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Collaborative insights in the public interest

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Planetary Solvency – finding our balance with nature

Global risk management for human prosperity

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Contents

IFoA and Exeter University would like to thank the members of the Planetary Solvency Technical Advisory Group for their support and valuable insight in shaping this report: Ajay Gambhir (Accelerator for Systemic Risk Assessment), Professor Erica Thompson (UCL), Professor Aled Jones (Anglia Ruskin University), Russ Bowdrey (MSCI), Jo Paisley (GARP), Doug Baird (Natwest), Laurie Laybourn (Strategic Climate Risks Initiative and Chatham House), Dr Luke Kemp (university of Notre Dame), Professor Michael Obersteiner (Oxford), Molly Jahn, Nick Silver (Callund Consulting), Hanna Williams, Dr Nicola Ranger (Oxford), Trevor Maynard (Cambridge), Willemijn Verdegaal (TREX), Mark Manning (Visiting Senior Fellow, London School of Economics and Political Science), Karen Ellis (WWF), Sir David King (CCAG), Patrick Cleary, Zack King, Stephan Harrison (Exeter), Robert Clarke (Client Earth).

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Key findings

The risk of Planetary Insolvency looms unless we act decisively. Without immediate policy action to change course, catastrophic or extreme impacts are eminently plausible, which could threaten future prosperity.

Critical observations

1. **We are part of the Earth system, which we depend on**
   - Our society and economy fundamentally depend on the Earth system which provides essentials such as food, water, energy and raw materials.
   - These ecosystem services, including climate regulation, are not substitutable, meaning they must be protected as they cannot be replaced by technology when they are gone.
   - This means societal development, wellbeing, prosperity, and economic health are intertwined with and dependent on the Earth system.
   - We need to recognise this dependence and manage our activity to be within planetary boundaries.
   - An urgent policy response is required to achieve this as our current market-led approach to mitigating climate and nature risks is not delivering.

2. **The stability of the Earth system is threatened**
   - Climate change and nature loss, driven by human activity, threaten the stability of the Earth system.
   - Impacts are already severe with unprecedented fires, floods, heatwaves, storms and droughts. If unchecked they could become catastrophic, including loss of capacity to grow major staple crops, multi-metre sea level rise, altered climate patterns and a further acceleration of global warming.
   - We risk triggering tipping points such as Greenland ice sheet melt, coral reef loss, Amazon forest dieback, and major ocean current disruption.
   - Tipping points can trigger each other, causing a domino effect or cascade of accelerating and unmanageable damage.
   - If multiple tipping points are triggered, there may be a point of no return, after which it may be impossible to stabilise the climate.

“Our society and economy fundamentally depend on the Earth system which provides essentials such as food, water, energy and raw materials.

3. Unmitigated climate change and nature-driven risks have been hugely underestimated

- Climate change impacts are materialising at lower temperatures than estimated. The severity and frequency of extreme events are unprecedented and beyond model projections.
- This is now a matter for human security with populations impacted by fires, floods, food system shocks, water insecurity, heat stress and infectious diseases.
- If unchecked, then mass mortality, involuntary mass migration, severe economic contraction and conflict become more likely.
- Severe societal upheaval could spread from vulnerable regions through our globalised socio-economic systems, driving responses such as food or water hoarding, acting as feedback loops to worsen social, economic, and political challenges.
- Our agency to mitigate climate may be progressively eroded, or derailed, as resources become constrained by the need to respond to increasingly chaotic physical and socio-political events.

4. Paris Agreement goals were not informed by realistic risk assessment, they implicitly accept high risk of crossing tipping points

- The average temperature for the last 12 months was 1.5°C above pre-industrial temperatures and the rate of warming has accelerated.
- Breaching 1.5°C risks triggering multiple climate change tipping points and every fraction of a degree increases the risk.
- There is a time lag between emissions and the warming that is experienced, meaning that unless emissions are reduced, more warming is in the pipeline.
- The Earth may be more sensitive to greenhouse gases than we thought, which means net zero carbon budgets may now be negative for the 1.5°C goal.
- Ongoing emissions and the loss of natural carbon sinks will drive further warming and more severe disruptive events globally.
- Research is required to inform actions to limit these impacts.

5. Global risk management practices for policymakers are inadequate, we have accepted much higher levels of risk than is broadly understood

- Policymakers often prioritise the economy, with their information flows focused on this. But our dominant economic model doesn't recognise a dependence on the Earth system, viewing climate and nature risks as externalities.
- Climate change risk assessment methodologies understate economic impact, as they often exclude many of the most severe risks that are expected and do not recognise there is a risk of ruin. They are precisely wrong, rather than being roughly right.
- The degradation of natural assets such as forests and soils, or the acidification and pollution of the ocean, act as a risk multiplier on the impacts of climate change and vice versa. Traditional risk management techniques typically focus on single risks in isolation, missing network effects and interconnections, underestimating cascading, compounding risks.
- Current risk management approaches fall short of the RESILIENCE principles detailed in this report for realistic and effective risk management. Consequently, policymaker risk information is likely to significantly understate the potential impact of climate and nature risks, weakening the argument for urgent action.
- These limitations mean that policymakers are likely to have accepted much higher levels of risk than is commonly realised.

> **The severity and frequency of extreme events are unprecedented and beyond model projections.**

Recommendations to mitigate risk

To mitigate the risk of Planetary Insolvency and prepare society to be resilient to those impacts which are unavoidable, policymakers must implement realistic and effective approaches to global risk management. Our recommendations are to:

1. **Implement Planetary Solvency assessments**

    - Establish independent annual risk assessments to provide clear global systemic risk information to national and supra-national governance institutions.
    - Given the level of risk to peace and security, an independent body could be commissioned to provide Planetary Solvency assessments to the UN Security Council (UNSC). These risk assessments should leverage the RESILIENCE principles detailed in this report for realistic and effective global risk management.
    - UNSC could then cascade these risk assessments, integrating them into global initiatives such as the *Pact for the Future*,[1] ensuring a structured, risk-led approach.

2. **Set Planetary Solvency limits that respect planetary boundaries**

    - Develop risk limits and thresholds to manage our activities within these.
    - Develop a range of metrics that monitor planetary health, as well as human societal indicators such as the economy, health, equity, food and water security.
    - Use the precautionary principle when faced with uncertainty, for example, to minimise likelihood of breaching tipping points.
    - Excluding risks due to uncertainty breaches the precautionary principles — a best estimate is better than no estimate at all.
    - Revisit climate goals from a risk perspective and implement a process to update carbon budgets annually, which accounts for warming experience and emissions.

3. **Enhance governance structures to support Planetary Solvency**

    - Formalise Planetary Solvency to provide relevant bodies and the public with concise, risk-led information on risk implications of failing to meet global goals. Initially this could be UNSC or a member nation of UNSC, before cascading to other relevant parties such as international financial institutions and relevant international regional forums.
    - Provide information in an easy-to-digest form, built off realistic systemic risk assessments that recognise tipping points and other non-linear risk drivers. This may help to support the achievement of other goals, for example Article 12 of the Paris Agreement around climate change education and awareness.
    - Improve transparency by reporting risk assessments publicly.

4. **Build policymaker capacity on systemic risk management**

    - Enhance policymaker understanding of ecological interdependencies, tipping points and systemic risks so they understand why these changes are needed.
    - Assess how to embed systemic climate and nature risks into the risk management processes of nation states, in line with work from the IPPR, which states: *"climate change should be a core part of national security planning"*.[2]
    - Produce a Planetary Solvency risk overlay to complement key global scientific outputs, to sit alongside the IPBES and IPCC summaries for policymakers.
    - Risk outputs should be independently produced in line with the RESILIENCE principles, without allowing signatories to veto content. Risk outputs should also identify areas for further research and commission where more information is needed.

5. Take action to mitigate risk

- Create incentives and design policies that enable societies to collaborate towards just and sustainable futures within planetary boundaries.
- Explore options to limit global warming and avoid triggering tipping points. Given the risks, uncertainties and economics, policies should be explored to:
  - Accelerate decarbonisation by reducing emissions to zero as quickly as possible, by identifying and leveraging positive socio-economic tipping cascades
  - Remove greenhouse gases from the atmosphere
  - Repair and restore damaged parts of our natural ecosystems
  - Explore further emergency action which may be required to slow global warming
  - Build resilience to worsening and inevitable climate impacts

> **Policymakers must implement realistic and effective approaches to global risk management.**

Foreword – the urgent need for risk-infomed policy

Tim Lenton
Chair in Climate Change and Earth System Science, University of Exeter

Actuaries deal with risk and uncertainty. The techniques they have developed underpin the functioning of the global pension market with $55 trillion of assets, and the global insurance market, collecting $8 trillion of premiums annually, to help us manage risk. Society trusts actuaries and other risk management professionals to minimise the risk of failure in these markets by managing the complex risks these industries face. This report shows how policymakers can adapt these risk management techniques and apply them to the global risks we currently face.

Global risk management is currently failing and blind to systemic risk

Risk management can fail. Following the global financial crisis, Her Majesty Queen Elizabeth II famously asked the London School of Economics why nobody had noticed it was on its way. They concluded this was *'a failure of the collective imagination … to understand the risks to the system as a whole.'* As well as a failure to see systemic risk, risk management can fail because risks aren't understood due to incomplete knowledge, or are disregarded as they are considered unlikely to occur. Risks can also be badly communicated, with important messages lost in scientific detail, or fall victim to misaligned incentives such as short-term profit winning over long-term sustainability.

High-profile climate change assessments in wide use significantly underestimate risk as they exclude many of the most severe risks we could face. Yet it is these extremes that should drive policy decisions – what is society willing to accept? And what actions can we take to mitigate those outcomes that we find unacceptable? Policymakers are currently unable to hear warnings about risks to ongoing human progress, or unwilling to act upon them with the urgency required.

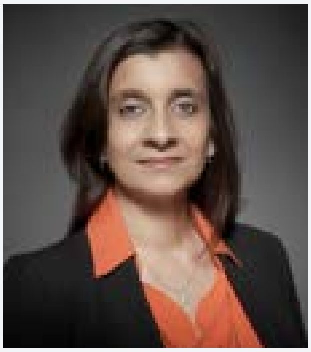
Planetary Solvency

Planetary Solvency addresses this by bringing together well-established risk management techniques, cutting edge systemic risk assessment methodologies and the deep understanding of science to develop the RESILIENCE principles, a set of guidelines for effective civilisational risk management. Planetary Solvency incorporates Earth system challenges, human society, and the economy, proposing a way to define and communicate novel risk limits for our global society, to demonstrate the need for increased urgency from those with agency. Combining science and risk is important; science provides a deeper understanding of the issues faced, risk assesses the consequences and recommends actions to mitigate or avoid them.

Put simply, Planetary Solvency provides a risk management approach for policymakers to steer human activity safely, within tolerances, to deliver a 'Good Anthropocene'.[3]
The choice is simple: continue to be surprised by rapidly escalating and unexpected climate and nature-driven risks, or implement realistic Planetary Solvency risk assessments to build resilience and support ongoing prosperity. We urge policymakers to work with scientists and risk professionals to take this forward before we run the ship of human progress aground on the rocks of poor risk management.

IFoA Presidential introduction

Kartina Tahir Thomson
President, Institute and Faculty of Actuaries



Kalpana Shah
Immediate Past President

Paul Sweeting
President-elect

In our previous report *Climate Scorpion – the sting is in the tail*, we coined the phrase 'Planetary Solvency', setting out the idea that financial risk management techniques could be adapted to help society manage climate change and other risks. In this paper, we expand this concept to show:

1 **The very high level of risk we have accepted with current global goals, the low chance of achieving those goals and the risk of 'Planetary Insolvency'.**

2 **How risk management techniques, informed by the latest science, can help us develop a set of principles to get back into a safe operating space for humanity.**

3 **The need for an evolution of policy solutions, including building risk capacity and ecological literacy, to take urgent action and avoid the risk of ruin.**

In 2015 *Climate Change – a risk assessment* [4] was published. This collaborative intergovernmental report, supported by the IFoA and other risk professions, showed why a risk management approach was needed for climate change and how this could be developed. In the decade since then the scale and pace of climate change impacts have outpaced expectations, while the scale and pace of human activity has continued to drive planetary outcomes, with a non-trivial risk of ruin — the loss of prosperity due to severe societal and economic disruption. We are breaching multiple planetary boundaries and the impact of our activity on the Earth risks the *'massive and irreversible harm'* [5] warned of in the Stockholm declaration over 50 years ago. Our activities are pushing the Earth system out of the stable conditions of the Holocene that supported the development of our global civilisation, with increasing risks to food, water, health, our economic system and human society.

Planetary Solvency is a global risk management methodology

Actuaries seek to understand risks and avoid financial insolvency, or the risk of ruin. We consider scenarios that might cause insolvency in a process we call reverse stress testing, which helps to inform choices to reduce risk. Our experience in understanding and managing risk enables us to uncover uncomfortable possibilities, to which mainstream debates struggle to give sufficient weight.

Planetary Solvency applies these techniques to the Earth system. The essentials that support our society and economy all flow from the Earth system, commodities such as food, water, energy and raw materials. The Earth system regulates the climate and provides a breathable atmosphere, it is the foundation that underpins our society and economy. Planetary Solvency assesses the Earth system's ability to continue supporting us, informed by planetary boundaries, tipping points in the Earth system and other scientific discoveries to assess risks to this foundation – and thus to our society and the economy.

Our illustrative assessment of Planetary Solvency in this report shows a more fundamental, policy-led change of direction is required. Our current market-led approach to mitigating climate and nature risks is not delivering. There is an increasing risk of severe societal disruption (Planetary Insolvency), as our economic system drives further global warming and nature degradation.

For example, commonly used 'net zero' carbon budgets only give a 50/50 chance of limiting warming to well below 2°C. Put another way, the chance of them failing to limit warming is as high as the chance of them limiting warming, which seems unreasonable given the risks faced. This is not well recognised.

Developing a process for monitoring, reporting and acting on these risks that leverages the RESILIENCE principles developed here to provide clear, concise, timely and realistic information to policymakers could help to accelerate risk-informed policy decisions and avoid catastrophic impacts that are likely on current trajectories.

We urge policymakers to commission a Planetary Solvency assessment as part of the Pact for the Future initiative,[6] to add a risk overlay to the rigorous analysis of climate and nature provided by the scientific community. Risk builds on science to ask the questions: 'What might happen?', 'How bad would that be?' and 'How likely is that?', translating complex scientific analyses into a language that may be more easily understood by non-experts. The answers to these questions will give policymakers better information on the level of risk they have accepted. This can then inform decisions about the urgency of response and how much effort to expend relative to other priorities.

Our current market-led approach to mitigating climate and nature risks is not delivering.

1. The urgent need for global risk management

In this section we explain why we need Planetary Solvency. We cover our fundamental reliance on the Earth system, and the need to manage our activity to avoid destabilising this foundation, which our society and economy rest on. We use the case study of climate change risk assessments to highlight why and how policymakers may have inadvertently accepted much higher levels of risk than they think.

Human activity and the Earth system – a short primer

The progress of our civilisation is remarkable. Driven by ingenuity, adaptation, and cooperation we have had unprecedented, although very uneven, wealth creation, technological advances, increases in population and longevity. Although little acknowledged in modern society, our global civilisation evolved during a period of climate stability, which enabled the rise of agriculture, cities and complex societies.

Approximately 11,700 years ago, the Earth system entered an unprecedented period of stability: the Holocene epoch. Carbon dioxide levels had risen from ice age lows, boosting plant productivity, and temperatures and precipitation patterns stabilised. Humans independently transitioned from nomadic hunter-gatherers to settled agriculturalists in at least six different parts of the world. As innovations, fertile soils, dependable growing seasons, and moderate climates allowed us to reap the excess energy agriculture yielded, it supported the development of complex societies, technological advancements, and intercontinental trade networks.

A suite of complex and interconnected Earth systems underpins the conditions we experience: the atmosphere, hydrosphere, biosphere, and lithosphere provide 'ecosystem services' that regulate global temperature, circulate water and nutrients, and sustain biodiversity. Scientists have defined operating thresholds for the Earth system, known as planetary boundaries: safe biophysical boundaries for the planet.

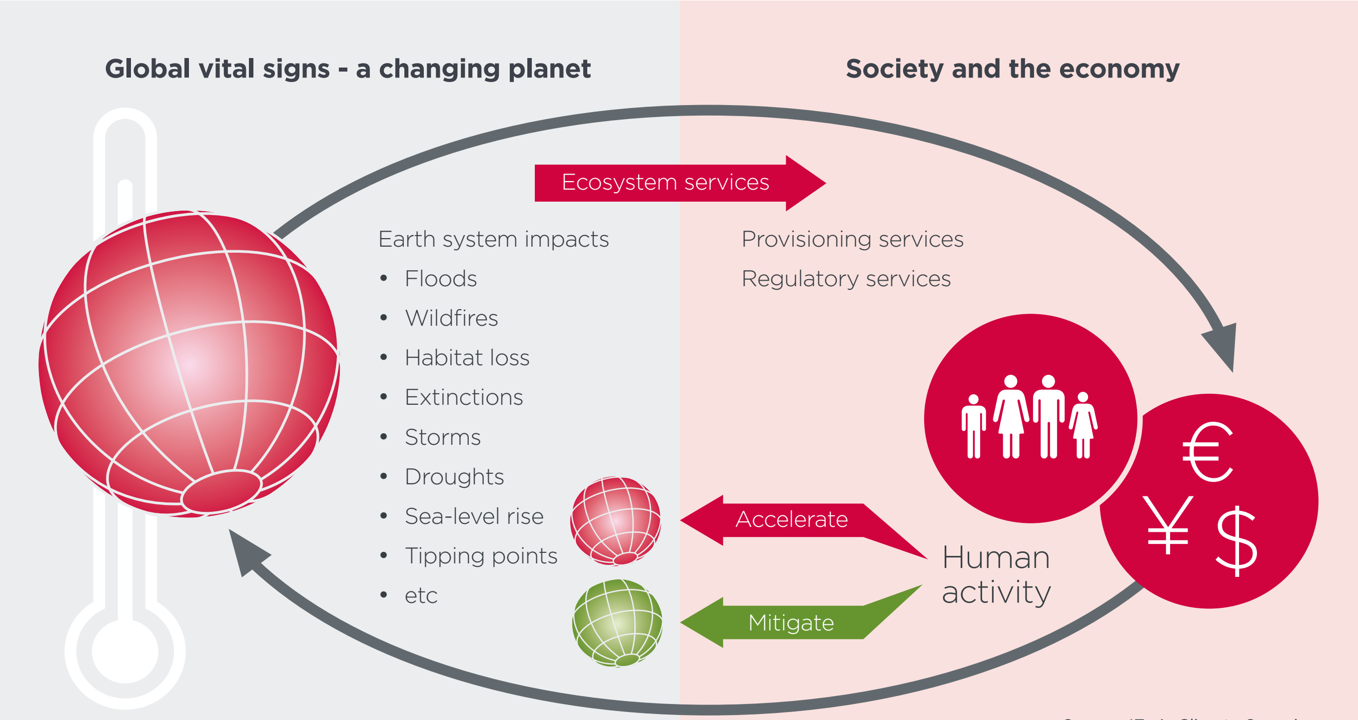
More recently scientists have had to develop Earth System Boundaries (ESBs) that also take into account the need to minimise significant harm to humans from Earth system change. We can think of ESBs as equivalent to solvency limits for our society. If we cross them, society is insolvent – and we have crossed several of them.

Since the Industrial Revolution there has been unprecedented resource extraction, powered by fossil energy, population growth and technological innovation. This has driven significant Earth system disruption, alongside inequality and health crises. Greenhouse gas levels have soared, causing global warming. Deforestation and land use change have eroded biodiversity and disrupted ecosystems. Agricultural practices and industrial processes have overloaded natural cycles with pollutants such as nitrogen, phosphorus and plastics.

Human activity is having a profound negative influence on our natural systems, as well as on human health. This situation presents unprecedented risks, and profound responsibilities. If we continue on our current trajectory, we risk pushing the Earth system into a much less habitable state.

By managing our activities to get back within planetary boundaries, we can try to ensure that future generations inherit a world where our global civilisation can continue to thrive within a stable Earth system. This is illustrated in Figure 1 on the following page, which shows the interaction between our society and the Earth system.

Figure 1: Interaction between human activity and the Earth system



Source: IFoA, Climate Scorpion

Defining Planetary Solvency in relation to the Earth system

Planetary Solvency assesses the ongoing ability of the Earth system to support our human society and economy. If critical ecosystem services are disrupted, then disruptions to human systems can be expected to occur, for example disruption to food, water, energy, infrastructure or manufacturing systems, with associated societal and economic shocks.

In the same way that a solvent pension scheme is one that continues to be able to provide pensions, a solvent Earth system is one that continues to provide the services we rely on, support ongoing prosperity, and a safe and just future. An insolvent planet is one in a state where we have degraded the Earth system to such an extent that we can no longer receive enough of the critical services we rely on to support our society and economy. For example, shortages of food and fresh water, or uninhabitable climatic conditions. Ecosystem services are often non-substitutable, meaning that once they are lost, they are unable to be replaced through another process and hence their loss undermines economic production.[7]

To maintain Planetary Solvency, we need to put in place mechanisms to ensure our social, economic, and political systems respect the planet's biophysical limits, thus preserving or restoring sufficient natural capital for future generations to continue receiving ecosystem services.

We define Planetary Solvency as:

Managing human activity to minimise the risk of societal disruption from the loss of critical support services from nature.

Maintaining Planetary Solvency will require accelerated action. Transitioning to renewable energy, restoring ecosystems, adopting sustainable agriculture, reducing inequality, changing economic incentives and transforming consumption patterns are critical. However, beyond technological and policy solutions, this challenge demands a shift in perspective, recognising that humanity is not separate from nature, we are embedded in it and reliant on it. The stability of this foundation, gifted by billions of years of evolution and finely tuned processes, is no longer a given.

Global risk management for human prosperity

This is a risk management problem on a global scale. In a nutshell, risk management requires the use of imagination to assess the likelihood of adverse outcomes, followed by taking action to mitigate risks outside appetite.

The urgency of the action is dictated by the proximity and severity of the risk — slamming on the brakes when a child runs into the road versus slowing down gently for a pedestrian crossing.

The most important decision any government has to make about the risks faced is one of priority; how much effort to expend on countering risks, relative to the effort that must be spent on other issues.[8] Climate change and other risk assessments should help to inform that decision; the more severe the risk, the greater the urgency.

Case study - climate change risk assessments

For climate change, although it will have a range of societal impacts, significant focus is typically given to economic consequences, seeking to answer the question: 'what would the impact of climate change be on GDP?'. The answer to this helps to inform the question of prioritisation.

Unfortunately, many high-profile, public climate change risk assessments are significantly underestimating risk because they exclude many of the real-world impacts of climate change, such as the impact of tipping points, extreme events, migration, sea level rise, human health impacts or geopolitical risk. Furthermore, they calculate ongoing economic growth, even in a hothouse world, as climate damages are lower than growth assumptions. These results conflict with scientific predictions of significantly reduced human habitability from climate change.[9]

These risk assessments are precisely wrong, rather than being roughly right. The benign but flawed results may reinforce the narrative that these are slow-moving risks with limited impacts, rather than severe risks requiring immediate action.

Such an approach does not meet the requirements of the principles for risk management listed in section 4, excluding uncertain, high-severity events from models, rather than making best estimates and adopting the precautionary principle.

To address this potential global risk management failure and support the development of realistic Planetary Solvency risk assessments, we develop in this report a set of principles for realistic risk assessment: the RESILIENCE principles, characteristics that any global risk assessment methodology should meet. We then use these principles to develop illustrative Planetary Solvency outputs.

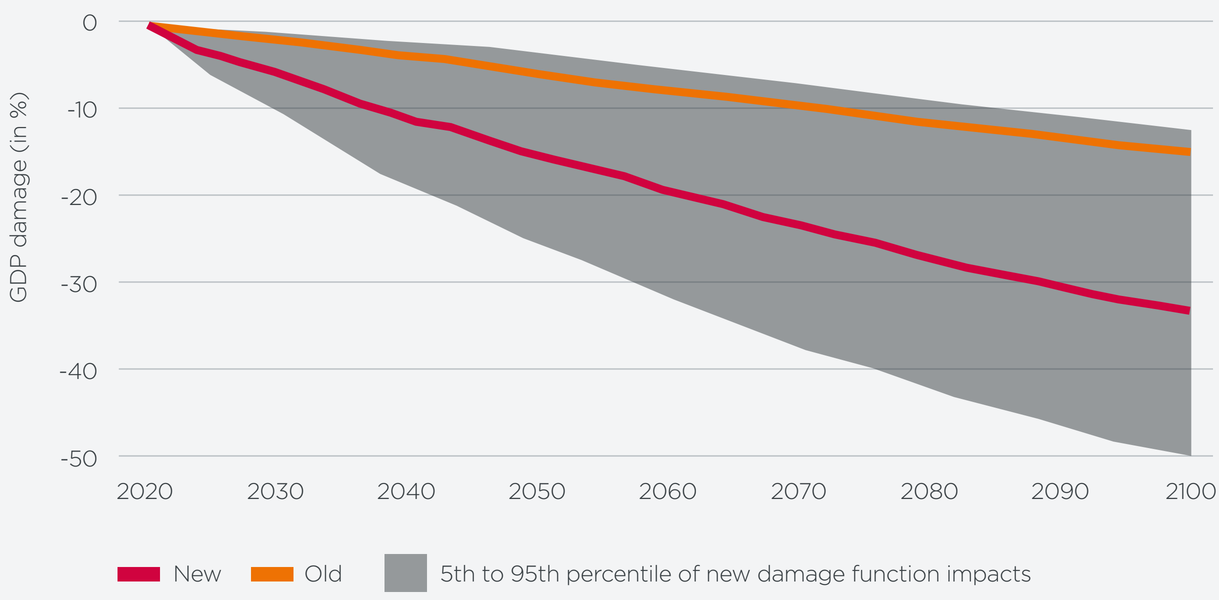
The wide range of climate change economic impact estimates

The Network for Greening the Financial System (NGFS) provides analysis of a range of estimates for the negative GDP impact of climate change under a current policies scenario of 3°C of warming by 2100. These range from 2% GDP *(Nordhaus & Boyer)* impact to 44% GDP *(Bilal & Känzig)* impact by 2100.[10] Alternative methodologies provide wider ranges still: up to 63%.[11] What is important to understand is that these results are the output of complex models, which are highly dependent on the methodologies used for calculations and assumptions. For example, in *The Emperor's New Climate Scenarios* a methodology based on a technique known as reverse stress testing suggests to 'expect 50% GDP destruction – somewhere between 2070 and 2090'. A prudent approach would be to take the highest estimate of economic loss and reduce it when evidence becomes available that it is over-stated, rather than the other way round.

In their latest update, the NGFS propose using a GDP damage estimate based on the Kotz et al paper *'The economic commitment of climate change'*,[12] which estimates that physical risks from climate change in a current policies scenario might reduce GDP growth roughly 1/3rd by 2100, i.e. GDP is still forecast to grow in this scenario, but to grow less than it would if climate change didn't occur.[13]

Figure 2: Global GDP loss projections under NGFS current policies scenario

Source: NGFS Climate Scenarios Technical Presentation



As illustrated in Figure 2 above, there is a large range of GDP loss estimates in the NGFS scenarios, with the grey shaded area of possible losses using this approach ranging from less than 5% GDP damage in 2050, to around 25%.

This is a wide range, with the expected value (the red line in Figure 2), showing a 15% reduction in global GDP by 2050. The authors state that: *'These damages already outweigh the mitigation costs required to limit global warming to 2°C'*, i.e. it will be overwhelmingly positive economically to limit global warming.

However, the limitations of this assessment based on the Kotz et al paper show that it excludes many of the most severe risks that are now expected if we do not manage to limit global warming. As well as the assumption that an economic recession is impossible no matter how severe climate shocks become, the approach does not consider the impacts of climate tipping points, climate-driven extreme events, human health impacts, resource or migration-driven conflict, geopolitical tension, nature-driven risks, or sea level rise. The authors themselves acknowledge that when these additional factors are considered, real economic impact will likely be greater than estimated in their study.

This is analogous to carrying out a risk assessment of the impact of the Titanic hitting an iceberg but excluding from our model the possibility that the ship could sink, the shortage of lifeboats, and death from drowning or hypothermia. The modelled results would be reassuring but dangerous as they would severely understate the level of risk. That is to say, even though the results show a very material reduction in GDP of 15% by 2050, it may be an underestimate as it does not capture all the risks we expect.

However, some policymakers are still using the earlier Nordhaus damage estimate to justify an assertion that while climate change is of concern, it is not an immediate priority due to the negligible expected impact of 2% of GDP damage by 2100 at 3°C of warming. A deeper analysis of the assumptions underpinning this estimate shows that as well as excluding from analysis many of the risks now expected to occur, it also excludes 87% of the economy from analysis, assuming that a number of sectors will be negligibly affected by climate change.[14]

Although models typically provide thorough documentation of assumptions and limitations, few policymakers are likely to fully understand these. This increases the likelihood of policy decisions being based on model outputs that significantly understate risks and are inconsistent with climate science. Put another way, policymakers who use these model outputs may be accepting far higher levels of risk than they think.

2. From financial solvency to planetary solvency

Risk management professionals, including actuaries, have well-established processes to help pension funds and organisations such as insurance companies to manage risk and uncertainty over long time horizons. In this section we lay out what these processes are to illustrate how they can be applied to the global challenges we face.

The actuarial approach to managing risk and uncertainty

Risk is often characterised by referring to events that might occur and the impact these events would have on an objective. Risks may be categorised by likelihood (the chance that a risk event may occur) and severity (the impact of an event should it occur). 'Tail risks' is a term often used to describe low-likelihood but high-severity risks; actuaries would say that these sit at the extreme end of the risk distribution. On the other hand, uncertainty cannot be easily quantified or modelled. The outcomes themselves may be unknown or we may not be able to assign a probability to their occurrence due to uncertainty about outcomes.

Risk management is the set of coordinated activities used to direct and guide an organisation regarding risk. Risk professionals, including actuaries, work with long-term financial institutions of societal importance, such as pension funds and insurance companies. They support these institutions to take decisions today to ensure that over time they can meet their future commitments – their liabilities – with a sufficiently high level of probability. The risk management control cycle ensures that action is taken to safeguard desired outcomes and ensure payments can be made even if the future develops in an adverse way for the organisation.

The control cycle has five main components:

- **Risk identification** involves recognising all the risks that might threaten the objectives of an organisation. Part of this process is determining to what extent the organisation is willing to have their objectives exposed to these risks – in other words, its risk tolerance.
- **Risk measurement** involves estimating the probability of a risk occurring and its severity. This involves deriving assumptions and forming a view about what is likely to happen in the future.
- **Risk control** means taking actions to reduce the probability of a risk happening or limiting the severity of the potential outcome.
- **Risk financing** determines the likely cost of the risk, and the financial resources required to cover it, combined with the level of likelihood.
- **Risk monitoring** is the regular assessment of all risks, incorporating experience as it emerges, reviewing whether assumptions remain valid or should be adjusted, and identifying any new or previously omitted risks. Where risks approach or breach pre-agreed limits, known as risk appetites, actions are taken to mitigate impacts and return a risk to within tolerance.

Actuarial approaches take uncertainty into account, asking not just 'What is likely?' but 'What is possible?' This includes considering extremely bad scenarios, often driven by tail risks or a combination of risks, that could 'break' an organisation. Our starting point is 'What do we want to avoid?' A process known as reverse stress testing identifies scenarios that could cause failure (insolvency).

A critical part of this process is ensuring consistency between the assumptions that underpin scenarios and their plausibility.

In summary, risk management identifies when action is required to mitigate risks that are outside tolerance and might drive adverse outcomes if they occurred. Action is then taken to try to ensure that even if tail risks do happen, the organisation will be able to mitigate these adverse outcomes, even if they are unlikely.

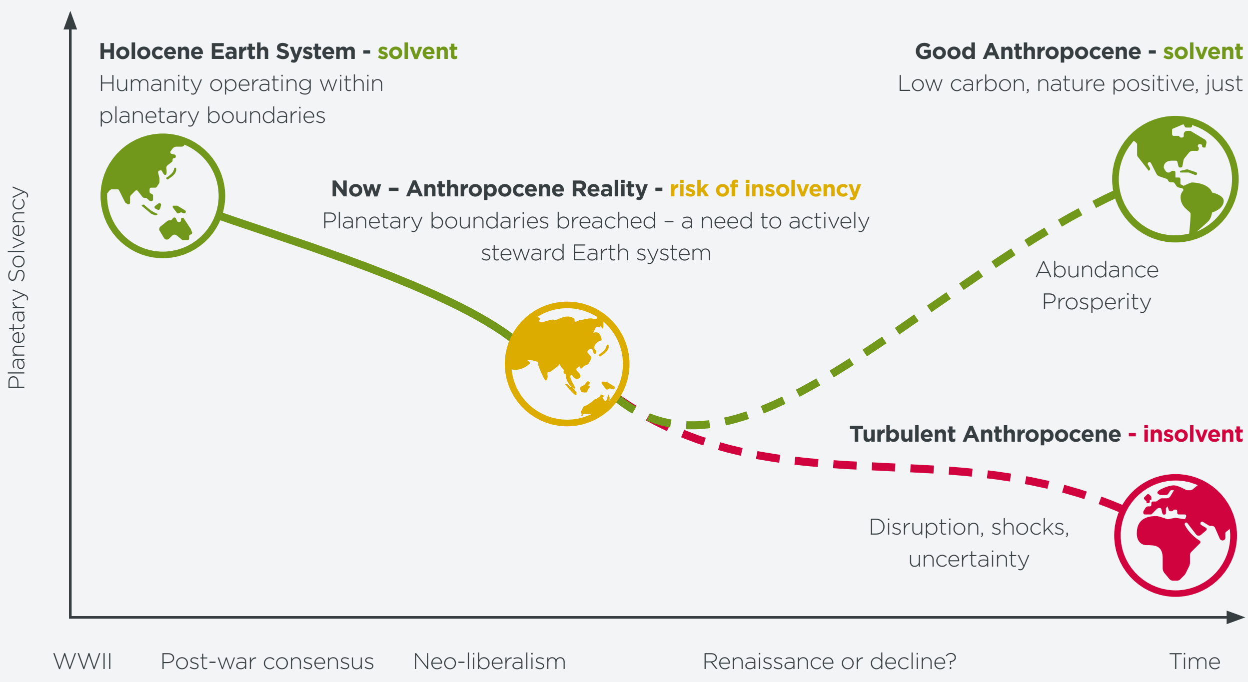
For example, insurance companies hold capital to meet the liabilities they expect to meet in the future, as well as to cover adverse events so they can avoid becoming insolvent. In Europe the amount of capital insurers are required to hold is set at a level designed to withstand an extreme loss scenario that would occur only once in 200 years. Put another way, the amount of capital held is calculated to give a 0.5% chance that an insurance company would fail in any one year. Nuclear facilities have an even higher threshold for failure, designed to cope with hazards on a 1 in 10,000 basis.

From financial to planetary solvency

We can replace the solvency of an insurance company with our shared objectives: those of the Paris Agreement to limit global warming, the Kunming-Montreal biodiversity agreement and the United Nation's Sustainable Development Goals, which have the overarching objective of 'all people enjoying peace and prosperity'. Taken together the goals of these agreements should keep our activities within planetary boundaries, minimising risks, as well as reducing inequality and improving health. Climate change and nature loss present a clear risk to these goals. Viewed through this lens, we can assess the activities we are undertaking to manage climate-change, nature and societal risk and form a view as to whether these are adequate when compared to established risk management standards. As illustrated in the diagram below, there is clear risk of insolvency if we do not change course.

A risk management approach, although informed by science and data, is different to a scientific approach. In science, a hypothesis is proposed, data is gathered to test this hypothesis, and then conclusions are drawn about the validity of the hypothesis. In the case of climate change, where data is scarce or risks are hard to model, the scientific community has arguably been biased towards erring on the side of least drama. In particular, this scientific approach means scientists are reluctant to make statements not supported by evidence. This has led to under-prediction

Figure 3: The Anthropocene Reality and Planetary Solvency



Source: Sandy Trust, How to Save the World, 2022 on key attributes of global warming.[15] A risk management approach instead requires that, even where evidence is not available, we should explore plausible outcomes and take steps to manage the risk, especially if the outcomes have the potential to be severe. We apply expert judgement to estimate the likelihood and severity, revising our estimates as more evidence becomes available.

For risk management to be effective, decision makers must understand the business model and the risks. Financial regulators[16, 17] ensure that senior individuals with influential decision-making and risk-taking responsibilities are fit and proper. This includes assessing the honesty, integrity, competence and capability of these senior individuals.

Given the societal importance of the risks we now face, the same principles apply to governments and non-financial regulators, as well as business. It is important for decision makers in all areas, but especially policymakers who are de facto Planetary Solvency managers, to ensure they have the climate, ecological and risk literacy to make complex decisions under uncertainty. They need to be open and honest in their dealings and be capable of engaging with the public in good faith. Importantly, they need to be accountable for their decisions.

Risk management principles and realistic risk assessment

In 2015, King et al[18] worked with a broad set of stakeholders, including the IFoA, to develop a set of recommendations *'to improve our assessment of climate change risk to better inform decisions on risk reduction.'* These recommendations were to apply the right principles, broaden participation in the process and report to the highest decision-making authority. They identified the key risk management principles as:

- **Assess risks in relation to objectives, or interests**
  Start from an understanding of what it is that we wish to avoid, then assess its likelihood.
- **Identify the biggest risks**
  Focus on finding out more about worst-case scenarios in relation to long-term changes, as well as short-term events.
- **Consider the full range of probabilities**
  Bearing in mind that a very low probability may correspond to a very high risk, if the impact is catastrophic.
- **Use the best available information**
  Whether this is proven science or expert judgment. A best estimate is usually better than no estimate at all.
- **Take a holistic view**
  Assess systemic risks as well as direct risks. Assess risks across the full range of space and time affected by the relevant decisions.
- **Be explicit about value judgments**
  Recognise that they are essentially subjective and present them transparently so that they can be subject to public debate.

One of the authors of the report, Simon Sharpe, provided further recommendations for realistic risk assessment, covering three dimensions: probability, impact and time horizon.[19]

- **Probability**
  Explore the full range of outcomes, including those that sit in the extremes (tails) of the distribution. The interconnected nature of risks must be considered, along with how best to use systemic risk analysis techniques to build a picture of common risk drivers and how risks might interact.
- **Impact**
  Consider severity and the potential for non-linear responses to change and the risk of systemic collapse. Identify risk thresholds and explore how likely these thresholds are to be crossed across a range of different scenarios. Examine how likely those scenarios are to occur.
- **Time horizon**
  Consider short-term risks as well as the full timescale across which a risk emerges, and avoid arbitrary cutoff points, often 2100. For some risks, such as sea level rise, where full impacts emerge over very long timescales, it is appropriate to explore horizons beyond 2100 since this is when the highest impacts emerge.

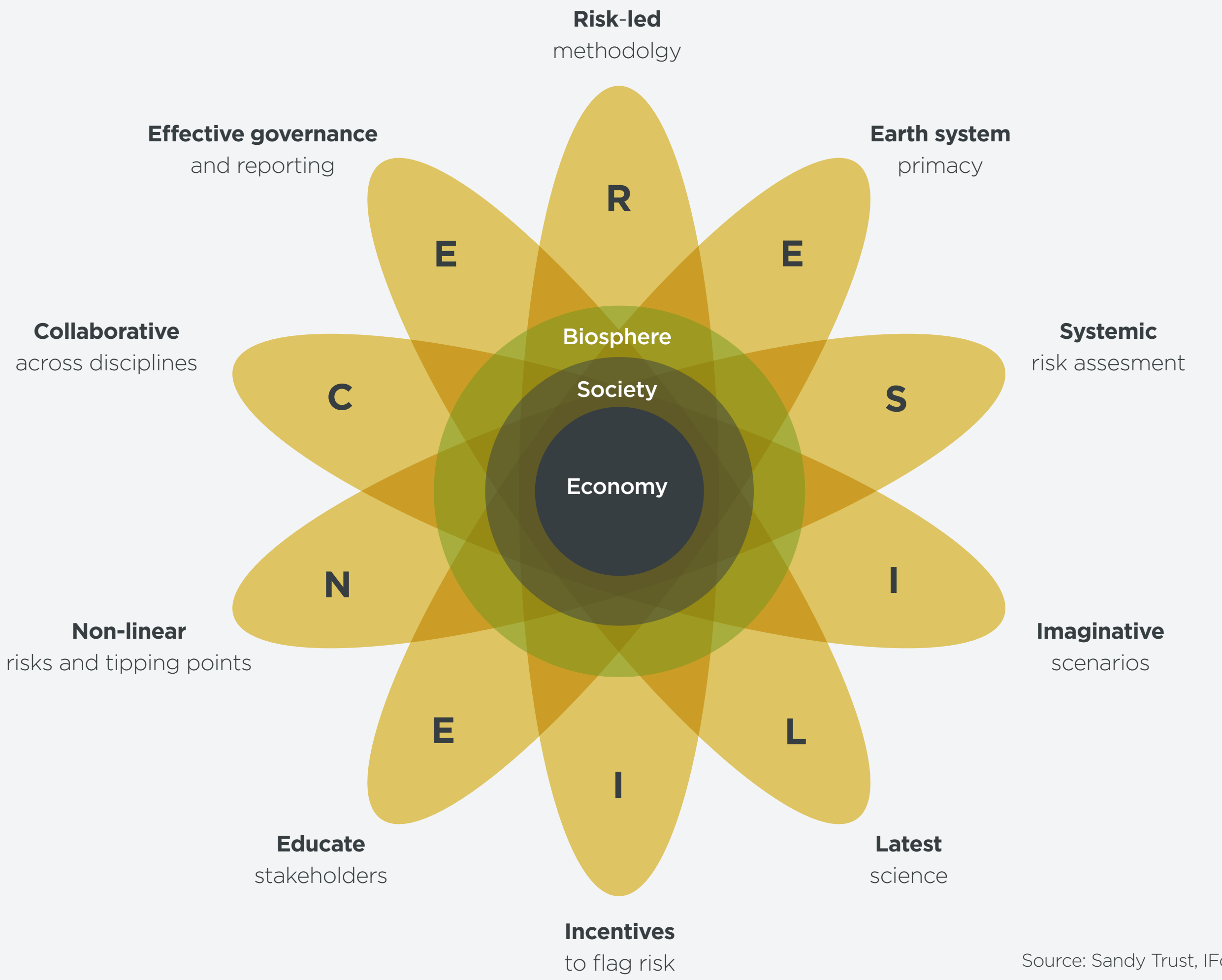
In the following section we build on these inputs and wider developments to develop the RESILIENCE framework, a set of more detailed principles for the characteristics required to deliver an effective global civilisational risk management framework: Planetary Solvency.

For risk management to be effective, decision makers must understand the business model and the risks.

3. The RESILIENCE principles

In this section we introduce the RESILIENCE principles, designed to support effective and realistic Planetary Solvency risk assessments, as illustrated in the diagram and table below. A fuller explanation of each principle and the rationale behind it follows the table.

Figure 4: The RESILIENCE principles



Source: Sandy Trust, IFoA

The diagram above illustrates the point that our economy rests on society and that our society rests in the Earth system, with these systems now deeply interconnected.

Table 1: Summary of the RESILIENCE principles

Principle	Explanation
Risk-led methodology	Set clear risk limits and track trends using a global dashboard.
Earth system primacy	Prioritise Earth system health over short-term economic metrics.
Systemic risk assessment	Assess interconnections between societal and environmental risks.
Imaginative scenarios	Assess tail risks and combinations of risks.
Latest science	As IPBES and IPCC reports take several years to produce, there is a need to incorporate current science in a more timely fashion.
Incentives to flag risk	Reward risk identification and communication, even if unlikely, to mitigate scientific reticence and consensus.
Educate stakeholders	Invest time in building ecological, climate and systemic risk literacy amongst policymakers.
Non-linear risks and tipping points	Consider exponential risks, the potential for unprecedented threshold events and the impact of tipping points.
Collaborative across disciplines	Work across science, risk, security, private and public sectors to build deeper insights and reduce blind spots.
Effective governance and reporting	Embed into appropriate governance structures, maintain independence and report transparently.

The RESILIENCE principles

Resilience means the ability to bounce back after a disturbance, the capacity to maintain essential function and the potential for transformation. The RESILIENCE principles are designed to make society resilient though effective and realistic global risk management practices.

R. Risk-led methodology

Risk management requires that we set appropriate limits for risk, take action to manage risks that trends close to or above our appetite for them and develop a set of decision-useful metrics (key risk indicators) to support risk-informed decisions.

Risk practitioners have developed a range of tools and communication techniques to support decision makers to make risk-informed decisions. In addition to determining appropriate Planetary Solvency risk appetites in relation to societal objectives, a risk impact matrix will be required to communicate risk position clearly, and a risk dashboard to provide summary information to policymakers.

A Planetary Solvency risk appetite could be set as having a very low appetite for:

Climate, nature and societal risks that undermine the ecosystem services upon which life on Earth depends, threatening human prosperity.

This is then sub-divided into more granular statements, with an assessment carried out against each component to test whether we are taking too much risk, i.e. outside appetite. A Planetary Solvency risk appetite statement could then be to seek to minimise the risk of significant societal disruption driven by climate and nature risks, including:

i. Crossing Earth system tipping points and triggering tipping cascades

ii. Habitat loss and species extinctions

iii. Breakdown of critical ecosystem services

iv. Climate change above 1.5°C

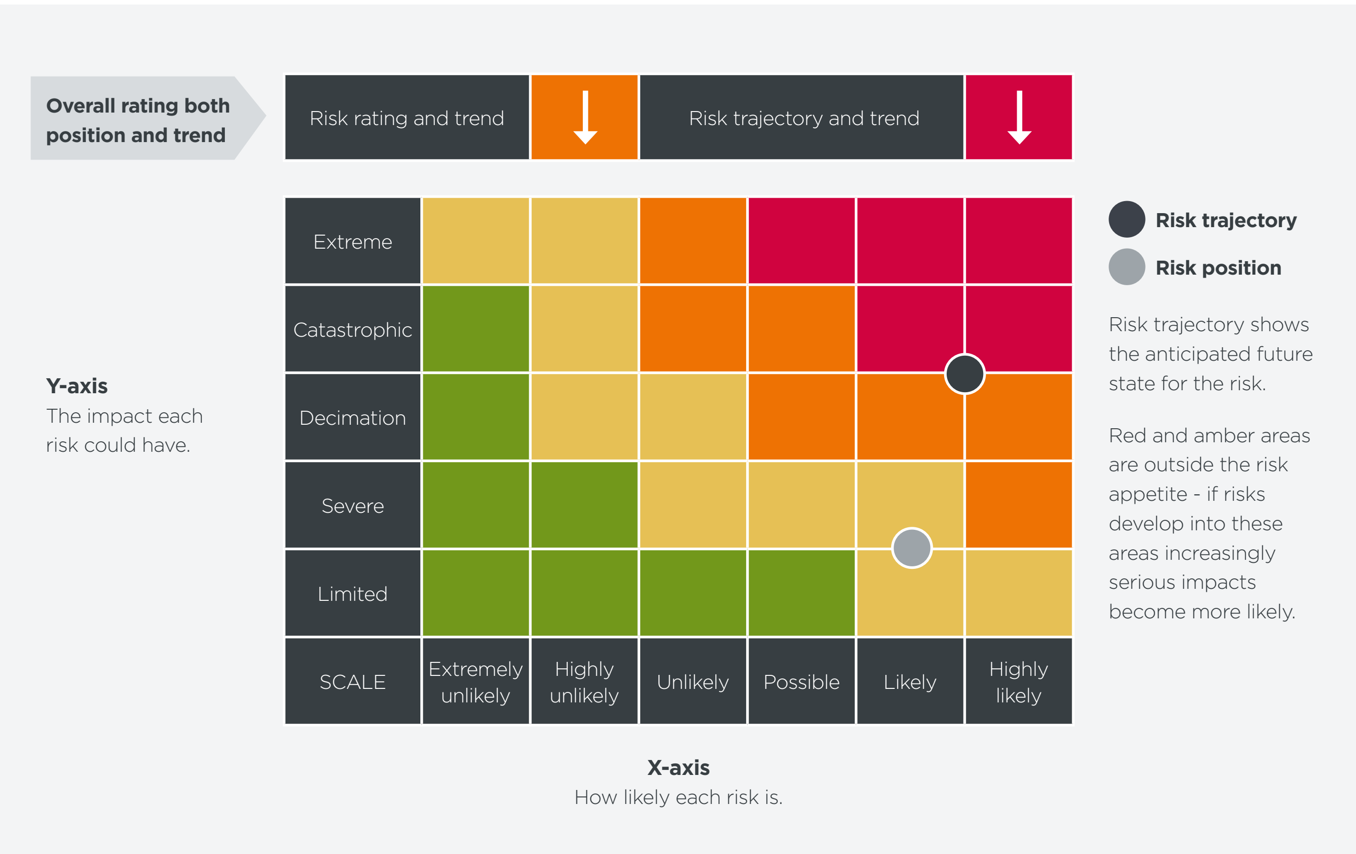
v. Climate and nature driven forced displacement, conflict and mass mortality events

vi. Derailment risk (society is too distracted by escalating crises to address root causes).

Another frequently used risk tool is the risk impact/likelihood matrix, the characteristics of which are explained in Figure 5 below. This can be adapted for Planetary Solvency to communicate which risks are most material, likelihoods and potential impacts. This could use a standard likelihood scale but with an adapted impact scale, suitable for assessing societal impact, adapted from the thinking in the paper *Climate Endgame: Exploring Catastrophic climate change scenarios*,[20] which defined a set of novel societal impact terms:

- **Systemic risk** — The potential for individual disruptions or failures to cascade into a system-wide failure
- **Extreme climate change** — Mean global surface temperature rise of 3 °C or more above preindustrial levels by 2100
- **Extinction threat** — A plausible and significant contributor to total extinction risk
- **Societal collapse** — Significant sociopolitical fragmentation and/or state failure along with the relatively rapid, enduring, and loss of capital and systems identity; this can lead to large-scale increases in mortality and morbidity
- **Global catastrophic threat** — A plausible and significant contributor to global catastrophic risk; the potential for climate change to be a global catastrophic threat can be referred to as 'catastrophic climate change'
- **Global decimation risk** — The probability of a loss of 10% or more of global population and the severe disruption of global critical systems such as food within a given timeframe (years or decades).

Figure 5: Explanation of a risk impact/likelihood assessment matrix



While *Climate Endgame* focused on climate change, Planetary Solvency expands this analysis, assessing risk likelihoods and impacts across five dimensions: economy, mortality, climate change, nature and society. A Planetary Solvency risk impact matrix is shown in Appendix I.

E. Earth system primacy

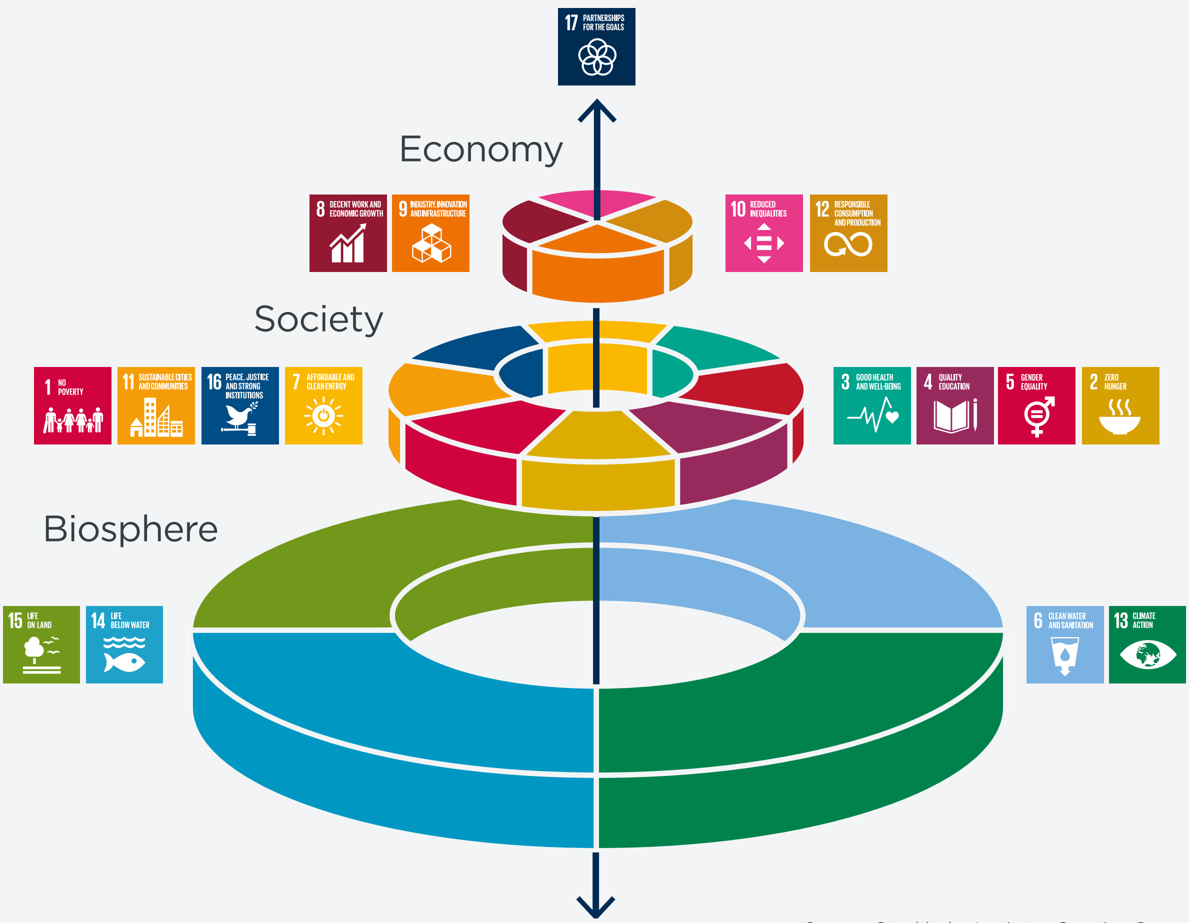
Society monitors many metrics but it is often the case that economic measures are elevated in importance above others, with GDP in particular the subject of significant political focus and a material factor in deciding some elections. However, the inputs to our economy, raw materials and energy flow from the Earth system. Planetary Solvency includes the economy as a key dimension of our global risk management framework but recognises that our society and economy rest and rely on the Earth system. This is in line with the SDG wedding cake, which illustrates *'how economies and societies should be seen as embedded parts of the biosphere. This vision is a move away from the current sectorial approach where social, economic, and ecological development are seen as separate parts'.*[21]

S. Systemic risk assessment

Traditional risk management approaches often consider risks in isolation, attempting to estimate the likelihood and severity of a particular risk, to inform whether any action is required to avoid or adapt to the risk. However, the Earth system, our society, and our economy form a highly interconnected dynamic complex system. This intricate relationship can result in cascading and compounding risks through various interactions. We illustrate this in Appendix II using the example of water risk and tipping point interconnectedness. Traditional risk management approaches can struggle with complex systems and may underestimate risk proximity and severity because they do not capture network effects.[22]

The Accelerator for Systemic Risk Assessment has produced principles for systemic risk assessment,[23] listed in Figure 7 on the next page, with reference to how these compare to a number of the characteristics which contributed to the polycrisis. The RESILIENCE principles are designed to be congruent with these principles.

Figure 6: The SDG Wedding Cake



Source: Stockholm Institute, Creative Commons

Figure 7: Principles to guide systemic risk management

Systemic risks and polycrisis characterised by:	Navigating polycrisis requires principles:
Self-interest	Universal responsibility
Anthropocentrism	Non-human sanctity and interdependence
Inequity and injustice	Justice
Rule of the few	Individual and collective agency
Reductionism	Complexity
Overt focus on knowable risks	Uncertainty
Interactions across local and global	Cross-scale
Narrowly-focused evidence and methods	Multiple ways of knowing
Lack of compassion	Compassion
Current systems creating crises	Transformation

Source: Accelerator for Systemic Risk Assessment

There are several tools and methodologies that can be used for systemic risk assessment, with analytical techniques including causal loop diagrams, systems mapping, systems dynamics and Bayesian belief networks.[24] Examples of systemic risk assessment can be found in the WEF Global Risk[25] outlook, which uses a systems mapping approach, the UN's Interconnected Disaster Risk report,[26] which analyses six interconnected risks that represent large global issues, and the IPPR's security blind spot,[27] which examines the risks to UK national security from cascading climate change impacts and tipping points (AMOC & SPG collapse[28]). The Cascade Institute has also developed a framework for 'polycrisis analysis', designed to support governments with assessing and responding to global risks more effectively.[29]

The systems mapping approach allows users to identify interactions between risks visually and see risk clusters: groups of risks which might not individually cause concern but which in aggregate require attention.

The Interconnected Disaster Risk report provides a useful methodology for identifying shared root causes, risk impacts and drivers. It applies systemic risk analysis to groundwater depletion, accelerating extinctions, mountain glaciers melting, space debris, unbearable heat and uninsurable future.

All six risks analysed had a common root cause and driver as follows:

- **Shared risk driver:** insufficient future planning - lack of foresight to act on an oncoming problem.
- **Shared root cause:** insufficient risk management - A lack of perception, awareness or preparation in governance relating to risk management and response.

Planetary Solvency seeks to address this by providing a mechanism for policymakers to have better foresight of oncoming problems and improved risk management mechanisms.

In *Climate Scorpion*, we created a causal loop diagram showing how environmental breakdown drives systemic risk, leading to severe negative outcomes including political instability, violent conflict, and mass mortality, all of which may lead to derailment risk[30] where escalating demands to manage increasingly chaotic conditions could divert work, resources and political support from environmental action, worsening the changes, and further breakdown of the planetary system.

I. Imaginative scenarios to examine tail risks and uncertainty

It is common practice in financial services to imagine scenarios that may have adverse impacts on a company, covering a range of risks such as financial, reputational and operational. Scenarios will be informed by industry events as well as by emerging trends such as geopolitics, new technologies and environmental issues like climate change. Firms consider the potential financial impact of scenarios, the controls they have in place to mitigate risks, such as measures to stop fraud, as well as wargaming particularly adverse scenarios with senior management to rehearse decision making under crisis conditions. Wargaming might typically include combinations of risks, for example adverse market movements combined with operational issues, leading to reputational damage. Additionally, some regulators require firms to carry out reverse-stress testing, a process whereby firms develop scenarios that would cause insolvency.

Imaginative scenarios should include examining tail risks from combinations of factors that drive adverse outcomes, even where they cannot be precisely quantified. Examples are given of potential physical risk events in *No time to lose*,[31] a collaboration between USS (the UK's largest pension scheme) and Exeter University, which provides a number of detailed narrative scenarios that explore the potential for cascading compounding climate-driven risks that may occur until 2030.

From a risk management perspective, understanding extreme outcomes is key, especially when we are operating under conditions of high uncertainty. A risk-based approach aims to limit the probability of very bad outcomes to an acceptably small value. From a climate change perspective, this would involve exploring the worst outcomes, even if their probability is low or cannot be accurately quantified due to a lack of reliable data, asking the question: 'How bad can it get?'

It is these extremes that would drive policy decisions – what is society willing to accept? And what actions can we take to mitigate those outcomes that we find unacceptable? These are value judgements, and it would be important to be transparent about who makes them, as well as the implications of decisions.

Despite the importance of examining worst-case scenarios, in *Climate Endgame*, Kemp at al[32] found that while there is evidence that climate change outcomes could be catastrophic, even with modest levels of warming, the extreme impacts are under-examined, with very few quantitative estimates of extreme impacts from above 3°C warming.

The paper found that the focus of the IPCC reports had drifted towards lower temperatures over time, in part due to the Paris commitment to limit warming to well below 2°C, even though this may be premature considering current commitments do not yet put us on this pathway.

In addition to the lack of consideration of the impacts of higher warming scenarios, limited attention has been given to the low probabilities of success associated with our approach to climate change. For example, widely discussed carbon budgets only give a 50% (heads or tails) or less chance of limiting global warming to 1.5°C and assume no surprises such as tipping points, which is unrealistic.[33] This probability of failure is very high when compared to, for example, society's appetite for insurance company failure, which is set at 0.5%, a one in 200 year chance.

Carbon budgets are uncertain because it is challenging to model all the complexities of the Earth system accurately with respect to climate change. In particular, there is ongoing debate around a particularly critical assumption: how sensitive the Earth is to greenhouse gases.

Risk management deals with uncertainty in a number of ways:[34]

1. **Understand the source of uncertainty**
   Identify the limits to our knowledge, models, assumptions, data and problem framing. Explore the sensitivity of outcomes to changes in these factors to understand the 'what-ifs'. Consider introducing prudence into assumptions, particularly those where outcomes are material and detrimental. Prudence here means erring on the side of caution in relation to impacts, regardless of the causality. Rather than take the view that Rather than take the view that we shouldn't say there is an iceberg until we are confident there is one, we should instead say: 'There may be an iceberg, we should steer well clear or reduce our speed.'

2. **Adaptability, resilience and optionality**
   Try to understand what we can control and what might go wrong. For those things that cannot be controlled, we need to think about building resilience and the corrective options available to respond.

   Optionality is about understanding when decisions taken might close off alternative options, it is important for transformation and adaptability.

3. **Drive awareness and management of adverse outcomes**
   Explore unquantifiable scenarios, even if the underlying causes are too complex, and plan for a range of possible outcomes.

L. Latest science to inform risk assessments

There can be a significant time lag between scientific papers being published and their incorporation into global methodologies. For example, many net zero approaches utilise carbon budgets based on analysis undertaken for the IPCC's Special Report on 1.5°C of warming published in 2018. However, these carbon budgets are highly unlikely to continue to be appropriate given the intervening six years which have included ongoing high levels of emissions and increasing temperatures.

Furthermore, there is a significant volume of scientific output that requires analysis, in order to form a view on a number of the key dimensions of the risk assessment. Planetary Solvency provides a mechanism for pulling together current scientific outputs, synthesising and summarising these and presenting them concisely, with reference to potential human societal impacts rather than scientific metrics such as parts per million of greenhouse gas concentrations, which may not be in the risk currency of policmakers.

I. Incentives to flag risks

A realistic risk assessment is different from that followed by most in the scientific community.[35] Scientists are geared toward making predictions that are as accurate as possible. In contrast, risk management is often concerned with estimating the realistic worst-case scenario and the probability of that scenario. Uncertainty may discourage scientific communication, whereas it will encourage risk communication.

This risk management approach is referred to as the precautionary principle, which emphasises caution if it is possible that a given course of action may cause significant harm, particularly where there is high uncertainty. One of the most important expressions of the precautionary principle internationally is the Rio Declaration from the 1992 United Nations Conference on Environment and Development.[36] It is in common use as a concept by national governments including the EU[37] and UK.[38] Risk management also emphasises taking appropriate action to mitigate the risks faced. Combining science and risk is important: science provides a deeper understanding of the issues faced, risk assesses the consequences and recommends actions to mitigate or avoid them.

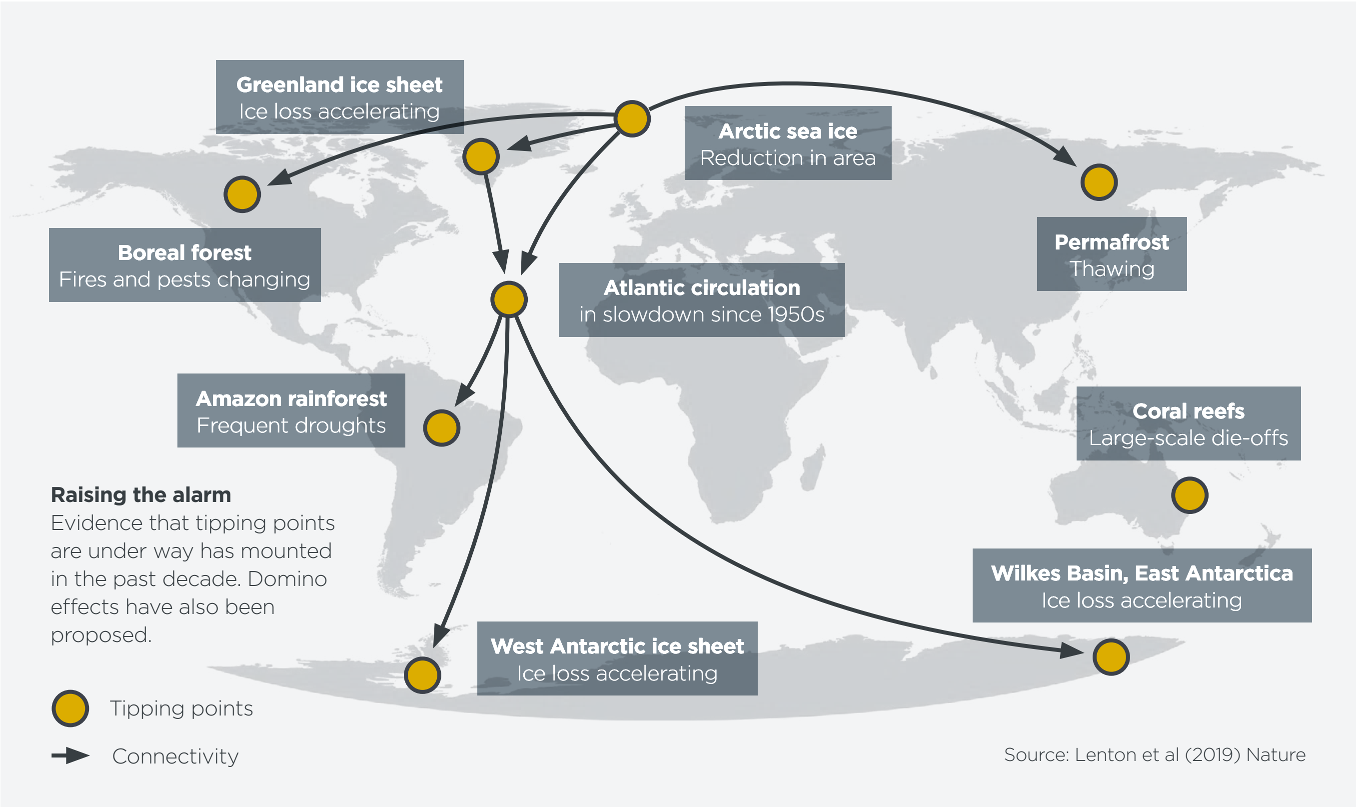
E. Educate stakeholders

Understanding our dependence on and links to nature is a paradigm shift for many. Leaders and decision makers across the globe need to understand why these changes are needed. They must be ecologically and climate literate, understand both positive and negative tipping points, our interconnection with nature, risk interconnectedness and the importance of policy in driving solutions.

Economic dependency on nature is unrecognised in dominant economic theory,[39] which fails to recognise energy, food and other raw materials as factors of production. This means that it provides an incomplete model for Planetary Solvency and is unable to recognise the risks that emerge from nature degradation. Another way of putting this is that traditionally, economic activity rests on drawing down from our stock of natural assets to create wealth (assuming this can continue in an unlimited way), rather than ensuring they can continue to support our society and the economy in the future.

> **Economic dependency on nature is unrecognised in dominant economic theory which fails to recognise energy, food and other raw materials as factors of production.**

Figure 8: Climate system tipping points – current state observations



N. Non-linearity and tipping points

Warming of 1.5°C is extremely risky, with a chance of triggering multiple climate tipping points such as the collapse of ice sheets in Greenland, West Antarctica and the Himalayas, permafrost melt, Amazon die back and halting major ocean current circulation.

These tipping points may cascade, triggering each other. Collectively, these physical system tipping points act to accelerate global warming (by increasing GHG levels) and the impacts, (e.g. accelerating multi-metre sea level rise).

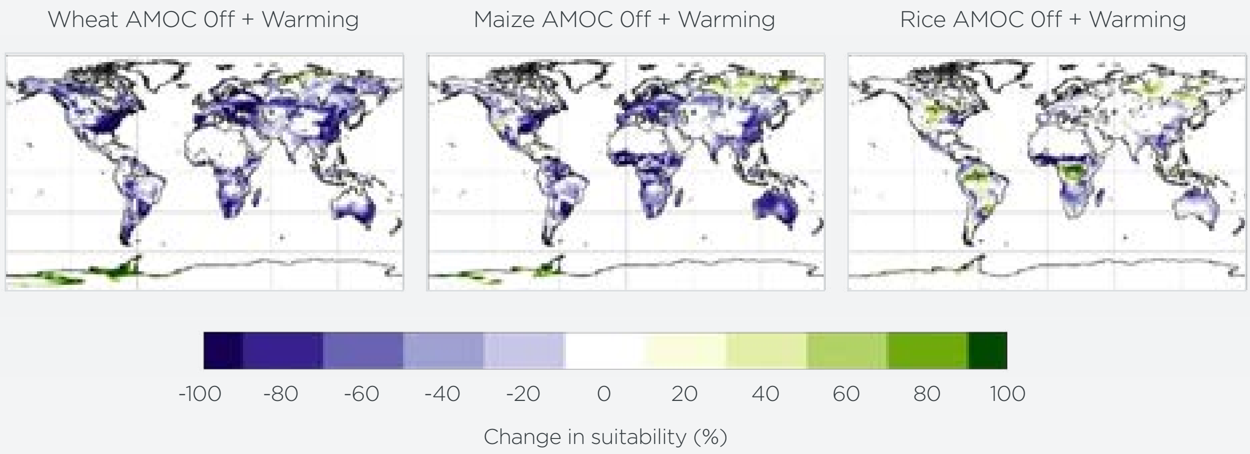
Recent research on climate tipping points identified 16 tipping elements[40] that could be triggered beyond certain temperature thresholds. While the report considered these tipping points independently, there are multiple interactions between tipping points that risk triggering 'cascades', where tipping points trigger one another like dominoes. The collective effect of these interactions is to lower the temperature threshold at which a tipping point is triggered, i.e. making it likely to happen sooner rather than later.

However, many high-profile climate risk assessments do not account for tipping points, largely because it is difficult and no empirical data exists on their impact on human society.

> **More than half the suitable land for growing wheat and maize could be lost.**

This has been called a security blind spot,[41] for example, 'tipping points in the Atlantic Ocean's circulation pose critical risks'. Some scientists estimate there is a 45% chance of a collapse in key ocean current circulations, possibly as early as 2040, which is 'unignorably high'. Impacts would include significant reductions in the northern hemisphere in staple crop-growing capability. More than half the suitable land for growing wheat and maize could be lost compared to a world without climate change, as illustrated in Figure 9 on the following page, with deeper shades of purple indicating greater losses for crop suitability.[42]

Figure 9: Impacts of a tipping point on growing wheat and maize
Difference in crop suitability between present day and the effects of an AMOC collapse plus 2.5°C of global warming.



C. Collaborative across disciplines

Leaders and decision-makers have a role not only as recipients of a completed risk assessment, but also at the beginning of the process, in defining the objectives and interests against which risks should be assessed, i.e. defining their risk currency. This will enable scientists and other experts to ensure their assessments are as relevant as possible.

Scientists naturally have the lead role in understanding changes to the Earth system driven by climate change and nature impacts. At the same time, experts in politics, technology, economics, and other disciplines can provide information relevant to future scenarios, such as emissions trajectories, and the indirect impacts of climate change and nature risks as they interact with human systems.

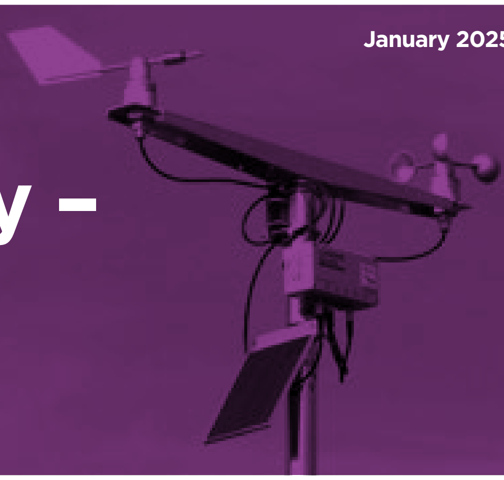
To ensure the most relevant information or uncertainty is communicated to decision-makers, it can be helpful to make a distinction between information gathering and risk assessment. Information gathering activities, such as primary scientific research or influential synthesis reports (IPCC and IPBES), may be free to collect whatever is useful or interesting. Risk assessment must interrogate that evidence in relation to defined objectives, and according to a specific set of principles. Separating these tasks may allow both to be carried out more effectively. For example, such a separation of tasks is often made within intelligence agencies.

Risk assessments could benefit from involving not only scientists, but also those for whom risk assessment is a central part of their professional expertise. Qualified individuals could be drawn from fields such as defence, intelligence, insurance, public health and individuals with good foresight capability.

E. Effective governance and reporting

Planetary Solvency risk assessments should report to the highest decision-making authorities. As King et al[43] stated, *'a risk assessment aims to inform those with the power to reduce or manage the risk.'* Assessments of specific, local, or sectoral risks of climate change may be directed at those with specific, local or sectoral responsibilities. Assessments of the levels of climate change, nature and societal risks as a whole should report directly to those with responsibility for governance as a whole. At the national level, this means the head of government, the cabinet, or the national security council. At the global level, it means institutions where heads of government meet to make decisions.

Furthermore, risk assessments need to be made on a regular and consistent basis, so that in areas of uncertainty, any changes or trends in expert judgment are clearly visible over time. Adopting Planetary Solvency, underpinned by the RESILIENCE principles, would facilitate this. In line with risk management best practice, an independent organisation should take on the responsibility of providing annual Planetary Solvency Assessments.



4. Planetary Solvency – illustrative output

In this section we provide illustrative Planetary Solvency outputs, an overall Planetary Solvency risk dashboard and supporting information on the climate change dimension.

This is presented in the type of format that might typically be provided to a risk committee. The objective is to provide summary and decision-useful information, not detailed analysis. A full Planetary Solvency assessment would include all five dimensions of mortality, the economy, climate, nature and society, leveraging the significant work undertaken across these spheres, with supporting information provided for each dimension, similar to the more detailed information provided for climate change.

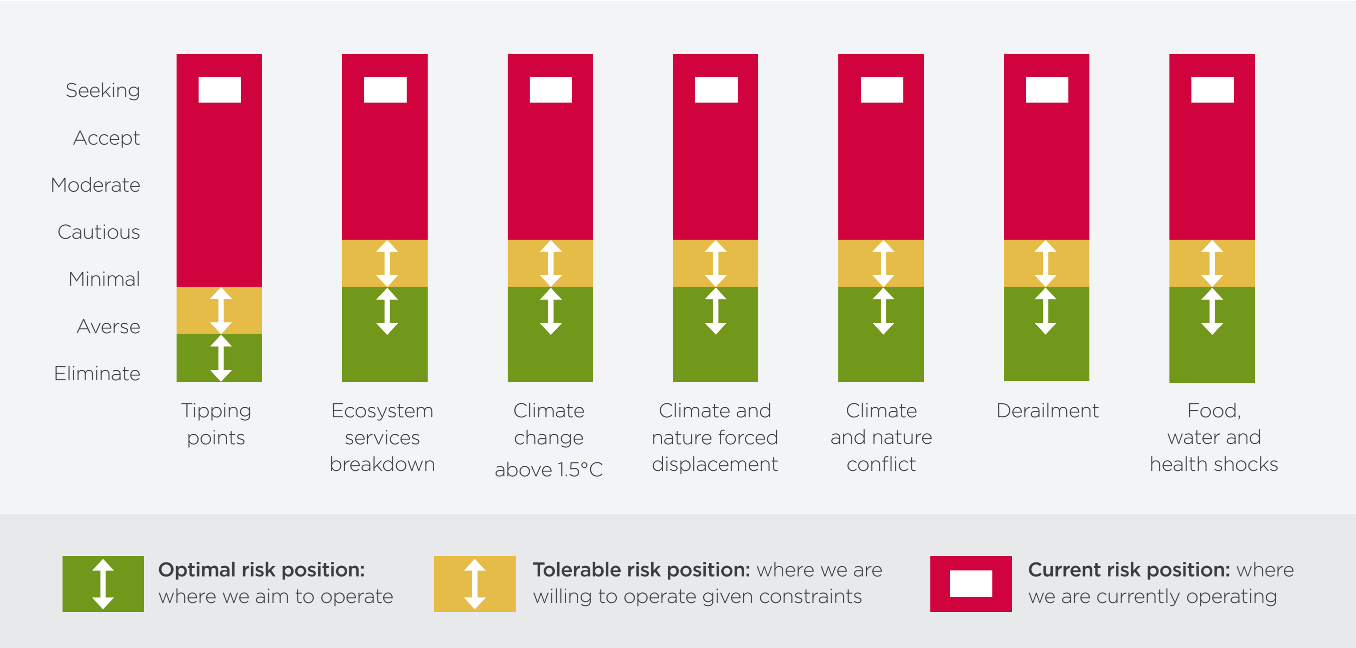
It is important to note no new scientific research is being undertaken to support these analyses, this is a risk-led framing of various Earth system science outputs.

Once a risk appetite and risk matrix is defined (see Appendix I), then it is relatively simple to assess position against appetite, as well as plotting risk positions and trajectories. Based on the impact definitions in the risk matrix, our risk trajectory is concerning, with catastrophic or even extreme climate impacts likely or highly likely by 2050. As with any risk management exercise, the likelihood and impact levels need to be combined, so that the high likelihood and high impact should ring a loud warning bell.

The climate change risk assessment is accompanied by high-level commentary, supported by further detail. This detailed information is a supplementary climate change analysis document, available on request, to support the climate change headlines provided in this document.

As with any risk management exercise, the likelihood and impact levels need to be combined, so that the high likelihood and high impact should ring a loud warning bell.

Figure 10: Planetary Solvency risk appetite assessment



Planetary Solvency risk appetite assessment

Figure 10 above shows a graphical representation of the example risk appetite statement for Planetary Solvency, based on the authors' views on the risks faced and our current position against planetary boundaries. It shows that we are currently implicitly accepting most of these serious risks.

The boxes indicate the risk position, showing that we have implicitly accepted all these risks with our current approach. Put another way, we are in the red zone and well outside risk appetite.

Our risk appetite is indicated by the green and yellow zones, where we seek primarily to eliminate these risks, or at most minimise the likelihood and impact of these risks and associated uncertainties.

This analysis is reflected in the Planetary Solvency summary dashboard which follows in Figure 11. High level summary commentary articulates the risk position and trajectory, which are plotted on the risk impact matrix for the climate, nature, societal and economic dimensions. We have not shown an assessment for mortality in this illustration, as very limited research has been carried out on the potential for large-scale loss of life in relation to these interconnected risks on which to base an assessment.

This shows that although the risk impacts today are becoming *Severe*, the trajectory is concerning, with *Catastrophic* to *Extreme* impacts *Likely* or *Highly Likely* by 2050. This very high likelihood should be cause for concern and viewed as taking all risks well outside risk appetite.

Risks are interconnected; climate and nature impacts are likely to have societal consequences. But as in financial services, a *Catastrophic* level of warming does not mean there will be an immediate *Catastrophic* economic shock or mortality event. For example, today we are at around 1.3°C of warming, so *Severe* on the climate dimension but still impacts are *Limited* on the economic and mortality dimension. Nonetheless, even *Limited* mortality impacts may well be deemed unacceptable by many. However, as climate and nature risks ratchet up, increasingly severe societal impacts become more likely.

Planetary Solvency dashboard

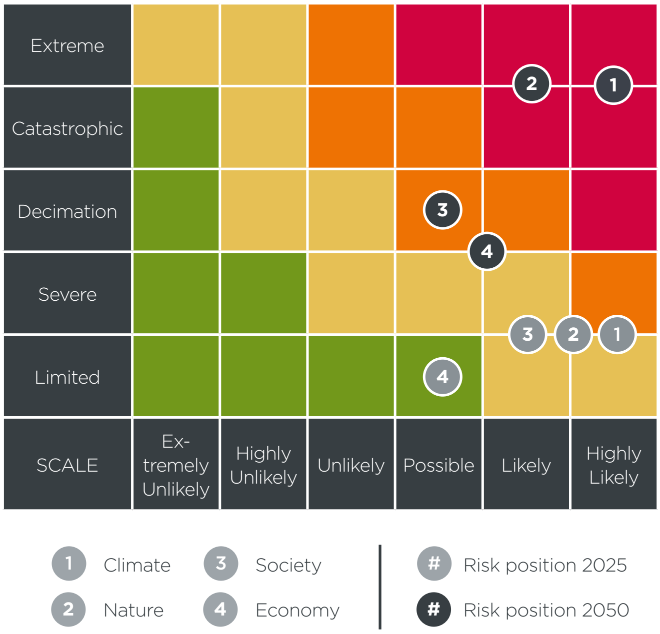
Figure 11: Planetary Solvency Summary Dashboard

Planetary Solvency Risk Rating and Trend	↓	Planetary Solvency Risk Trajectory and Trend	↓

Planetary Solvency Risk position and trajectory

There has been a significant increase in 2025 risk position, with overall position now outside risk appetite. Global climate impacts *Severe*. Nature impacts anticipated *Severe* imminently. Increasing societal fragmentation with active conflicts, heightened geo-political tension and severe stresses on vulnerable states. Economic losses and Mortality still *Limited*.

Risk trajectory pushes all risks further out of appetite soon, with increased breaches of risk tolerances *Likely*. Immediate policy action required to mitigate risks of *Catastrophic* level or greater impacts this century and possibly well before 2050. Cascading and interconnecting nature of risks requires systemic approach and solution.



Planetary Solvency Risk Description & Commentary

1

Climate change: There is a risk that climate change is not mitigated, leading to further global temperature increases and increasingly severe climate impacts, which overwhelm societies ability to adapt.

A. Risk position: AMBER
Impact *Severe* in 2024 with increase in $billion+ loss events and 10k+ mortality events globally. Ongoing increase of emissions and GHG levels, with warming implications. Transition is accelerating.

B. Risk trajectory: RED
Tipping points increase risk exponentially past 1.5C. Emissions and GHG levels imply >2C by 2050. Highly likely *Catastrophic* warming levels experienced pre 2050 with *Extreme* warming Possible to Likely. Policy support required to radically accelerate transition, reduce emissions and leverage natural solutions.

2

Nature: There is a risk that global ecosystems are degraded, natural resources exhausted and biosphere resilience threatened, leading to the breakdown of critical ecosystem services that society rel ies on.

A. Risk position: AMBER
2024 impacts trending to *Severe*. Water and food system stresses increasing. Continued degradation of nature assets, multiple planetary boundaries breached, high extinction rates, multiple ecosystem threats and major ecoservices at risk. Global agreement in place to mitigate biodiversity loss but limited progress on implementation

B. Risk trajectory: RED
Ongoing extractive economy continues to drive risk of multiple ecosystem and related ecoservice failures, exacerbated by climate, with *Catastrophic* risks at least likely and *Extreme* risks possible pre 2050. Policy support required to mitigate risks and global governance over global commons required, linked to and supporting climate policies.

3

Society: There is a risk the path to stabilise the Earth system is derailed by interacting biophysical and socioeconomic factors, with physical risks and resource shortages driving geopolitical tension and conflict.

A. Risk position: YELLOW
Limited to *Severe* impacts in 2024. Several areas of high and ongoing geopolitical tension including multiple active conflicts with risk of contagion, fragile states vulnerable to climate and nature impacts and a trend of increasing economic protectionism.

B. Risk trajectory: AMBER
Nature and climate risk trajectories will drive further biophysical constraints including stresses on water supply, further food supply impacts, heat stress, increased disease vectors, likely to drive migration and conflict. Possible to Likely risk of *Severe* to *Decimation* level societal impacts, with increasingly severe direct and indirect consequences of climate and nature risks driving socio-political fragmentation in exposed and vulnerable regions.

4

Economy: There is a risk that interacting biophysical and socioeconomic factors, lead to economic shocks and contraction of GDP.

A. Risk position: GREEN
Limited economic impacts in 2024, although scale of climate events and subsequent losses continues to trend upwards.

B. Risk trajectory: AMBER
Latest estimates of climate impacts now forecast 19% GDP impact by 2050, *Decimation* or *Catastrophic* level economic impacts now *Possible* due to high range of uncertainty impact of interconnected risk drivers.

5. Climate risk dashboard and headlines

In this section we provide illustrative Planetary Solvency information for the climate change dimension.

A full Planetary Solvency assessment would make this supporting analysis available for each risk dimension. A more detailed climate change analysis document that supports these headlines is available on request.

Figure 11: Illustrative Planetary Solvency Climate Change Dashboard

		2025	②	2050
① **Paris Agreement goals will not be met without immediate policy action, risking ruin**	**Risk rating and trend**	↓		↓

A. Risk position: AMBER
Impact severe, trending to decimation in 2024 with globally increased $billion+ loss events and 10k+ mortality events. Now >1.5°C (12 mth average) implying overshoot. Ongoing increase of emissions and GHG levels, continued fossil fuel investment. Transition accelerating.

③

B. Risk trajectory: RED
Highly likely catastrophic warming levels of >2°C by 2050, driven by emissions, GHG levels and accelerated warming. Tipping points increase risk exponentially past 1.5°C, risks to food security and GDP. Policy needed for adaptation, to accelerate transition and reduce emissions.

④

Physical risk	Energy transition	Risk & uncertainty
• Warming accelerated in 2023, above 1.5°C on 12 mth average, overshoot. • GHGs + emissions also breaking records, more warming in pipeline. • Climate impacts increasingly severe globally: fire, flood, heat, drought. • Nature an undervalued ally that continues to be degraded.	• Energy transition accelerating supported by rapid scaling of transition finance. • $1 trillion investment in fossil fuels and an all time record for coal investment. • GDP requires energy, implying more fossil fuel use if renewables absent. • Energy security and geo-political implications if transition is executed.	• Tipping point risk increases >1.5°C and several tipping points now triggered. • Climate sensitivity, Earth may be much more sensitive to GHGs than we think. • Additional factors driving accelerated warming - aerosol cooling, loss of albedo. • Climate models understate risk, miss non-linear risk impacts and cascading risks.

⑤ **Policy action required to bend risk trajectory to amber**

1. Implement realistic risk assessment to complement science and communicate risk position and trajectory clearly to policymakers.
2. Prepare for faster than expected warming and higher sensitivity. Revisit carbon budgets, decarbonisation pathways and temp ratings.
3. Adaptation required for increasingly severe and unprecedented risk environment, link resilience to national security agenda.
4. Policy support to accelerate S-curves of energy transition and reduce emissions. Consider nuclear and other alternatives as key mitigants.
5. Incorporate nature and justice into national and corporate transition plan requirements, with supporting education on these topics.

Source: Sandy Trust, IFoA analysis

Explanatory notes to dashboard

1. A headline – what is the key message from a risk perspective for policymakers.
2. The risk position is amber and the trend is red. Red is outside appetite, risking insolvency or ruin.
3. Explanation of risk and trend ratings, high level summary with risk impacts (limited, severe, catastrophic etc).
4. High level summary of key risk positions, trajectories and areas of risk and uncertainty.
5. Proposals for policy action to mitigate risks and avoid the red zone.

Paris Agreement goals will not be met without immediate policy action, risking ruin

Risk monitoring

1. 12 month average temperatures have exceeded 1.5°C above pre-industrial level

- Global warming has accelerated, with average temperatures remaining over 1.5°C above pre-industrial temperature.[44] The decadal rate of warming has increased to 0.26°C per decade.[45] It is not yet known whether this recent increase is a temporary fluctuation or permanent shift. Climate scientists have yet to explain it fully.
- Global averages hide local extremes. Record high temperatures are occurring continuously across the globe, with multiple locations now experiencing 40°C to 50°C peaks.[46] Polar regions are experiencing temperatures 30°C to 40°C higher than normal.[47]
- There is a lag between greenhouse gas levels rising and temperatures increasing. We have not yet experienced the full extent of warming caused by current greenhouse gas levels.[48]

Risk measurement

2. This warming trend is likely to accelerate further as emissions continue at high levels

- *Catastrophic* levels of warming, >2°C by 2050, are likely unless immediate action is taken. This trajectory will breach the *solvency limits* of the Paris Agreement.
- Coal demand hit record levels in 2023.[49] Consequently, greenhouse gases are also at record high levels and increasing,[50] driving further warming.
- Degradation of natural carbon sinks (e.g. deforestation, over-fishing, pollution) means the natural world is starting to absorb less carbon, which will accelerate warming.[51]
- Other factors acting to accelerate warming include forest fires releasing carbon, ice melt reducing reflectivity, reduction of ocean heat uptake and loss of aerosol cooling.[52]

Record high temperatures are occurring continuously across the globe, with multiple locations now experiencing 40°C to 50°C peaks.[46]

3. Current 'net zero' carbon budgets need revising as they will not limit warming to 1.5°C

- Current temperatures demonstrate that 'net zero' carbon budgets, which are not themselves being achieved, are unlikely to limit warming to 1.5°C-2°C.[53]
- Net zero carbon budgets are highly uncertain because models do not fully capture all the complexities of the Earth system and assume no 'surprises' such as tipping points, deforestation, large fires or increases in other greenhouse gases such as methane.[54]
- Net zero carbon budgets were set to have a 50% (or at best 66%) chance of staying below 1.5°C or 2°C. If we set carbon budgets based on a higher probability of limiting warming, they become negative, i.e., we need to remove carbon from the atmosphere.[55]
- The Earth may be much more sensitive to greenhouse gases than the central assumption used in carbon budgets,[56] implying much more warming than expected by many models.

Risk Identification

4. Climate change is driving increasingly severe impacts: fires, floods, heat and droughts

- Climate change risk position is trending to severe or catastrophic.
- Climate change is driving increasingly severe impacts sooner than expected: fires, floods, heat and droughts.[57] This is a human security issue with food, water and heat stresses impacting populations. If unchecked, mass mortality and/or migration and/or severe economic shocks are likely.[58]
- Climate assessments have consistently under-stated climate risks,[59, 60] meaning policymakers lacked information on the level of risk they accepted by agreeing the Paris goals of 1.5°C and 2°C in 2015, implicitly accepting much higher levels of risk than was understood at the time of setting these goals.
- Current approaches need expanding to deal with the high levels of risk and uncertainty. Scientists have been superb at equipping the world with detailed information on what is happening and what is likely to happen. This needs to be combined with risk expertise to assess consequences, tail events and actions required to mitigate or avoid them.[61] Given high levels of uncertainty, this is likely to require a blend of qualitative and quantitative scenarios combined with expert judgement.

5. Paris goals risk triggering multiple climate tipping points as we breach 1.5°C

- Warming above 1.5°C is extremely risky. The chance of triggering multiple climate tipping points cannot be ruled out, such as the irreversible collapse of ice sheets, abrupt permafrost thaw, Amazon die back[62] and halting major ocean current circulation.[63]
- Impacts could be catastrophic, including significant loss of capacity to grow major staple crops and multi-metre sea level rise. Some tipping points act to accelerate climate change through release of greenhouse gases, loss of carbon sinks or further loss of reflectivity.[64] Others, such as AMOC collapse, might change the pattern of climate change.
- Tipping points may interact to form tipping cascades, which would further accelerate the rate of warming and severity of climate impacts.[65] If multiple tipping points are triggered, there may be a point of no return, after which it may be impossible to stabilise the climate.[66]

Risk Control

6. Policy action to reduce emissions, accelerate energy transition, adapt and mitigate risk

- The energy transition is accelerating[67, 68, 69, 70, 71] with solutions now available and cost competitive. The pace can be increased[72] by policies that work to leverage cross-sectoral positive socio-economic tipping points and restore natural carbon sinks.[73]
- Simultaneously policy action accompanied by regulation to reduce emissions as close to zero as possible is required. This should include accelerated phase out of fossil fuels, action to reduce methane emissions and protection of carbon sinks.
- Nations will need to adapt in order to be resilient to future shocks.[74] Adaptation priorities should be informed by realistic risk assessments, carried out in line with best practice risk management principles and provided to global, regional and national authorities.
- To inform policy options to mitigate risk, policymakers should commission research on a full range of risk mitigation options, including greenhouse gas removal and solar radiation management.
- Research should consider synergies and trade offs of mitigation options with other risk areas, including the need for just transitions.

Appendix I: Risk impact matrix

The table below shows the Planetary Solvency risk impact and likelihood matrix utilised for the illustrative Planetary Solvency outputs contained in previous sections.

Figure 12: Planetary solvency risk impact and likelihood definitions (illustrative)

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

Likelihood of the risk occurring over a certain timeframe	Extremely Unlikely	Highly Unlikely	Unlikely	Possible	Likely	Highly Likely
	<1%	1-10%	10-40%	40-60%	60-90%	≥90%

Appendix II: systemic risk assessment

In this section we provide an illustration of the need for systemic risk assessment with two case studies: a water risk case study and an illustration of the interconnectedness of tipping points. Both of these case studies indicate the potential for risk to be under-estimated if not assessed systemically.

Exploring water risk - a qualitative systemic risk assessment

Water security considers both the availability and quality of water. Climate change and biodiversity loss increases hazards to our water supply and infrastructure in the following ways:[75]

- Increased droughts and dry spells affecting the availability of water.
- Extreme weather events such as floods and storms disrupting water infrastructure which can lead to shortages and contamination of the water supply, and increase the risk of infectious disease outbreaks.
- Higher sea levels and more intense storms increase the salinisation of ground water resources.
- Seasonal extremes can drive water scarcity and drier conditions year-on-year can lead to a long-term decrease in groundwater tables and soil moisture, which in turn impacts agriculture and food production.
- Melting of mountain glaciers which are important water sources for many.
- Biodiversity loss and deforestation directly impacts water supply as forests are essential as water catchments and natural water purifiers.[76]

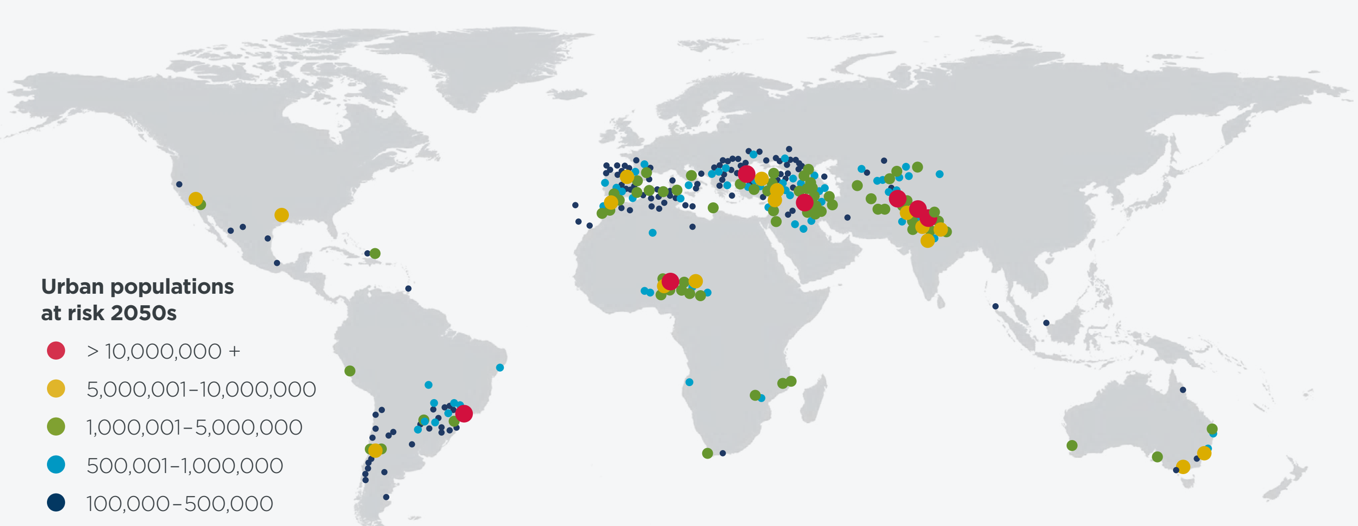
Water scarcity has strong links with other systemic risks including food and energy security,[77] which both have high dependency on water access and can exacerbate water shortages due to their production processes.

Water security is affected by a number of socioeconomic factors such as population growth, production techniques and consumption of food. It is estimated that between 1.5 and 2.5 billion people are exposed to water scarcity globally, with these numbers projected to increase to estimates of up to 4 billion at 4°C.[78] Population growth and socioeconomic changes have increased the global demand for water and it is estimated that the gap between water demand and supply will be 40% by 2030.[79] By 2050, it is projected that at least one in four people will suffer recurring water shortages.[80]

The effects of climate change on water availability and quality are not felt equally around the world. North Africa and the Middle East are likely to have their populations experiencing extreme water stress (<500m^3 per head per year): 17% and 14% of their populations by 2050 respectively.[81] Urban water supply is particularly vulnerable, with the potential to lead to significant societal impacts.[82]

The economic impact of water scarcity could lead to a decrease in up to 6% of gross domestic product (GDP) in certain regions.[83] Water scarcity has knock on effects for agriculture and energy sectors. Agricultural water use is projected to increase due to demand as well as climate change-induced water requirements. In addition, water scarcity increases vulnerability of rain-fed agricultures, changes to weather patterns impact crop yields and there are increased risks for fisheries and aquaculture, which in turn leads to food shortages and societal fragilities.[84]

Figure 13: Decline in urban water availability by 2050



Source: UNESCO, UN-Water, 2020: United Nations World Water Development Report 2020: Water and Climate Change, Paris, UNESCO (Figure 11)

Energy and industrial water demand for freshwater is projected to rise significantly and trigger competition for water across sectors.[85] This in turn could have knock on effects on the world's electricity generation. Hydropower and thermoelectric power are extremely vulnerable to water shortages, with water vital to their functioning. Critically, water is needed for cooling down high temperatures in thermal power plants.[86]

Lack of water can have huge impacts on society, for example, with regards to Water, Sanitation and Hygiene (WaSH). Unsafe water and sanitation can lead to infections such as cholera and dysentery, undernutrition and well-being impacts. It is estimated that nearly two million preventable deaths occur globally each year due to inadequate water and sanitation.[87]

Changes to the water cycle could lead to disruption to freshwater ecosystems and water transportation routes, which in turn can affect both commerce, e.g. fishing stocks, and international security.[88] Water scarcity may also lead to broader societal impacts, including in countries that are not as affected by water security issues. Water shortages are likely to displace millions in the future and lead to an increase in migration. For example, in Iraq, it is estimated that 90 percent of the land is at risk from desertification and land degradation. This is causing two issues: rising water salinity ruining agricultural output and the forced migration of many rural communities to urban areas.[89] Such responses increase resource competition and conflict.

The 2023 *Interconnected Disaster Risks*[90] report from the UN highlights two water-related risks, groundwater depletion and mountain glacier melting, as approaching risk tipping points. For groundwater, when the water table in a given aquifer drops consistently below well depth, access to groundwater will become problematic, increasing the risk to farmers of being unable to irrigate their crops. For mountain glacier melt, the volume of water released increases until a maximum is reached, known as peak water. After this tipping point, glacier meltwater volume decreases as the glacier continues to shrink, with effects on freshwater availability for humans and other species.

Further analysis is provided by Water Witness in their *Towards Fair Water Footprints*[91] report, that shows high income countries have significant external water footprints, typically between 40% and 80%, but in some cases as high as 94%, which can be traced to economies in the global south which face extreme water insecurity and climate vulnerability. They estimate as much as half of the external 'blue' water footprint of the global north is unsustainable.

The growing demand-supply gap for natural resources, coupled with climate change, is highlighted as one of the top global risks in the *World Economic Forum Global Risks Report*.[92] As highlighted above, by 2030 there could be a 40% shortfall in global water supply if there are no changes made to water management.[93] Water security is a multi-faceted issue that not only directly impacts human health but also impacts society and the economy in a number of ways that will only be exacerbated further by climate change.

Earth system tipping points and risk interconnectedness

Tipping points are elements of the Earth system which can shift into a qualitatively different state, such as the irreversible melt of an icesheet, a forest turning to savannah or an ocean current switching off. At today's levels of warming, tipping points associated with coral reefs are likely and tipping points associated with the Greenland and west Antarctic ice sheets, North Atlantic Sub Polar Gyre and permafrost abrupt thaw cannot be ruled out.[94] Further tipping thresholds are likely to be crossed as 1.5°C is passed, including boreal forest, mangroves and seagrass meadows.

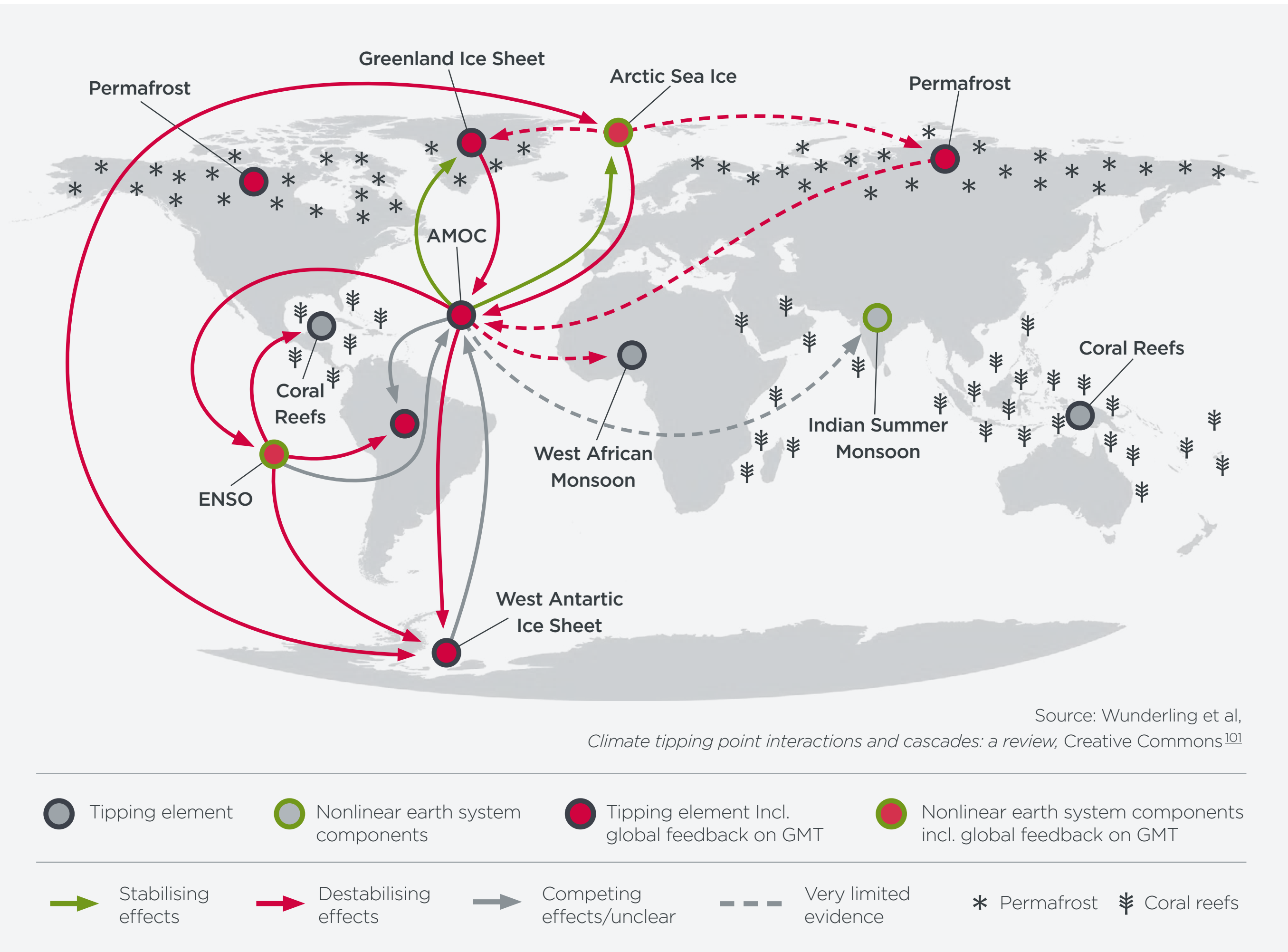
While tipping points have primarily been analysed with reference to climate change, a number of these are critical ecosystem tipping points.[95] Marsden et al identify the following critical ecosystems as Earth system tipping points that require prioritisation by policymakers:

- Amazon rainforest
- Tropical peatlands
- Boreal forests
- Coral reefs
- Mangroves
- Biodiversity

Early warning signals suggest that we are heading towards tipping points for the Greenland ice sheet,[96] Amazon rainforest[97] and Atlantic Meridional Overturning Circulation (AMOC).[98] One study shows that if the AMOC were to shut down and global temperatures were to increase by 2.5°C, the land area available for growing wheat and maize globally reduces by approximately half.[99] Interactions between tipping points tend towards destabilisation with the potential for one system causing another tipping point to be passed. Potential interactions between tipping points are shown in Figure 14 below and in the Amazon Rainforest case study below, which shows that nature loss (deforestation) acts to accelerate tipping points.

The diagram below[100] illustrates these interactions and the potential for tipping cascades, with red arrows indicating a destabilising influence. Tipping points with a red circle indicate they will accelerate warming, either through loss of albedo (e.g. Arctic sea ice) or release of GHGs (e.g. permafrost melt).

Figure 14: Interactions between tipping elements on a world map



Source: Wunderling et al, *Climate tipping point interactions and cascades: a review*, Creative Commons[101]

Amazon Rainforest case study

An examination of the Amazon tipping point demonstrates the importance of a systems approach to risk management. A recent paper explored tipping point thresholds from a climate perspective,[102] providing up to date analysis on the temperature ranges which might trigger tipping points, estimating that the mean temperature estimate for the Amazon tipping point is 3.5°C of warming. However, when deforestation and the influence of the already changed climate is taken into account, this reduces to 1.5°C of warming if deforestation exceeds 20%-25%.[103]

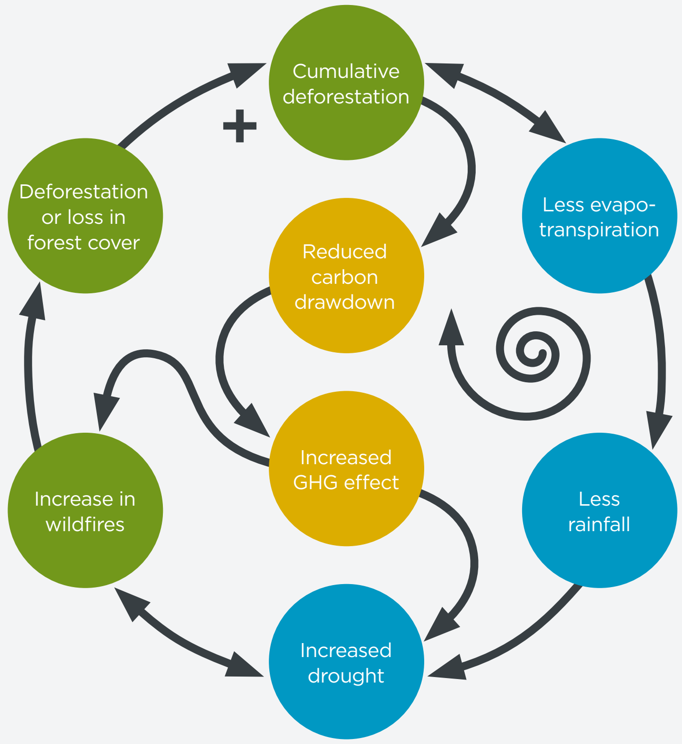


Figure 15: Amazon causal loop diagram: Deforestation, drought, wildfires.
Source: IFoA (adapted from Staal et. al., 2020)

The Amazon is a complex web of hydrological systems and ecosystems and is considered a critical Earth system. It's home to more than 10% of Earth's biodiversity and holds more than the equivalent of 15-20 years of (2024) global carbon dioxide emissions.[104] In 2021, research showed the southeastern Amazon became a carbon source - emitting more carbon emissions than it absorbed.[105] A combination of both increasing temperatures and deforestation risks breaching a tipping point, causing the dieback of large amounts of the Amazon rainforest and a shift into a dry savannah.[106] Table 2 highlights this complicated relationship and the significant impact deforestation can have on the resilience on the rainforest.

Table 2: Conditions for an Amazon Rainforest tipping point

	Temperature	Deforestation rate
Current	+1.2°C (20-year average)	17%
Tipping point (before accounting for deforestation)	+3°C to 5°C	[unaccounted] %
Tipping point (allowing for deforestation)[107]	+1.5°C to 2°C	20-25%

"Keeping the Amazon Forest resilient in the Anthropocene will depend on a combination of local efforts to end deforestation and degradation and to expand restoration, with global efforts to stop greenhouse gas emissions."[108]

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