Institute and Faculty of Actuaries

Anglia Ruskin University

Collaborative insights in the public interest

April 2026

Planetary Solvency: Tipping into the wild unknown

Global nature risk management

by Aled Jones
Georgina Bedenham
Mary Goldman
Andre Ranchin
Nick Spencer
Ian Trim

The degradation of global ecosystems and exhaustion of natural resources are already undermining the resilience of society and the economy.

Contents

Foreword

> Nature is not a luxury; it is our most fundamental form of critical infrastructure.

Emma Howard Boyd CBE, Chair, Group Board, ClientEarth

Nature is not a luxury; it is our most fundamental form of critical infrastructure. Yet, as this vital report on Planetary Solvency makes clear, we are currently managing our global natural assets with a level of negligence that would be unthinkable in any other sector of the economy. We are treating a finite, interconnected ledger of biological wealth as an infinite extraction fund, and the maths simply no longer adds up.

The risks of nature and biodiversity loss are no longer distant or theoretical. We are witnessing the erosion of the very foundations of our stability. When we lose soil fertility, pollinator populations, or the climate-regulating functions of our forests, we aren't just losing 'the environment' – we are losing food security, flood protection, and pandemic resilience.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has warned that roughly one million species now face extinction, many within decades. This is not merely a biological tragedy, it is a systemic solvency crisis. We are pushing multiple Earth system processes beyond safe operating limits, moving toward tipping points where the damage becomes irreversible on any human timescale. This vulnerability is now a matter of state priority, as evidenced by the UK Government's National Security Assessment on Global Ecosystems, which explicitly recognises the collapse of global nature as a top-tier threat to national stability and economic continuity.

The urgency is compounded by the fact that our current economic models remain blind to these realities. We are failing to measure what we value, and consequently, we are failing to manage it. We need a radical shift in mindset: from the "exploitation" of nature to a "balance" with it. This requires a new approach to risk that integrates ecological literacy into the heart of policy and business.

We are already seeing the vanguard of this shift in the legal and governance spheres. Movements toward Rights for Nature and the inclusion of Nature on the Board are no longer fringe ideas; they are becoming essential frameworks for institutional accountability. By working with legal experts and the actuarial profession, we are beginning to define what it means for a corporation or a state to have a fiduciary duty to the biosphere.

To the finance sector, the message is clear: nature risk is financial risk. Every investment portfolio is embedded in the physical world. If the underlying ecological services collapse, the financial assets they support will face sudden and catastrophic write-downs. We must move beyond climate-only modelling to integrated climate-nature scenarios.

The Planetary Solvency dashboard provides the map we have been missing. It is time for investors and policymakers to use it to steer us back within safe limits. Our prosperity, and our security, depend on it.

Nature is the foundation of our lives, not a "nice to have", and it is crumbling. Restoring nature is not something we can postpone for later. It is the infrastructure that keeps food on the table, makes economies possible, and holds societies together. This vital report shows that if we continue to treat ecosystems as expendable, we're not just gambling with wildlife or distant forests, we're putting our own solvency at risk – financial, social, and civilisational.

Professor Paul Behrens, University of Oxford

Nature underpins 100% of investor portfolios, whether directly; through supply chains; or simply to ensure the thriving of the human capital powering productivity. Its degradation represents an economic risk; a national security risk; and is currently a materially mis-priced financial risk that undermines financial stability and expected return on investments. The IFoA has highlighted the financial implications of these risks, and it is incumbent upon investors and policymakers to respond decisively. Integrating nature into financial models—both quantitatively and qualitatively—is an essential step to fully capture the risks and opportunities it presents.

Faith Ward, CRIO Brunel Pension Partnership and Chair, IIGCC Institutional Investors Group on Climate Change (IIGCC)

Nature is a key financial risk, standing alongside climate change in impacting the stability of our economies. This report powerfully demonstrates why decision-makers must treat nature loss with the same urgency and rigour as climate risk. We welcome its recommendations for policymakers and the financial sector, which offer pragmatic steps to begin to take the necessary action to safeguard ecosystems and avert irreversible harm.

James Wilde, Chief Sustainability Officer, Standard Life

For centuries, we have treated nature as if it were free. In reality, it is the infrastructure that keeps our economies functioning, providing the ecosystem services that regulate water, protect communities from floods and sustain the systems on which prosperity depends. When these natural systems break down, we experience water that is too much, too little, or too dirty. Here in the UK, the consequences are already visible in disrupted roads, railways, substations and the cities, companies and communities that rely on them. Reports like this help actuaries and decision-makers recognise nature loss for what it truly is: a systemic risk to economic solvency.

Robert Gardner, CEO and co-founder of Rebalance Earth

Actuaries have the tools to quantify and manage uncertain and long-term risks. Nature loss fits is such a risk, and is not addressed because politically challenges make it easier to avoid addressing the risks. This necessary and excellent report demonstrates that biodiversity is a foundational condition for the solvency of our economic system. The frameworks to understand this already exist, but the more pressing challenge is embedding them into the institutions and decisions where they can actually make a difference.

Nick Silver, Callund Consulting

We, as humans, sit atop the apex of a complex ecosystem which supports us. The survival of our civilisation, if not our species, depends upon its integrity- which we are willfully destroying. Pollution, habitat loss, hunting and intensive agriculture mean that we have reduced the world's wildlife populations by 73% since 1970. Climate change will act as a force multiplier to such impacts. Destroying the ecosystem upon which we depend does not pose a risk which needs to be factored into current behaviour. It leads, with certainty, to disaster. The only risk is in not acting. The only question which a report such as this should raise is why we are not doing so, and why we should care so little for our planet, ourselves and our children.

Professor Hugh Montgomery OBE, University College London

Our failure to protect and restore nature can have disastrous consequences for food supply chains. Above-target food price inflation for climate and nature-impacted foods and empty shelves are not a thing of the future, they are happening now and affecting people on low incomes the worst. This report acknowledges the problems but crucially it offers solutions and makes a compelling case for a mindset shift among actuaries, the financial sector and decision makers to recognise nature as a foundation to our society and economy.

Sofia Parente, Head of Supply Chains Policy, WWF-UK

This important report adds to the substantial and growing evidence that nature-related risks are not only financially material for corporates and financial institutions but also threaten the prosperity of economies and the stability of financial systems. It provides a timely call for action that can be taken now to manage these risks - notably integrated climate-nature scenario analysis, which is also recommended by the TNFD.

Emily McKenzie, Technical Director, Taskforce on Nature-related Financial Disclosures (TNFD)

The recently released Business and Biodiversity Assessment of the Intergovernmental Platform on Biodiversity and Ecosystem Services highlighted that knowledge is already available as a basis for urgent action. This report is a welcome further addition to the knowledge base, showcasing how action to address nature degradation and climate change together can lead to benefits for entire socioeconomic systems in addition to benefits for our natural world.

Sebastian Bekker, Technical Lead, Methods & Metrics, UNEP-WCMC.

Nature risk is financial risk. Our economic wellbeing depends on nature. Unless financial institutions adopt an integrated planetary solvency mindset, they will misprice the risks coming from climate change and nature loss, and overlook the opportunities relating to combined solutions. Integrating biodiversity into risk assessment, scenario analysis and investment decisions is essential for delivering resilient and sustainable long-term financial outcomes.

Peter Elwin, Finance for Biodiversity Foundation

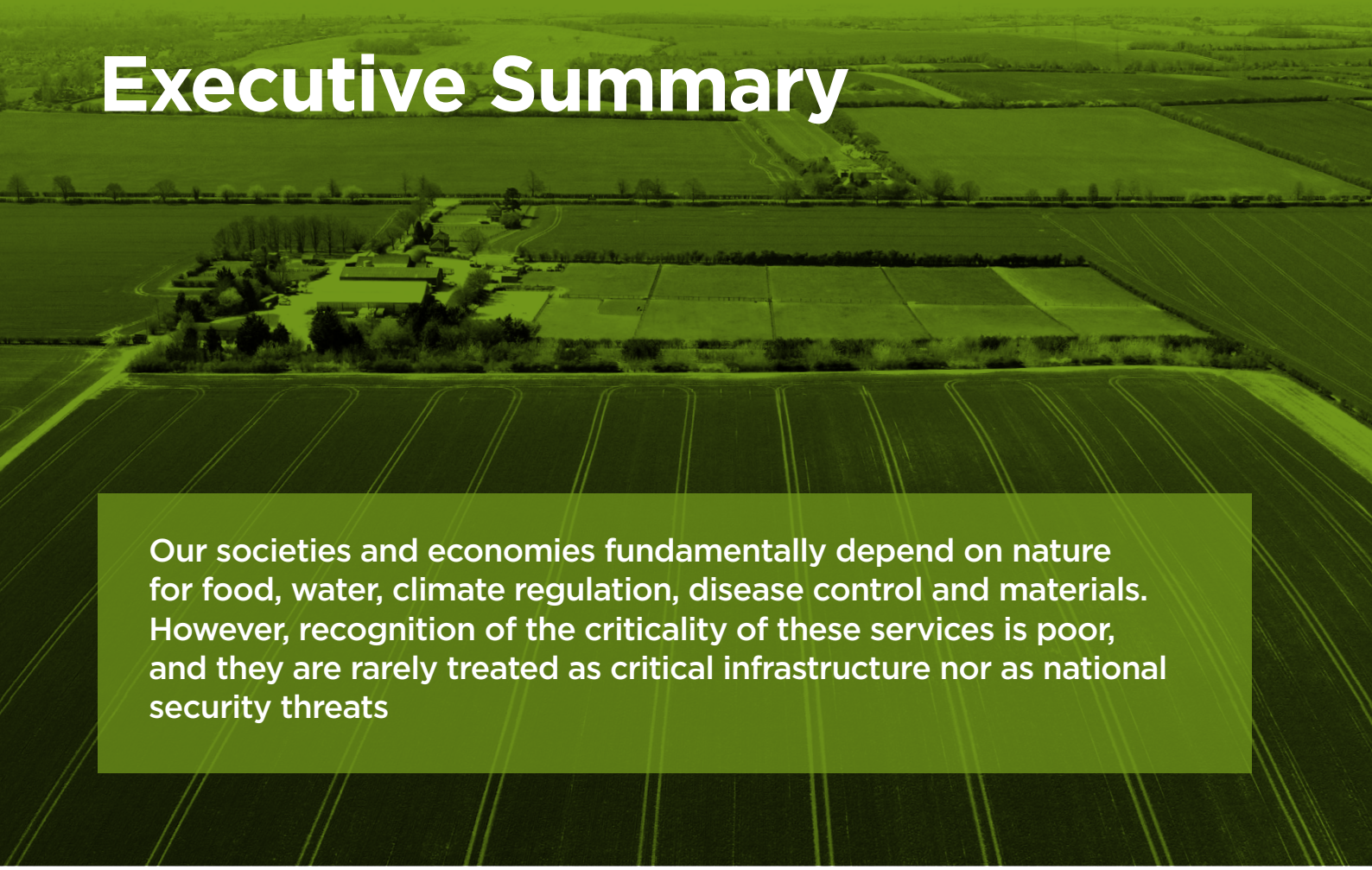
“This is a timely report following the Government’s National Security Assessment on global biodiversity loss. It adds to the growing body of evidence, clearly setting out how impacts are already unfolding and how the economic risks they pose are both material and accelerating. We support the call for urgent progress on integrated climate–nature risk analysis and closer cross-sector coordination to address systemic nature risks and deliver wider benefits for society.”

Phoebe Cox, Senior Nature Associate, Green Finance Institute

“For too long our economic systems have ignored the reality of the interconnected risks we face, treating the demise and/or death of the nonhuman world as something to exploit for profit and our own utility. As this report makes clear, we are reaching the moment when nature forcefully calls in her debts. The findings support the case for placing nature at the centre of how we assess and respond to the risks we face — in mind, in method, and in action. This is not idealism; it is the radical rethink we need.”

Philip Tovey, Director, Nature-Centric Approaches, Accelerator for Systemic Risk Assessment (ASRA)

Executive Summary



Our societies and economies fundamentally depend on nature for food, water, climate regulation, disease control and materials. However, recognition of the criticality of these services is poor, and they are rarely treated as critical infrastructure nor as national security threats

Global biodiversity loss and ecosystem degradation directly threaten societal resilience, security and prosperity, particularly via food, water and health systems.

Nature loss is accelerating across forests, soils, freshwater and oceans, pushing multiple Earth system processes beyond safe operating limits and towards tipping points, including in critical ecosystems such as the Amazon and global coral reefs (Lenton et al., 2025).

The impact of nature loss

Once key ecological thresholds are crossed, ecosystem services like pollination, flood protection and carbon sequestration may collapse irreversibly on human timescales, with no technological substitute at scale.

Chronic risks, including soil degradation, shifts in rainfall patterns, water scarcity and pollinator decline, are already undermining agricultural yields and increasing volatility in global commodity markets.

Acute shocks such as compound breadbasket failures, fishery collapse, trade disruptions and extreme weather, are already translating into higher and more volatile prices for food and other essentials (Walker, 2025), leading to supply shortages and inflation. Experts judge that UK food-related civil unrest is “at least possible” within the next decade (Jones et al., 2023).

In a context where many households already face food insecurity and hardship, further nature-driven price rises risk deepening inequality, undermining public health and straining social cohesion and public finances.

Increase in zoonotic diseases

Around 70% of emerging infectious diseases originate in animals (Millbank & Vira, 2022), with land-use change, deforestation and wildlife trade increasing the risk of future pandemics.

Efforts to improve mitigations against this are described as fragile and threatened by reductions in global health funding (WHO, 2026). This equates to risk–seeking behaviour from a planetary solvency point of view.

The Covid-19 pandemic, with trillions in economic costs, represents only a small fraction of the potential zoonotic hazard space, with hundreds of thousands of viruses estimated to have the capacity to infect humans and global connectivity amplifying future outbreak risks. Increasing antimicrobial resistance (AMR) magnifies these pandemic risks, with only limited efforts to curb the risk multipliers from excessive and poorly managed use of antibiotics in healthcare and animal husbandry.

Recommendations

In this report we recommend that governments, central banks and regulators should embed nature-related risks into national security strategies, fiscal planning and financial stability assessments, using realistic, systemic scenarios that reflect the joint dynamics of climate, biodiversity, food, health and geopolitical risks.

This requires moving beyond climate-only modelling to integrated climate-nature scenarios, improved metrics for ecosystem condition, and routine use of Planetary Solvency dashboards to track risk position and trajectory against safe limits.

That necessitates a shift in mindset, from exploiting nature to finding our balance with nature.

The UK national security assessment on global ecosystems (HM Government, 2026) found that global ecosystem degradation and collapse threaten UK national security and prosperity. The cascading risks of ecosystem degradation are likely to include geopolitical instability, economic insecurity, conflict, migration and increased inter–state competition for resources.

Adopting a Planetary Solvency mindset enables decision makers to treat nature as critical infrastructure, not a free resource, recognising that safeguarding ecosystem services is a precondition for prosperity, stability and security.

This includes aligning economic and security policy with planetary boundaries, reframing nature restoration and protection as national security investment, and embedding ecological literacy across institutions.

For actuaries and those working in the financial service industries, the most important conclusion is that nature and biodiversity cannot be ignored.

Financial risks, impacts and society's prosperity are all dependent on nature. Failure to take account of nature–related risks represents a failure to understand and manage risks to individual organisations as well as almost certainly magnifying the risks of ecosystem collapse and the consequent societal impacts.

Failure to take account of nature–related risks represents a failure to understand and manage risks to individual organisations as well as almost certainly magnifying the risks of ecosystem collapse and the consequent societal impacts.

1. The Planetary Solvency dashboard

Imagine nature as a vast, interconnected ledger – a financial balance sheet containing all living things. Each ecosystem is a critical account: forests, oceans, wetlands, deserts. Each account holds assets like species, nutrients, climate regulation, and generates dividends in the form of clean air, fertile soil, medicine, water and food security.

Many of our accounts are now overdrawn. For years, withdrawals (deforestation, pollution, overfishing) have far exceeded deposits (conservation, restoration). At first, the system absorbs the imbalance. But eventually, the ledger hits zero and then plunges into ecological debt.

This is where planetary boundaries (Richardson, et al., 2023; Rockstrom et al., 2009) come in (Figure 1). We do not know enough yet to determine if recovery is possible when we move beyond a planetary boundary, however these boundaries are often set near ecosystem tipping points – a threshold beyond which ecosystems will not recover.

When coral reefs collapse or pollinators vanish, the nature dividends stop, and the ecosystem services provided are not substitutable. Financial risks increase, supply chains falter and insurance claims rise.

Investors holding portfolios which rely on these natural assets – as most portfolios do – could face sudden write-downs (Ranger et al., 2024). Beyond a planetary boundary, recovery is slow, costly, and often incomplete. Beyond a tipping point, recovery cannot be assumed to be possible, and alternative sources of the same ecosystem service are needed, if that is possible. The risk is not just volatility, it is irreversibility.

The risk is not just volatility, it is irreversibility.

Figure 1: The evolution of the planetary boundaries framework (Stockholm Resilience Centre, 2025). Reproduced under Creative Commons.

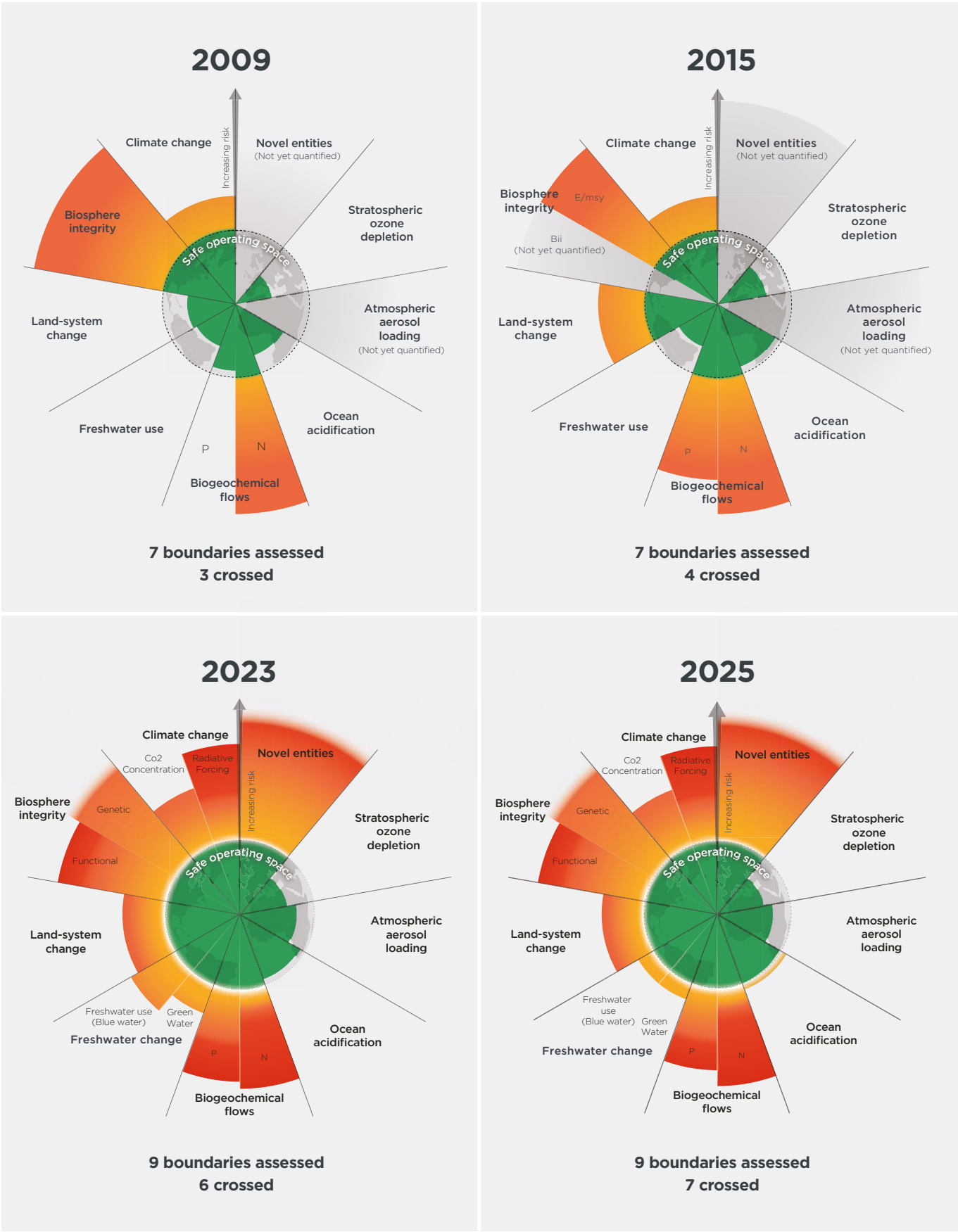
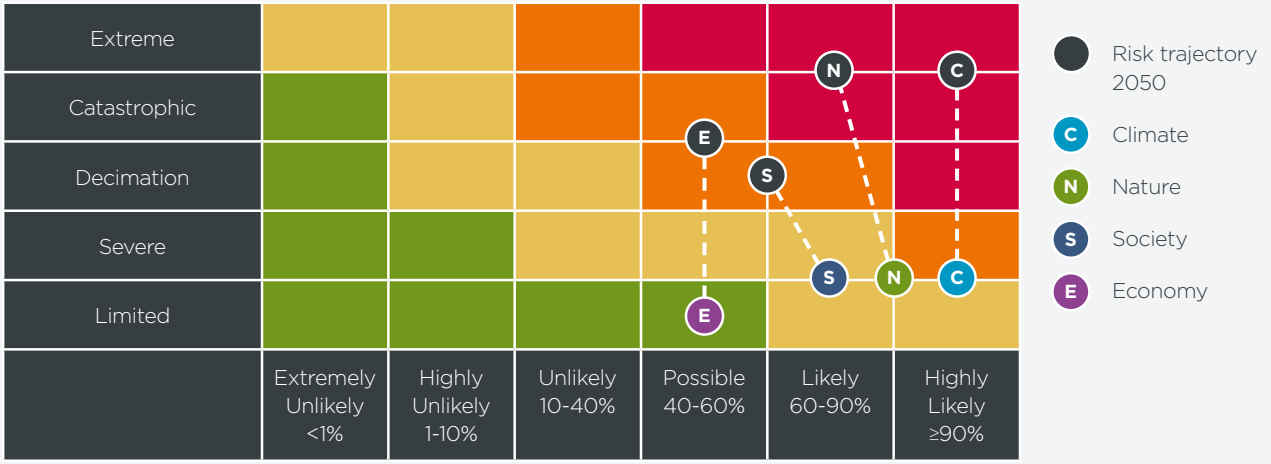


Figure 2: The Planetary Solvency risk position and trajectory (Trust et al., 2025).



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.

The financial impacts of environmental degradation

The evidence is clear: nature, ecosystem and biodiversity risks are not distant or theoretical. They are immediate, systemic, and accelerating.

The Institute and Faculty of Actuaries' Planetary Solvency report (Trust et al., 2025) starkly warned that unchecked environmental degradation will likely lead to severe GDP contraction and catastrophic impacts that threaten future prosperity.

This report builds on those findings, demonstrating that the breakdown of critical ecosystem services – pollination, water purification, carbon sequestration, and disease regulation – threatens not only environmental stability but also economic and societal resilience.

We note that nature risk is captured on the Planetary Solvency Dashboard (see **https://global-tipping-points.org/planetary-solvency/**) as shown in *Figure 2* and summarised as:

"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 relies on."

While ecosystems are inherently local, the global nature of supply chains means that levels of consumption in one part of the world can be a long way away from the damage, degradation and impact they cause.

That makes it easier to ignore or overlook the growing systemic risks – they appear limited because they are distant. Their consequences, however, can be severe.

As the global system moves beyond tipping points, these local impacts will aggregate and global tipping points may be breached, leading to potentially extreme risk and global impact over the next few decades.

From the perspective of the Planetary Solvency risk dashboard, our societal risk appetite means we should seek to avoid:

- Crossing Earth system tipping points and triggering tipping cascades
- Habitat loss and species extinctions
- Breakdown of critical ecosystem services
- Every 0.1°C of climate change above 1.5°C, even as overshoot.

Climate and nature impacts are increasingly severe. On the current trajectory, the prioritisation of economic growth, resource extraction, and short-term financial profit escalates the risk of ecosystem breakdown and ecosystem service collapse.

Crucially, the dashboard framework warns that immediate policy action is required to mitigate the risk of catastrophic or greater impacts this century. The cascading and interconnected relationships of these risks means that systemic solutions are needed to address the scale and complexity of the challenge.

- **January 2025**: California wildfires, driven by drought, record heat and extreme Santa Ana winds, destroyed more than 16,000–18,000 structures, caused tens of billions of dollars in damage, including a record $61.2bn loss, and resulted in dozens of confirmed deaths, with broader estimates far higher.
- **July 2025:** Texas Hill Country floods killed more than 120 people, with around 170 still missing, and caused an estimated $18–$22bn in total economic losses, making it one of the deadliest and costliest inland flood disasters in U.S. history.
- **2025:** U.S. severe storm season set records with 21 billion-dollar events, including a mid-March outbreak of 113 tornadoes that killed 43 people and caused over $10bn in damage, contributing to a total annual storm-related cost of $115bn
- **May 2025:** Cyclone Remal struck Bangladesh and India with winds over 110 km/h, killing at least 34 people and damaging thousands of homes.
- **June–July 2025:** Heavy pre-monsoon rains triggered flash floods across multiple Pakistani provinces, destroying infrastructure and killing at least 79 people.
- **June–July 2025:** Massive wildfires fuelled by heatwaves and strong winds forced 50,000 residents to evacuate, and devastated farmland and forests in İzmir Province in Turkey.
- **June–July 2025:** Temperatures exceeded 40°C across southern Europe and England, contributing to an estimated 1,500 excess deaths.

Undermining resilience

The degradation of global ecosystems and exhaustion of natural resources are already undermining the resilience of society and the economy. We are breaching planetary boundaries at an accelerating pace, pushing the biosphere towards irreversible tipping points and entering what scientists describe as the sixth mass extinction (WWF, n.d.).

While nature has a remarkable capacity to recover, there are limits. Once critical thresholds are crossed, ecosystem services may collapse, and recovery may no longer be possible. Tens to hundreds of millions of years of evolution cannot simply be recovered in hundreds or even thousands of years.

This report highlights a number of actions that need to be taken, globally and nationally, by policymakers, actuaries and financial modellers in order to ensure nature is integrated into decision making.

We first outline short-term risks that we face as a result of nature degradation, followed by longer-term risks. We then explore how actuaries and financial modellers currently assess these risks in their decision making, before outlining a set of recommendations.

We acknowledge that a lot of work on nature as a critical infrastructure is underway and should be welcomed, including evolving nature investment models and approaches, alongside global drives towards international frameworks that drive real change. However, more action is urgently needed.

While nature has a remarkable capacity to recover, there are limits.

The aim of this report is to provide some context to the nature risks that are faced, validation of their financial importance, and ways these can be better incorporated into our risk scenarios and thinking.

It is not exhaustive, and is intended only to illustrate some of the risks we will face as a result of nature degradation and biodiversity loss. Further work is needed to explore the full range of risks that should be considered in decision making – for example, this report does not cover in detail broader risks associated with water.

2. Significant short-term risks from nature

The planetary dashboard associates the current outlook of nature-based risks as 'likely' to 'highly likely' to occur with a 'limited' to 'severe' impact[1]. This reflects the challenges and risks from degradation of nature that already exist in the short term.

The long-term pathway is less certain, but the planetary dashboards associate the long-term, nature-based risk outlook to be likely to incur between 'catastrophic' and 'extreme' impacts without significant mitigating efforts.

Two examples are in food systems and pandemics. Food system risks are often under-appreciated, and could have both direct inflationary consequences, as well as impacting short- and long-term economic outlook. Even developed countries such as the UK are particularly vulnerable to food system risks, with material risks of civil unrest in the short- to medium-term (next 10 years).

The Covid-19 experience (2020–2022) highlights significant potential impacts of pandemics. Weaknesses in the husbandry of natural habitats and biodiversity losses contribute to increasing the risks of future pandemics.

2.1 Food system risks

In this section we highlight potential near-term and significant risks from the food system.

There are now over eight billion people on the planet, and over the past century a green revolution has seen global agricultural output grow by more than 400% to feed the population boom (Ritchie, Rosado & Roser, 2023). Since the turn of the century alone, global production has grown by more than a third.

This growth in production has not seen a similar increase in environmental footprint due to greater efficiency of land use (Komarnytsky et al. 2022). However, it has created a number of chronic and acute risks in the food system (Benton et al. 2021).

1 | See Appendix, Table 1 for descriptions of occurrence probability and impact assessments. Further details on planetary solvency available at **https://global-tipping-points.org/planetary-solvency/**.

The food system, and its inputs, needs to operate within planetary boundaries (Conijn et al 2018). Agriculture requires stable and predictable weather (Ray et al. 2015, Gowdy 2020), soil health and nutrients, biodiversity including pollinators (Crist et al. 2017), water, and an ever-increasing rate of technological improvement to support mechanisation and industrial processes (Timmer 1988, Levers et al 2018). Currently several of these planetary boundaries have been breached, resulting in a number of chronic and acute risks to the food system.

Addressing risks in the food system means accounting for the externalities that producing food has (such as its contribution to climate change), as well as building resilience or responding to shocks. These will all place inflationary pressures on food prices in the future, and while the impact on food price inflation due to climate change in global north countries has been modest to date (Gammans & Schaefer, 2025), future impacts are expected to grow significantly, as has already been seen in global south countries (Odongo et al., 2022).

Any significant impact on food that reduces availability, affordability, accessibility or quality, can lead to increased food insecurity, malnutrition and even social unrest, especially in the context of a cost of living crisis.

Civil unrest in the UK as a result of a food system crisis was deemed as at least possible over the next 50 years by over 80% of experts interviewed as part of the Jones et al. (2023) study. Over 40% thought it was at least possible within the next 10 years.

Chronic risks within the food system

Food grain production is concentrated into a few countries and global distribution managed by a few companies. Over 80% of the world's wheat is produced in the top ten countries of China, EU, India, Russia, USA, Canada, Pakistan, Australia, Ukraine and Turkey. ADM, Bunge, Cargill and Dreyfus (the ABCD of food) together manage over three quarters of global grain trade.

This concentration results in an increased risk of disruption if a region loses the ability to produce food (Gaupp et al., 2019, Chen et al., 2024) or transport food, such as the case of Ukraine (Lin et al., 2023) or the Suez Canal, where any disruption can have an outsized impact (Bailey & Wellesley, 2017, Verschuur et al., 2023).

For example, climate change and ecosystem degradation is seeing the viability of agricultural production in some regions at least changed, if not reduced. Crops are adapted to local weather patterns, diseases and soil conditions. As weather conditions change – for example, increased drought conditions on the west coast of the USA – the types of crops and how they are managed need to change.

Some of these chronic risks are also at risk of experiencing tipping points, with ecosystem collapse possible or, for example, a permanent change to the monsoon patterns in India or West Africa (Ben-Yami et al., 2024).

Soil health is in precipitative decline globally, and while estimates of the true extent of soil degradation are difficult to obtain, recent studies have explored regional impacts and found that in the US corn belt soil degradation has resulted in lower crop yields and $2.8bn in annual losses (Thaler et al., 2021).

Soil is impacted by and has an impact on seven of the nine planetary boundaries (Steffen et al., 2015) and contributes over $11tn annually in ecosystem services, with the majority of that value being food (Kopittke et al., 2021).

Changes to water availability (both absolute and seasonal), growth in antibiotic resistance, and challenges in securing resource inputs such as animal feed or technology components all add to these risks.

A recent survey of farmers (Jones et al., 2024) found that alongside these chronic risks, government policies on carbon sequestration, biodiversity and trade were creating further uncertainty around land use in the future, leading to additional chronic risks.

Olam Group is a global agribusiness specialising in food commodities like coffee, cotton, and rice. Olam's 2023 financial report offers an example of a physical risk translating into a significant profit decline.

The company stated it grappled with 'higher exceptional losses' arising from an 'industry-wide aberration for almond yields in Australia for the season.' An exceptional loss associated with almond yields was material enough to be segregated from normal operational fluctuations. However, as an agricultural business highly exposed to a range of agricultural commodities, Olam might expect to see an increase in the frequency and intensity of what we now consider exceptional loss as nature declines further.

A precise dollar figure for the yield decline was not isolated, it was cited as a primary driver for a 55.7% drop in the company's Profit After Tax and Minority Interest (PATMI). This event, and the associated disclosure, directly connects a nature-related physical risk to a material negative impact on shareholder profit (Olam Group (2024)).

Whilst annual food price inflation has slowed in the UK, it soared to almost 20% in 2023 (Figure 3), then after falling to below 3%, was rising again at the end of 2025.

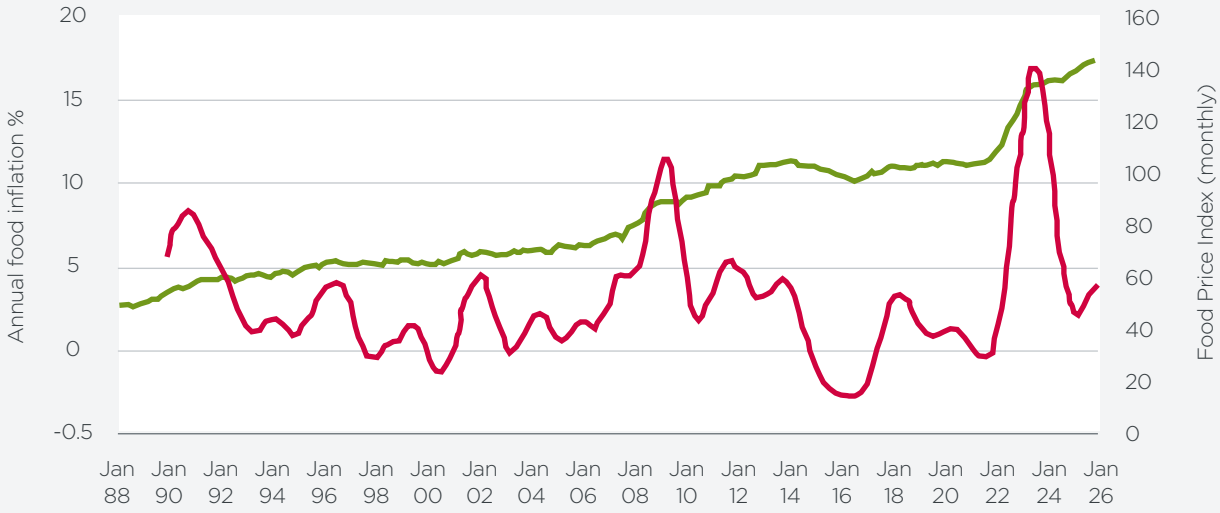
In 2022/23 a record 9.3 million people in the UK were experiencing severe hardship leading to, and being driven by, deteriorating physical and mental health (Trussell, 2025).

As highlighted by Dominic Watters, lived and living experience researcher, when speaking about research highlighting the chronic risks in the UK food system[2]: *"Food crises don't come from a lack of calories alone; they come from a lack of dignity, voice, and care. The stigma and dehumanisation of food insecurity are already creating cracks in our society. If we want a genuinely resilient and 'ready' United Kingdom, we cannot build it on systems of shame."*

In 2024, 6.5 million people in the UK accessed charitable food provision such as food banks or food parcels, and nearly a third of homes in the most deprived areas are classified as food insecure (Trussell, 2025).

Further pressures on food prices from climate change or nature risks will only make these challenges more difficult to solve, and could lead to significant societal risk (Bridle et al., 2026).

Figure 3: UK Food price inflation (red) and index (green) showing a sharp increase in inflation between 2022 and 2024 (National Statistics, 2026).



The food system also has several human-related chronic risks, including a skills shortage across the sector and globe, and weather-related impacts, such as extreme heat, on the ability of labour to harvest food.

The price of food does not take into account all the externalities that the food system creates, most notably its impact on climate change and biodiversity. However, increasing the cost of food produces an affordability challenge in a world where food poverty is already endemic.

Moreover, food poverty is not restricted to mid– and lower–income countries. For example, the Trussell Trust (Trussell, 2025) found more than one in four (27%) UK children were growing up in food insecure households (i.e. households which were going without or cutting back on quality or quantity of food).

Therefore, the food system, while being highly optimised and efficient, is vulnerable to a host of chronic risks.

2 | **https://www.york.ac.uk/news-and-events/news/2026/research/food-crisis/**

Acute risks within the food system

While chronic risks in the food system represent significant global risk, in the short term major impacts could be felt through a large array of acute risks. Agricultural production has already been the subject of shocks globally (Lunt et al. 2016, Hunt et al. 2021, Kornhuber et al. 2023, Chen et al. 2024, Homer–Dixon et al., 2015), with the severe limitations on major breadbaskets becoming increasingly common. Indeed, senior industry experts have recently highlighted the significant threat to food security that they now perceive (Inside Track, 2025).

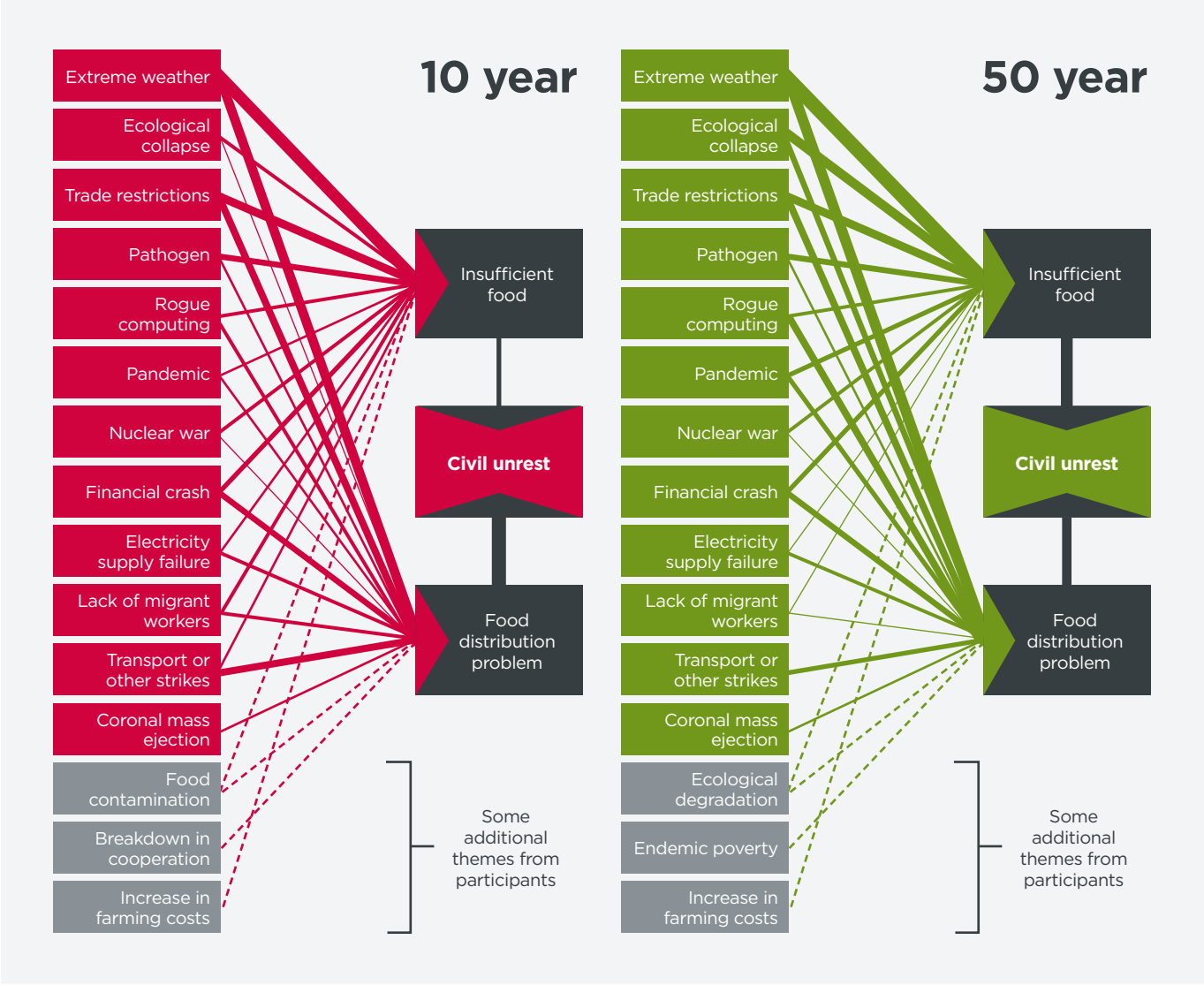
Recently Jones et al., (2023) identified 17 different types of risk (see *Figure 4*) over the next 10 and 50 years that may impact the UK food system. Of these, extreme weather, ecological collapse, and pathogens were considered by food experts to be in the top four risks (alongside trade), and all relate to nature's interaction with the food system.

Importantly, the experts felt it was the interaction between these risks within a complex system that created a substantial risk to the food system in the UK over those time horizons.

They found, for example, that some risks may be compounding (e.g. extreme weather risk such as a flood in the USA could occur alongside a geopolitical –tension-based trade restriction risk, resulting in significantly higher prices of imports).

Some risks may be coupled (e.g. a drought impacting food production may be coupled to an increase in energy prices due to increased energy demand during a heatwave), and some risks may be cascading (e.g. a heatwave could trigger a pathogen risk).

Figure 4: Food risks identified and prioritised by food system experts over a 10 and 50 year time horizon (Jones, et al., 2023). Reproduced under Creative Commons.



The food system represents a complex and multidimensional challenge with many interacting parts (see *Figure 5*). With approximately 8% of people facing hunger, and over two billion people not able to afford a healthy diet, the United Nations Sustainable Development Goals (SDGs) have identified access to food as a critical component to achieving prosperity in the future, with SDG2 focusing on zero hunger.

Whilst food is very political, there remain systemic vulnerabilities that are not addressed in policy (Falloon et al., 2022). Often policy responds to these risks, rather than builds resilience.

Recent examples include the effects of drought on Russian wheat harvests (Hunt et al., 2021), solar storms impacting GPS trackers on farms in the US (Griffin et al., 2025), labour strikes at ports disrupting supply chains in the US (Rose et al., 2024), and conflict impacting food production and export, such as the Russian invasion of Ukraine (Ben Hassen & El Bilali, 2022).

Figure 5: Chronic and acute risks in the food system. Adapted from Bridle et al. (2026).

Lack of access to affordable food, coupled with the cost of living crisis (Broadbent et al 2023), food poverty (Goudie 2022), and inequality (Hood & Waters 2017), can lead to significant societal impacts, including impacts on physical and mental health (Colombo et al., 2024).

Therefore, understanding these chronic and acute risks and their potential impact across society, including morbidity, mortality, productivity, insurance, investment and wider financial risks, is vital.

Any acute risks acting on top of the chronic risks could lead to deep economic instability, if not globally then certainly regionally and nationally (Natalini et al., 2019, Jones et al., 2023).

As part of an effort to understand these risks further, a major investment in research across the food system has recently been undertaken by the UK Government. One of the projects funded as part of this initiative, Backcasting to Achieve Food Resilience in the UK[3], has developed a serious game (Barefood, 2026), which is being rolled out with a number of senior stakeholders across the food system to encourage decision-makers and experts to explore and plan for complex vulnerabilities within the UK food system.

This project has identified 40 acute crises that need to be better understood so that interventions in the food system can be properly designed to build its resilience. The acute crises are selected based on potential UK vulnerabilities, with those relating to nature listed in *Table 2* in the **Appendix**.

Other crises include cyber attack, energy price spikes, war in Europe, public finance crunch, trade war, and misinformation leading to a collapse in trust. That's in addition to a breakdown in trust in elected officials, shift in diets towards increased meat consumption, retail supply breakdown, general strike, shortages in labour, power outage, panic buying, nuclear fallout, shift in diet following a collapse in diet medication, and a collapse in insurance.

Starbucks, a publicly traded global coffee retail chain, notes in its 2024 annual report that extreme weather conditions in Brazil have impacted coffee prices in the past.

The company discloses that it is likely these events will occur in the future with greater severity and intensity, having similar or worse impacts on price volatility.

Starbucks also cites in their annual report that nature-related risks like water supply and availability, and pests and disease, could further impact coffee prices (Starbucks (2024)).

3 | **https://www.aru.ac.uk/global-sustainability-institute-gsi/research/backcasting-to-achieve-food-resilience**

2.2 Zoonotic diseases

The recent Covid-19 pandemic illustrated the significant systemic risks that zoonotic diseases – diseases caused by microbes of animal origin that have been transmitted to humans – pose to society.

Throughout history, the capacity of zoonotic diseases to develop into pandemics has created devastation, spreading plagues, smallpox and outbreaks of different strains of influenza (Keesing and Ostfeld, 2021).

The widespread dislocations caused by the Covid-19 pandemic were the latest in a line of pandemics emerging from animal origins, with the first recorded zoonoses occurring 2000 years ago.

It is now estimated that 70% of emerging diseases (e.g., Ebola, Zika, Nipah encephalitis), and almost all known pandemics (e.g., influenza, HIV/AIDS, Covid-19) originate from microbes emerging from contact between wildlife and people (IPBES, 2020).

Animals share their pathogens with us in the same way as we share them with each other – via aerosols, saliva, blood, etc. Whether the virus is then picked up by the human host will depend on multiple factors, such as the immune system, but nonetheless, closer proximity and more frequent interactions between biodiversity and humans will increase the potential for transmission.

Once the transfer has happened from animal host to humans, the disease can then evolve into human-to-human transmission, with devastating effects.

Our ongoing destruction of nature, by bringing us into ever closer contact with host species and coupled with our ever-increasing globalisation of travel and trade, is driving an increase in the emergence of these devastating diseases, and amplifying their effects on a global scale.

An increasing prevalence of zoonotic diseases

Whilst zoonotic diseases have been devastating populations throughout history, they appear to be emerging more frequently in the present time.

Recent decades have seen a steady increase in the emergence of zoonotic diseases, with fewer years between outbreaks, fewer years with no outbreaks, and outbreaks that spread to populations on more continents (Bernstein et al., 2022; IPBES, 2020).

> **Throughout history, the capacity of zoonotic diseases to develop into pandemics has created devastation.**

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) stresses that unless we introduce preventative strategies, e.g. conservation measures, that deal with the root causes of the transfer of pathogens, such as the destruction of forests, then we should expect the increase in pandemics to continue (IPBES, 2020).

Our increasingly globalised economies and interconnected societies will cause the diseases to become even more devastating in terms of lives lost and economic turmoil as the pathogens are provided transfer routes around the world.

The destruction of nature drives an increase in zoonotic diseases

There are clear links between anthropogenic destruction of nature, such as changes in land use and deforestation in the most biodiverse areas of the planet, and the spread of zoonotic diseases (Guégan et al., 2020).

As we push further into forests, dive deeper into the oceans and enter other pristine environments, the causes of biodiversity loss become ever more closely intertwined with the causes of global pandemics.

Converting forests to agriculture or exploiting them for logging or mining, intensifying our agricultural practices, and expanding the cross-border trade in wildlife, bring people and wildlife into ever closer contact, providing animal microbes the opportunity to cross from their hosts to humans.

The effects of these cross-species transfers are then amplified, as the new human hosts move to highly dense city environments, and board transportation, spreading the potentially devastating pathogens around the world.

The effects of our ongoing destruction of nature are amplified by climate change, with the make up of ecological communities themselves changing as species shift to deal with climatic changes (Pfenning–Butterworth et al., 2024).

However, the destruction of nature and the increasing prevalence of zoonotic disease is somewhat of a paradox. By reducing the diversity of nature, we appear to be increasing the presence of zoonotic diseases caused by our interactions with nature.

The amplification effect suggests that more diverse habitats are pathogen hotspots, as they have greater diversity of pathogens and species (Marie and Gordon, 2023). Conversely, the dilution effect suggests that higher levels of biological diversity can act as a break on the spread and development of zoonotic diseases.

It is suggested that more diverse communities hosting potentially dangerous pathogens can help to control the development and spread of diseases by regulating populations of susceptible hosts, or by interfering with the transmission process (Civitello et al., 2015).

Perhaps the resolution to this apparent conflict, then, is in understanding that the species most likely to thrive in environments impacted by human encroachment, such as bats, rodents and monkeys, are also those more likely to play host to zoonotic diseases (Keesing and Ostfeld, 2021).

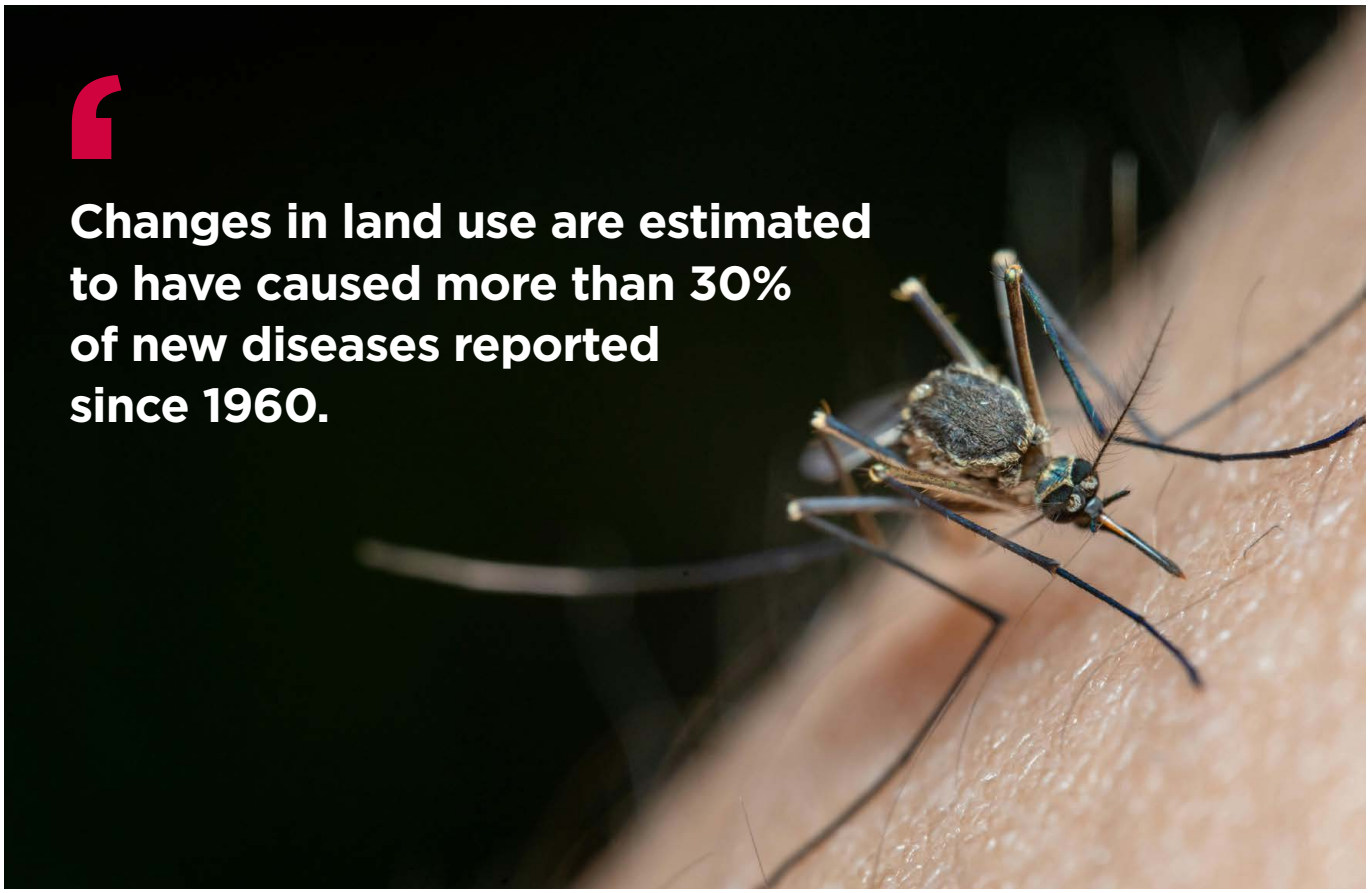
We are, in effect, removing the diversity that helps to suppress potential diseases, whilst promoting the species most adept at spreading them.

The increased incidence of zoonotic diseases can also be explained by changes in land use that bring people into closer proximity to areas where pathogens are most prevalent.

Changes in land use are estimated to have caused more than 30% of new diseases reported since 1960 (IPBES, 2020). For example, research suggests that as people have encroached on forest areas, they have become more exposed to the Ebola virus (Rulli et al., 2017). The fragmentation of forests can also increase the potential transfer of vector-borne diseases such as malaria, where diseases spread by carriers such as mosquitoes (Alvarez et al., 2025).

Further, when pristine environments are cleared and habitats destroyed, for example to create new agricultural land or provide access for mining, roads and trade routes connect remote areas to towns and cities, creating new pathways through which pathogens can travel.

This is coupled with more people living in densely populated cities and an increase in global travel, which amplifies the dangers of new diseases and increases the chances of them developing into pandemics (Marie and Gordon, 2023).



Associated costs and undiscovered risk

The dangers of zoonotic diseases were made starkly visible by the recent Covid-19 pandemic, which to date has killed an estimated 7.1 million people around the world (WHO COVID-19 dashboard). It has cost the global economy between $17tr and $35tr (McKibbin & Fernando, 2023), and impacted livelihoods and social wellbeing as communities tackled both the catastrophic loss of life and the measures implemented to tackle its spread (Decerf et al., 2024).

However, Covid-19 is only the tip of the potential iceberg. IPBES (2020) suggests that less than 0.1% of the potential zoonotic viral risk has been discovered, with 1.7 million viruses occurring in mammals and water birds (the hosts most commonly identified as origins of novel zoonoses). Of these, 631,000–827,000 could have the ability to infect humans (IPBES, 2020).

It is estimated that the annual expected loss in Gross National Income (GNI) from viral zoonotic disease outbreaks since 1950 is $212bn – this excludes the costs of outbreaks of viruses in domestic livestock, such as the UK's foot and mouth disease (Bernstein et al., 2022).

IPBES (2020) estimates that the cost of emerging zoonotic diseases is significantly higher, and could be over $1tn per year. However, the global strategies to prevent pandemics, based on reducing the wildlife trade and land use change, are estimated to cost between $22bn and $31.2bn.

Even if we include all conservation measures, estimated to be between $78 and $91bn per year (OECD, 2020), the figure is still an order of magnitude lower than the potential costs before any other co-benefits are considered. This underlines the importance of introducing integrated preventative solutions to tackling these challenges, such as conservation measures.

Tackling pandemics

Whilst nature and biodiversity loss are driving an increased risk of pandemics, their severity can be mitigated by the ways they are tackled when they arise.

To date, the prevailing approaches to tackling zoonotic pandemics have been predominantly reactive in their nature, with response measures targeted at responding to a specific virus through, for example, vaccines (Bernstein et al., 2022).

The introduction of vaccines and medical treatment are often virus and disease specific, whereas pre-emptive strategies aimed at reducing exposure to viruses and their transfer cover the full suite of potential diseases.

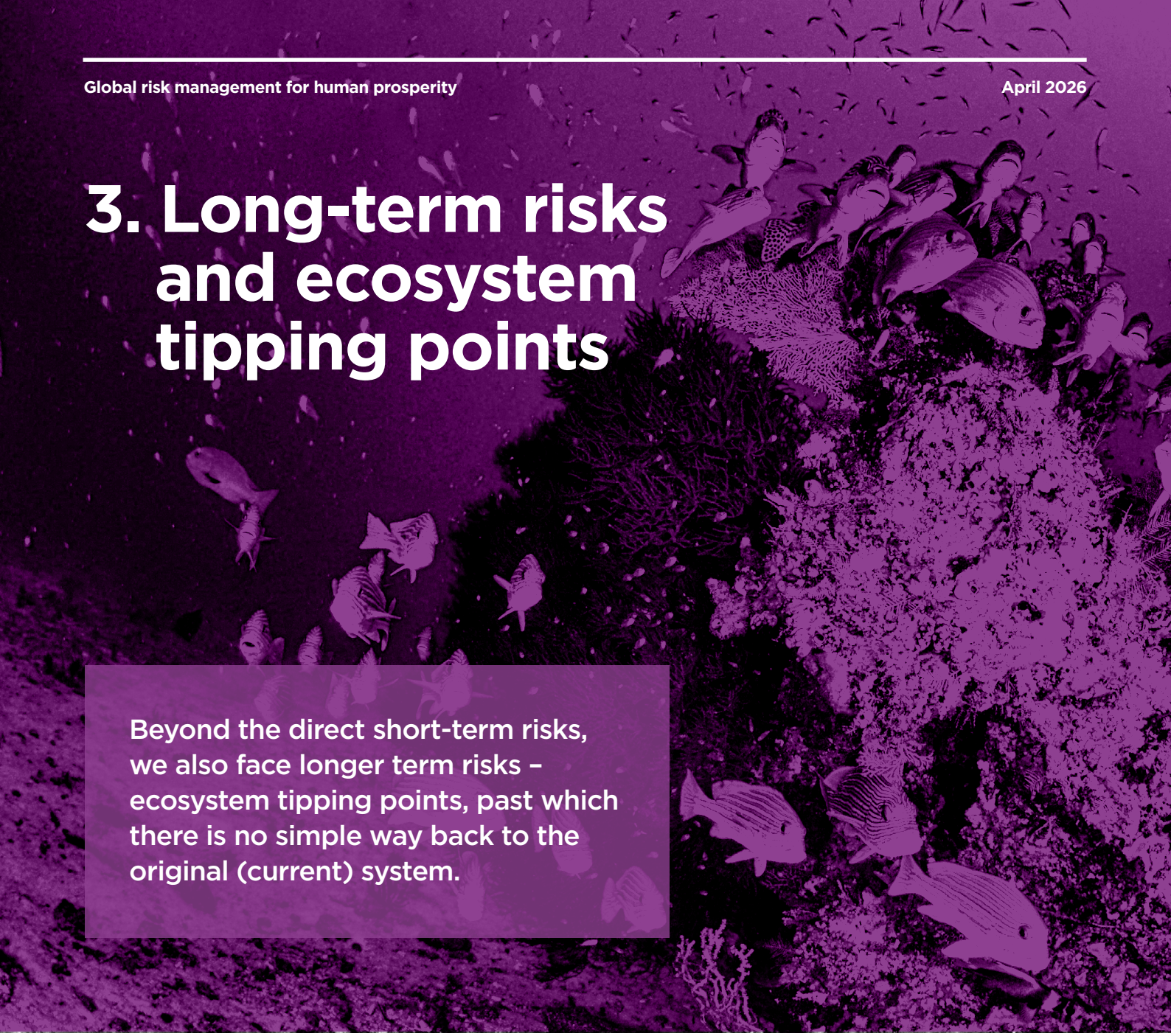
However, such pre-emptive measures targeted at reducing the transfer of pathogens are much rarer, for example human health considerations driven by land use change are hardly ever considered in planning decisions.

The risk of transfers of zoonotic diseases and associated pandemics could be reduced by implementing proactive strategies that help to conserve protected areas and reduce exploitation of biodiversity hotspots (IPBES, 2020). The WHO's One Health initiative takes this approach, looking to integrate measures that tackle human, animal and environmental health (WHO, 2025).

It is estimated that implementing such pre–emptive strategies would save 1.6 million lives a year and reduce mortality costs by $10 trillion (Bernstein et al., 2022). Such strategies include:

- Promoting the concept of One Health initiatives aimed at tackling human, animal and environmental health.
- Better surveillance and data gathering on the diversity, abundance and location of species that share zoonotic pathogens with humans.
- Further research around the interactions between climate, biodiversity and diseases to better understand the amplifying and dilution effects of different species and drivers.
- Greater controls over deforestation and land conversion that bring people into closer contact with potential pathogens as forests are cleared to make way for (e.g.) agriculture, timber or mining.
- Consideration of the external costs to human health when implementing land conversion planning decisions.
- More well-trained veterinarians, especially in spillover hotspots, are needed to prevent spillover from wildlife or livestock into people.
- Better controls on wildlife hunting and trade.
- Need for better viral surveillance and data on trade.
- Creating institutional capacity for primary prevention in wildlife trade.

3. Long-term risks and ecosystem tipping points



Beyond the direct short-term risks, we also face longer term risks – ecosystem tipping points, past which there is no simple way back to the original (current) system.

The current degradation of nature and biodiversity is accelerating towards critical tipping points. These shifts pose profound risks to planetary stability and economic resilience.

The first of these tipping points, tropical coral reefs, has already been exceeded. The consequences are almost certainly irreversible for these habitats and the coastal regions they protect from severe weather, along with the food and economic livelihoods of an estimated 500 million people.

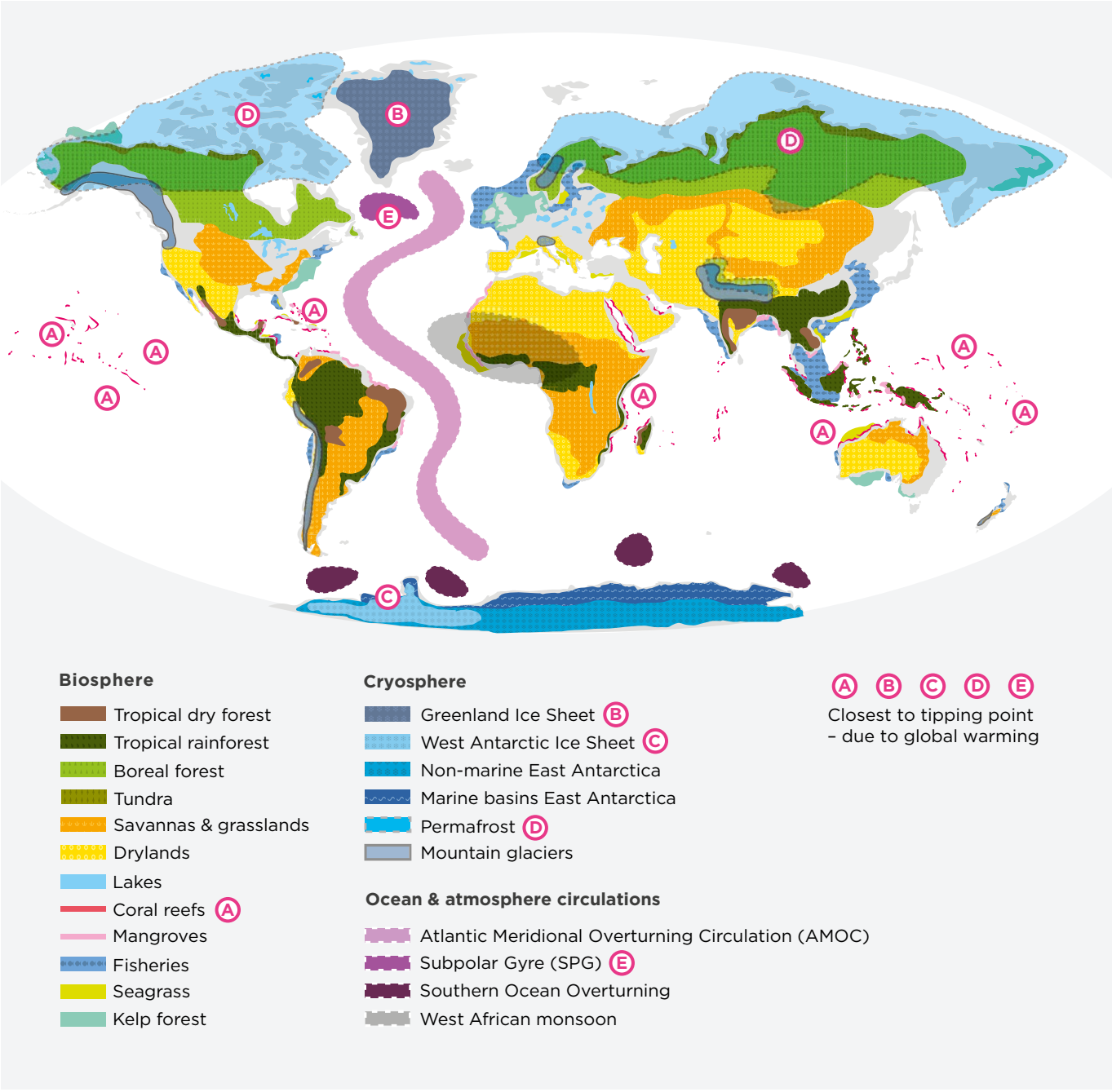
For political and financial decision makers, understanding and addressing nature-related risks is no longer optional.

Figure 6 on the following page illustrates some of the global tipping points which are exacerbated by climate change.

Key tipping points across terrestrial and marine ecosystems (Marsden et al., 2024), create significant implications for financial systems and society over multiple timescales. In this section we outline three of those potential tipping points – deforestation, pollination and marine.

> **The current degradation of nature and biodiversity is accelerating towards critical tipping points**

Figure 6: Parts of the Earth system identified as featuring tipping points (Lenton et al., 2025). Reproduced under Creative Commons.



3.1 Deforestation tipping points

Deforestation and forest degradation remain two of the most visible and impactful drivers of biodiversity loss. Tropical forests, which host over 50% of terrestrial species (Pillay et al.., 2022), are being cleared at an alarming rate for agriculture, mining and infrastructure.

According to Global Forest Watch[4], the world lost 26.8 million hectares of natural forest in 2024 alone. This is larger than the entire UK, which spans about 24.9 million hectares. This activity generated around 10 gigatons of carbon emissions.

4 | **https://www.globalforestwatch.org/dashboards/global/**

The Amazon rainforest, which has been resilient for over 60 million years, is approaching a tipping point (Flores et al., 2024) as a result of deforestation and climate feedback loops, with cascading effects on global carbon cycles and rainfall patterns.

In the most extreme cases, deforestation can even lead to a chain reaction which ultimately ends in desertification (Gallagher, 2025). By 2050, up to 47 percent (Igini, 2024) of the Amazon could hit critical ecological tipping points because of deforestation and global warming.

Financial exposure to deforestation risk is significant. Forest loss affects supply chains, increases costs, and introduces reputational and regulatory risks. For example, the World Bank estimates that nature-related financial risks in Brazil alone could reach billions annually due to deforestation-linked liabilities (Calice et al., 2021).

Deforestation screening metrics can help identify companies contributing directly or indirectly to forest loss, enabling financial institutions to assess and manage portfolio risks, including through company engagement.

By 2030, regulatory pressure is expected to intensify, with frameworks like the Taskforce on Nature-related Financial Disclosures (TNFD) requiring asset owners to disclose deforestation exposure, and the EU Deforestation Regulation prohibiting goods associated with deforestation from entering the EU market.

By 2050, failure to mitigate deforestation could result in regulatory intervention, stranded assets, disrupted supply chains and even systemic financial instability.

3.2 Pollination Tipping Points

Another critical tipping point on land is pollinator collapse. It represents a profound environmental and financial threat, with cascading consequences across ecosystems and economies.

Pollinators, especially bees, underpin around three quarters of global crop production (Ritchie, 2021), playing a key role for food systems worth over $250bn annually. Their decline – which is driven by habitat loss, climate change, pollution, pesticide use and disease – is a systemic issue which impacts biodiversity and food security.

In the UK alone, bees and other pollinating insects have on average lost a quarter of their habitat since 1980 (Powney et al., 2019).

From an economic standpoint, the erosion of pollination services could lead to reduced crop yields, increased food prices and inflationary pressures. As pollinator populations dwindle, manual pollination becomes necessary, a costly and inefficient substitute that further strains agricultural systems.

Moreover, the loss of pollinators undermines resilience to climate shocks and threatens long-term financial stability.

3.3 Marine Tipping Points

Marine biodiversity is under siege from overfishing, pollution and climate change. Oceanic tipping points include the collapse of fish stocks and the breakdown of nutrient cycles, which could destabilise food systems and coastal economies.

Coral reefs, which support 25% of marine life, are projected to decline by up to 90% by 2050 under current warming trajectories (Hoegh-Guldberg, Jacob & Taylor, 2017).

Pollution – including plastic waste and chemical runoff – degrades water quality, disrupts food chains and weakens species resilience. Overfishing compounds this by removing key species, destabilising ecosystems and reducing biodiversity.

Together, these pressures can push marine systems past critical thresholds, leading to collapses in critical fish populations and the loss of ecosystem services vital both for local communities and global food security.

Around the UK, warming seas have already begun shifting fish populations northward, with cod, haddock, and salmon being replaced by species like anchovy, bluefin tuna and squid. This shift is not just ecological but economic, as it threatens the viability of traditional fisheries and the communities that depend on them.

A UK-funded project launched in 2025, called TiMBER (Steinhoff, 2025), is investigating these changes, focusing on the North Atlantic, one of the world's marine hot spots. The project aims to anticipate and model the socio-economic consequences of tipping points which could expose half a billion people globally to annual flooding events, and trigger severe repercussions for biodiversity, food security, and agriculture.

Looking ahead to 2050, the implications of marine tipping points are expected to be profound. Ocean health could become a determinant of sovereign creditworthiness and global trade viability.

If global warming, ocean acidification, overfishing and pollution continue on their current trajectories, the economic and social consequences are likely to be severe. In the event of more extreme tipping points, such as the collapse of the Gulf Stream (Sybren et al., 2025), the consequences could be even more catastrophic.

For investors and policymakers, integrating marine biodiversity metrics into sustainability reporting and financial models will be essential to manage risk and support sustainable development in an uncertain future.

If global warming, ocean acidification, overfishing and pollution continue on their current trajectories, the economic and social consequences are likely to be severe.

4. Modelling nature risk – complexity and interactions

The Planetary Solvency dashboard shows nature at a critical juncture. Severe impacts are already likely or very likely to be on the horizon. There are a number of significant short-term risks, including threats to food systems and rising potential for pandemics.

In the longer term, we face the consequences of cascading tipping points, where it may not be simple, or potentially even possible to reverse impacts and harms. Actuaries, policymakers, regulators and all long-term financial modellers face the challenge of understanding our economic system over the longer term.

Whilst the evidence collated for the planetary solvency dashboard shows the significant (severe or worse) impacts from nature related risks, these considerations are all but absent in the models and tools that have been used to date. This includes the modelling tools typically used by governments and financial institutions to understand the financial impacts of climate change.

This section will consider the role of biodiversity scenarios, looking at some of the key modelling challenges including land use, lack of metrics and macroeconomic connections and showing how these are being overcome.

It is our conclusion that, whilst including nature within our financial modelling is challenging and complex, it is also necessary.

4.1 Criticality of incorporating nature risks and impacts into our economic projection models and scenarios

In their paper *"Nature at Risk, Models at Fault: Why Biodiversity Can't Wait"*, the IFoA Biodiversity Scenarios Working Party summarised that *"there is no use case for climate scenarios that do not explicitly allow for and integrate biodiversity considerations and impacts."* It summarised the three scenario realities as:

1. Climate and biodiversity are intrinsically linked and mutually reinforcing
2. The impact of biodiversity risks on the UK economy and financial institutions are equal to or greater than climate risks, and
3. The outcome of climate and biodiversity pathways are fundamental to understanding the potential state of our future economy and macro-economic impacts to financial institutions.

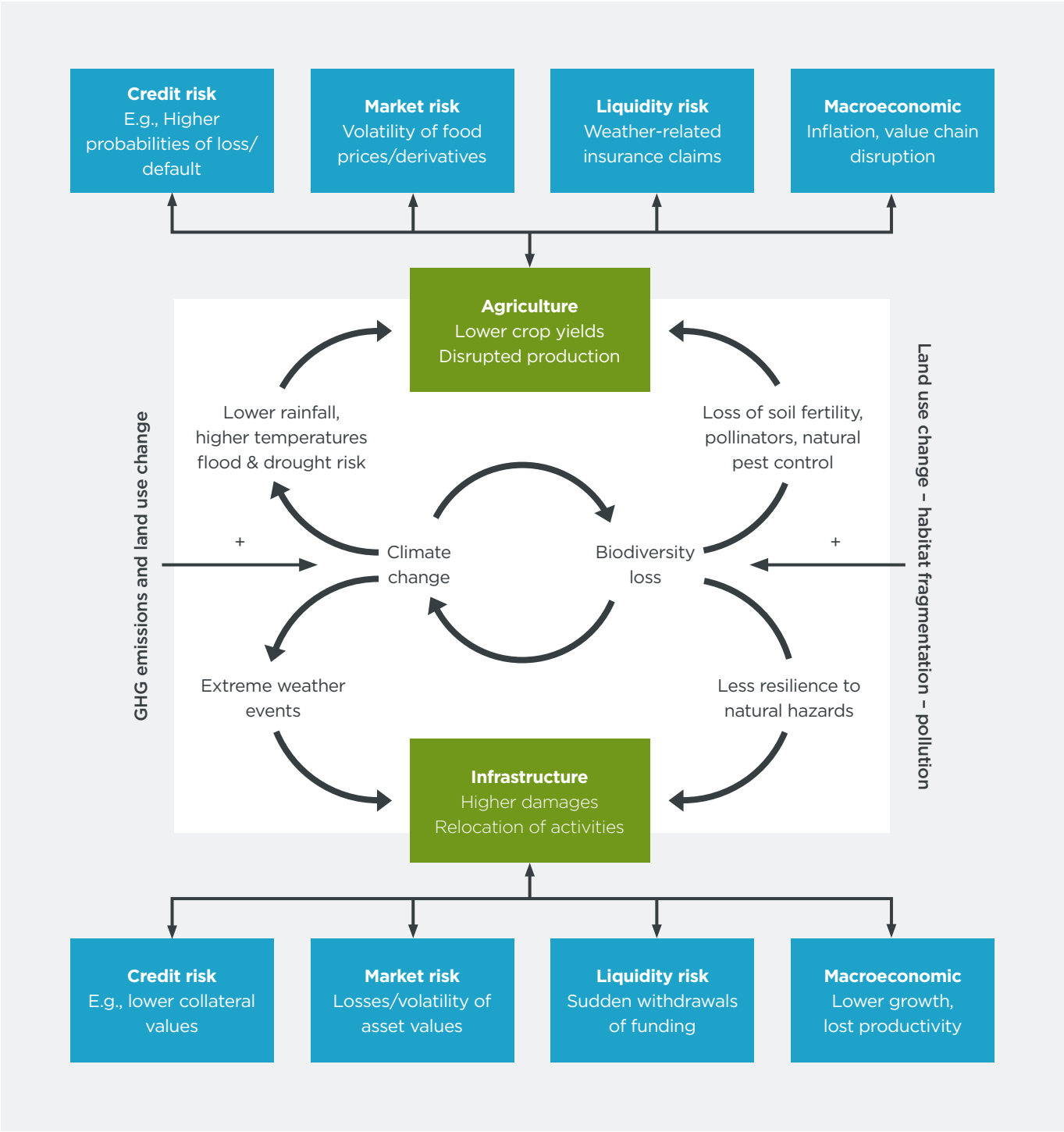
The most critical aspect of the lack of use case for climate-only scenarios was that climate and biodiversity risks are deeply interlinked and mutually reinforcing.

Climate change accelerates biodiversity loss and vice versa (*Figure 7*). Biodiversity loss weakens natural climate regulation systems and lowers our resilience to severe weather and climate shocks.

Biodiversity loss has the potential to turn natural greenhouse gas (GHG) sinks into sources of GHG emissions. These risks amplify each other through feedback loops, compounding threats to economies, societies, and financial markets that exceed individual risk assessments.

Political acknowledgement of this has been slow – but connected impacts of climate and nature was a key theme of the 2025 COP30 in Brazil, and is explicitly recognised by the UK government.

Figure 7: Interconnected climate and biodiversity related physical impacts and their links to financial risks (Kedward et al., 2022). Reproduced under Creative Commons.



The incorporation of biodiversity impacts is also critical, as they can be very significant. Biodiversity underpins ecosystem services essential to economic stability, health, food production, and climate regulation. Biodiversity loss poses systemic, long-term risks to society and the financial system.

There is a material risk of biodiversity and nature–related macroeconomic impacts equalling the 2008 Global Financial Crisis, or even the Covid-19 pandemic, within the next 10 years (World Economic Forum, 2025; Dasgupta, 2024). Biodiversity risk is both inter-related with, and of an equivalent size to, climate risk. Thus, meaningful future scenarios need to incorporate the analysis of both climate and biodiversity pathways.

This presents a direct challenge to the current industry usage of climate scenarios from the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), the International Energy Agency (IEA), and similar scenarios.

It suggests they should not be the core basis of regulatory and disclosure efforts. Indeed, their continued use risks undermining not only the direct purpose of these scenarios – providing resilience against future climate changes – but can create significant blind spots for risk assessment, policy, and financial decision making.

A singular focus on climate can also lead to solutions that are detrimental to biodiversity (for example, through biofuels or monocrops). Failure to incorporate biodiversity leads to misleading outputs and underestimation of both chronic and acute risks.

Considering biodiversity and nature impacts both feasible and likely transition pathways. This was directly illustrated by the Inevitable Policy Response's (IPR) Forecast Policy Scenario (FPS)+ Nature scenarios.

These scenarios explicitly sought to build on the existing FPS scenario, in order to consider the impact of seeking to meet the broader (Kunming-Montreal) biodiversity goals alongside the Paris Climate goals. It thus exemplifies some of the differences that considering nature can create.

4.2 Quantifying land use change

It is well documented and widely acknowledged that human activities are the primary driver of the current mass extinction (Ceballos, et al., 2015). Efforts to measure the impacts of human activities are complicated by the complexity of nature and biodiversity itself. A fundamental nature management challenge is that there is no single metric with which to understand the scope and scale of nature and biodiversity tipping points across a complex system.

This is in contrast to the metrics associated with mitigating and managing climate change, where science-driven policy discussions have coalesced around a single metric: carbon.

Nature is a dynamic system that intersects and interacts with climate, and lacks such a universal indicator to holistically assess how various activities may hasten its decline, or contribute to its restoration.

The Kunming-Montreal Global Biodiversity Framework (hereafter the Global Biodiversity Framework) (CBD, 2022) includes 23 targets aimed at addressing the drivers of biodiversity loss, such as pollution and unsustainable consumption (Convention on Biological Diversity).

The implementation of the Global Biodiversity Framework looks to be even more challenging than that for the Paris Agreement. At the end of 2025, less than a third of the signatories have completed national biodiversity strategies and action plans to align with the goals of the agreement.

Moreover, the Global Biodiversity Framework sidesteps some of the challenges associated with nature-related metrics. Instead, the target 3 of the framework focuses on achieving a goal – to conserve 30% of land, waters and seas by 2030, preserving and reclaiming land for nature and biodiversity.

However, this approach recognises that space undisturbed by human activity is necessary to enable the earth to reclaim a crucial balance critical to not only activity, but all life: we must rebalance the ledger for life by creating the conditions for nature and biodiversity to flourish.

The Global Biodiversity Framework goals and targets are critical to staying within planetary boundaries and meeting humanity's needs. If we don't understand the relationships between land use, climate change, and climate and nature tipping points, neither international policy nor integrated assessment modelling will be able to safeguard our natural resources and their ability to replenish for future generations.

The Global Biodiversity Framework focus on land-use also supports a focus on land-use modelling where we have a significant modelling history and integration with macroeconomic models. This opens the potential to apply land use modelling within existing climate-related macroeconomic models to help understand the complex relations between climate, nature and biodiversity. This could also help reinforce policy focus on land and the intensity of land use or land appropriation for human v. 'natural' activities.

Finally, there are many examples of local environments hitting nature tipping points. In such cases, there are almost always visible challenges in how land has been leveraged to serve humanity with insufficient attention or regard to maintaining nature. Thus, land degradation could also be a useful proxy for understanding the scope and scale of tipping points, albeit additional research will be required to illuminate the critical thresholds and regional tipping points that can contribute to dangerous biological disequilibria.

These examples typically illustrate how understanding the intensity of land use change, and the total area of land for built environment and human activities relative to the amount of land for nature biodiversity, can be an important macroeconomic modelling proxy for nature that can help inform how to approach this challenge when considering narrative or analytical approaches.

We are facing immediate impacts as well as long-term risks

We are already observing examples of how disequilibrium in the natural system has impacts on our financial system. Nature and climate risk are starting to be seen as matters of national security (HM Government, 2026) with unilateral and protectionist measures being taken.

The quality and quantity of food available has been impacted, with knock-on effects on food systems and food prices. We can see examples across different continents and on global pricing. Given the current and material impacts of disequilibria on our food systems, there is an immediate need to better understand and model the short-term risks of systemic degradation of nature.

In 2023, Associated British Foods (ABF) was impacted by severe flooding in Mozambique, which affected the group's cane sugar estates and many partner-grower operations.

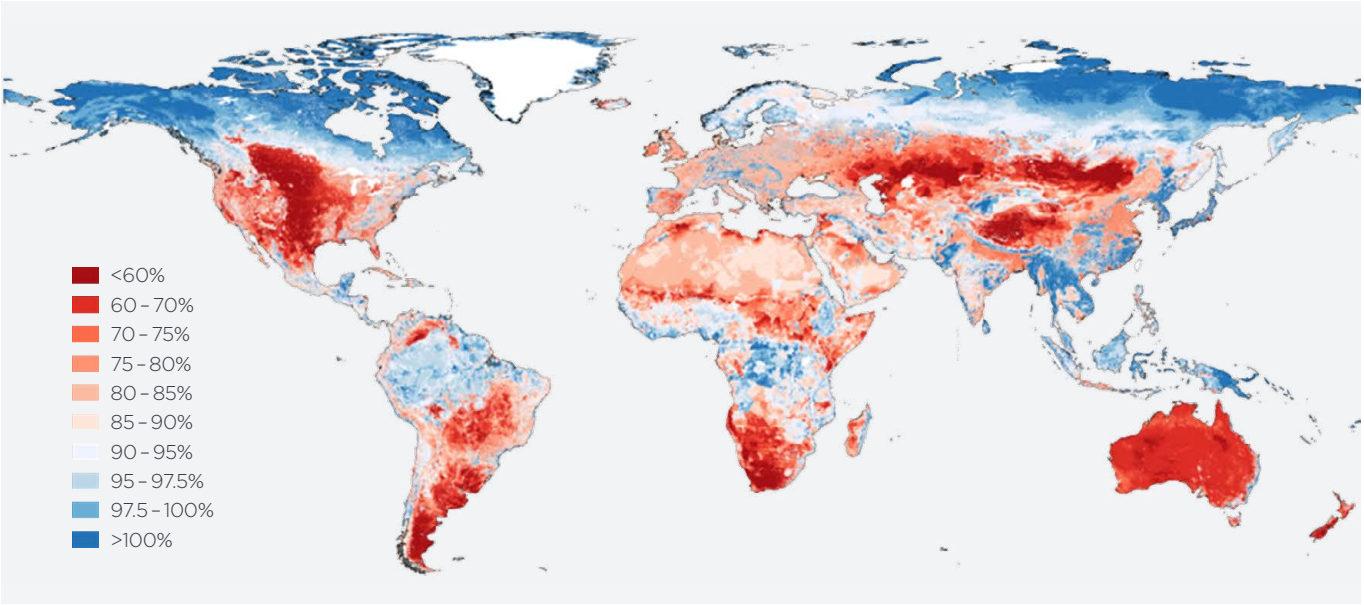
Due to the impacts of this flood event, ABF took a non-cash exceptional impairment charge of £35m in their accounts to write down the net asset value of the business.

At the same time, sugar production levels in the UK were exceptionally low at 0.74 million tonnes – 27% lower than the prior year's harvests. This was the result of a sequence of unusually poor weather conditions, which reduced the crop size and lowered beet yields and sugar content.

Despite ABF's global footprint, which allows it to diversify its exposure to risk, it is trading on global food commodities.

In its annual report, the company noted that the impacts of physical risks directly impacted profitability, as it was necessary to buy and import sugar to bridge the gap between promised sugar contracts and actual sugar production, given the shortfall in British sugar beet production (Associated British Foods, 2023).

Figure 8: Biodiversity intactness of ecological assemblages in terms of the total abundance of originally occurring species, as a percentage of their total abundance in minimally disturbed primary vegetation (Biodiversity Intactness Index; BII). (Newbold et al., 2016). Reproduced under Creative Commons.



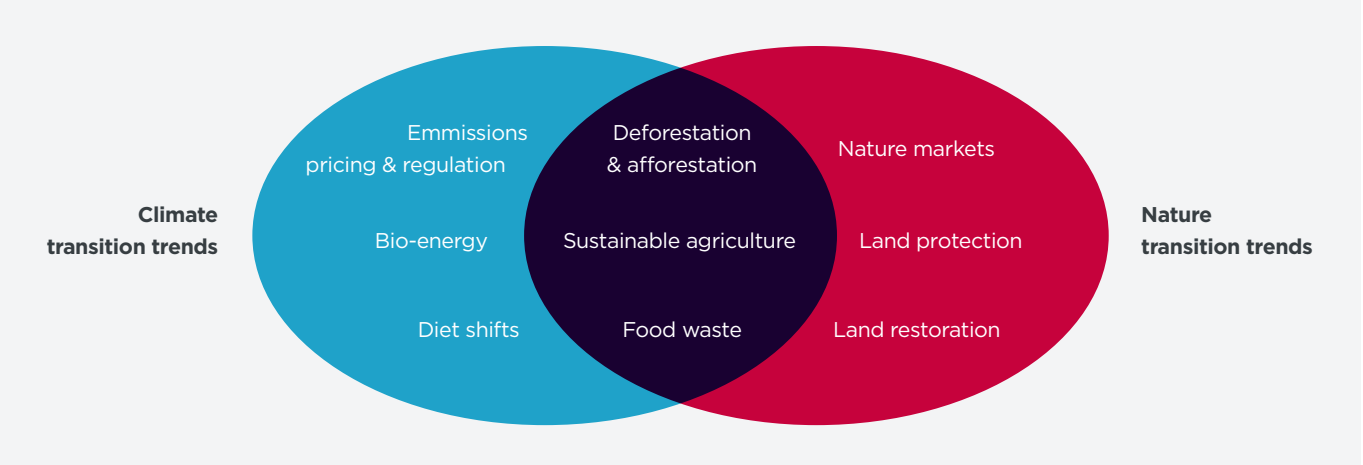
On a medium to long-term basis, the rate and change of land use can act as a warning sign for how close we are to nature and biodiversity collapse. It provides a first cut and an important metric that can support greater integration of nature, biodiversity, climate change, and human activity.

However, it will continue to be difficult to capture nature and biodiversity tipping points, as they are driven by complex multidimensional risk drivers. In the real world, and for specific cases, we must consider these warning lights in concert with a range of indicators, including the global state of biodiversity (*Figure 8*). Near the thresholds of specific tipping points, we will need to move beyond this single metric and embrace the broader complexity.

This proposal is not just theory, some modellers have made practical progress. By focusing on land use requirements (*Figure 9*), the IPR FPS+ Nature scenarios identified three new areas of nature-specific policy efforts (land protected, land restoration and development of nature markets), alongside required shifts in six policy areas that intersect with climate (carbon pricing, bioenergy, diets, deforestation, sustainable agriculture and food waste).

The conclusions of the FPS+ Nature scenarios work illustrated the need for different policy pathways to be followed and how some, climate- aligned policies would actual be harmful to the overall climate and nature goals. So that failure to incorporate biodiversity leads to misleading outputs and underestimation of both chronic and acute risks.

Figure 9: Inevitable policy response FPS+ Nature scenario interlinked trends from climate and nature transitions.



However, despite the clear evidence of significant risk, and importance of jointly considering biodiversity and climate risks, biodiversity is typically missing from published climate scenarios and regulatory focus. Existing models lack consensus on measurement, face severe data gaps, and struggle to capture non-linear, cascading, and tipping-point events.

4.3 The lack of metrics necessitates the role of narrative scenarios

These gaps in the modelling focus and regulatory oversight are leading to misleading scenarios, understatement of risks and misdirection of risk mitigations. An expert workshop hosted by the Institute & Faculty of Actuaries in early 2025 found three challenges for actuaries and all finance professionals:

1. Biodiversity scenario modelling faces data, technical and conceptual challenges
2. The need to apply system thinking, complex risk modelling and narrative scenario development
3. The need to challenge regulators, existing practices and vested interests on the necessity of altering current climate scenarios to include biodiversity.

However, the workshop also found that are existing modelling examples that have overcome these challenges using norms-based approaches (with alignment to Global Biodiversity Framework goals) and narrative-based approaches focused on extreme-but- plausible scenarios. As noted above, land use metrics are not ideal, but can be helpful as a first attempt and lead to impactful results, as seen in the IPR FPS+ nature scenarios.

Partly due to the data gapsand more particularly due to their intersectional nature, integrated quantitative assessment models alone are insufficient, as they are unable to encompass outcomes that arise from factors outside of their data set and construction philosophy.

Decision makers, regulators and standard setters must become more comfortable with narrative-based scenarios to avoid “false confidence” in (flawed) model quantification and better prepare for the systemic nature of the risks.

Narrative approaches are typically better suited to exploring the impacts of tipping points. Tipping points have high impact into new system states, but uncertain probabilities on when thresholds will be reached and the pace at which the full impacts will unfold.

Narrative scenarios can explore these impacts with visibility on the uncertainties. Tipping points can create multi-modal distributions in integrated assessment models which make it harder to identify the underlying risk drivers and the most appropriate risk management and mitigation approaches.

4.4 Macro-economic impacts of the twin biodiversity and climate crisis

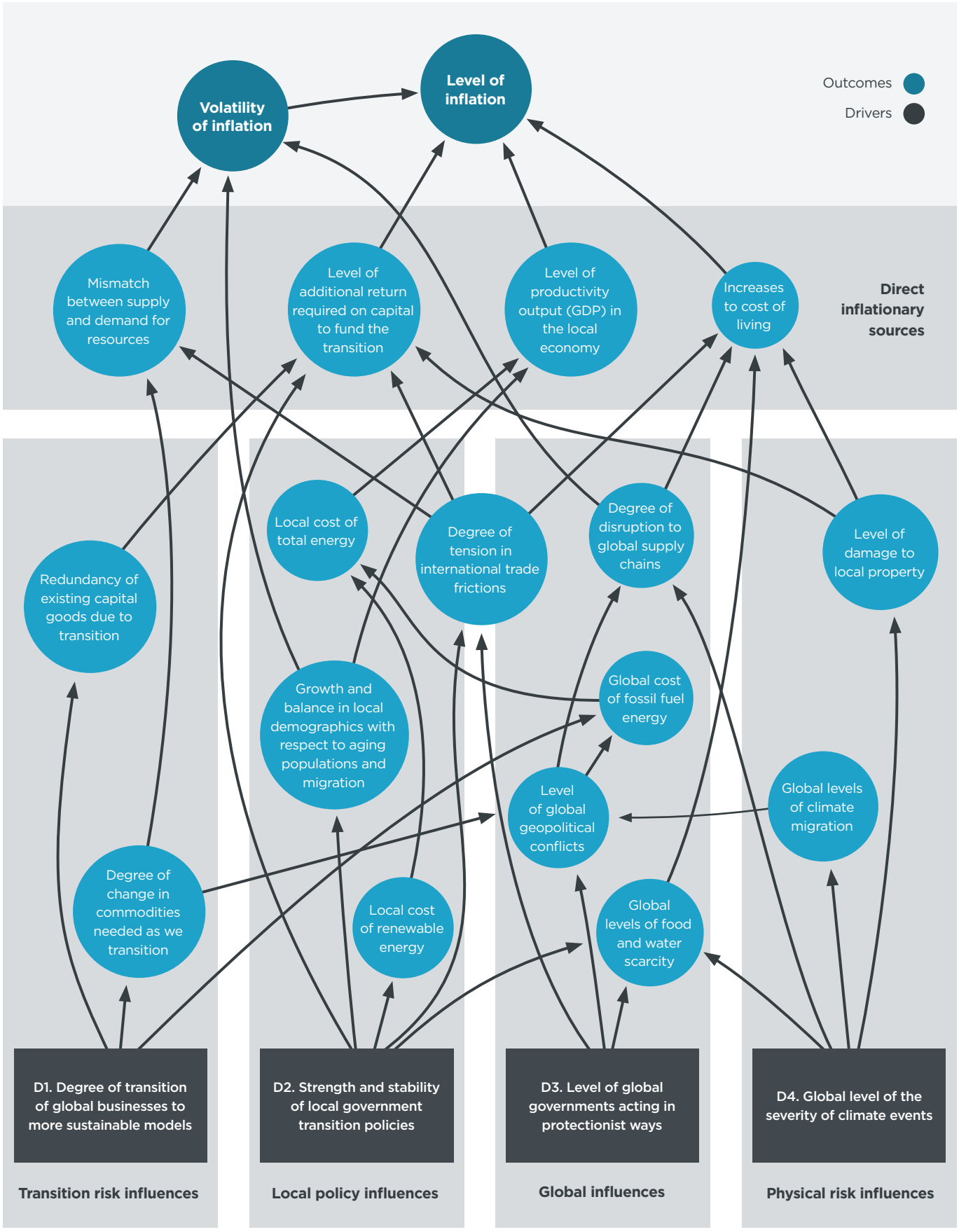
The development of complexity-based techniques to understand the climate and nature crisis is also helping to identify and model some of the potential systemic macro-economic and financial impacts.

In their model of climate impacts on inflation, Milliman explicitly consider both the impact of climate events on food and water scarcity, as well as intersections with government protectionism and fuel costs (*Figure 10*).

These investigations showed that core inflation could rise to over 4%, with tail risks of 10% or higher (Spencer & Drew, 2025). Malesios et al (2020) have shown multiple occasions of food shocks resulting in global food price inflation.

Decision makers, regulators and standard setters must become more comfortable with narrative-based scenarios to avoid “false confidence” in (flawed) model quantification.

Figure 10: Structure of the Milliman Sustainability Inflation Model (Milliman, 2025)



4.5 Challenging, complex, necessary

Nature's inconvenient truth is that integrating biodiversity-related risks into climate scenario analysis is challenging, complex and necessary. Nature and climate crises are interconnected risks, each with significant impacts and influence on any sustainable transition pathways.

They are challenging and complex as we face gaps in data and deal with the multi-dimensionality of appropriate metrics, and complexities in their intersection with other risks, society and the economy, along with uncertain but high impact tipping points.

There are existing biodiversity and complex risk scenario examples that show these challenges can be overcome. The necessary next steps are to ensure this becomes universal practice, embedded into supervisory expectations alongside the upskilling of financial professionals to enable them to develop narrative scenarios for complex, interconnected risks.

5. Key recommendations

The 2026 UK government national security assessment (HM Government, 2026) stated "Every critical ecosystem is on a pathway to collapse *(irreversible loss of function beyond repair)".* So without a fundamental change of direction, we face the prospect of irreversible ecological collapse which would lead to almost certain societal and economic collapse.

Policymakers face a stark choice: continue business as usual and risk irreversible collapse, or act decisively to restore balance with nature, safeguard critical ecosystem services, and secure long-term Planetary Solvency.

Actuaries and the wider financial sector need to embrace the uncertainty that is inherent in future trajectories of the nature crisis, including tipping points, and avoid reliance on backward-looking modelling to become more comfortable with narrative approaches to risk management.

Here we make some recommendations for policymakers, financial modellers and actuaries. The window for meaningful action is closing rapidly, with tipping points already being reached. Immediate, systemic, and proactive measures are required to mitigate the imminent risks of further ecosystem collapses[5], to bring humanity back from its current trajectory and ensure nature's ability to sustain all future generations.

5 | "A realistic possibility some ecosystems ...start to collapse from 2030" (HM Government, 2026),

5.1 Recommendations for policymakers

1. **Mindset shift to become Planetary Solvency managers – recognise nature as a foundation to our society and economy**

   Ecosystems underpin human society. Their collapse will directly impact food security, supply chains, public health, and financial stability. Policy should recognise nature as core – integral to risk management, economic planning, and national security.

   Progress needs to be made in strengthening financial regulation around adoption of natural capital accounting, nature-related financial disclosures and scenario analysis. Integrating nature and biodiversity metrics into financial and economic models ensures that risks from nature are no longer ignored, and will better inform policy and investment in support of nature positive efforts.

2. **Working with nature on a global scale – accelerate global coordination and individual national actions**

   Planetary boundaries and ecosystem tipping points do not respect borders. International cooperation is essential with an urgent need for national governments to develop and implement robust biodiversity strategies, aligning with global frameworks such as Target 3 of the Global Biodiversity Framework, and adapting them to local contexts.

   Nature should be proactively embedded into all policy development and decision making. Given the geo-political backdrop, coalitions of the willing should be formed to make progress rapidly, rather than waiting for global consensus to emerge. But this should be done in an inclusive and just way, with particular attention paid to the inclusion of indigenous peoples, local communities and other vulnerable groups.

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

   Global risk management is currently failing and blind to systemic risk. Current climate scenarios are insufficient, as highlighted by the IFoA Biodiversity Scenarios Working Party. Climate and biodiversity risks are mutually reinforcing and must be modelled together.

   All scenario analysis and stress testing, whether for financial institutions, food systems, or national security, should explicitly incorporate biodiversity and nature tipping points and capture the complexity and interdependence of climate and nature risks.

   This must include enhancing policymaker understanding of ecological interdependencies, tipping points and systemic risks so they understand why such risk assessment is needed.

4. **Invest in prevention, repair and monitoring, rather than reactive approaches**

   The policy focus needs to shift from reactive responses to proactive investment in prevention, conservation and restoration to ensure risk reduction and future resilience. The costs of responding to ecosystem crises, such as zoonotic disease-driven pandemics, far exceed the costs of prevention.

   Integrated strategies such as One Health approaches, better surveillance, data gathering and stronger controls on land conversion and wildlife trade are cost-effective and urgently needed.

   Policymakers can access these cost benefits through investment in scientific research, monitoring systems, and the upskilling of professionals to develop and interpret holistic, narrative scenarios, risk dashboards and policy responses.

5. **Cross-economy collaboration is vital**

   Land use is a primary driver of biodiversity loss, and sustainable management of land is crucial. However, land use metrics must be complemented by broader indicators to capture the full impact of biodiversity loss and the cascading, and often unpredictable, effects elsewhere, including extra-territorial risks which can be transmitted into countries.

   Food systems are highly optimised but dangerously exposed to biodiversity loss. Concentration risk needs to be acknowledged and reduced to ensure there is resilience and cross-sectoral anticipatory planning for acute crises, using approaches such as systems thinking.

   Coordination should be encouraged between the environment, finance, health, and food sectors to address systemic nature risks and maximise co-benefits for nature and wider society.

5.2 Recommendation for actuaries and the financial sector

6. Quantify biodiversity risk

Quantifying biodiversity risk is complex but increasingly feasible. Tools like ENCORE (**https://encorenature.org/en**) and IBAT (**https://www.ibat-alliance.org/**) allow investors to assess exposure and performance across sectors.

The Taskforce on Nature-related Financial Disclosure (TNFD) framework, launched in 2023, provides guidance on governance, strategy, and risk management for nature-related disclosures.

By 2030, there is the opportunity for biodiversity metrics to be embedded in regulatory reporting, stewardship, and investment mandates. This is an important first step towards tackling the environmental tipping points we are currently facing.

Actuaries should stay abreast of these developments, employ currently available metrics and tools into their work and look to refine their approaches as data and techniques evolve.

7. Adopt qualitative narratives

Traditional economic models fail to account for nature and other economic externalities, leading to misaligned incentives and overexploitation. However, this is often because ecosystem services and wider biodiversity do not lend themselves easily to robust measurement, as nature's value and societal impact can be subjective, long term, location-specific, non-linear and uncertain, even as quantification of certain parts of nature risk improves.

Therefore, quantitative scenario generators should be complemented with qualitative scenarios, and narratives should be used, as the latter are better able to incorporate these features of nature risk into decision making (NGFS, 2023). If designed with affected stakeholders, they can better account for risks not just to the economy but also to people.

8. Recognise the systemic risk

Nature degradation is a systemic risk. Biodiversity tipping points are not distant threats, they are unfolding now.

The World Economic Forum ranks biodiversity collapse as the second-largest global risk over the next decade (WEF, 2025). The ECB warns that species loss can compromise economic resilience and exacerbate vulnerability to future shocks (Ceglar et al., 2024).

Integrating ecosystem services into financial accounting is essential for accurate risk pricing. Natural capital should become a core component of national productivity and progress (i.e. within the successor of GDP), and play a key role in public and private investment valuations.

9. Understand the limits of financial models

Ecosystems provide critical services such as pollination, water purification and carbon sequestration. These services underpin economic activity and our financial system. The 2024 bulletin by the European Central Bank (ECB) estimates that ten ecosystem services in the EU generated €234 billion in annual benefits (Ceglar et al., 2024). Yet these services are often undervalued and are routinely excluded from financial models.

There needs to be better awareness by actuaries, financial service professionals and broader economic advisors of the "Economics of Biodiversity", as articulated in the Dasgupta Review (Dasgupta, 2024).

10. Be aware of tipping points

For actuaries and other financial professionals, the path forward involves recognising nature as a foundational asset class, integrating biodiversity into financial decision making, and aligning portfolios with our planetary boundaries.

The cost of inaction is steep, and will only increase as we start facing the irreversible consequences of ecosystem tipping points.

Actuaries will need to be aware of the nature-related risks to their portfolios and the broader economy, navigating a path from their current portfolios to these future ones.

5.3 A critical alert towards action

Actuaries have a professional duty to consider and communicate potential gaps in their models and take steps to remediate these gaps where possible. We hope all actuaries will do so. However, actuaries can only respond to and model the financial system and risks they observe.

Through the use of Planetary Solvency frameworks and reports such as these, actuaries can highlight to their profession, policymakers and society the perils they see ahead. But they can't change them.

Actuaries, working with others, are able to model and share insights from scenarios, but it is the conversations with clients, stakeholders, policy makers and others that will make the difference.

Actuaries can help illustrate the risks, highlight the uncertainties and frame a Planetary Solvency perspective. However, the risk and reserve quantification for individual firms cannot address the systemic risks of the broader system. The planetary risks will only change if there is sufficient collective action to do so.

Such collective change is as hard as it is important. It is also urgent.

References

Associated British Foods, 2023, *Annual Report and Accounts 2023*. p. 27. Available at: **https://www.abf.co.uk/content/dam/abf/corporate/oar-and-rr-2023/oar/abf-annual-report-2023.pdf.downloadasset.pdf** (Accessed: 3 September 2025).

Alvarez, J., Postel-Vinay, N., Melis, A., McKenzie, E. and Ranger, N., 2025, Evidence review on the financial effects of nature-related risks. University of Oxford. Available at: **https://search.datacite.org/works/10.13140/rg.2.2.13882.09924**

Bailey R. and Wellesley L., 2017, Chokepoints and vulnerabilities in global food trade. Chatham House. Available at: **https://www.chathamhouse.org/2017/06/chokepoints-and-vulnerabilities-global-food-trade** (Accessed on 19 July 2023)

Barefood, 2026. Game available to download at **https://www.tabledebates.org/resource/barefood**

Ben Hassen, T. and El Bilali, H., 2022. Impacts of the Russia-Ukraine war on global food security: towards more sustainable and resilient food systems?. Foods, 11(15), p.2301.

Ben-Yami, M., Good, P., Jackson, L.C., Crucifix, M., Hu, A., Saenko, O., Swingedouw, D. and Boers, N., 2024. Impacts of AMOC collapse on monsoon rainfall: A multi-model comparison. Earth's Future, 12(9), p.e2023EF003959.

Benton T., Bieg C., Harwatt H., Pudasaini R. and Wellesley L., 2021, Food system impacts on biodiversity loss: three levers for food system transformation in support of nature. Chatham House. Available at: **https://www.chathamhouse.org/sites/default/files/2021-02/2021-02-03-food-system-biodiversity-loss-benton-et-al_0.pdf**

Bernstein, A.S., Ando, A.W., Loch-Temzelides, T., Vale, M.M., Li, B.V., Li, H., Busch, J., Chapman, C.A., Kinnaird, M., Nowak, K., Castro, M.C., Zambrana-Torrelio, C., Ahumada, J.A., Xiao, L., Roehrdanz, P., Kaufman, L., Hannah, L., Daszak, P., Pimm, S.L. and Dobson, A.P., 2022, 'The costs and benefits of primary prevention of zoonotic pandemics', Science Advances, 8(5), pp. eabl4183 Available at: 10.1126/sciadv.abl4183.

Bridle, S., Smith, E., Jones, A., et al., 2026, 'Understanding overlooked pathways to UK food system crisis', Sustainability, 18(2), 1342

Calice, P., Kalan, F.D. and Miguel, F., 2021. Nature-related financial risks in Brazil. Policy Research Working Papers.

CBD, 2022, Decision adopted by the Conference of the Parties to the Convention on Biological Diversity: Kunming-Montreal Global Biodiversity Framework, UN Convention on Biological Diversity, **https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf**

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., García, A., Pringle, R.M. and Palmer, T.M., 2015. Accelerated modern human-induced species losses: Entering the sixth mass extinction. Science advances, 1(5), p.e1400253.

Ceglar, A., Parker, M., Pasqua, C., Boldrini, S., Gabet, M. and van der Zwaag, S., 2024. Economic and financial impacts of nature degradation and biodiversity loss. Economic Bulletin Articles, 6.

Chen, J., Anderson, W., You, L., and Pope, E., 2024, Observed trends in multiple breadbasket yield shocks *Environ. Res. Lett.* 19 104005 **https://doi.org/10.1088/1748-9326/ad7040**

Civitello, D.J., Cohen, J., Fatima, H., Halstead, N.T., Liriano, J., McMahon, T.A., Ortega, C.N., Sauer, E.L., Sehgal, T., Young, S. and Rohr, J.R., 2015, 'Biodiversity inhibits parasites: Broad evidence for the dilution effect', Proceedings of the National Academy of Sciences, 112(28), pp. 8667–8671 Available at: 10.1073/pnas.1506279112.

Colombo P.E., Milner J., Pastorino S. and Green R., 2024, Population health impacts and associated monetary gains from the taxation of salt and sugar in the United Kingdom *medRxiv* Preprint **https://doi.org/10.1101/2023.08.16.23294155**

Compass Group, 2024, Compass Group Annual Report 2024. p. 48. Available at: **https://www.compass-group.com/content/dam/compass-group/corporate/oar-2024/annual-report-2024.pdf** (Accessed: 8 November 2025).

Convention on Biological Diversity, (n.d.), Goals and Targets. Available at: **https://www.cbd.int/gbf/targets** (Accessed: 3 September 2025).

Conijn J.G., Bindraban P.S., Schröder J.J. and Jongschaap R.E.E., 2018, Can our global food system meet food demand within planetary boundaries? *Agriculture, ecosystems & environment* 251 244-256 **https://doi.org/10.1016/j.agee.2017.06.001**

Crist E., Mora C. and Engelman R., 2017, The interaction of human population, food production, and biodiversity protection Science 356 260-264 https://doi.org/10.1126/science.aal2011

Dasgupta, P., 2024. *The economics of biodiversity.* Cambridge University Press.

Decerf, B., Mendes, A., Yonzan, N., Friedman, J. and Pennings, S., 2024, Lives, Livelihoods, and Learning: A Global Perspective on the Well-Being Impacts of the COVID-19 Pandemic. World Bank

Falloon P. *et al.*, 2022, What do changing weather and climate shocks and stresses mean for the UK food system? *Environ. Res.* Lett. 17 051001

Flores, B.M., Montoya, E., Sakschewski, B. et al. 2024, Critical transitions in the Amazon forest system. *Nature* 626, 555-564

Gallagher, M., 2025, Deforestation and its path to desertification, Green Packs, Available at: **https://greenpacks.org/how-can-deforestation-lead-to-desertification/**

Gammans, M. and Schaefer, K.A., 2025. Is Climate Change a Driver of Food Price Inflation? *Choices,* 40(3), pp.1–7.

Gaupp F., Hall J., Mitchell D. and Dadson S., 2019, Increasing risks of multiple breadbasket failure under 1.5 and 2 °C global warming *Agricultural Systems* 175 34-45 **https://doi.org/10.1016/j.agsy.2019.05.010**

Goudie S., 2022, New data show 4 million children in households affected by food insecurity *The Food Foundation.* Available at: **https://foodfoundation.org.uk/publication/new-data-show-4-million-children-households-affected-food-insecurity** (Accessed on 14 December 2022)

Gowdy J., 2020, Our hunter-gatherer future: climate change, agriculture and uncivilization *Futures* 115 102488 **https://doi.org/10.1016/j.futures.2019.102488**

Griffin, T.W., Knipp, D.J., Shank, J., Skov, T.M., McIntosh, S.W. and Leamon, R.J., 2025. Impact of the Gannon Storm on corn production across the Midwestern USA.

Homer-Dixon T. et al., 2015, Synchronous failure: the emerging causal architecture of global crisis *Ecology and Society* 20 **http://dx.doi.org/10.5751/ES-07681-200306**

Hood A. and Waters T., 2017, Living standards, poverty and inequality in the UK: 2016-2017 to 2021-2022 *IFS.* Available at: **https://ifs.org.uk/sites/default/files/output_url_files/R127.pdf** (Accessed on 5 August 2024)

Hoegh-Guldberg, O., Jacob, D. and Taylor, M., 2019. Chapter 3: Impacts of 1.5 ºc global warming on natural and human systems, International Panel on Climate Change (IPCC) special report, Available at: **https://www.ipcc.ch/sr15/chapter/chapter-3/** (Accessed 16 December 2025)

HM Government, 2026, Global biodiversity loss, ecosystem collapse and national security: A national security assessment, **https://assets.publishing.service.gov.uk/media/696e0eae719d837d69afc7de/National_security_assessment_-_global_biodiversity_loss__ecosystem_collapse_and_national_security.pdf**

Hunt E. et al., 2021, Agricultural and food security impacts from the 2010 Russia flash drought *Weather Clim. Extrem.* 34 100383 **https://doi.org/10.1016/j.wace.2021.100383**

Hussain, A., 2024, "Rice Battle Heats Up as India, Pakistan Lift Export Curbs." *Al Jazeera,* 2 Oct. 2024, **www.aljazeera.com/news/2024/10/2/rice-battle-heats-up-as-india-pakistan-lift-export-curbs**. (Accessed 3 Sept. 2025)

IFoA, n.d., Planetary Solvency Dashboard, Institute & Faculty of Actuaries **https://global-tipping-points.org/planetary-solvency/**

Igini, M., 2024, Up to 47% of Amazon Rainforest At Risk of Collapse by Mid-Century Due to 'Unprecedented Stress' From Global Warming and Deforestation, Earth.org, Available at: **https://earth.org/up-to-47-of-amazon-rainforest-at-risk-of-collapse-by-mid-century-due-to-unprecedented-stress-from-global-warming-and-deforestation/**

Inside Track, 2025, Investor Memo: To our investors, directors, owners and creditors, Inside Track, UK, Available at: **https://drive.google.com/file/d/1tATFmJG0wOtLDHxionMX0qNEXw49tjRl/view**

IPBES, 2020, Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Zenodo. Available at: **https://search.datacite.org/works/10.5281/zenodo.4147317**

Jones, A., Bridle, S., Falloon, P., Fredenburgh, J., Reynolds, C., 2024, 'Results of a Survey of UK Farmers on Food System Vulnerability over the short and long term', Sustainability, 16 (16), 6851

Jones, A., Bridle, S., et al., 2023,. 'Scoping potential routes to UK civil unrest via the food system: results of a structured expert elicitation', Sustainability, 15 (20), 14783

Kedward, K., Ryan–Collins, J., & Chenet, H. (2023). Biodiversity loss and climate change interactions: financial stability implications for central banks and financial supervisors. Climate Policy, 23(6), 763-781

Keesing, F. and Ostfeld, R.S., 2021 'Impacts of biodiversity and biodiversity loss on zoonotic diseases', Proceedings of the National Academy of Sciences, 118(17), pp. 1-8 Available at: 10.1073/pnas.2023540118.

Komarnytsky S., Retchin S., Vong C.I. and Lila M.A., 2022, Gains and losses of agricultural food production: implications for the twenty-first century *Annual Review of Food Science and Technology* 13 239–261 **https://doi.org/10.1146/annurev–food–082421–114831**

Kopittke, P.M., Menzies, N.W., Dalal, R.C., McKenna, B.A., Husted, S., Wang, P. and Lombi, E., 2021. The role of soil in defining planetary boundaries and the safe operating space for humanity. Environment International, 146, p.106245.

Kornhuber K., Lesk C., Schleussner C.F., Jägermeyr J., Pfleiderer P. and Horton R.M., 2023, Risks of synchronized low yields are underestimated in climate and crop model projections *Nat. Commun.* 14 3528 **https://doi.org/10.1038/s41467–023–38906–7**

Lenton, T. M., Milkoreit, M., Willcock, S., Abrams, J. F., Armstrong McKay, D. I., Buxton, J. E., Donges, J. F., Loriani, S., Wunderling, N., Alkemade, F., Barrett, M., Constantino, S., Powell, T., Smith, S. R., Boulton, C. A., Pinho, P., Dijkstra, H. A. Pearce–Kelly, P., Roman–Cuesta, R. M., Dennis, D. (eds), 2025, The Global Tipping Points Report 2025. University of Exeter, Exeter, UK. ©The Global Tipping Points Report 2025, University of Exeter, UK.

Levers C. et al., 2018, Archetypical patterns and trajectories of land systems in Europe *Reg. Environ. Change* 18 715-732 **https://doi.org/10.1007/s10113–015–0907–x**

Lin F., Li X., Jia N., Feng F., Huang H., Huang J., Fan S., Ciais P. and Song X.P., 2023, The impact of Russia-Ukraine conflict on global food security *Global Food Security* 36 100661 **https://doi.org/10.1016/j.gfs.2022.100661**

Lunt T., Jones A.W., Mulhern W.S., Lezaks D.P.M. and Jahn M.M., 2016, Vulnerabilities to agricultural production shocks: an extreme, plausible scenario for assessment of risk for the insurance sector Clim. *Risk Manag.* 13 1-9 https://doi.org/10.1016/j.crm.2016.05.001

Malesios, C., Jones, N., Jones, A., 2020, 'A change-point analysis of food price shocks', Climate Risk Management, 27, 100208

Marie, V. and Gordon, M.L., 2023, 'The (Re-)Emergence and Spread of Viral Zoonotic Disease: A Perfect Storm of Human Ingenuity and Stupidity', Viruses, 15(8), pp. 1638 Available at: 10.3390/v15081638.

Marsden, L., Ryan–Collins, J., Lenton, T.M. and Abrams, J.F., 2024. Ecosystem tipping points: Understanding the risks to the economy and the financial system. UCL Institute for Innovation and Public Purpose, Policy Report 2024/03.

McKibbin, W. and Fernando, R., 2023. The global economic impacts of the COVID-19 pandemic. *Economic Modelling,* 129, p.106551.

Milbank, C. and Vira, B., 2022. Wildmeat consumption and zoonotic spillover: contextualising disease emergence and policy responses. The Lancet Planetary Health, 6(5), pp.e439-e448.

Milliman, 2025, The Milliman Sustainability Inflation Model, Available from **https://vle.actuaries.org.uk/course/view.php?id=2924&section=15**

Natalini D., Bravo G. and Jones A.W., 2019, Global food security and food riots – an agent–based modelling approach *Food Security* 11 1153-1173 **https://doi.org/10.1007/s12571–017–0693–z**

National Statistics, 2026, Consumer Price Inflation Tables (table 38), HM Government, Available from **https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/consumerpriceinflation**

Newbold, T., Hudson, L.N., Arnell, A.P., Contu, S., De Palma, A., Ferrier, S., Hill, S.L., Hoskins, A.J., Lysenko, I., Phillips, H.R. and Burton, V.J., 2016. Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. Science, 353 (6296), pp.288-291. Data available online: **https://data.nhm.ac.uk/dataset/global–map–of–the–biodiversity–intactness–index–from–newbold–et–al–2016–science**

NGFS, 2023, Recommendations toward the development of scenarios for assessing nature-related economic and financial risk, Networking for Greening the Financial System: Technical document. Available at **https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs_nature_scenarios_recommendations.pdf**

Odongo, M.T., Misati, R.N., Kamau, A.W. and Kisingu, K.N., 2022. Climate change and inflation in Eastern and Southern Africa. *Sustainability,* 14(22), p.14764.

OECD, 2020, A comprehensive overview of global biodiversity finance. Paris: OECD Publishing. Available at: **https://doi.org/10.1787/25f9919e–en**

Olam Group, 2024, 'To Our Shareholders, A Letter from our Co–Founder & Group CEO', in *Olam Group Annual Report 2023*. Available at: **https://www.olamgroup.com/content/dam/olamgroup/investor-relations/ir-library/annual-reports/annual-reports-pdfs/2023/olam_annual_report_2023.pdf** (Accessed: 3 September 2025).

Pfenning-Butterworth, A., Buckley, L.B., Drake, J.M., Farner, J.E., Farrell, M.J., Gehman, A.M., Mordecai, E.A., Stephens, P.R., Gittleman, J.L. and Davies, T.J. 2024, 'Interconnecting global threats: climate change, biodiversity loss, and infectious diseases', The Lancet. Planetary health, 8(4), pp. e270-e283 Available at: 10.1016/S2542-5196(24)00021-4.

Pillay, R., Venter, M., Aragon-Osejo, J., González-del-Pliego, P., Hansen, A.J., Watson, J.E. and Venter, O., 2022. Tropical forests are home to over half of the world's vertebrate species. Frontiers in Ecology and the Environment, 20(1), pp.10-15.

Powney, G.D., Carvell, C., Edwards, M. et al. 2019, Widespread losses of pollinating insects in Britain, Nat Commun, 10, 1018

Ranger, N., Oliver, T., Alvarez, J., Battiston, S., Bekker, S., Killick, H., Hurst, I., Liadze, I., Millard, S., Monasterolo, I. and Perring, M., 2024. Assessing the materiality of nature-related financial risks for the UK. Green Finance Institute, 135pp

Ray D., Gerber J., MacDonald G. K. and West P. C., 2015, Climate variation explains a third of global crop yield variability *Nat. Commun.* 6 5989 **https://doi.org/10.1038/ncomms6989**

Richardson, J., Steffen W., Lucht, W., Bendtsen, J., Cornell, S.E., Donges, J.F., Fetzer, I. et al. 2023. Earth beyond six of nine Planetary Boundaries. Science Advances, 9, 37

Ritchie, H., Rosado, P., and Roser, M., 2023, "Agricultural Production" Published online at OurWorldinData.org. Available at: **https://ourworldindata.org/agricultural-production**

Ritchie, H., 2021, "How much of the world's food production is dependent on pollinators?" Published online at OurWorldinData.org. Available at: **https://ourworldindata.org/pollinator-dependence**

Rockström, J., Steffen, W., Noone, K., Persson, Å. et al. 2009. A safe operating space for humanity. Nature 461: 472-475 DOI 10.1038/461472a

Rose, A., Miller, N., Chen, Z., Roberts, F. and Tucci, A., 2024. Economic Impacts of Complex Disasters Affecting the Twin Ports of Los Angeles and Long Beach and their Supply Chains: A Labor Strike, Power Outage, and Terrorist Attack Scenario. Power Outage, and Terrorist Attack Scenario(September 28, 2024).

Rulli, M.C., Santini, M., Hayman, D.T.S. and D'Odorico, P., 2017, 'The nexus between forest fragmentation in Africa and Ebola virus disease outbreaks', Scientific Reports, 7(1), pp. 41613 Available at: 10.1038/srep41613

Spencer, N., and Drew., A., 2025, The rise and fall: Climate change and inflation modelling, The Actuary, Available at: **https://www.theactuary.com/2025/01/09/rise-and-fall-climate-change-and-inflation-modelling** (Accessed: 16 December 2025)

Starbucks (2024) Starbucks Fiscal, 2024, Annual Report. Available at: **https://s203.q4cdn.com/326826266/files/doc_financials/2024/ar/Starbucks-Fiscal-2024-Annual-Report.pdf** (Accessed: 8 November 2025).

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., De Vries, W., De Wit, C.A. and Folke, C., 2015. Planetary boundaries: Guiding human development on a changing planet. science, 347(6223), p.1259855

Steinhoff, N., 2025, Goodbye, cod? New £4.25m project to investigate climate 'tipping points' in marine ecosystems, Oceanographic, Available at: **https://oceanographicmagazine.com/news/new-project-investigates-climate-tipping-points-in-ocean/** (Accessed 16 December 2025)

Stockholm Resilience Centre, 2025, Planetary Boundaries, Licenced under CC BY-NC-ND 3.0, Azote for Stockholm Resilience Centre, Stockholm University. Available at: **https://www.stockholmresilience.org/research/planetary-boundaries.html**

Sybren Drijfhout et al., 2025, Shutdown of northern Atlantic overturning after 2100 following deep mixing collapse in CMIP6 projections, Environmental Research Letters, 20 (9), 094062

Thaler, E.A., Larsen, I.J. and Yu, Q., 2021. The extent of soil loss across the US Corn Belt. Proceedings of the National Academy of Sciences, 118(8), p.e1922375118.

Timmer C. P., 1988, Chapter 8 the agricultural transformation *Handbook of Development Economics* 1 275-331 **https://doi.org/10.1016/S1573-4471(88)01011-3**

Trussell, 2025, Hunger in the UK, September 2025, **https://cms.trussell.org.uk/sites/default/files/2025-11/hunger_in_the_uk_261125.pdf**

Trust, S., Saye, L., Bettis, O., Bedenham, G., Hampshire, O., Lenton, T.M. and Abrams, J.F., 2025. Planetary Solvency-finding our balance with nature, Institute & Faculty of Actuaries, **https://actuaries.org.uk/media/wqeftma1/planetary-solvency-finding-our-balance-with-nature.pdf**

Verschuur J., Koks E. E., Li S. H. and Hall J. W., 2023, Multi-hazard risk to global port infrastructure and resulting trade and logistics losses *Communications Earth & Environment* 4 **https://doi.org/10.1038/s43247-022-00656-7**

Walker, I, 2025, Roundup: climate shocks driving UK food inflation, Green Central Banking, **https://greencentralbanking.com/2025/10/22/roundup-climate-shocks-driving-uk-food-inflation/**

WEF, 2024, Global Risks Report 2024, World Economic Forum, Available at: **https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2024.pdf**

WHO, 2025, One Health. World Health Organisation, https://**www.who.int/health-topics/one-health#tab=tab_1**

WHO, 2026, Six years after COVID-19's global alarm: Is the world better prepared for the next pandemic?, World Health Organisation, **https://www.who.int/news/item/02-02-2026-six-years-after-covid-19-s-global-alarm-is-the-world-better-prepared-for-the-next-pandemic**

WHO COVID-19 dashboard, Available at: **https://data.who.int/dashboards/covid19/deaths** (Accessed: 21 September 2025).

World Economic Forum, 2025, Global Risks Report 2025, World Economic Forum, Geneva, Available at: **https://www.weforum.org/publications/global-risks-report-2025/**

WWF, n.d., What is the sixth mass extinction and what can we do about it? **https://www.worldwildlife.org/resources/explainers/what-is-the-sixth-mass-extinction-and-what-can-we-do-about-it/**

Appendix

Table 1 below shows the Planetary Solvency risk impact and likelihood matrix utilised for the illustrative Planetary Solvency outputs contained in previous sections.

Table 1: 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%

Table 2 below illustrates the crises examples included in the BAFR–UK serious game.

Table 2: Crisis from the BAFR–UK serious game

Area	Threat
Environmental	• Drought in England • Crop failures overseas • Fungal outbreak • Contamination scandal • Collapse of fish stock • Biosecurity breakdown • Polluted rivers • Asian hornet • Forest collapse • Usutu virus (birds) • Yellow rust (wheat) • Disease outbreak in farmed fish
Technological	• Cyber attack • Rare earth metal shortage • AI transport crash • Power outage • Carbon dioxide shortage
Financial	• Public finance crunch • Energy price shock • Insurance collapse • Nature market collapse • Collapse of a major bank

Area	Threat
Political	• War in Europe • Trade war • Local election crisis • General strike • Labour crisis • Nuclear fallout • Fishery protests • Red diesel tax change • Autocracy in a G20 country • China export ban • Breakup of UK • Corporate rate tax rise
Consumer	• Infowars • Increase in meat consumption • Panic buying • GLP–1s (collapse) • Animal rights protest • Fuel price strike

Institute and Faculty of Actuaries

Global risk management for human prosperity **April 2026**

Beijing
Room 512 · 5/F Block A · Landgentbldg Center · No. 20 East Middle 3rd Ring Road
Chaoyang District · Beijing · 100022 · People's Republic of China
Tel: +86 (10) 6611 6828

Edinburgh
Spaces · One Lochrin Square · 92 Fountainbridge · Edinburgh · EH3 9QA
Tel: +44 (0) 207 632 2100

London (registered office)
1-3 Staple Inn Hall · High Holborn · London · WC1V 7QJ
Tel: +44 (0) 207 632 2100

Malaysia
Arcc Spaces · Level 30 · Frankfurt Room · The Gardens North Tower
Lingkaran Syed Putra · 59200 Kuala Lumpur
Tel: +60 12 591 3032

Oxford
Belsyre Court · 1st Floor · 57 Woodstock Road · Oxford · OX2 6HJ
Tel: +44 (0) 207 632 2100

Singapore
Pacific Tech Centre · 1 Jln Kilang Timor · #06-01 · Singapore · 159303
Tel: +65 8778 1784

actuaries.org.uk