by FSD Africa for African Natural Capital Alliance, used with permission)

7.1.7 The climate ambition for the organisation needs to align with the company's overall mission and its other targets, including other sustainability-related targets, as illustrated by Figure 8.

7.1.8 Examples of climate targets for financial and other institutions include:

— **Net-zero emissions or similar decarbonisation targets** A common target among organisations is committing to achieving net-zero emissions or an alternative specified level of emissions across their portfolios by 2050.
— **Fossil fuel divestment and exclusion** Several financial institutions are actively divesting from fossil fuel companies and/or have committed to no new financing or underwriting of fossil fuel after a certain date.
— **Increased sustainable finance** Another common target is a committed amount of financing and investment to support the transition to a net-zero economy by a certain date.
— **Climate risk assessment and disclosure** Financial and other institutions are also committing to disclosing the climate-related risks in their portfolios in line with global standards and frameworks by a certain date. This may also include disclosure of their GHG emissions.

In setting their climate ambition, organisations also need to consider the 'Just Transition' and hence impacts of climate strategy on workers while balancing the urgency of global climate action.

7.1.9 **Step 5: Define strategy** This involves defining the organisation's strategy for achieving its climate ambitions. The strategy should consider the organisation's current risk exposures, opportunities and capabilities identified in the previous steps. It will then define "how to win" and "where to play" to achieve the company's climate targets.

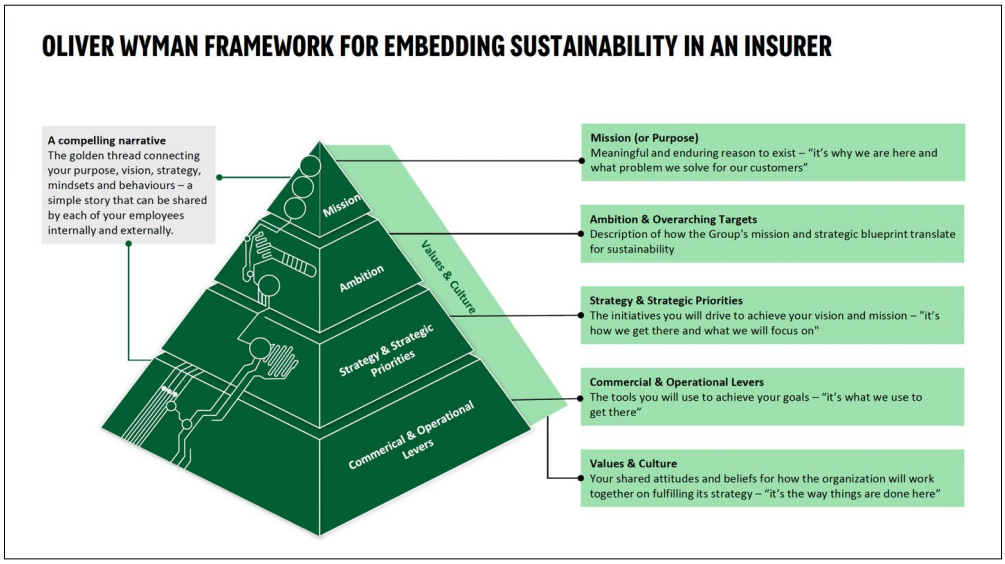

FIGURE 8. Embedding sustainability in an insurer (Oliver Wyman © 2024, used with permission)

7.1.10 Importantly, the climate strategy needs to be aligned with the overall commercial strategy and the organisation's mission. If this is not the case, the climate agenda is unlikely to be mainstreamed within the organisation and will remain a side issue.

7.1.11 **Step 6: Integrate strategy into business operations** Once the strategy is clearly defined it needs to be supported by a detailed plan with corresponding targets and metrics. Figure 9 gives an illustration of what a transition plan might look like for an insurer with the ambition to be net zero by 2050.

7.1.12 To ensure effective strategy implementation it should be supported by a governance policy framework which details roles, responsibilities and processes throughout the organisation. Training and capacity building will also be necessary within responsible teams as illustrated in the climate transition plan framework in Figure 9.

7.2 Areas of actuarial involvement

7.2.1 Actuaries can play a critical role in the setting and embedding of climate strategy for organisations by leveraging their expertise in risk assessment, data analysis, modelling and communicating complex issues. Specific skills and attributes of actuaries that may be valuable include:

— Risk assessment and measurement: The actuarial role in this function is detailed in Section 4 and forms an important input into the strategy process. Since actuaries understand the modelling, they are able to support on the areas around this, such as developing data strategy and risk appetite.

— Breadth of understanding of risks and processes within financial services (but

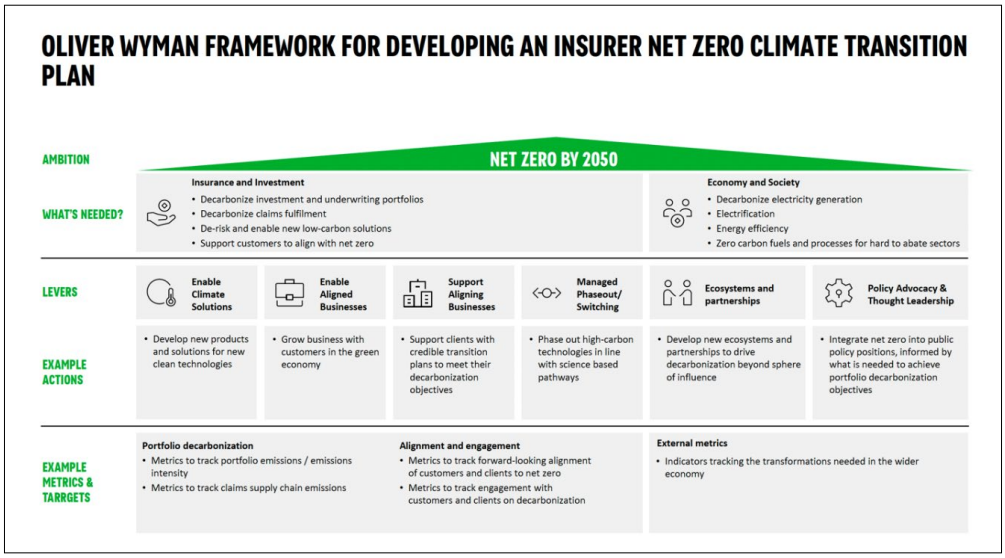

Figure 9. Framework for developing net zero climate transition plan (Oliver Wyman © 2024, used with permission)

potentially also other) organisations enables actuaries to take an externality, like climate change, and determine the implications throughout the organisation. This is supported by an actuary's understanding of business needs and stakeholder preferences in different areas of the company, as well as the linkages between them.

— The combination of breadth of understanding, technical knowledge and ability to solve complex long-term problems enables a valuable actuarial contribution to climate strategy development. This allows actuaries to engage effectively with both high-level strategy and the technical detail to propose pragmatic solutions that involve compromises, but with a thorough understanding of the trade-offs and implications. This would include assessing the reasonability of targets set/ability of an organisation to meet strategic targets as well as any stipulated management actions.

— Professionalism: climate strategy is a new field, and actuaries are able to contribute a rigorous professional approach to the various stages of developing and implementing climate strategy.

— Communication: The ability of actuaries to communicate complex issues at various levels of detail allows them to communicate effectively with various stakeholders. Additionally, actuaries can leverage existing technical and software skills to translate climate risks and impacts into dashboards or metrics that resonate with executive management and facilitate informed decision-making for the purpose of climate strategy.

8. CORPORATE GOVERNANCE

8.1 Climate change and corporate governance

8.1.1 The World Economic Forum (WEF) notes eight guiding principles to be incorporated by corporate boards in establishing effective climate governance (WEF, 2019):

— **Climate accountabilit**y The board is accountable for the company's long-term resilience with respect to potential shifts in the business landscape that could result from climate change.
— **Subject command** The board should ensure that there is sufficient knowledge, skills, experience and background to effectively debate and take decisions in respect to climate-related threats and opportunities.
— **Board structure** The board should determine the most effective way to integrate climate considerations into its structures and committees.
— **Material risk and opportunity assessment** The board should assess short-, medium- and long-term materiality of climate-related risks and opportunities.
— **Strategic and organisational integration** The board should ensure that climate change informs strategic investment planning and decision-making processes and is embedded across the organisation.
— **Incentivisation** The board should ensure that executive incentives consider climate-related targets and indicators.
— **Reporting and disclosure** The board should ensure that material climate-related risks, opportunities and strategic decisions are consistently and transparently disclosed to all stakeholders.

8.1.2 This is consistent with the requirements set out by the TCFD and IFRS S2 Standards requiring board oversight of climate-related risks and opportunities, including any committee or equivalent body or management charged with governance (TCFD, 2017; ISSB, 2023).

8.1.3 The business case for better governance practices is supported by a study examining a sample of 832 multinational companies over the period 2011–2020, which found that effective climate governance leads to higher financial performance. This observed relationship was further strengthened when the companies display better climate performance i.e. performance of a company based on its reduction of environmental emissions in operations and production. (Aibar-Guzman et al., 2024)

8.1.4 As an extension of operationalising corporate governance practices relating to climate change and sustainability, the role of the Chief Sustainability Officer (CSO) has emerged and evolved in recent years. According to a report issued by Deloitte and the Institute of International Finance, the CSO is emerging as the "sense-maker in chief" in organisations, being asked to interpret changes in the external sustainability environment and determine the strategic consequences. The research outlines three conditions that appear to lead to a CSO appointment (Deloitte, 2021):

— the pace of changes in the external environment is quicker than internal to the organisation hence focused supported is needed to adapt;
— external stakeholder scrutiny is intensifying expectations on organisations where internal structures, executives and governance frameworks have not yet found a way to deliver; and
— acknowledgement by the business that ESG-relates issues are strategic.

The report also found the responsibility of the CSO to generally comprise of:
— making sense of the external environment and bringing those insights back into the company;
— helping organisations reconfigure and deliver on their strategy; and
— providing thought leadership and collaboration, connection and education to teams.

8.1.5 The above findings are supported by more corporations globally appointing CSOs or Heads of ESG, reflecting growing awareness by boards and corporates. According to research done by PwC in 2021, around 30% of the 1640 companies analysed had a formal CSO role, with another 50% of companies having a CSO with limited remit. The same research suggests that companies with CSOs are better ESG performers. The research also states:

> Among the companies that scored an A-rating, almost all (98%) had an executive with at least some sustainability responsibility.

Furthermore, the study also outlines that in 2021, 28% of CSO appointments were part of the C-suite – this number was just 9% in 2016 – indicating the upward trajectory in appointments (PwC, 2022).

8.2 Areas of actuarial involvement

8.2.1 In an article published by the AIA, the author notes that actuaries play an essential role in corporate governance, able to promote and facilitate the consideration of risk while balancing shareholder and customer interest. Actuaries are able to provide the advice necessary for management and the board to make decisions that are the best for the business.[48]

8.2.2 Actuaries are often found on boards (or supporting committees) of financial service companies, and hence could be expected to expand their roles to ensure that they contribute towards effective management of climate-related risks and opportunities. These types of roles work to actuarial strengths, can be extended beyond financial services and bring a diversity of skills and knowledge to managing climate change uncertainty.

48 https://www.actuaries.digital/2023/05/15/what-role-do-actuaries-play-when-it-comes-to-corporate-governance

8.2.3 As part of exploring how more actuaries can serve on public company boards of directors, the Actuaries on Boards Task Force under the Society of Actuaries interviewed actuaries serving Board roles on the topic:[49]

> I think that our actuarial skills would have really good application on boards, but as specialists in technical matters or, more importantly, as seasoned professionals with experience in risk management. This could be potentially in almost any industry, not just insurance.
>
> (S. Michael McLaughlin, past president of the Society of Actuaries)

> An actuary can quickly grasp new concepts and new businesses, so even if they came out of, let's say, the health business, it would not be difficult for them to quickly understand the auto business or the annuity business
>
> (Marla Glabe, Fellow of the Society of Actuaries and board-member)

> I think an actuary is expected in an insurance company or other insurance firm to have good judgement and objectivity, and I think those are two items which are very important for any company board. So from that point of view those are two strengths of an actuary which would be useful to nearly any company.
>
> (Phil Briggs, Fellow of the Society of Actuaries and board-member)

> If you're setting up models and the regulators are saying that they have the right to come in and talk to board members about the model, then make sure that the board has some level of reasonable knowledge about what the models do and how they do it. Who would be better than an actuary to answer these questions?
>
> (Monica Hainer, Fellow of the Society of Actuaries,
> CEO of London Life Reinsurance Company and board-member)

8.2.4 In assessing how actuaries can perform in a CSO role it is important to dissect the typical tasks allocated to this role and how this relates to the skillset that actuaries possess. *Harvard Business Review* sets out eight critical tasks for CSOs, each of which are explored below.[50]

8.2.5 **Ensuring regulatory compliance** The financial services industry is highly regulated across the world and actuaries are already well-versed in unpacking and implementing regulatory guidance and requirements. As a result, actuaries, in the role of the CSO, would be well positioned to extend what they are currently doing to also include sustainability-related regulatory compliance. Furthermore, as noted within the EU as well as

49 https://www.soa.org/globalassets/assets/Library/Newsletters/The-Actuary-Magazine/2012/february/act-2012-vol9-iss1-hamblin.pdf

50 https://hbr.org/2023/03/the-8-responsibilities-of-chief-sustainability-officers

in South Africa, the prudential regulators have started publishing compulsory or voluntary requirements, meaning that there will be a need for adequate sustainability oversight and accountability across various matters. A CSO with actuarial skills will be a distinct advantage given their understanding of the financial services industry and given relevant regulations. This skillset (i.e., interpretation and implementation of regulatory requirements and reporting) can be easily extended to other non-financial services industries.

8.2.6 **ESG monitoring and reporting** Actuaries already have experience across risk and performance monitoring and reporting, whether through monthly reporting (e.g., monthly risk reporting), quarterly regulatory reporting or annual reporting (e.g., ORSA). Therefore, ESG requirements can be considered as an additional dimension to add to their already well-understood monitoring and reporting process. Furthermore, some disclosure requirements might require industry-specific metrics be disclosed. The CSO will need to have a good understanding of what these metrics mean, how they are derived and the inherent uncertainty underlying these measures (all of which are an extension of the actuarial skillset).

8.2.7 **Overseeing the portfolio of sustainability projects** Currently, actuaries are already involved in overseeing various projects across the financial services industry. If we think of a Chief Risk Officer (CRO) in an insurance company, very often an actuary, they oversee the ORSA process whereby actuaries are already involved in the planning, review and coordination of the different components of the ORSA. Actuaries are also known for evaluating risks and impact which is critical, especially when overseeing projects; this skill can be applied across industries.

8.2.8 **Managing stakeholders' relationships** Actuaries are already employed in executive positions across the financial services industry. Although this is not an actuarial-specific skillset, this is part of the general business skills that actuaries possess. This is also a key skill that actuaries possess that is transferable to other industries.

8.2.9 **Building organisational capabilities** Although not unique to the actuarial skillset, actuaries are subject to ensuring continuing skills development as part of their professional duties, as well as being responsible for the upskilling of actuarial teams and capabilities in the organisations in which they operate. Therefore, actuaries can extend this role while working with other relevant expertise within the organisation to identify gaps and design appropriate educational initiatives for upskilling and/or outsourcing missing capabilities.

8.2.10 **Fostering cultural change** In line with the comments made above, actuaries have historically been instrumental in driving cultural change within financial services primarily from a risk perspective as well as acquiring a range of strategic leadership roles such as chief executive, finance, underwriting, marketing and risk officers. Consequently, fostering cultural change is an extension of these roles which drive transformation, and require that risk be positioned with a lens of sustainability.

8.2.11 **Scouting and experimenting** Actuaries are known for being analytical,

problem-solvers, critical thinkers and long-term thinkers, and are therefore well-placed to promote innovation across industries and sectors. From a financial services perspective, actuaries have a good understanding of the industry and therefore a good understanding of the impact of any sustainability-related innovation on the operating model, as well as on their risk and opportunities. This is where frameworks such as the actuarial control cycle becomes key.

8.2.12 **Embedding sustainability into processes and decision-making** Actuaries in the position of CSO in the financial services industry are well placed to drive:

— development of sustainable products;
— sustainable investment;
— risk assessment and effective communication to stakeholders (together with the CRO); and
— risk monitoring and management, as well as progress on sustainability targets and the use of the outcomes to make decisions (together with the CRO).

8.2.13 Given that actuaries typically have an in-depth understanding of the financial services industry, as CSOs they would be able to bring actuarial and deep industry knowledge to sustainability-related decision-making. Furthermore, actuaries are well placed to understand and communicate the insurance-specific metrics that are likely going to be impacted by sustainability.

8.2.14 Thinking more broadly than the financial services industry, the principles described above are also transferable to different industries. Actuaries have the relevant problem-solving, analytical and critical thinking skills to be able to unpack what sustainability means for different businesses and to embed the processes and decision-making; as a matter of fact, there are quite a few actuaries already working in non-financial services sectors.

9. REPORTING AND REGULATION

9.1 Overview of current and emerging reporting requirements

9.1.1 There are currently several global reporting standards relating to the disclosure of climate-related risks, GHG emissions and opportunities (and in some cases wider sustainability reporting). Table 1 summarises some of the key standards.

9.1.2 Due to the number of ESG reporting frameworks and standards it is expected that the ISSB is ideally placed to achieve standardisation of ESG reporting on a global scale.[51] Figure 10 demonstrates the synergies/and relationship between the ISSB and other global sustainability frameworks.

9.1.3 The introduction of IFRS S2 by the ISSB in June 2023 represents a critical step in standardising climate-related financial disclosures. The ISSB has also issued industry-

51 https://www.sibylline.co.uk/wp-content/uploads/2023/04/postSibylline-Situation-Update-Brief-Standardisation-of-ESG-Reporting-Final.pdf

TABLE 1. Summary of climate-related disclosure reporting standards

Name	Overview	Compliance
Task Force on Climate-related Financial Disclosures (TCFD)[52]	The TCFD provides a framework for companies to disclose climate-related risk and opportunities covering four key elements of governance, strategy, risk management, and metrics and targets.	Voluntary, however some jurisdictions have made disclosure under the TCFD mandatory (e.g., UK, New Zealand, and Japan)[53]
International Sustainability Standards Board (ISSB) IFRS S1 and IFRS S2	IFRS S1 requires companies to disclose material information on all sustainability-related risks and opportunities that could reasonably be expected to affect their prospects.[54] IFRS S2 sets out the requirements for climate-related disclosures.[55]	Voluntary unless stipulated as mandatory by local regulators/stock exchanges[56]
Sustainability Accounting Standards Board (SASB)	Industry-specific standards for companies to disclose financially material sustainability information to investors and to be used as a tool for implementing the ISSB standards.[57]	Voluntary[58]
Global Reporting Initiative (GRI) Standards	The GRI Standards provide global best practice for reporting publicly on a range of economic, environmental and social impacts.[59]	Voluntary[60]
Carbon Disclosure Project (CDP)	A global disclosure system to allow companies to complete a questionnaire on their environmental impact (including climate)[61]	Voluntary
European Union Regulations: Non-Financial Reporting Directive (NFRD) Corporate Sustainability Reporting Directive (CSRD) Sustainable Finance Disclosure Regulations (SFDR)	All three directives aim to promote sustainability and ESG reporting in the financial sector: NFRD focuses on non-financial reporting, requiring companies to disclose information on a range of ESG topics, such as environmental impact, social issues, and anti-corruption measures. The CSRD builds on the NFRD, expanding the scope of reporting and introducing new requirements, such as reporting on ESG risks and opportunities. The SFDR focuses on financial market participants, requiring them to disclose information on how they integrate sustainability risks and opportunities into their investment decisions and provide information on their investments' sustainability impact.[62]	Mandatory in the EU

52 https://www.fsb-tcfd.org/
53 https://www.nortonrosefulbright.com/en-au/knowledge/publications/bedb913e/global-standards-on-sustainability-and-climate-related-disclosure-launched
54 https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s1-general-requirements/
55 https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s2-climate-related-disclosures/
56 https://sasb.ifrs.org/wp-content/uploads/2022/03/SASBStandardsandIFRSF-030222.pdf
57 https://sasb.ifrs.org/sasb-your-pathway-to-issb/
58 https://help.sasb.org/hc/en-us
59 https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-english-language
60 https://www.glosus.com/en-us/sustainability-data/gri/
61 https://www.cdp.net/en/info/about-us
62 https://www.crediblesg.com/blogs/understanding-the-eu-taxonomy-differences-between-nfrd-csrd-and-sfdr/

UK Sustainability Disclosure Requirements	This is a framework designed to enhance transparency and provide robust, decision-useful information about sustainability-related matters for investment funds and listed issuers. It includes sustainability-related product labels, product- and entity-level disclosures, and rules to prevent greenwashing.[63]	Mandatory
US Regulations: Securities and Exchange Commission (SEC) The Enhancement and Standardization of Climate-Related Disclosures for Investor California Senate Bills (SB) 253 and 261	The SEC rules require information about a registrant's climate-related risks that have materially impacted, or are reasonably likely to have a material impact on, its business strategy, results of operations, or financial condition. In addition, certain disclosures related to severe weather events and other natural conditions will be required in a registrant's audited financial statements.[64] The state of California enacted two bills that mandate both climate risk and GHG disclosures for certain public and private companies "doing business" in California.[65]	Mandatory
South African Reserve Bank (SARB) Guidance notes on climate-related disclosures for banks and insurers	The guidance notes mandate integrating climate-related risks into governance, strategy, and risk management frameworks, following international standards like the TCFD and ISSB. The guidance notes require detailed disclosures on metrics, targets, and performance, emphasising the treatment of climate risks as financial risks. Additionally, it encourages proactive risk management and transition planning, with future expectations of external assurance for these disclosures[66]	Voluntary

specific guidance to implementing IFRS S2 requirements. This approach acknowledges that climate-related risks and opportunities vary significantly across different sectors. For instance, the risks faced by a mining company due to regulatory changes aimed at reducing GHG emissions differ significantly from those faced by a financial services firm managing climate-related investment risks. This guidance is essential for helping organisations identify and disclose relevant climate-related information to the users of their financial statements. This guidance integrates elements from the Sustainability Accounting Standards Board (SASB) standards, providing industry-specific metrics and disclosure topics that enhance the relevance and comparability of climate-related disclosures. For example, in the consumer goods sector, the guidance includes metrics related to the sourcing of raw materials and the environmental impacts of production processes, while in the technology and communications sector, it might focus on energy consumption and the carbon footprint of data centres. The sector-specific guidance also includes illustrative

63 https://www.gov.uk/government/publications/sustainability-disclosure-requirements-implementation-update-2024
64 https://www.sec.gov/files/rules/final/2024/33-11275.pdf
65 https://www.grantthornton.com/insights/articles/esg/2023/mandatory-climate-reporting-is-here-are-you-ready
66 https://www.cover.co.za/news/draft-guidance-notes-for-banks-and-insurers-on-climate-related-risks-and-disclosures

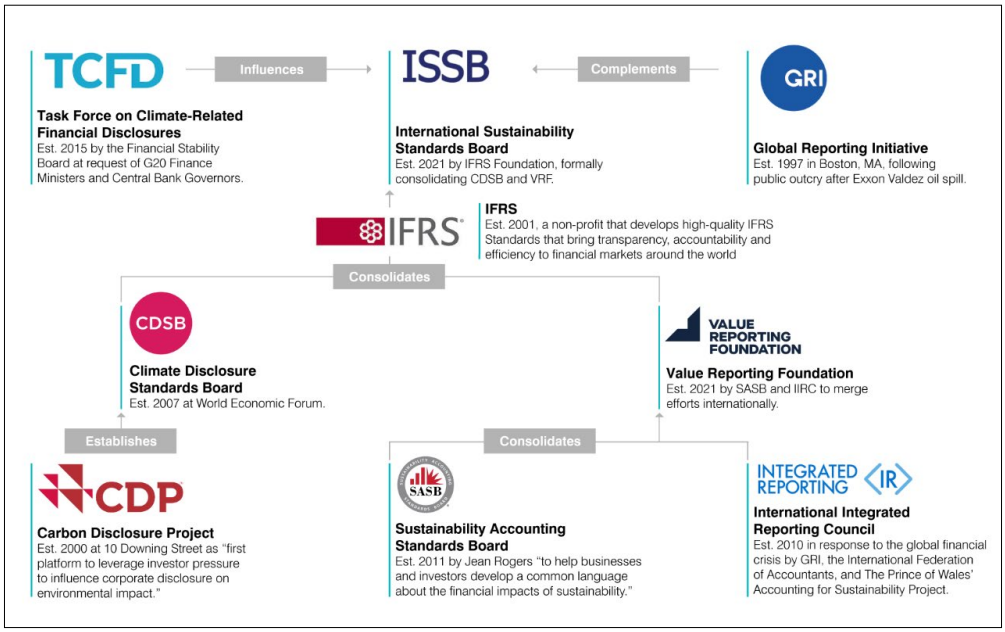

Figure 10. ISSB synergies with other global sustainability reporting frameworks (Source: Auditboard Inc)[67]

examples to help entities understand how to apply the disclosure requirements practically. These examples serve as a reference for developing industry-specific disclosures (ISSB, 2023).

9.1.4 The standard outlines core content areas that must be addressed in disclosures, including governance, strategy, risk management, and metrics and targets. Specifically, the standard mandates the disclosure of specific metrics and targets related to climate-related risks and opportunities: Entities must disclose information on GHG emissions, covering scopes 1, 2, and 3, including the measurement approach, inputs and assumptions used.

9.1.5 Entities must also disclose metrics related to transition risks, physical risks, emissions reductions and climate-related opportunities. For example, companies must report the amount and percentage of assets or revenues that are vulnerable to transition risks, such as regulatory changes aimed at reducing carbon emissions, as well as physical risks, such as the potential for damage from extreme weather events. This requirement ensures that stakeholders can assess the potential financial impact of these risks on the organisation and understand the company's exposure to different types of climate-related risks.

9.1.6 Targets set to mitigate or adapt to climate risks must include details on the metrics used, the base period, milestones and whether the target is absolute or intensity-

67 https://www.auditboard.com/img/blog/ISSB-consolidation.png

based (i.e., whether the target is defined as the total amount (or change in the total amount) of a given measure, or whether the target is defined as the ratio (or change in the ratio) of that measure to a business metric). For example, a company might set a target to reduce its GHG emissions by 30% by 2030, using 2020 as the base year. The company would then need to disclose the metrics used to track progress toward this target, such as the annual reduction in emissions, as well as any interim targets or milestones along the way.

10. OVERVIEW OF CURRENT AND EMERGING REGULATORY BODY DEVELOPMENTS

10.1 The issuance of reporting standards reflects the global regulatory response to increased climate risk. The Financial Stability Board (FSB) notes that a more consistent global approach to addressing climate-related risks will help to better assess and mitigate financial vulnerabilities. As part of its 2022 report, the FSB sets out recommendations to be incorporated in global supervisory and regulatory approaches including:

- Authorities need to accelerate identification of information needs for supervisory and regulatory purposes to address climate-related risks and work towards identifying, defining and collecting climate-related data and key metrics that can inform climate risk assessment and monitoring.
- Supervisory oversight, internal audit reviews and third-party verifications could enhance the reliability of data and prevent greenwashing.
- Common definitions for physical, transition, and liability risk should be considered across jurisdictions and sectors.
- Authorities should start with qualitative and available quantitative information and move towards regular standardised reporting requirements.
- Authorities should consider the system-wide impact of climate-related risks and use scenario analysis and stress testing for macroprudential purposes.
- Scenario analysis and stress tests should include physical and transition risks, key financial sectors, interdependencies and feedback loops, and a system-wide perspective.
- Future exercises should also consider other financial risks such as liquidity and insurance risk and use the NGFS scenarios as appropriate.
- Authorities within a jurisdiction should cooperate and coordinate to inform a system-wide view of climate-related risks and conduct joint exercises if possible. Global coordination and cooperation towards common reporting frameworks would also help understanding of the impacts of climate-related risks. (FSB, 2022)

10.2 The International Association of Insurance Supervisors (IAIS) issued their final of four public consultations (in July 2024) as part of their work in promoting a globally consistent approach and addressing any gaps in the global framework of insurance supervision. In summary, the four consultations covered the following:

- The first consultation proposed changes to the Insurance Core Principles (ICP) to position climate risk within the global framework for insurance supervision and discuss whether changes were required to existing supporting material related to governance, risk management and internal controls.[68]
- For the second consultation, two papers were proposed covering market conduct and scenario analysis. The paper of climate risk market conduct aimed to help supervisors to identify instances of potentially unfair treatment of consumers that emerge in relation to natural catastrophe protection products or sustainability-focused products (for example through greenwashing). The paper on climate risk scenario analysis covered how it can be used as a tool for supervisors and insurers to understand the risks to which the insurance sector is exposed as well as how scenario analysis exercises should be used.[69]
- The third consultation covered proposed changes to selected ICP guidance to cover climate risk as it relates to corporate governance, risk management, internal controls, valuations of assets and liabilities for solvency purposes, investment activities of insurers and insurers' enterprise risk management frameworks.[70]
- The latest consultation proposes two sets of supporting material covering issues related to supervisory reporting and public disclosure, as well as macroprudential considerations and supervisory cooperation. The former provides supervisors with advice in developing supervisory reporting and public disclosure regimes and how this may be tailored to the individual needs of respective jurisdictions. The latter provides advice, illustrations, recommendations and examples of good practice on how macroprudential supervision be implemented in the context of climate-related risk drivers (including the need for climate risks to be embedded in group-wide supervision of insurers).[71]

10.3 European regulators continue to lead in supervising climate risks. The European Central Bank (ECB) has comprehensive guidelines for banks on managing and disclosing climate-related risks and conducts climate stress tests and scenario analyses with the intention to step up its focus in climate change in 2024 and 2025.[72] The European Systemic Risk Board (ESRB) is developing various frameworks for relating climate risks to financial stability covering financial stability risk surveillance, macroprudential policy options and broader risks relating to nature that are expected to be exacerbated by climate change (ECB

68 https://www.iaisweb.org/2023/03/public-consultation-on-climate-risk-supervisory-guidance-part-one/
69 https://www.iaisweb.org/2023/11/public-consultation-on-climate-risk-supervisory-guidance-market-conduct-and-scenario-analysis/
70 https://www.iaisweb.org/2024/03/public-consultation-on-climate-risk-supervisory-guidance-icp-guidance-and-supporting-material/
71 https://www.iaisweb.org/2024/07/public-consultation-on-climate-risk-supervisory-guidance/
72 https://www.ecb.europa.eu/press/pr/date/2024/html/ecb.pr240130~afa3d90e07.en.html

& ESRB, 2023). The European Securities and Markets Authority (ESMA) is working on dynamic climate risk modelling and assessing the financial impacts of greenwashing and sustainability claims.[73] Similarly the Financial Conduct Authority (FCA) in the UK has introduced the Sustainability Disclosure Requirements,[74] and the Bank of England has begun biennial climate stress tests.[75] Similar developments have been observed across the United States, Australia and Asia.

10.4 The impact of climate risk on existing risk-based financial regulations such as Basel and Solvency II also needs to be considered. EIOPA notes that Solvency II covers management of climate risks alongside other risks faced by insurers through the requirement to integrate sustainability risks as part of risk management and governance structures. EIOPA is however investigating the potential for sustainability risk differentials (green, non-green and brown) between (green, non-green and brown) assets and reassessing the appropriateness of the scope and calibration of parameters underlying the standard [76]

10.5 As regulatory frameworks and standards continue to develop, the role of assurance in climate risk reporting will become even more significant. The FSB further notes that the main objectives of a global assurance framework are to enhance the quality and reliability of sustainability-related information through third-party assurance, with compliance and enforcement of high-quality assurance requirements being a key deterrent to greenwashing. The International Auditing and Assurance Standards Board (IAASB) and the International Ethics Standards Board for Accountants (IESBA) are working on and have made substantial progress towards a global set of assurance, ethics and independence standards. The FSB notes the challenges in assessing reliability of climate information for both preparers and assurance practitioners given that existing data sets may be immature, and calculations may require significant judgement and have a high degree of estimation uncertainty. (FSB, 2023b)

11. AREAS OF ACTUARIAL INVOLVEMENT

11.1 Actuaries are currently active throughout the financial regulation and reporting chain. This presents a natural extension of existing roles to make a contribution towards more robust, consistent and transparent reporting on climate risks and opportunities.

73 https://kpmg.com/xx/en/home/insights/2024/02/esg-regulatory-essentials.html
74 https://www.gov.uk/government/publications/sustainability-disclosure-requirements-implementation-update-2024
75 https://www.bankofengland.co.uk/stress-testing/2022/results-of-the-2021-climate-biennial-exploratory-scenario
76 https://www.eiopa.europa.eu/publications/solvency-ii-leading-way-managing-sustainability-risk_en

11.2 As noted in other Sections of this paper, actuaries are able to contribute across risk management, strategy and modelling relating to climate risks, GHG emissions and opportunities, and are consequently able to report on these areas (i.e., completion of qualitative and quantitative disclosures). Much like the existing roles in valuations or technical provisioning within the financial services space, actuaries have experience disclosing matters relating to data used, key assumptions, methodology choices and areas of judgement, all areas the FSB recognises as a challenge for climate-related matters.

11.3 Actuaries are also able to assess compliance of companies with regulatory and financial reporting requirements (e.g., providing assurance on compliance with the IFRS S2 standards, conducting a review and providing recommendations on integration of climate risks as part of the risk management process, checking compliance of calculations underlying estimates with standards like the GHG protocol for emission quantification). This is also an extension of actuaries' current role in performing audit procedures on estimates that are subject to uncertainty and judgement.

11.4 As organisations work to comply with evolving regulations, actuaries can provide valuable advisory services. This includes performing gap analyses of current reporting processes relative to mandated requirements (e.g. TCFD or IFRS S2) and assisting in developing compliance roadmaps. Actuaries can help organisations manage the risks associated with non-compliance and recommend steps to achieve compliance. This might include suggesting improvements to data collection processes, enhancing the transparency of disclosures, or developing new models to better assess climate risks.

11.5 In addition to gap analysis, actuaries can provide ongoing regulatory advisory services to ensure that organisations remain compliant with both IFRS S2 and other relevant climate-related disclosure standards. This includes staying informed about changes in the regulatory environment, interpreting the implications of new regulations, and advising on strategies to meet evolving compliance requirements.

11.6 The IAA also notes that actuaries as members of a professional body must meet high standards of conduct, qualification, and practice. Additionally, they are subject to monitoring by professional colleagues and disciplinary procedures and hence supervisory authorities can rely upon actuaries' experience, training and professional integrity (IAA, 2002). Therefore, actuaries can support financial regulators or supervisors with the design and implementation of their climate-related supervisory frameworks, which cover:

— Building internal expertise of supervisors by providing specialised training on climate risk (its impact as well as potential innovative solutions). This can include running wider awareness campaigns (on insurance and other financial products) to improve financial inclusion and literacy (Access to Insurance Initiative (AII), 2019).

— Design and standardisation of data collection requirements and metrics for supervisory monitoring.
— Development and standardisation of industry guidance based on best-practice global frameworks both in general and for the actuarial profession operating within specialist areas (e.g., guidance on greening investment portfolios, developing innovative products).
— Design of stress tests and scenario testing to be incorporated as part of supervisory measures. This also includes modelling industry-wide impacts of climate risks including under various scenario pathways.
— Supporting regulators in performing risk and feasibility studies and developing clear regulation for the purposes of approving new financial products and/or distribution channels (e.g., parametric insurance).
— Modelling required for the recalibration of standard formulae used for prudential capital requirements including performing industry impact analyses covering the implications of revised capital calibrations and/or change in formulaic construct (such as the impact on solvency, future industry resiliency, costs, and operations).

12. GOVERNMENT

12.1 Overview of government's role in climate change

12.1.1 The Council on Foreign Relations, a US-based think tank, summarises seven ways in which governments are responding to climate change:[77]

— Carbon taxes linked to corporate GHG emissions, with the revenue being used to pursue climate change mitigation and adaption such as paying for social programmes, investing in clean energy and reducing taxes for the public.
— Cap and trade systems designed to limit GHG emissions in a city or country, by capping emissions for companies (through their allocated permits) who in turn can trade permits with other companies to produce more emissions.
— Clean energy standards requiring or encouraging utility companies to generate a certain percentage of their electricity from low-emitting sources such as solar or wind power.
— Participation in international agreements such as the Paris Agreement which encourages participating countries to submit their National Determined Contributions (NDCs), in turn determining their domestic mitigation and adaptation measures to achieve their NDC. This also includes the establishment of international funding like the Green Climate Fund to assist developing countries with climate change adaptation and mitigation activities.
— Determination of adaptation policies aimed at making countries less vulnerable to climate-related disasters.

77 https://education.cfr.org/learn/reading/how-do-governments-combat-climate-change

— Investment in new technologies such as renewable energy, nuclear energy, carbon capture and geoengineering as part of decarbonisation and adaptation efforts.
— Efforts to minimise financial risks by implementing policies to prepare for climate-related economic shocks (e.g., climate-change related regulation for financial institutions like banks and insurance companies).

12.1.2 Enacting these changes and policies will necessitate alterations in infrastructure, business conduct and consumer habits. This encompasses initiatives like transitioning from personal vehicles to public and active transportation, developing cities with low carbon footprints that are habitable, opting for revised agricultural and consumption practices, enhancing material efficiency and recycling efforts, employing circular economy concepts, and equipping present and forthcoming employees for jobs in the green economy (World Bank, 2023).

12.1.3 However, the 2023 Production Gap Report highlights that, in aggregate across 20 of the major producer countries (comprising 82% and 73% of global fossil fuel production and consumption respectively), governments still plan to produce more than double the amount of fossil fuels in 2030 than would be consistent with limiting warming to 1.5°C. At the current rate, countries would require near total phase out of coal production use by 2024 and reduction in oil and gas production by 75% by 2050 (from 2020 levels). This highlights the need for greater transparency on plans and projections to support fossil fuel reduction as well as adopt near- and long-term reduction targets (SEI et al., 2023).

12.1.4 Implementing climate policies to enable the faster response required is inherently complex, intertwining political, economic, social, and technical elements. Testament to the complexity, the World Bank has noted a total of 4500 climate policies introduced globally over the past three decades, not all of which have been effective. Key drivers of the complexity include unique national considerations (e.g., political system, industrial structure), obtaining both political and public buy-in (i.e., ministries, regulators, private sector and civil society), capacity at various levels of government, characteristics of vulnerable populations and just transition considerations, ability to transition to new technologies and infrastructure, and effective coordination with global partners and players (World Bank, 2023).

12.1.5 Actuaries operating in the public sector have also highlighted challenges faced by public sector entities in implementing TCFD recommendations, citing the lack of public sector guidance and widespread adoption, limitations on being able to flex remuneration packages in the public sector to reflect climate-related performance metrics, as well as political shifts in priorities.[78]

78 https://actuaries.blog.gov.uk/2024/01/11/adopting-tcfd-recommendations-in-the-public-sector-part-2/

12.2 Areas of actuarial involvement

12.2.1 The prior section highlights the complexity of the considerations required in setting climate-related national policy. Lusani Mulaudzi, a public interest actuary within the ASSA, notes that actuaries have a critical role in public interest by conducting research and performing cost-benefit analyses that inform policy decisions relating to areas such as energy supply and demand modelling, social security and community impact. The IAA further notes its support of the development of public policy providing an illustration of areas where they do and can contribute. This has been considered as part of the potential areas of involvement noted below.[79]

12.2.2 The IAA also notes that actuaries have a key role in guiding stakeholders, such as policymakers, through decisions related to adaptation and mitigation. Utilising data and scientific research from experts like climate scientists and engineers, actuaries can apply their expertise in risk assessment under uncertainty to deliver useful information for decision-makers at different levels, including businesses, government bodies, regulators and rating agencies. We can pinpoint and measure the potential for adaptation using methods like before-and-after studies, even with limited historical data. Additionally, our adeptness in scenario analysis is an asset in the decision-making process (IAA, 2023).

12.2.3 Actuaries, in tandem with a multidisciplinary team of specialists can assist in objectively informing and implementing government policy. This could include:

— Performance of risk-based evaluation of climate and disaster risks and driving effective and efficient risk mitigation and adaptation. This includes assessment of economic, environmental and social costs associated with natural disasters across various levels (e.g., national, regional, provincial, municipal, etc).
— Assistance in setting up relevant metrics and a framework to conduct on-going monitoring of the effectiveness of risk mitigation and/or adaptation policies in place.
— Development of models covering multi-sectoral impacts, integrating stochastic and forecasting elements to enable scenario modelling and assessment of long-term impact of policy decisions e.g. impact of implementing minimum energy usage targets from renewable sources.
— Use of models developed to identify vulnerable sectors and communities to inform decisions relating to issues such as regulatory reform, allocation of funding and sufficiency of social security support.
— Use of models and projects to develop key metrics and targets for achieving policy objectives and cascading national objectives for implementation by relevant government departments.
— Integrate consideration of climate and disaster risks within national construction codes and land use and long-term planning (e.g., as part of feasibility assessments for long-term infrastructure projects). This could include consideration of consistency

79 https://actuaries.asn.au/Library/Brochure/2020/ClimateChangePolicyPosition20.pdf,

between how risk is measured and monitored for government departments in comparison to that implemented in building codes or other regulations to facilitate enforcement and monitoring.

— Engagement with policymakers to understand their needs and assist in identifying and defining the problem statement and required analysis for decision-making and/or performing a cost-benefit analysis. This would include designing the required research, result or outcomes, risks, time horizon and data that would be required for modelling purposes.

— Performance of cost-benefit analyses of mitigation and adaptation strategies against climate and disaster risks, including wider impacts such as household and business financial security, health, environmental and social impacts (e.g., impact of projected energy mix on energy supply and demand. This could contribute towards assisting with budgetary allocation between mitigation versus adaptation action).

— Involvement in the modelling of economic, environmental, and social impacts associated with various public-private partnerships such as disaster response, adaptation education providers in meeting risk management and financial criteria.

— Addressing the issue of insurance affordability and availability. This relates to both the existing protection gap and further widening due to increased frequency of climate and disaster events. This could include exploration of potential options available to increase cover to vulnerable communities. Such examples could include assessing the feasibility of national insurance schemes, partnering with insurers to provide low-cost insurance or parametric cover, costs of insurance versus building adaptation measures in vulnerable communities, design and valuation of national catastrophe bonds.

— Use of actuarial funding or reserving techniques to mitigate the uncertainty associated with the cost and timing of climate disasters, ensure that sufficient funding is available given the trajectory of climate-related disasters, inform efficient allocation of funds for the purposes of risk mitigation versus investment into mitigation and/or adaptation projects.

— Assistance in formulating investment strategy, investment policy, asset valuation and decisions as described in Section 7.

— Modelling the longer-term impacts of climate change (such as reduced air quality and increased heatwaves) on mortality, morbidity and consequently the expected impact on the public and private health systems and sufficiency of social security support.

— Communication of the financial and economic implications from the range of analysis to policymakers in an accessible manner.

13. CARBON FOOTPRINT IN PRODUCT DEVELOPMENT

13.1 Overview of current and emerging market practice

13.1.1 A significant portion of a product's environmental impact is not only in the use of the product, but through its production, transportation and disposal. This led to the concept of a Life Cycle Assessment (LCA) (Guinée et al., 2011). An LCA is defined as "the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product through its life cycle" (ISO 14040, 2006).

13.1.2 Product carbon footprints (PCF) are a subset of the LCA, the accounting of which (as defined in the GHG Protocol Product Life Cycle Accounting and Reporting Standard) follows the approach set out in the International Organization for Standardization (ISO) 14040 series of life cycle assessment standards. The PCF only allows for GHG emissions and removals that occur during a product's life cycle and hence does not cover the full environmental performance of a product (e.g. impact on water) (WRI & WBCSD, 2011).

13.1.3 The benefits of an LCA (Curran, 2006) can similarly be extended to conducting a PCF assessment which enables manufacturers and companies to:

— obtain a systematic and consistent evaluation of the emissions profile across their products (including that of competitors);
— enable the establishment of key performance indicators (KPIs) to facilitate the monitoring, reporting and reduction in emissions; and
— weigh the trade-offs and refine elements (e.g., costs, reputational, emissions, product design, compliance) associated with one or more specific products, processes, suppliers, and customers over the product life cycle.

13.1.4 A study comparing the product life cycle carbon footprint across 866 products from a wide range of industry sectors and 145 companies in 28 countries (mainly from the United States, Canada, Europe and Japan), as disclosed in Climate Change Questionnaires under the Carbon Disclosure Project (CDP), noted the following observations (Meinrenken et al., 2020):

— carbon intensity of products within sectors denoted significant variability indicating that sector-level understanding of a product is not sufficient to understand and quantify emissions (and hence product and company specific information is necessary);
— a detailed understanding of the product's life cycle covering upstream and downstream processes was correlated with steeper reported reduction achievements; and
— a notable proportion of the companies with reported changes (approximately 33%) had noted changes in their product life cycle emissions due to updates in LCA methodology and/or model parameters reflective of the self-reported nature of the statistics and expected improvement as companies build on their existing methodology and request external audit of the results.

13.1.5 Figure 11 summarises the key steps to estimating the PCF based on the GHG Protocol Product Life Cycle Accounting and Reporting Standard (Note: this assessment is more focused on a product-level assessment of emissions as opposed to emissions reporting at a corporate-level which is discussed in Section 3.1.4:

13.2 Areas of actuarial involvement

13.2.1 The process in Figure 11 bears resemblance to a conventional actuarial valuation process, allowing leverage of key skills such as data and statistical analytics, risk assessment and modelling in the following areas:

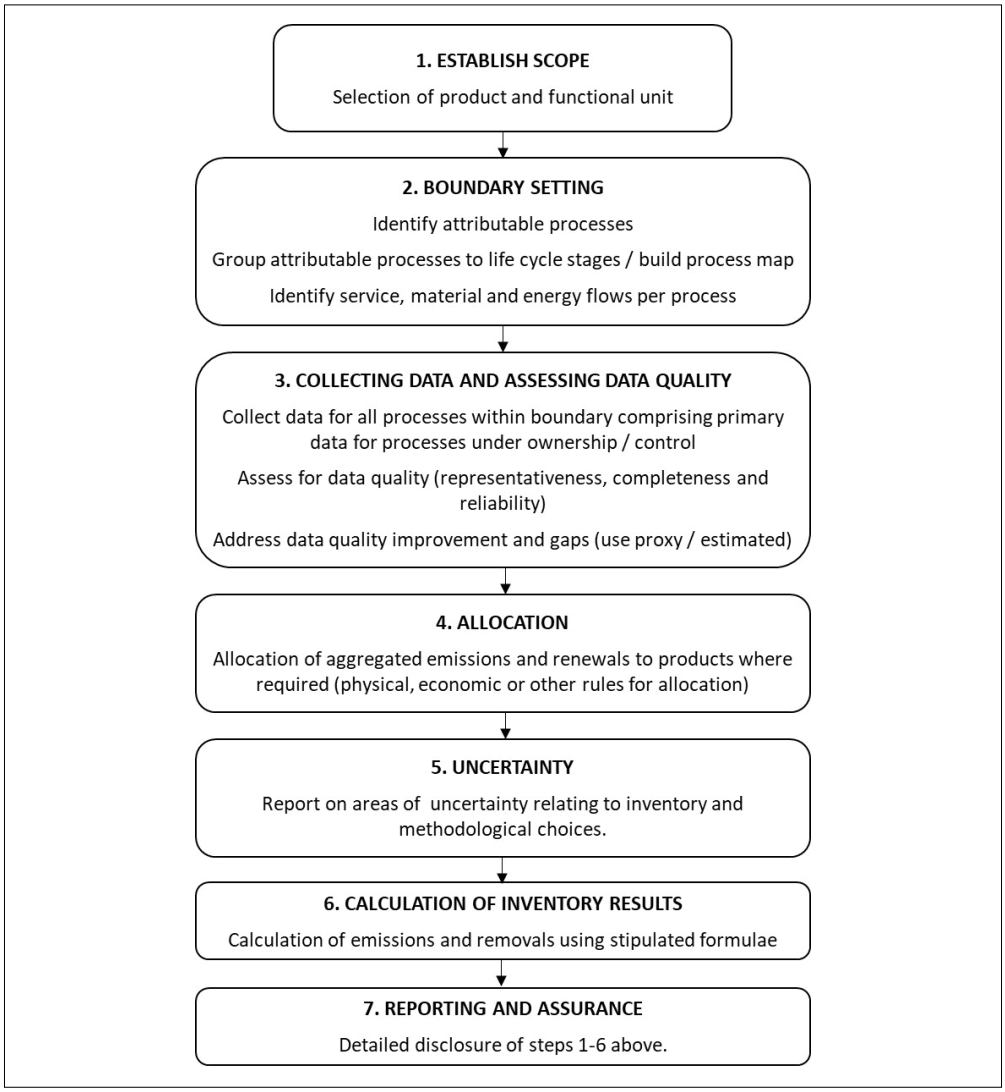

Figure 11. Approach to PCF calculation (WRI & WBCSD, 2011)

- Application of data validation techniques (e.g., anomaly identification, multiple source checks, qualitative review, etc.) to assess the accuracy, completeness and appropriateness can be extended to data relating to each process such as materials and energy flows per process. This can extend to the application of data governance principles which would include establishing a process for data sourcing, extraction, validation, adjustments, and review, allowing for an iterative process to data quality improvement. (See also commentary in Section 3.2 on data-related involvement.)
- Determination of appropriate rules for the disaggregation of data to the relevant processes and, depending on the nature of the allocation required, selection and testing of suitable proxies.
- Model building to implement the emission calculations as specified in the GHG protocol (see Section 4.2 for further commentary). This also creates a base to develop and implement model governance principles which would include elements such as ensuring appropriate in-built controls throughout the calculations, sense-check on results (for example, across products within a company or other industry players) and independent validation of results.
- Incorporation of stochastic elements into the PCF estimation model to capture areas of risk and uncertainty. This can be used to perform various analyses to inform decision-making such as:
  - the extent of potential emission variability across products (e.g., lower emission variability would be favoured over higher variability as part of product design)
  - likelihood associated with various outcomes i.e. carbon intensity is above an internally set threshold
  - elements of the processes that are significant contributors to variability or where results exhibit higher sensitivity to variations in assumptions (e.g., there may be greater uncertainty on supplier raw material extraction methods increasing emission uncertainty)
  - allowance for correlations within processes across products
- Incorporation of projection elements into the PCF estimation model that can be used to quantify expected carbon intensity of products, reverse stress testing to identify scenario reductions expected to be achieved or not achieved, model expected PCF for new or planned products.
- Perform cost-benefit analysis to evaluate the potential implications of emission reduction strategies (e.g. low-carbon technologies, changes in suppliers, etc) on current and projected PCF measures.
- Use of stochastic and projection elements from the PCF estimation to inform future business or product strategy as part of the company's wider decarbonisation targets (informed by scenario analyses and cost-benefit analyses).
- Assistance in the documentation and preparation of the reporting on emissions

including details on data, key assumptions, methodology and areas of uncertainty and judgement.

— Assistance in communicating results of emissions modelling performed with key stakeholders (e.g., decision-makers across the business value chain, Board of Directors etc.) and vendors (e.g. as part of procurement discussions).

13.2.2 While the above involvement can be extended across a wide range of industries, coordination with other industry specialists and decision-makers across the end-to-end business value chain is imperative to ensure that relevant expertise and understanding of the process is incorporated into any decisions and/or judgements underlying the data, assumptions and methodologies used in modelling.

14. OTHER AREAS OF CORPORATE SUPPORT

14.1 Mergers and acquisitions (M&As)

14.1.1 Given the systemic nature of climate risks and increasing number of industries becoming subject to regulation and/or legal action, there is an increasing need for buyers and sellers to understand the potential impact of climate change on businesses and anticipate developments. There is also no set approach for assessing climate risk in a transaction where each entity requires a preliminary assessment of its risks, with consideration of factors such as materiality of various climate risk types, applicable regulation, and customer and investor profile and activism.[80]

14.1.2 However, climate change should not only be viewed through a risk mitigation lens but also as an opportunity to create long-term value, with 53% of private equity respondents choosing not to pursue a deal on the basis of ESG factors, and 32% stating that ESG is a primary driver of value creation, according to PwC's 2023 Global Private Equity Responsible Investment Survey.[81]

14.1.3 Actuaries are therefore able to contribute to the assessment of climate risks and opportunities in M&A engagements through the following:

— review of the target company's processes of integration of climate risk into its existing risk management processes, highlighting any material gaps;

— review of the target company's approach and models used for climate risk quantification, emissions measurement, and overall scenario modelling for reasonability, filling any observed gaps through independent calculations;

— review of integration of climate risks into the relevant asset and liability valuations contained in the balance sheet (e.g., assessing the fair value of long-dated instruments that are exposed to climate risk);[82] and

80 https://www.lexisnexis.com/community/insights/legal/practical-guidance-journal/b/pa/posts/climate-change-considerations-in-m-a-transactions-219770921

81 https://www.pwc.com/us/en/services/esg/m-and-a-value-creation.html

82 https://www.grantthornton.co.uk/insights/accounting-for-climate-risk-in-balance-sheet-valuations/

— review and quantification of the link between plans to manage risk and the impact of forecasted profits.[83]

14.2 Insurance cost optimisation

14.2.1 Rising insurance costs experienced by companies has been a consequence of rising frequency and severity of claims driven by factors such as inflation, natural catastrophes, and geopolitical tensions.[84] As an example, businesses in the UK were expected to see rises of 10 to 20% in the cost of their annual insurance bill in 2022.[85]

14.2.2 While actuaries within insurance companies are already working on implementing pricing and risk mitigation strategies as well as product innovation to address the challenges of rising costs for insurers, they can also play a role in assisting corporates as part of their annual placement and/or renewal of insurance cover in the context of climate risk and related factors. This would include assisting corporates to demonstrate the effectiveness of risk mitigation measures across their business (e.g., business interruption plans in event of climate events), using relevant data from the business to support a lower risk profile (e.g., on-site incident of heat-related incidences on record temperature days) and explore feasibility of self-insurance (e.g., captive insurance).

15. FINANCIAL INSTRUMENT ISSUANCE

15.1 In July 2022, the European Central Bank announced its incorporation of climate change considerations into its purchases of corporate sector securities with the intention to gradually decarbonise its corporate bond holdings by increasing holdings in companies with better climate performance. The climate scoring approach would consider the issuers past GHG emissions, credibility and ambitiousness of targeted emissions as well as quality of climate disclosures (e.g., completeness and verification by third parties).[86] Additionally, a study performed on US public non-financial companies indicates that companies with poor environmental performance, including having a more significant carbon footprint, are associated with lower credit ratings and high bond yield spreads, particularly when located where stricter environmental regulations exist (Seltzer et al., 2022).

15.2 Given the increased focus on the consideration of ESG factors relating to issuance of corporate financial instruments, actuaries would be able to assist with the supporting analysis to quantify and report on a corporate's climate performance.

83 https://www.grantthornton.co.uk/insights/accounting-for-climate-risk-in-balance-sheet-valuations/
84 https://www.insurancejournal.com/news/international/2023/11/28/749767.htm
85 https://www.pwc.co.uk/press-room/press-releases/double-blow-for-business-as-rising-insurance-costs-pushes-up-ann.html
86 https://www.ecb.europa.eu/mopo/implement/app/html/ecb.faq_cspp_climate_change.en.html

16. STRATEGIC WORKFORCE PLANNING

16.1 The Climate Change Committee (CCC) in the UK performed an analysis of the impact of net zero on workers and skill needs in the UK. Some key observations included:

— Changes in the workforce are necessary to create new low-carbon market and transform processes, products and supply chains from high to low carbon.
— Net zero is required to take place in the context of a labour market that is constantly evolving, driven by trends of automation, digitalisation and changing immigration systems.
— Workers currently employed in sectors that have a core role in delivering net zero will be the most impacted. While this is around one fifth of workers in the UK, the proportion of workforce would vary widely globally depending on local sector concentrations.
— While some jobs are expected to be phased out in high-emitting sectors, it is possible that more jobs will be created through sectors such as construction, renewable energy generation and electric vehicles. The potential growth in new sectors is, however, not guaranteed and would require active reskilling and upskilling of the workforce and management of international competition.
— The transition creates a range of opportunities including job creation and diversifying/transforming the workforce though this needs to be managed to ensure a just transition (CCC, 2023).

16.2 Strategic workforce planning is therefore a key component of a company's overall transition strategy. Actuaries can assist in the analysis and modelling of current and future workforce supply and demand, required capabilities and the business's capacity to achieve the enhancements to the workforce required to meet its wider business and financial responses to climate change. This could include putting in place processes to measure and monitor progress against workforce transformation goals as part of a company's sustainability reporting and to drive business decisions.[87]

17. RESTORATION INSURANCE SERVICE COMPANIES

17.1 Restoration insurance service companies (RISCOs) are social enterprises that typically partner with local communities in conservation and restoration efforts (e.g., flood reduction benefits through mangrove conservation).[88] RISCOs typically contract directly with insurance companies in return for an annual fee for continued conservation and/or restoration efforts, where payment is linked to the site-specific flood reduction benefits.[89]

87 https://www.pwc.co.za/en/services/people-and-organisation/workforce-capability.html
88 https://napglobalnetwork.org/innovative-financing/restoration-insurance-service-companies
89 https://www.climatefinancelab.org/ideas/restoration-insurance-service-company-risco/

17.2 Actuaries can assist in bridging the relationship between RISCOs and insurance companies in identifying alternative services that can be provided, for example, wildfire adaptation (creation of fuel breaks) or restoration (protection of fire refugia, creating physical conditions for regeneration). This can also include assessing and modelling the impact of risk reduction to the insurance company, and calculating appropriate compensation to the RISCO that reflects the extent of risk reduction over the long periods of time.

18. WAY FORWARD

18.1 Enhancing the actuarial skillset and engaging on climate-related issues

18.1.1 The evolving landscape of climate change presents new challenges and opportunities for actuaries, necessitating the acquisition of additional technical and other skills. As actuaries increasingly engage with climate risk assessment and sustainability initiatives, there is a growing need for expertise in areas beyond traditional actuarial competencies.

18.1.2 Climate-related work requires a minimum level of understanding of climate science and climate change. An understanding of climate science is essential for building and interpreting climate models, in order to assist organisations to make informed decisions. However, as noted by Schiller & Crugnola-Humbert (2022), actuaries are not expected to become climate experts. Sharanjit Paddam reiterated this message noting that actuaries are, however, required to understand how climate-related events impact companies. The multifaceted nature of climate risk requires actuaries to collaborate across various disciplines, including environmental science, engineering, and economics. Schiller & Crugnola-Humbert (2022) emphasise the need for actuaries to work closely with experts from these fields to develop consistent climate scenarios and interpret their results. This interdisciplinary collaboration is essential for developing a holistic understanding of climate risks and their potential impacts on financial and insurance markets.

18.1.3 Traditional actuarial models, which rely heavily on historical data, are likely inadequate for predicting future climate-related risks. Taylor (2023) highlights the limitations of traditional financial models in capturing the complexities of climate-related risks, which are characterised by significant uncertainties. As discussed by Reddy & Thomson (2015), there is a need to develop actuarial tools that are specifically aimed at assessing environmental risks.

18.1.4 Graham Hall suggested the following top three skills he considers important in hiring someone for a climate risk modelling role:

— familiarity or experience working with climate scenarios;
— risk management experience (i.e., base knowledge of risk processes and frameworks); and
— experience in building complex financial models.

18.1.5 A significant challenge in actuarial modelling is the current lack of technical expertise to translate potential future climate scenarios into financial variables that can be incorporated into models (Wason et al., 2020). As a result, there is a growing need for actuaries to acquire proficiency in climate modelling. This involves the use of advanced statistical and data modelling techniques, including machine learning, big data techniques, predictive analytics, and integration of climate scenarios in scenario analyses and stress testing. These skills enable actuaries to analyse large and complex climate datasets, including those related to weather patterns, carbon emissions, and energy consumption. Actuaries are also able to develop more accurate risk models that account for the potential impacts of climate change.

18.1.6 In addition to technical skills, actuaries must develop competencies in sustainability reporting and ESG metrics. This involves:

— The ability to understand, interpret and implement the frameworks and standards used in sustainability reporting, such as the TCFD, the GRI, and SASB.
— Understanding green finance instruments, such as green bonds and climate risk insurance products, and integrating ESG considerations into investment strategies such as those outlined in UNPRI (2020).
— Familiarity with carbon accounting and the implications of carbon pricing mechanisms for evaluating the financial impacts of regulatory changes and market shifts.
— Familiarity with concepts such as sustainable finance to provide comprehensive risk assessments and advice on integrating environmental considerations into business strategies and governance structures (Gelmini & Vola, 2022).

18.1.7 Actuaries must also develop an understanding of regulatory requirements related to climate risk. This includes familiarity with local and international regulations that mandate the reporting and management of climate risks. Staying updated with these regulations ensures that actuarial practices align with legal standards and contribute to broader sustainability goals. This knowledge is critical for informing risk assessment and management strategies and to ensure that actuaries are well-positioned to advise clients on regulatory risks and opportunities.

18.1.8 Outlined below are practical steps actuaries can take to deepen their understanding of climate-related risks and incorporate this knowledge into their work:

— Actuaries should start by familiarising themselves with the basics of climate science and the potential impacts of climate change. This includes understanding key indicators such as global temperature rises, sea level changes, and the frequency of extreme weather events. This can be achieved through attendance and participation in climate-related webinars, workshops, and pursuing online courses and certifications that may be specifically tailored for actuaries or other risk professionals. For example, The IFoA offers a Climate Risk and Sustainability

course.[90] Additionally, several actuaries, both locally and internationally, have completed GARP's Sustainability and Climate Risk qualification[91] or the CFA Institute's Climate Risk, Valuation and Investing Certificate.[92]

— Engaging with materials from the IPCC can provide foundational knowledge. Obtaining certifications such as the Chartered Enterprise Risk Actuary (CERA) designation can enhance expertise in understanding and managing climate-related risks.

— Building networks and collaborating with experts in climate science and related fields will assist actuaries in enhancing their climate knowledge. This can be achieved through participation in interdisciplinary forums, professional associations and working groups. For example, actuaries can work on projects that involve collaboration with environmental scientists and other experts or join or form climate change working parties within their professional organisations and with other non-actuarial organisations to share knowledge and develop best practices.

— Climate-related disclosures and risk management requirements are becoming more stringent globally. Actuaries should stay informed about reporting regulations and the implications this has on their work.

— Actuarial professional bodies (e.g., ASSA, IFoA etc) also play a key role in accelerating actuaries' understanding of climate science and the integration of climate-related risks into actuarial work. Butt et al., (2012) stress the importance of updating the actuarial curriculum to equip actuaries with the necessary skills to tackle emerging topics. This includes topics on climate risk assessment and environmental economics.

18.1.9 Nick Spencer, previous chair of the IFoA sustainability board, however notes that most actuarial practitioners in the climate and sustainability space have been self-taught (due to lack of formal education channels historically), encouraging individuals who have a passion or interest to just start learning. He further states that actuaries can start by thinking about their role or about areas they would like to support (e.g. TCFD reporting) and start by understanding the requirements and learn by doing. This must be balanced with acknowledgement of the complexity of the subject and maintenance of professionalism in addressing uncertainty. A similar sentiment was shared across majority of our interviews.

90 https://actuaries.org.uk/learn/lifelong-learning/climate-risk-and-sustainability-course/
91 https://www.garp.org/scr
92 https://www.cfainstitute.org/en/programs/climate-risk-valuation-investing

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Wendy Walford, Head of climate risk at Legal & General

ABBREVIATIONS AND ACRONYMS

ACRIFA	Africa Climate Risk Insurance Facility for Adaptation
AIA	Actuaries Institute of Australia
AII	Access to Insurance Initiative
ARC	African Risk Capacity
ASSA	Actuarial Society of South Africa
CAGR	compound annual growth rate
CCC	Climate Change Committee
CDP	Carbon Disclosure Project
CERA	Chartered Enterprise Risk Actuary
CRO	Chief Risk Officer
CSO	Chief Sustainability Officer
CSRD	Corporate Sustainability Reporting Directive (
ECB	European Central Bank
EFRAG	European Financial Reporting Advisory Group
EIOPA	European Insurance and Occupational Pensions Authority
ERM	Enterprise Risk Management
ESG	Environment, social, governance
ESMA	European Securities and Markets Authority
ESRB	European Systemic Risk Board
FAO	Food and Agricultural Organisation of the United Nations
FCA	Financial Conduct Authority
FSB	Financial Stability Board
GARP	Global Association of Risk Professionals
GDP	Gross Domestic Product
GHG	greenhouse gas
GPI	Global Reporting Initiative
IAA	International Actuarial Association
IAASB	International Auditing and Assurance Standards Board
IAIS	International Association of Insurance Supervisors
ICP	Insurance Core Principles
IEA	International Energy Agency
IESBA	International Ethics Standards Board for Accountants
IFoA	Institute and Faculty of Actuaries
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IRM	Institute of Risk Management
ISO	International Organisation for Standardisation
ISSB	International Sustainability Standards Board
LCA	Life Cycle Assessment

M&A	Mergers and acquisition
NAV	Net Asset Value
NDC	National Determined Contribution
NDSI	Nairobi Declaration on Sustainable Insurance
NDVI	Normalised Difference Vegetation Index
NFRD	Non-Financial Reporting Directive
NGFS	Network for Greening the Financial System
ORSA	Own Risk and Solvency Assessment
PatPA	Partnership on Transparency in the Paris Agreement
PCAF	Partnership for Carbon Accounting Financials
PCF	Product carbon footprints
RISCOs	Restoration insurance service companies
SARB	South African Reserve Bank
SASB	Sustainability Accounting Standards Board
SEC	Securities and Exchange Commission
SFDR	Sustainable Finance Disclosure Regulations
SMEs	Subject Matter Experts
SSPs	shared socioeconomic pathways
TCFD	Task Force on Climate-related Financial Disclosures
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNPRI	United Nations Principle for Responsible Investing
USD	United States Dollar
WBCSD	World Business Council for Sustainable Development WEFWorld Economic Forum
WMO	World Meteorological Organization
WRI	World Resources institute

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