First Interim Report to the Climate Change Committee of the Advisory Group on the Economics of Climate Risk and Adaptation

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1 Remit and modus operandi

The Advisory Group on the Economics of Climate Change Risk and Adaptation (referred to in this document as the Economics Advisory Group) was set up by the Climate Change Committee (CCC) in response to a desire to build more economic evidence on the benefits of adaptation and resilience building in the UK in their advice and supporting research to be published alongside their independent assessment of climate risk for the Fourth UK Climate Change Risk Assessment (CCRA4-IA). The group has been specifically tasked with addressing how economics can best be used in the Fourth Climate Change Risk assessment to drive effective and efficient adaptation policy; and how economics can best be integrated into adaptation and resilience policy making, with a high level of ambition and novel thinking.

The Advisory Group met four times between March 2023 and February 2024. This first interim report distils the group's initial thinking and advice to the CCC with respect to the contribution of economics to assessing the impact of Climate Risk and adaptation actions in their analysis for CCRA4-IA. This report, written by the chair, reflects the Chair's personal perspective on the economics of climate change adaptation whilst incorporating the views of the group.

Based on discussions among the group members, and grounded in the literature, for this first interim report we focus on providing a number of principles that CCRA4 might be advised to follow. A second report might illustrate how economic tools and approaches can be employed in practice to guide investments in climate change adaptation, provide case studies of how these tools can be applied, and propose economic risks that the CCC might prioritise.

1.1 The team

The Economics Advisory Group comprises the following members:

Angela Francis, WWF
Laurie Laybourn, Global Systems Institute at the University of Exeter and Chatham House
Theresa Lober, Bank of England
Andy Stuckey, HM Treasury
Michael Mullan OECD
Amelia Fletcher, University of East Anglia
Dr James Rising, University of Delaware
Simon Sharpe, Climate Champions Team
Elizabeth Sukkar, Economist Impact
Professor Vera Trappmann, Leeds University
Carlos Eduardo Frickmann Young, Instituto de Economia - UFRJ
Carys Roberts, IPPR
Samira Barzin, University of Oxford
John Barry, Queen's University Belfast

The chair would also like to thank members of the CCC secretariat for their help in preparing this report, especially Daisy Jameson.

1.2 Report structure

The rest of this report is structured as follows. Section 2 introduces the report in the context of the current and future risks the UK faces due to climate change, and proposes a number of themes and challenges that the group feels are central to any efforts to mainstream economics into decision making over climate change adaptation. Section 3 summarises a set of ten principles that the group proposes the CCC should follow with respect to addressing the risks and adaptation requirements for the UK. Section 4 explores these principles in more detail. Section 5 summarises some of the earlier efforts to address the economics of climate change adaptation. Section 6 concludes.

2 Introduction

There is now broad consensus that global warming needs to be kept well below 2 degrees above pre-industrialised levels (1850-1900) to avoid the most catastrophic damages from climate change.[i] Over 140 countries have committed to reaching net zero emissions, many by 2050,[ii] but even if net zero is achieved and warming is limited to well below 2 degrees, for at least the next 26 years, each country, in addition to meeting its own net zero commitments, will need to adapt and build resilience to a warming planet with more extremes of precipitation, more frequent and intense periods of extreme heat, and more severe storms.

These future risks will add to the already existing challenges that economies across the globe, including the UK, are facing. Climate change is already having scarring impacts on GDP in Europe[iii], is affecting the productivity of workers, and these costs, and the costs associated with extreme weather events, are likely to increase substantially without sufficient adaptation[iv,v]. This is in addition to the many human and ecological costs that may not be reflected fully in economic data and considerations.

The 2022 Global Assessment Report on Disaster Risk Reduction states that in the face of climate change impacts and increasing system threats, risk reduction efforts often seem too little and too late.[vi] It is well established that an economics lens on climate risk and adaptation to create and encourage action is vital.[vii,viii] Further, the economic case for adaptation action is clear and well-understood, but there is still a lack of urgency in the actions being taken to respond to this case.[ix]

Aside from physical risks that will impact the UK (including flooding, storms, and droughts), there will likely be inflationary pressures on key commodities as other countries see climate shocks to their economies and the cost of insuring assets will increase[x]. The value of internationally held assets are likely to fall, likely bringing disruption to the UK finance industry. Without additional action, the resilience of the UK economy to these climate change impacts will fall, making it much less likely that societies will be able to recover sufficiently quickly to withstand the worst impacts of climate change.

As a result of the changing climate, governments increasingly need guidance as to how best to invest in measures to build well-adapted and resilient economies. Ex-ante measures to build broad resilience to the changing climate, to undertake targeted adaptation, and prevent losses from climate change are currently under prioritised, despite evidence that ex-ante measures are more cost-effective than ex-post emergency responses.[xi] This will both protect

the communities at risk from climate change and will reduce pressure on public finances by reducing emergency ex-post expenditure. Planning is vital to ensure that communities and industries have the tools available to protect themselves against short-term shocks and gradual changes in the climate.

However, it is challenging for decision makers to undertake the needed investments in adaptation without a clear end-goal or vision of what they are trying to achieve. In part, this is because there is also no clear consensus as to what constitutes a "well-adapted" world, or even a "well-adapted" country, nor the role that economics might play in determining what "well adapted" might constitute. In part, this is because it is tricky to translate estimated community vulnerability into impacts and accurate economic costs, making it hard to understand the avoided cost and co-benefits of action. But more so, it may not be desirable to attempt to put an economic value on all the benefits from adaptation, if, for example, only a lower-or upper-bound value can be determined with confidence. Nor may it be desirable to aggregate all costs and all benefits, if, for example, aggregation obscures important potential trade offs, inequalities, or entry points for action. Further, in some cases it requires an explicit judgement on the amount of risk a society is willing to accept. Finally, the economic tool that has tended to be used to guide adaptation investments – cost benefit analysis – is, arguably, not fit for purpose on its own.

Given the challenges on measurement, valuation, aggregation, and prioritisation, questions are raised, such as whether adaptation decisions and spending should be driven by some cost-benefit analysis of investments in adaptation and resilience? Or whether there first should be some decision over what kind of a country people want to live in, and commitments be made to adapt sufficiently. Most likely, there will be some combination of what is cost effective, and what exposure to climate risk people feel is acceptable. It is not clear that economics will or "should" inform all the relevant decisions and choices that are made, but it can provide useful tools for enabling decisions, highlighting the costs of inaction, and demonstrating the benefits of action. It is clear however that economics could make a much greater contribution to government decision making over how much to spend, on what, and where, to improve adaptation and resilience.

What a well-adapted UK might look like in 2050, whether a well-adapted UK is affordable, and where adaptation spending might be focused, requires, arguably, an integrated and creative perspective on the contribution that economics can make to CCRA4. CCRA3 provides an excellent starting point from which to build on, with a focus on how to better integrate economics into the next CCRA report.

A number of themes and challenges have emerged from the Economics Advisory Group's discussions. First and foremost is a concern that inequality and vulnerability need to be central to any discussions over where adaptation spending should be focused. Second is the need to focus on risk and uncertainty, and a recognition that traditional cost benefit analysis is unlikely to be the best economic tool to address optimal investment in adaptation. Moreover, third, economics as a discipline has a lot to offer over and above variations on cost benefit analysis. This includes the role of learning in driving economic growth; the risk of lock-in, and option values from delaying investments, and how to optimise along transition pathways; and goal setting. But fourth, is a recognition that though economics has a central role in

determining an optimal adaptation strategy, there are questions that it cannot answer. Fifth is that if investment in adaptation is considered separately from mitigation, decisions are likely to be sub-optimal. Therefore ideally, the focus would be on resilient and well-adapted net zero-compatible growth pathways. Sixth, there are potential benefits from investments in climate change adaptation over and above combatting the negative impacts of climate change to help deliver other government priorities, such as Levelling Up. Other options may include behaviour changes that have secondary health or environmental benefits, that need to be considered.

There are a number of clear challenges that need to be tackled. These include the current poor understanding of the broad economic consequences of climate change on the UK, both today and in the future; a lack of sufficient investment in adaptation to date,[xii] leading to a likely sub-optimal level of resilience against climate risk; and insufficient guidance for decision makers in Government as to where, in what, and how much to invest in adaptation. Finally, there is insufficient attention paid to how investments in adaptation and resilience can and do change risk profiles of hazards linked to climate change. A greater focus on the co-benefits of adaptation action can provide justification for taking action despite uncertainty of future climate change.[xiii]

Out of the group's discussions, and taking account of these themes and challenges, the Economics Advisory Group, in this first report, provides a set of ten principles as a starting point for better integrating economics into the climate change risk assessment. We hope this report provides some pragmatic suggestions as to ways in which economics and economic thinking might be incorporated into CCRA4 from its early stages, in contrast to the earlier climate change risk assessments. CCRA1 (2012) incorporated some indicative valuation of risks and opportunities, whilst CCRA2 did not include any economics. CCRA3 again provided indicative valuations of risks and opportunities, with a focus on social valuation where possible, and interestingly found a larger economic impact of climate change on the UK economy than CCRA1. However, the economic analysis was retrofitted into the report. CCRA4 has the opportunity to integrate economics more comprehensively from the start, to ensure that policy makers have clear and practical guidance that can contribute to driving effective adaptation policy.

There are a number of useful concepts that can be taken forward in integrating economics into CCRA4. For example, focussing on finding end goals and targets for adaptation action and identifying where there are market failures that require Government intervention is key. Addressing the "economic optimal" level of adaptation may be a useful starting point for finding an indicative end goal and identifying the actions available to achieve that, but this should be as part of a wider conversation on what a "well-adapted" UK should look like, that explicitly takes account of vulnerabilities, inequalities, and residual risks.

3 Ten principles to guide thinking on better incorporation of economics into adaptation planning

Principle 1. Develop a method for establishing a vision of a well-adapted UK and the investment requirements to reach that vision, in the context of a transition to net zero

Climate change mitigation targets are guided in part by the finding from climate science and climate scientists that at a global level limiting warming to well below 2 degrees, and ideally to below 1.5 degrees above pre-industrial levels, is needed to avoid the worse impacts of climate change, and particularly to reduce the likelihood that we reach climate tipping points. Similarly, the UK may want to establish a vision of a well-adapted UK, that includes targets for policy makers to aim for, and the investment requirements to reach that vision. However, there is an important difference between how mitigation and adaptation are conceptualised, in that the UK can explicitly consider at the margin the costs and benefits of moving closer to or farther from the vision of a well-adapted UK. Further, the country will be required to make explicit or implicit choices as to what risks the country as a whole, and different stakeholders, are willing to tolerate, and are going to be willing to tolerate in the future. All these considerations and choices will need to be made whilst the UK also is committed to reducing its greenhouse gas emissions by at least 68% by 2030, compared to the 1990 baseline level, and achieving its 2050 net zero commitment.[xiv]

Principle 2. Ensure inequality and vulnerability are central to any assessments of the costs and benefits of expenditure on climate change adaptation

Some communities are more at risk of the impacts of climate than others, and often it is lower-income places and lower-income households that are more vulnerable and more exposed to climate change. For example, areas with more low-income households may have less green space, coastal areas are more likely to be deprived, and poor-quality housing has been linked to lower incomes and is more likely to overheat.xv Addressing some existing inequalities can have multiple dividends, not just adaptation, and as such there is potential for win-wins if these inequalities are explicitly identified. Arguably, to maximise the impact and acceptability of investment in adaptation, where impact is explicitly recognised as multi-dimensional, requires methodological approaches that take explicit account of inequality and vulnerability. Linked, but distinct, is that legitimacy matters, whether in regard to setting targets for a well-adapted UK, or for determining how adaptation investments change vulnerabilities and inequalities.

Principle 3. Move away from a focus on CBA towards a mix of approaches that focus on the economics of risk and uncertainty

Climate change changes risk profiles across space, time, and populations. Similarly, efforts to tackle climate change, whether focused on mitigation or adaptation, further change these risk profiles. Cost benefit analysis has long been criticised as not able to accommodate some of the most important aspects of tackling climate change, including the need to protect people, livelihoods, and assets from low probability high harm events. Alternative approaches can be used that are based on economic principles, but focused on how investments in adaptation

change risk and uncertainty. These include real options analysis (which allows for more efficient adaptation investment decisions by explicitly incorporating uncertainty and the option of responding to new information)[xvi]; and multi-criteria analysis (which accommodates normative judgement and technical expertise, multiple objectives, and both qualitative and quantitative indicators and criteria)[xvii].

Principle 4. Evidence of macroeconomic impacts of climate on the UK economy have a role, but should not be the primary focus of the economic analysis

CGE models and IAMS have a role to play, particularly for large-scale broad adaptations and understanding the fiscal sustainability implications of climate change on the UK economy. However, in general they are not best suited for understanding and guiding individual adaptation investments. Moreover, understanding the weaknesses and shortcomings of any macro estimates is critical. Climate-economy models typically fail to capture the stochastic nature of the changing climate, and miss deviations from the expected trajectory. For example, annual economic damages from climate change (as a percentage of GDP) are generally calculated by putting a temperature change into a non-linear damage function, and damages are discounted and aggregated across future years to give total climate changes damages. Without allowing for temperature variability, the models will not sufficiently capture uncertainty in total climate damages. Climate-economy models also may fail to pick up sequences of temperature autocorrelation. For example, governments need to be planning for situations in which anomalies, such as droughts, last for multiple years, rather than weeks.

An adaptation strategy that takes explicit account of vulnerable populations, and explicit account of the changing climate and corresponding distributional impact of adaptation investments, is unlikely to be one that is guided primarily by macro-economic models of the UK economy.

Principle 5. Incorporate a place-based approach that can accommodate adaptation actions that use different entry points (targeting hazard, exposure, or vulnerability) for reducing risk and take explicit account of a diversity of stakeholder preferences

Place-based approaches, that recognise local communities' preferences and inputs, and that may offer a suite of adaptation options that vary in, for example, their entry points, specifically, whether targeting the hazard, exposure, and vulnerability, may be more appropriate.

Further, any framework that is developed to address climate risks is likely to be more effective if, rather than focusing on identifying actions against one particular component of risk, instead considers actions that can address the risk through different entry points. For example actions could be explicitly focused where there are the most significant environmental, social and economic co-benefits (potentially through the framework of the Triple Dividend of Resilience).[xviii]

Principle 6. Develop an adaptation framework that can be adopted and flexed at different governance scales.

Building on principle 5, flexibility in terms of adaptation governance across time and space is likely to lead to more effective adaptation, in part by reducing the likelihood of path dependency and maladaptation, and in part enabling choices to be made across a suite of adaptation options, and changes in adaptation strategy.[xix] A quasi-option approach (that could, for example, take explicit account of the expected value of future information and the cost of adjusting to new information) is one way of harnessing the contribution of economics.

Principle 7. Take explicit account of how residual risk can be handled, including consideration of who takes responsibility for this residual risk

The Third National Adaptation Programme (NAP3) and the Fourth Strategy for Climate Adaptation Reporting[xx] call for a country that effectively plans for and is fully adapted to the changing climate. However, it is not clear what "fully adapted" means, and indeed whether "fully adapted" is an appropriate target. Arguably a discussion is needed as to what kind and types of risks the country is willing, or going to be willing, to tolerate, now and moving forward. Considerable investment will be needed to come anywhere close to being fully adapted, and it is not clear that, for example, it is feasible or optimal to be fully adapted and resilient to all climate shocks moving forward, especially where there are multiple and/or cascading shocks. As such, it is important to address residual risk explicitly and consider ways of managing these residual risks.

Principle 8. Consider explicitly adaptation to international/transboundary risks

The UK ranks 10th in the Notre Dame's ND-GAIN Country Index which summarizes a country's vulnerability to climate change and other global challenges, meaning it is less vulnerable to climate than other countries.[xxi] However, the UK is increasingly at risk of transboundary and international risks. These include diverse risks including the spread of infectious diseases such as dengue, and shocks to the food system. Adapting to these risks, and systemic risk more broadly, is likely to be particularly tricky to understand and prepare against, but increasingly important. A focus is therefore needed on risks that have global economic impacts and could have significant and scarring impacts on the UK economy.

Principle 9. Focus on low-probability high impact events in addition to more frequent lower-impact events that may degrade adaptive capacity over time

Countries increasingly need to adapt to both lower frequency but more extreme weather and climate events, and more frequent lower-impact events. Climate change is driving an increase in the frequency and severity of weather events, and yet both structural economic models and cost benefit analyses rarely accommodate this reality.[xxii] A real option approach is one way of accommodating "fat tail" distributions associated with extreme climate and weather events. In parallel, more frequent lower-impact events may also be challenging, albeit in different ways, particularly as their impacts on the economy and livelihoods are generally not so visible. For example, recent heatwave events in Europe appear to have prompted increased consideration of formalised protections for workers in high exposure sectors. Less attention is

being paid to how gradually increasing temperatures are also harming worker health with clear implications for labour productivity, labour supply, and economic growth.

Principle 10. Take explicit account of where economics struggles to provide guidance on adaptation policy

The economics profession has to some extent struggled to deal with many aspects of tackling climate change. Taking explicit account of the dimensions of adaptation policy that may not naturally lend themselves to economic analysis can, perhaps counter-intuitively, strengthen the role of economics in guiding optimal adaptation policy. For example, economics does not lend itself naturally to a rights-based approach, or to incorporating guard railing and precautionary principles. However, these different dimensions of tackling climate change can be incorporated, for example, by including constraints, bounding arguments, and supplementing quantified costs and benefits with a strong qualitative narrative.

4 Expanded discussion motivated by the ten principles

The need to reduce emissions to maintain a liveable world has understandably taken up much of the focus of policy makers and researchers to date, and reducing emissions to reach net zero by 2050, and thereby limit warming to well below 2 degrees, remains an imperative. In parallel, however, there is now an increasing and much needed focus on building resilient futures and how countries can best adapt to the changing climate.

The UK has already seen a 40-degree heatwave and the economic consequences associated with this event[xxiii], alongside wildfires, storms and flooding. These events are likely to increase in frequency and magnitude in the coming decades.[xxiv] Acting to improve resilience can help reduce these costs in the future.

The economics of mitigation is evolving, from a focus on the economically "optimal" level of warming, following Nordhaus, to more of a focus on what is the "best" way to reach net zero by 2050, where the "target" is informed by science and set by by governments collectively under the UNFCCC, with a focus on what a liveable planet requires, and where "best" might variously take into account cost, feasibility, and equity. Similarly, thinking on the economics of adaptation also needs to evolve, if the economics profession is to contribute in a meaningful way to the design and implementation of effective and equitable adaptation policies. This section, motivated by the ten principles above, explores in more detail how economics can contribute to better adaptation policies.

4.1 What we can learn from how climate scientists and economists have engaged with thinking on tackling mitigation

The temperature targets that inform commitments to emissions reduction are guided primarily by concern over "averting the worst impacts of climate change"[xxv] and ensuring a liveable planet (Figure 1). For example, National Resources Defence Council (NRDC) suggests that 1.5 degrees is an important focal point because the data suggest that multiple tipping points

could be triggered if temperatures go above 1.5 degrees, leading to irreversible climate impacts.[xxvi] There is considerable uncertainty over the temperatures at which thresholds might be reached and tipping points triggered, and so taking a precautionary approach seems like a sensible approach as a guiding policy, with a recognition that limiting warming to well below 2 degrees, and ideally to below 1.5 degrees, is needed to avoid the worse impacts of climate change, and particularly to reduce the likelihood that we reach climate tipping points.

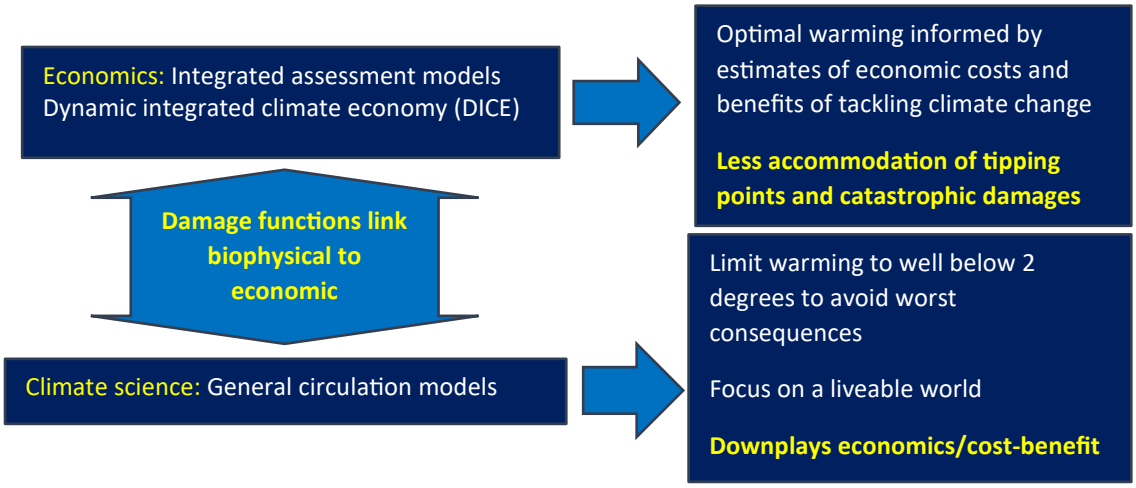

Figure 1: Schematic conceptualising early economics and science of mitigation

There are some important distinctions that need to be made between climate change adaptation and mitigation, and as such, adaptation thinking may differ from thinking that guides mitigation. For example, mitigation is a global public good, while adaptation is generally a local or national public good, and so the impacts of adaptation efforts may be more place specific, and adaptation may be more likely to be grounded in sub-national decision making.

Furthermore, adaptation efforts are not always labelled as such. Businesses and public agencies may, for example, take action to build their general resilience against risk, but not necessarily label it as "climate resilience". This makes identifying adaptation gaps difficult, unlike, for example, residual emissions.

If one were to follow the adaptation equivalent of a net zero emissions world, then arguably one might focus on the costs of reaching an agreed to "well adapted" state, with less attention to the economic value of the benefits. That is, one might focus on cost minimisation, or consider multiple dimensions including equity and risk. More usefully perhaps, economics can contribute by exploring the marginal costs and marginal benefits of transitioning towards a "well-adapted" country, and how investments in adaptation and building resilience change the climate risk profile that people and property face. As such, marginal trade-offs are particularly important, while it still remains important to consider the overall price tag when considering what well-adapted country looks like. For example, as a country moves closer towards being a well-adapted society, the marginal benefits increase, but the marginal costs also increase, very likely in a non-linear manner, and there are likely to be important distributional implications. For example, the marginal cost of tackling overheating in buildings increases as one moves from easy to implement measures, such as encouraging

people to close curtains and windows, through to more expensive measures, such as improving insulation and adding air conditioning. Some groups, such as those renting from private landlords, may be the least likely to be able to benefit from, for example, government subsidies for these more costly adaptation measures if the landlord cannot fully reap the benefits from any investment.

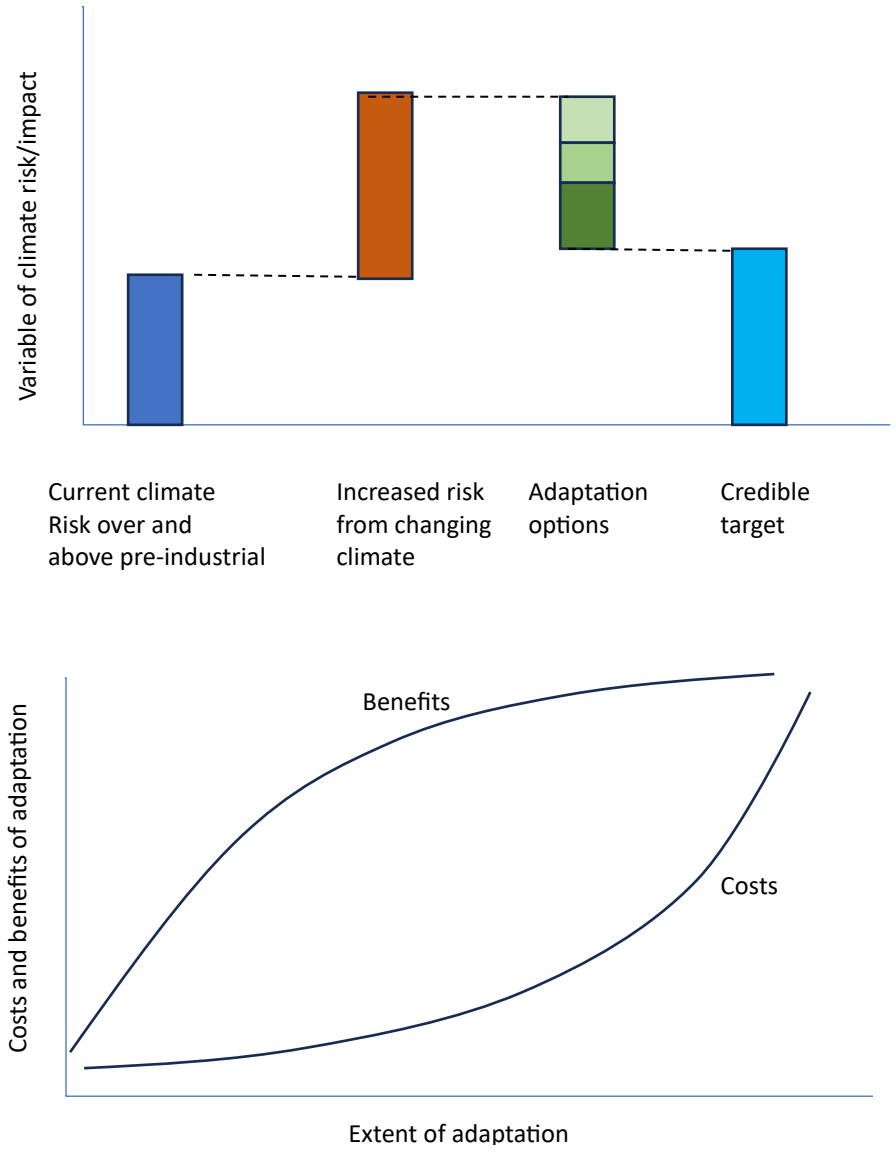

Figure 2. Conceptualising costs and benefits of adaptation

Figure 2 provides two very simple schematics. the upper panel conceptualises how different adaptation options can reduce the risks and impacts of climate change, and assumes there is some "credible" target, and most likely an adaptation gap, implying that societies will accept greater risk of climate impacts than are currently faced. The bottom panel suggests that the marginal costs and benefits of increased spending on adaptation change with the extent of adaptation. A credible target is likely to take into account the marginal costs and benefits of adaptation options, and the distributional impacts.

Can/should adaptation and mitigation be considered separately

There is increasing recognition that mitigation and adaptation are best not considered separately.[xxvii,xxviii] Rather, countries are on transition pathways, with dual aims of ensuring they are well adapted and resilient to climate change, whilst also achieving their net zero targets, generally by 2050 (Figure 3). What this means in terms of practical policy advice with regards to the economics of climate adaptation is not always obvious, but there are real risks of inefficiencies and maladaptations if adaptation and mitigation are considered separately.

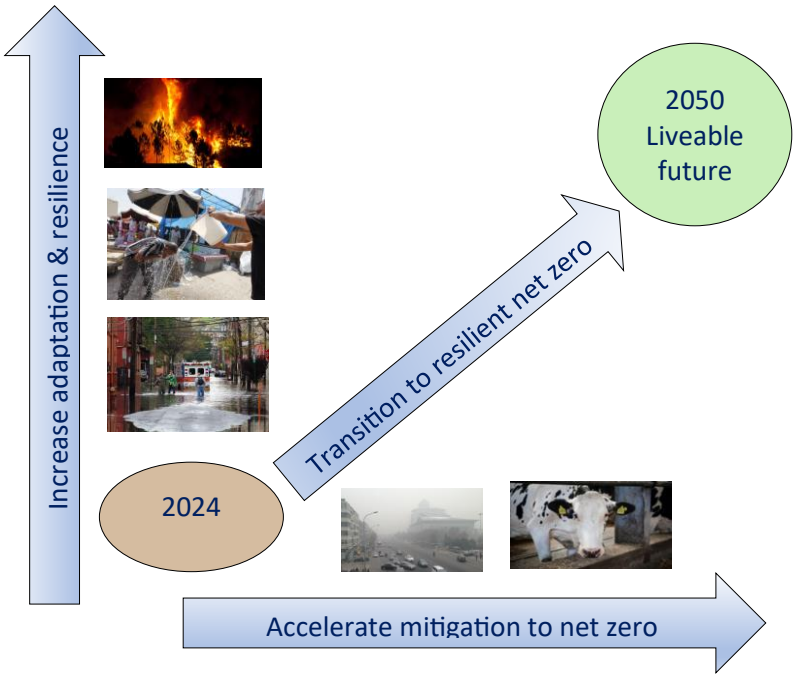

Figure 3: Conceptualising mitigation and adaptation along a 26 year trajectory

There are some clear areas where adaptation and mitigation are very much integrated, particularly with regards to nature-based solutions, and in these cases, it is not clear how the net benefits of adaptation and mitigation could sensibly be considered separately. For example, urban green spaces sequester carbon dioxide, provide localised cooling, improve biodiversity, and can support mental and physical wellbeing. In this example there is a mitigation-adaptation-health win-win-win opportunity. In contrast, air conditioning is a

much-discussed adaptation that can also lead to increased emissions and increased local ambient heat, and as such adaptation-mitigation trade-offs may need to be considered explicitly.[xxix]

In many cities across the globe, there have been found to be few mechanisms that formally ensure that adaptation and mitigation planning is coordinated. [xxx] A focus on the local economics of climate change adaptation in areas where there is clear scope for adaptation-mitigation co-benefits could help policy makers to determine where to focus spending on tackling climate change more broadly.

Lessons from focusing on distributional impacts of the transition to net zero

Much of the focus of what is often termed the "just transition" is on how individuals and communities are affected by a move away from high-carbon to low-carbon economies, recognising that it is important to address the potential for and implications of "'stranded assets' …'stranded workers' and 'stranded communities'".[xxxi] The International Labour Organisation focuses particularly on workers, defining a just transition as "[g]reening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind." However, a just transition matters not just because of equity concerns, but also because such a focus can help to accelerate the transition to a resilient net zero, building support from communities, and with the potential to offer economic benefits.

A focus on a "just adaptation" is similarly needed, which requires a focus on inequality and vulnerability, something that cost-benefit analysis is not particularly well suited to, though the method has been adapted to incorporate some distributional aspects. Indeed, the very advantages of cost benefit analysis, that it enables comparison across projects, that it converts costs and benefits into monetary terms, disadvantage the method with respect to a "just adaptation" transition. Distributional weights have been added to cost benefit analyses, to build in some consideration of equity concerns.[xxxii] But arguably this can still result in a somewhat opaque one-dimensional ranking of adaptation options.

4.2 Microeconomics of climate change adaptation: A framework for better building a vision of a "well-adapted" UK

A key requirement for encouraging adaptation action is building a framework that can be used to assess risk and the benefits of building resilience in a consistent way across the UK. This framework has been absent from previous Climate Change Risk Assessments, which led to the production of robust and detailed risk assessments but without a suitable decision-making framework to feed into.

COP28 saw the agreement on four global process targets for adaptation, including: "By 2030, all Parties to have in place gender-responsive, participatory, and fully transparent national adaptation plans, policy instruments, and planning processes covering ecosystems, sectors, people, and vulnerable communities, and to have mainstreamed adaptation in relevant strategies and plans".[i] These targets can be drivers in how CCRA4 improves the evidence base for implementing policy to build a UK resilient to the worst impacts of Climate Change.

A framework for a well-adapted UK might include clear pathways for moving beyond focussing on providing evidence on hazard and risk and focussing instead on filling gaps on the evidence of the impacts of these hazards and the effectiveness of adaptation action. This would involve a greater focus on understanding the impacts of climate events that are being experienced in the UK today, how they affect, for example, people, buildings, and infrastructure in different ways, and how the risks might change in the future. A critical role economics can play with respect to adaptation policy is providing evidence on more than just the quantifiable costs and benefits of adaptation, which, if considered in the absence of non-quantifiable and hard to quantify costs, can lead to poor decision making that fails to capture the full extent of the benefits of adaptation action.

CCRA4 can also provide more evidence on the costs of climate change to-date, the incidence of these costs, and how outcomes may have looked different with better adaptation action, through historical case study analyses. Evidence could also be presented on the effectiveness of critical adaptation actions against the risks we are likely to face in the future.

Naturally it needs to be explicitly acknowledged that there are likely to be many visions of what "well adapted" entails, some that focus on nature-based solutions, others that focus on technological fixes; some that prioritise managing the hazard, others that focus on reducing exposure and vulnerability; some that prioritising reducing the probability of breaching a particular tipping point, others that build more generic resilience to shocks. Because it is likely that the closer one gets to a "fully adapted" situation, the greater the marginal costs and the smaller the marginal benefits, "well-adapted" is likely to be somewhat distant from "fully adapted."

It will also be important to avoid the pitfalls of economic systems that tend to exclude key values, including the value of human health and biodiversity. A narrow scope of assessing benefits could lead to failure to adequately assess the value of protecting certain physical, economic, or social assets and therefore under-adapting to the impacts of climate change.

4.3 Moving away from cost-benefit analysis towards a mix of approaches that focus on risk and uncertainty

Cost-benefit analysis (CBA) has long been used to assess whether a project should be undertaken, by comparing the total costs and the total benefits, or presenting the ratio of benefits to costs. Yet though it is a reasonable starting point for thinking about the economics of climate change adaptation, there are increasingly criticisms of CBA as an economic tool to help tackle climate change, as articulated by the IPCC, and by Rachel Samson's to the point blog, "Cost-benefit analysis is the wrong tool for tackling climate change."

Some of the earlier criticisms of CBA, that it cannot accommodate non-market and intangible costs, can be addressed, simply by using non-market valuable approaches to assign a monetary value to those non-market costs and benefits. However, several important criticisms of standard approaches to CBA remain. These include that costs of adaptation tend to be over-estimated and benefits under-estimated; that CBA cannot accommodate transformative change; that CBA tends to take a static rather than dynamic perspective; that vulnerability and

inequality are tricky to accommodate; and that the tool does not handle risk and uncertainty well, especially low-probability high impact risk, and systemic risk.

Arguably the most important criticism is that standard CBA struggles to handle risk and uncertainty. Standard CBA typically reduces dimensionality that is needed when making policy decisions under deep uncertainty,[xxxiii] and is particularly unsuited to dealing with low-probability but catastrophic events ("fat tails"), in which situations it is unlikely to be efficient.[xxxiv] As such, it would be hard to argue that a standard CBA approach is well suited as a methodology for determining optimal levels of adaptation. However, there are ways that CBA can be expanded rather than rejected as a methodological approach. For example, probabilistic extensions of CBA can be used to inform adaptive flood risk management, taking account of the probabilistic arrival of new information (learning); incorporating frequency analysis of extremes; and incorporating anticipatory adaptation to inform efficient decision making that is particularly relevant in circumstances where large upfront fixed costs are required for projects with long technical lifetimes. Other improvements would be to incorporate real option analysis, and return periods (a one in a hundred-year flood, for example).[xxxv] More broadly, an optimal adaptation strategy is likely to evolve over time as more information becomes available, as the climate changes, and as global commitment to net zero by 2050 advances, and CBA is ill suited to accommodate such realities.[xxxvi] Finally, the benefits of adaptation action are less obvious and harder to justify using cost-benefit analysis, particularly because many of the benefits of adaptation action are uncertain, may be unquantifiable, and may be realised at different scales.

Box 1. Cost-benefit analysis in the context of climate change adaptation policy, Extracts from the IPCC

"Economic thinking on adaptation has evolved from a focus on cost-benefit analysis and identification of "best economic" adaptations to the development of multi-metric evaluations including the risk and uncertainty dimensions in order to provide support to decision makers" … "Economic analysis is moving away from a unique emphasis on efficiency, market solutions, and cost-benefit analysis of adaptation to include consideration of non-monetary and non-market measures, risks, inequities and behavioral biases, and barriers and limits and consideration of ancillary benefits and costs. One role of economics is to contribute information to decision makers on the benefits and costs, including a number of non-monetary items, and on the equity impacts of alternative actions. It does not provide a final ranking for policy makers. A narrow focus on quantifiable costs and benefits can bias decisions against the poor and against ecosystems and those in the future whose values can be excluded or are understated. Sufficiently broad-based approaches, however, can help avoid such maladaptation. Indeed the evidence shows that maladaptation is a possibility if the evaluation approaches taken are not comprehensive enough in this sense" … "There are, however, still unanswered questions on how to apply economic methods to this kind of problem (particularly when the changes caused by climate change are large and when people's valuations may be changed), and on how to improve the quality of information on the possible impacts and benefits" (Chambwera et al., 2014)."

4.4 Building a list of adaptation actions that use different entry points for reducing risk

Adaptation actions can be used to reduce hazards (e.g. ecosystem-based measures to reduce coastal flooding, planting trees to reduce run-off), exposure (e.g. resettlement of at-risk communities, better land use planning to account for climate risks, early warning systems), and vulnerability to risks (e.g. retrofitting housing against risks, providing insurance against risks).[xxxvii] These actions are likely to be adopted as part of a wider process of building resilience,[xxxviii] the capacity to be able to respond to and cope with shocks, adapting to a changing climate, and transforming when coping and adapting is no longer plausible. Adaptation tends to be associated with preserving existing structures in the economy and society. Transformation tends to be associated with more fundamental changes in how economic and societal systems operate. Therefore, in building a vision of a well-adapted UK, the CCC could focus on incremental adaptation, but a focus is also needed on the more fundamental and system-level changes that will be required when incremental adaptation to climate change is insufficient.

Government (and private and business) investment in adaptation can take many forms. For example, one can consider the different adaptation investments the government could take to tackle changes in rainfall patterns that can lead to a higher likelihood of flooding. As a consequence of the changing climate, the UK is likely to experience warmer and wetter winters, hotter and drier summers, and more frequent and intense weather extremes.[xxxix] The UK is already becoming wetter (2011-2020 was 9% wetter than 1961-1990), and flooding is getting worse. Nature-based solutions that slow down water flow, including wetlands and peatlands restoration, planting more trees, restoring the natural flow of rivers, and the development of water retention areas, can reduce the flood hazard. Alternatively, governments can build barriers such as embankments and polders that aim to keep flood waters away from people and property, or move people and property away from areas prone to flooding. Early warning systems can enable people to act before a flood, which could include simply moving items from the ground floor of properties, or evacuating an area, thereby reducing people's vulnerability and enabling them to reduce the exposure of some of their belonging. But the most vulnerable might not be able to act on this information. Each option has implications for costs, the distribution of benefits, and how the total flood risk is changed, and different individuals and groups may value and prioritise a suite of adaptation measures differently. As such there is not necessarily one optimal adaptation strategy. But economics can help to determine economic and non-economic costs and benefits associated with different interventions, and the distribution of those costs and benefits.

Box 2. The difference between adaptation and resilience

Adaptation and resilience are terms that are often used interchangeably. However, adaptation has been referred to a process or action that changes an individual so that they can better cope in a new environment, whilst resilience tends to emphasise the ability to cope with shocks and recover from their negative impacts.[xl] Resilience has also been described as a "whole of society endeavour", focusing on "preparedness for effects across networked systems."[xli] Another set of definitions distinguishes adaptation as a "process, action, or sometimes the result of the action", whilst resilience is characterised as "a condition or capacity."[xlii]

Incorporating a rights-based approach

The Office of the United Nations Commissioner for Human Rights defines a human-rights based approach to tackling climate change as one that "seeks to analyze obligations, inequalities and vulnerabilities and to redress discriminatory practices and unjust distributions of power that impede progress and undercut human rights."[xliii]

When considering and costing approaches that reduce climate risks faced by populations, it is important to address the different interests of different groups and the value placed on aspects of wealth, income, and wellbeing. It cannot be taken as given that welfare economics will sufficiently address these issues. Climate change will affect all areas of the UK, and taking a welfare economics approach for many risks could, for example, result in prioritising protecting areas of high asset value. Areas that could be marginalised include individuals' mental health and morbidity impacts, cultural considerations, and impacts on nature and ecosystem services, which, if they are undervalued relative to physical damages to assets/buildings for which it is relatively easy to assign a monetary value, can result in the misallocation of investment. It is therefore vital that an economics approach also provides guidance where appropriate on ethical issues that standard valuation techniques and policy appraisals will fail to capture.

There is no ex-ante reason why the target of a "well adapted" society should not embed a rights-based approach, and no reason why economics cannot incorporate such an approach. An economics approach that incorporates a rights-based approach might include, for example, setting rules that any "target" for adaptation must adhere to. This could include the right of populations to be protected from the worst impacts of a particular climate hazard; or the right of future generations, in addition to current generations, to experience the same level of protection against the worsening impacts of climate change. A question still remains as to how best a rights-based approach can guide the economics of climate change and provide guidance to decision makers.[xliv]

It is important to recognise that even if an explicit rights-based approach is not being taken, judgements implicitly have to be made about how reductions in risk and uncertainty are valued, and how risks are distributed across society, who gains and who loses from spending on adaptation. These judgements should be clear and developed in conjunction with the public and relevant experts.

5 Building on earlier efforts to address the economics of climate change adaptation

Efforts to address the economics of climate change adaptation are of course not new, there are both practical reports explicitly addressing this, and a rich peer-review literature. Here just a few examples are provided.

The IPCC's Chapter 17 tackled the economics of climate change adaptation in 2014,[xlv] highlighting the move away from a focus on cost benefit analysis towards an approach that explicitly included risk and uncertainty and multi-metric evaluations, and non-market and non-monetary measures. This chapter highlights how traditional approaches to cost benefit

analysis “can bias decisions against the poor and against ecosystems” and against future generations. Economic decision making under uncertainty, real options, and multi-metric approaches are highlighted.

The ECONADAPT project (econadapt.eu) focused on developing economic methods for assessing adaptive capacity.[xlvi] The guidance on how to factor in uncertainty into decision making is particularly constructive. A portfolio of adaptation options might variously be categorised as those that can be considered low or no-regret, those with clear win-win co-benefits, those that can be reversed, and where safety margins can be factored in, “hard” infrastructure versus “soft” non-infrastructure options, and those where there is an option value to delaying actions until additional information can be acquired.

Climateexchange.org.uk has undertaken several case studies on the economics of climate change adaptation.[xlvii] Their analysis of a 2015/16 flood event in Aberdeenshire proposed using cost-benefit analysis to compare the benefits of preventing flood damage (avoided damage) with the costs of preventing that damage (adaptation). Investments addressed included increasing the resilience of the housing stock, developing disaster risk plans, and longer-term flood management and management retreat strategies.

In addition, useful peer-reviewed articles and encyclopaedia entries include:

- Markandya, A., Galarraga, I. and de Murieta, E.S. eds., 2014. *Routledge handbook of the economics of climate change adaptation*. London, UK: Routledge.

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6 Concluding thoughts and next steps

This report suggests that a useful economics of climate change adaptation is by its nature messy. Cost benefit analyses can provide relatively easy to compare "neat" single dimensional measures of the overall costs and benefits of various adaptation options, but are rarely likely to provide sufficiently nuanced and granular guidance that takes into account some of the most important aspects of adaptation investment, including tackling low-probability high-risk events, and the spatial, temporal, and socio-demographic distribution implications of these investments.

Based on discussions and contributions from the Advisory Group on the Economics of Climate Risk and Adaptation, the CCC secretariat, and the Chair's personal perspective on the economics of climate change, this report brings together some of the group's thinking over the past 12 months. However, it represents just a small part of the rich discussions the group has had, and as such should be seen as a starting point for more detailed discussions and case studies of the practicalities of how economics can be fully integrated into CCRA4. The appendices below, contributed by individual members of the Advisory Group, provide examples of some of the ways in which members can contribute moving forward, in addition to proposed case studies and methodological deep dives.

Appendix 1. A Well-Adapted UK under Deep Uncertainty

Author: Prof James Rising

Deep uncertainty presents a pervasive challenge for achieving a "Well-Adapted UK". Adaptations can require decades to develop, and adaptation investments are made against the potential benefits expected for additional decades. However, the UK of 2050 and beyond is largely opaque to us. The impacts of climate change will coevolve with the structure of the economy and future technologies in complex ways. Even credible scenarios of how impacts, adaptation practices, and socioeconomics will interact– which are currently unavailable– will be of limited utility. The future UK will emerge out of a cascade of idiosyncratic events in ways that are almost impossible to predict.

Nonetheless, adaptation policy should engage with these uncertainties, be proactive in long-term investments, and, in response to deep uncertainty, support resilience, flexibility, and adaptive capacity.

Deep uncertainty exists when there is no agreed-upon quantification of risk. While high-quality projections of climate risk that capture many forms of uncertainty are available, there are several major gaps in our current projections. These include a very limited representation of the potential and effects of adaptation; almost no cross-sector, spillover (cross-region), and persistent (cross-time) effects; and little understanding how climate or adaptation will structurally change our lives and livelihoods (Rising et al. 2022). In addition, there are whole classes of risks that are currently missing from either the literature or major economic assessments, and the inclusion of adaptation is even lower (Fig. 1, drawn from Piontek et al. 2021).

Channel	# Studies	Inclusion	With adaptation	With feedbacks
Economic output	13	45%	38%	7%
Health	11	38%	14%	21%
Agriculture	10	34%	17%	24%
Coastal inundation	9	31%	17%	17%
Energy	9	31%	14%	21%
Extreme events	8	28%	21%	21%
Forestry	4	14%	10%	3%
Labour productivity	4	14%	3%	10%
Tourism	4	14%	3%	10%
Water availability	4	14%	10%	3%
Biodiversity/Ecosystems	2	7%	7%	0%
Fluvial floods	2	7%	3%	3%
Crime	1	3%	0%	3%
Ecosystems	1	3%	3%	0%
Fishery	1	3%	3%	3%
Local amenity	1	3%	3%	3%
Migration	1	3%	3%	0%
Transport	1	3%	3%	0%

Figure 1. A summary of recent (post-2010) assessments of economic impacts, as reported by Piontek et al (2021) supplementary information. "# Studies" is the number of assessments with each channel of impact; "Inclusion" is the percent of studies with that channel; "With adaptation" is the percent of studies that represents adaptation in that channel; and "With feedbacks" is the percent that includes economic feedback between sectors.

Despite these gaps, adaptation planning can be targeted, cost-effective, and high-impact. Numerous studies have shown that deep uncertainty does not preclude (and can heighten the need for) mitigation action (e.g., Wagner & Zeckhauser 2016, van der Ploeg & Rezai 2019, Jensen & Traeger 2022). The robust decision-making behind adaptation investments is even clearer, because of the immediate, local benefits these investments provide. Proactive adaptation can reduce costs by an order of magnitude (e.g., Diaz 2016) and often has significant side-benefits.

However, deep uncertainty does offer insights for the underlying tenets of adaptation planning. First, since realised impacts events are unlikely to follow any prepared scenarios, resilience becomes particularly significant. By "resilience", I mean that economic, infrastructure, and support systems should be able to "bounce-back" from many different kinds of events. This requires multiple independent fall-back options and multiple ways to coordinate that the agents in a system are familiar with.

This kind of adaptation is flexible, with an ability to react to unexpected new risks. It reflects a kind of robust health in the system and in the people and environments who make it up. A Well-Adapted UK will inspire its communities not just to be prepared, but also to be highly capable and inventive.

Investments into adaptation should be designed to be expanded. This means not only that infrastructure can be made bigger and better, but that the underlying capacity to enact adaptation is greater. Material capacity (the ability to mobilise resources) is only part of adaptive capacity, and a Well-Adapted UK also needs to develop a veteran ability to plan and use those resources.

A Well-Adapted UK should be more capable and robust to both climate-related and unrelated challenges facing it in the future, and addressing climate adaptation necessarily goes hand-in-hand with the revitalization of deprived areas, ensuring a flourishing natural environment, and continuing to lead in climate actions internationally.

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Appendix 2. Tipping points: A fundamental challenge to how we assess and manage climate risks

Laurie Laybourn, Global Systems Institute at the University of Exeter and Chatham House

'Tipping points' are moments when something changes abruptly. Think about leaning back on a chair. You can do so until the chair suddenly falls backwards. That moment is the tipping point. The previous state – in which you were balancing precariously – has been replaced by a new state: lying on the floor.

Tipping points exist in nature. For example, coral reefs are being stressed by climate change, which is making the water too warm. This stress could become so great that reefs enter a new state that leads them to die off.

Tipping points also exist in our societies. These can be destructive, such as if the cumulative effects of climate shocks reach the point where farming or other activities become unviable in a locality. They can also be constructive. For example, some renewable energy is now cheaper than dirty alternatives, a tipping point that is ushering in a new era of clean energy rollout.

This briefing explores these threats and opportunities and the implications for risk assessment and management. It draws on evidence from the 2023 Global Tipping Points Report, an international assessment of tipping points[1], among other sources.

Earth system tipping points

Tipping points are apparent in the Earth system. The Earth system is made up of the different inter-connected systems supporting life, including the biosphere (animals, plants, and all other living things), cryosphere (snowy, icy regions), oceans, and atmosphere.

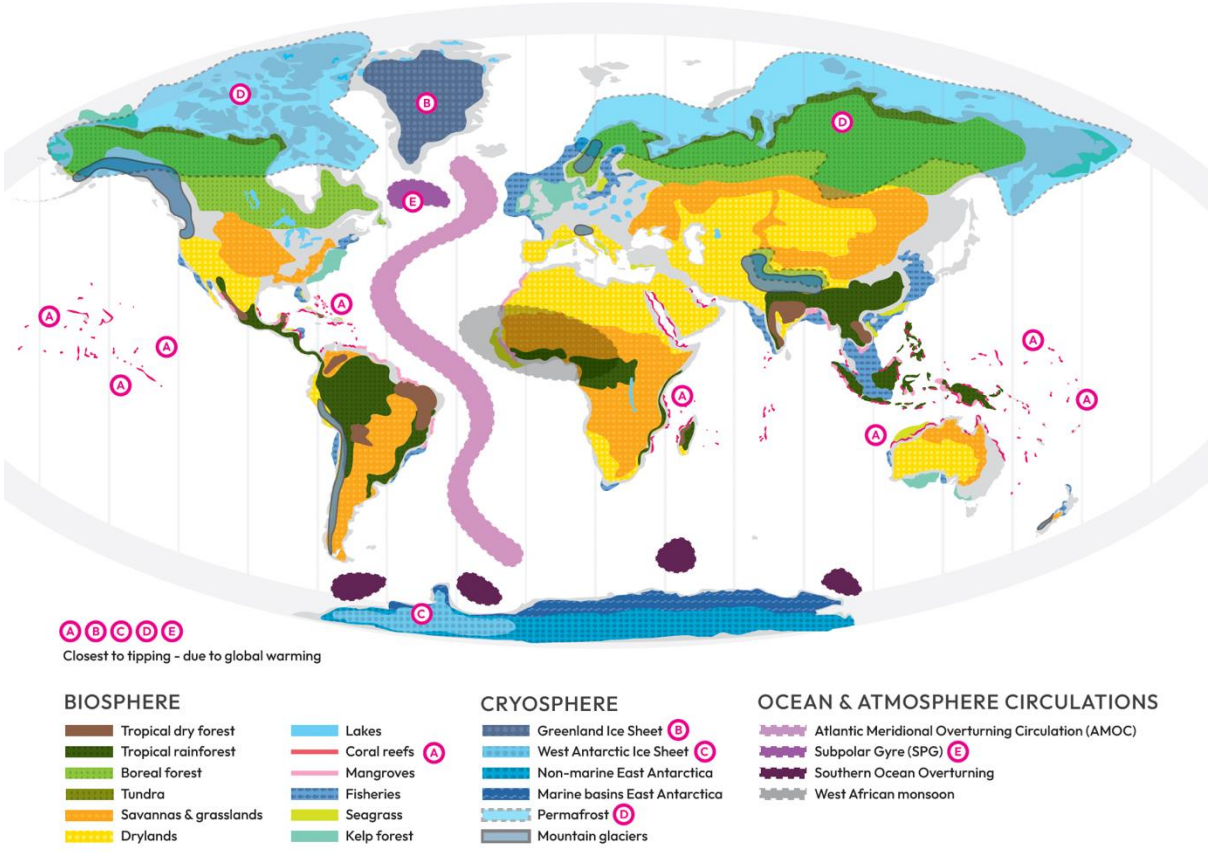
These systems do not always respond linearly to human impacts. Instead, pressure on some parts of these systems can become unbearable, with self-sustaining feedback mechanisms leading to a point – the tipping point – where their function shifts into a new state. Again, think of the chair. The interaction between your body and movement, the structure of the chair, and gravity create a feedback mechanism, pushing you beyond a threshold and onto the floor.

There is growing concern about Earth system tipping points. As the diagram below illustrates, twenty-six Earth system tipping points have been identified using evidence from observational records, knowledge of past shifts, and computer modelling. Climate change is now so severe that major tipping points are currently at risk of being crossed at current levels of global warming (marked with letters in the diagram). These are:

- The die-off of warm-water coral reefs (A)
- The runaway melting of Greenland and West Antarctic ice sheets (B and C)

[1] T. M. Lenton, D.I. Armstrong McKay, S. Loriani, J.F. Abrams, S.J. Lade, J.F. Donges, M. Milkoreit, T. Powell, S.R. Smith, C. Zimm, J.E. Buxton, E. Bailey, L. Laybourn, A. Ghadiali, J.G. Dyke (eds), 2023, The Global Tipping Points Report 2023. University of Exeter, Exeter, UK. https://global-tipping-points.org

- The thawing of permafrost regions (D)
- The collapse of the North Atlantic subpolar gyre's circulation (E)



The impacts and estimated costs of Earth system tipping points

Triggering Earth system tipping points would have severe impacts on societies and the natural world. To explore these impacts and estimates of economic costs, let's look at one example: the potential for the dieback of the Amazon.

A combination of human-induced deforestation, water stress, and the impacts of climate change could lead the regional climate to move to an alternative state that does not support the delicate rainforest, leading to massive forest loss on a continental scale.[2] This would lead to substantial physical effects in the first instance, including damage to biodiversity, reductions in water availability, and higher temperatures and heat stress.

One estimate puts the economic damages caused by Amazon dieback at between US$0.957 trillion and US$3.589 trillion over thirty years, largely due to the reduction or loss of natural processes that are foundational to economic functioning ('ecosystem services') such as water

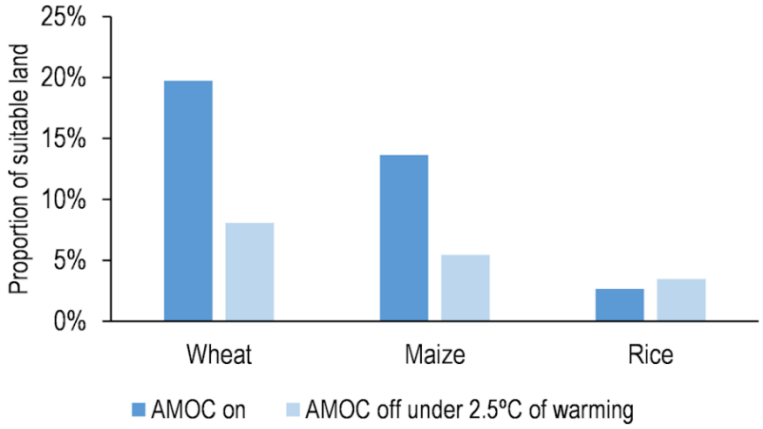
[2] https://www.theamazonwewant.org/spa_publication/amazon-assessment-report-2021/

supply, genetic materials, and productive soils.[3] In comparison, the Brazilian Amazon's estimated gross domestic product (GDP) is around US$0.15 trillion per year.[4]

Another tipping point has received growing media attention. This is the potential collapse of the Atlantic Meridional Overturning Circulation (AMOC), which poses a profound risk at the global scale. The AMOC operates like a "great conveyor belt", carrying warm, salty water from the tropics into the Northern hemisphere, where heat is lost to the atmosphere, leading the current to sink, returning colder water southward.[5]

Climate change is impacting the circulation and might trigger a tipping point, causing the AMOC to collapse. This would lead to a profound reorganisation of the ocean circulation, with major impacts on the climate system. A study commissioned by the OECD estimated that if the AMOC were to collapse at around 2.5ºC of global warming, more than half the suitable land for growing wheat and maize could be lost compared to a world without climate change, as the following diagram illustrates.[6]

Figure 2.5. **Percentage of global land suitable for crop growth**



These crops are critical to global food systems and so the OECD has concluded that "an AMOC collapse would clearly pose a critical challenge to food security, and combined with other climate impacts would have a catastrophic impact."[7] Another study estimates that the effect of an AMOC collapse on UK agriculture are "likely to include widespread cessation of arable farming" in Britain, partly driven by changes in temperature and a reduction in water availability.[8]

The economic consequences of these agricultural impacts would be profound. Where estimates do exist, they point to unbearable costs. For example, the costs of irrigation to restore water availability to UK arable framing after an AMOC collapse are estimated at "over £800 million per year, more than ten times the value of the arable production it would support."[9]

[3] Dollar figures are net present value as of 2018. Source: https://www.pnas.org/doi/full/10.1073/pnas.1721770115
[4] https://www.mdpi.com/2673-4834/2/4/64
[5] https://www.oecd.org/environment/climate-tipping-points-abc5a69e-en.htm
[6] https://www.oecd.org/environment/climate-tipping-points-abc5a69e-en.htm and https://doi.org/10.1787/55ea1cc9-en
[7] https://www.oecd.org/environment/climate-tipping-points-abc5a69e-en.htm
[8] https://www.nature.com/articles/s43016-019-0011-3%20
[9] https://www.nature.com/articles/s43016-019-0011-3%20

The need for improved analysis on threats

Yet the full costs of an AMOC collapse – and other tipping points – could be far higher than current estimates infer. In the case of AMOC, the other direct impacts beyond agriculture would include severe damage to nature, public health, economic stability, water availability, and so on. In turn, these would interact, creating further systemic effects, in a similar dynamic to those experienced from the COVID-19 pandemic, for example.

These cascading shocks play out relatively quickly, on timeframes that could present severe challenges to the capacity of some societies and socio-economic systems to adapt. In turn, Earth system tipping points can interact in ways that destabilise one another, making tipping 'cascades' possible.

The aggregate economic costs of these systemic risks could be vast. Yet modelling of the economic costs of climate change often do not account for the effects of tipping points. This means that many estimates of these costs are biased downward. One estimate of the combined impact of a number of tipping events shows routine economic costs of climate change might be underestimated by a factor of up to eight.[10]

This has led the OECD to warn that: "The fact that the estimates informing climate policy have until very recently failed to take into account tipping points means the cost of carbon has so far been very severely underestimated, justifying a much weaker and slower response to climate change than needed."[11]

Moreover, economic analyses are only able to consider and quantify a certain range of potential impacts. It is difficult to apply monetary costs to the impacts of forced migration, conflict, geopolitical destabilisation, political extremism, societal fragmentation, and psychological effects, to name but a few potential impacts of tipping points.

Systemic risks in general are often missed by mainstream modelling and scenario assessments of the risks posed by climate change.[12] In the UK, the Climate Change Committee has previously warned that "due to the potential for hidden tipping points and the unpredictability of systemic risks, the current model of conventional risk governance in the UK that focuses on single events, single sectors and characterisation of reasonable worst-case scenarios should be reviewed."[13] This is a problem in other countries. For example, a recent study of European Union institutions concluded that "cascading climate risks are, as yet, little understood and seldom assessed or managed. This is extremely dangerous."[14]

The inherent uncertainty of when and how tipping points could occur also presents challenges to understanding and action on these risks. In the case of AMOC, while evidence shows that a tipping point has occurred historically and that another is possible, it is unclear when this could happen.[15]

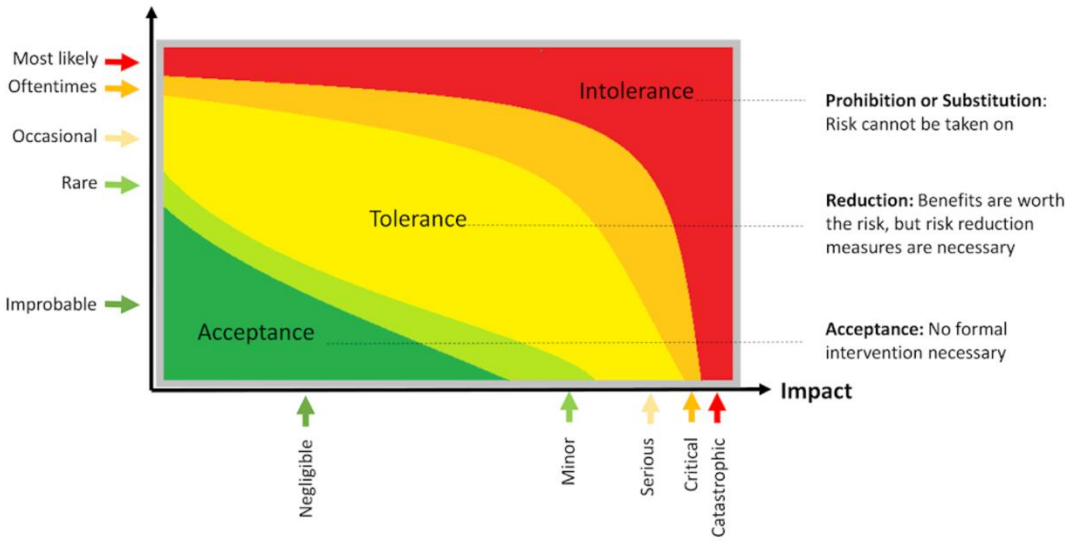
[10] https://www.nature.com/articles/nclimate2964
[11] https://www.oecd.org/environment/climate-tipping-points-abc5a69e-en.htm
[12] See, for example: https://actuaries.org.uk/emperors-new-climate-scenarios; https://www.pnas.org/doi/10.1073/pnas.2108146119
[13] https://www.theccc.org.uk/wp-content/uploads/2021/07/Independent-Assessment-of-UK-Climate-Risk-Advice-to-Govt-for-CCRA3-CCC.pdf
[14] https://www.cascades.eu/wp-content/uploads/2023/11/CASP10721-Recommendations-Resilience-SUMMARY-231122.pdf
[15] https://www.science.org/doi/10.1126/sciadv.adk1189

This uncertainty can sometimes be interpreted as there being a high probability that a collapse will not occur and the risk should therefore be disregarded.

Such a conclusion is unwise. As the IPCC has concluded, "there is medium confidence that the decline [of the AMOC] will not involve an abrupt collapse before 2100."[16] That is, a collapse this century cannot be ruled out with high confidence. A central conclusion of the growing scientific evidence on tipping points is that the likelihood of their being triggered is far higher at 1-2ºC of warming than previously understood. This in turn reinforces the critical need to limit global warming to below 1.5ºC with little to no 'overshoot'.

So, tipping points have evolved from threats that could be considered 'high impact, low likelihood' to those which are, at the very least, 'high impact and uncertain'. Indeed, the application of risk assessment principles – of identifying plausible scenarios and potential extremes – should have meant tipping points were considered as such all along. Growing evidence now supports the conclusion that some should be considered as 'high impact, high likelihood'.[17]

Altogether, this means tipping points warrant consideration in the highest category of concern for risk assessors: threats which present such high costs that even under high uncertainty and/or low probability they cannot be borne, as the following framework illustrates.[18]



This is particularly important when considering decarbonisation strategies into an uncertain future. Globally, the chaotic consequences of tipping events might create a vicious cycle in which governments are distracted from decarbonisation efforts, thereby increasing the chances that other climate tipping points are triggered.

This is 'derailment risk', the risk that the world is increasingly diverted from a pathway to sufficiently tackling the climate and nature crisis by the consequences of that crisis.[19] Many climate and nature risk assessment frameworks consider the risks resulting from failure to

[16] https://www.ipcc.ch/report/ar6/wg1/chapter/chapter-9/
[17] https://egusphere.copernicus.org/preprints/2023/egusphere-2023-1469/
[18] https://doi.org/10.5075/epfl-irgc-233739 adapted in https://www.oecd.org/environment/climate-tipping-points-abc5a69e-en.htm
[19] https://esd.copernicus.org/articles/14/1171/2023/

realise rapid sustainability transitions to date ("physical risk") and the risks resulting from these transitions going forward ("transition risk").[20] Yet there is no explicit agenda – in research nor practice – on the risks *to* sustainability transitions *from* both physical and transition risks and their knock-on consequences. This is a notable gap.

Constructive tipping point dynamics in societies

A crucial tool that can help mitigate tipping point risks are 'positive tipping points'. Tipping dynamics also exist in societies and can work in our favour. These positive tipping point opportunities can be exploited, whereby coordinated strategic interventions can lead to disproportionately large and rapid benefits that accelerate the transition of societies toward sustainability.

This is already happening in some cases. For example, targeted actions have created economies of scale that are now propelling the rapid uptake of renewable energy worldwide, which has reached or exceeded cost parity with fossil fuel power generation.

One positive tipping point can trigger others, creating a domino effect of positive change. For example, as electric vehicles pass a positive tipping point towards becoming a dominant form of transport, this could reduce the costs of battery technology. Lower-cost batteries in turn provide essential storage capacity to reinforce the positive tipping point to renewable power, which can trigger another tipping point in producing green ammonia for fertilisers, shipping, and so on.

Many areas of society could have the potential to be 'tipped', including politics, social norms, and mindsets.[21] But these opportunities are not realised on their own. They must be actively enabled. A range of interventions can do so, including technological innovation, the action of political and social movements, changes in behaviour and mindsets, and financial investments. These can create enabling conditions, altering the balance of feedback mechanisms, such as incumbency advantages and power imbalances, which allow for tipping to occur.

While these dynamics present considerable opportunity for rapid change and positive spill overs, economic modelling and policy approaches do not routinely factor in the potential processes and benefits of positive tipping points, in much the same way as the impacts of Earth system tipping points are under-estimated and -factored.

As a recent study on the UK economy concluded, conventional cost–benefit approaches – which are predominantly used to guide economic policymaking – "are inappropriate tools for assessing non-marginal structural change. The key cost parameters change as a result of the actions we take and the innovation pathways we generate."[22]

The resultant feedback dynamics are hard to model and so are often excluded, which can bias analyses of the cost of decarbonisation to be far higher and estimates of the co-benefits and spill-over effects to

[20] https://www.whitehouse.gov/cea/written-materials/2021/11/03/new-tools-needed-to-assess-climate-related-financial-risk-2/
[21] https://www.sciencedirect.com/science/article/abs/pii/S0921800921003013
[22] https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2024/01/Boosting-growth-and-productivity-in-the-UK-through-investments-in-the-sustainable-economy.pdf

be lower. In turn, this can discourage policy action away from active intervention to trigger positive tipping points and accelerate sustainability transformations.

Conclusion: a paradigm shift in risk assessment

Climate risk assessment and management often focuses on higher-probability impacts and average changes. These include chronic effects like sea level rise and worsening heat extremes. These threats can be easier to model and apply quantitative impact estimates. In turn, existing decision-making methods can be applied to risk management, particularly cost-benefit analysis.

As the previous sections have shown, in many ways, tipping points present a paradigm shift in the risks and opportunities associated with Earth system destabilisation. This should be answered with a paradigm shift in how we understand and act on these dynamics. The uncertain, complex, and potentially high impacts of tipping point dynamics in the Earth system and societies means that additional approaches to risk assessment and management are needed.[23] These include:

1. **Improving economic modelling of the threats and opportunities of tipping points**. This will require investment in coordinated, interdisciplinary research on the interactions between Earth system tipping points and societies, their role in the emergence of systemic risk, and how constructive socio-economic tipping dynamics can accelerate transformations to more sustainable and resilient systems and maximise co-benefits of decarbonisation and nature restoration. This modelling should be readily applicable to options appraisal and evaluation methods used in government.
2. **Using narrative-based scenarios to inform risk assessment and management**. A 'quantitative first and only' approach to assessing risks is unsuitable for tipping points and systemic risks. Instead, scenario storylines that incorporate a mixture of quantitative and qualitative insights can be more effective.[24] These should be educated by transparency over and rigorous debate on the assumptions, limitation, and uncertainties behind analyses. A wide range of expertise and stakeholders is needed to develop effective scenarios, including those most exposed and vulnerable to the risks. Such a scenarios approach will require culture change in certain government departments and systems.
3. **Applying scenarios in stress testing and planning exercises**. The high levels of uncertainty, complexity, and potential impact of both destructive and constructive tipping dynamics means that optimisation approaches to decision-making are less effective. It is implausible to be able to identify the 'optimal' level of adaptation to the systemic risks threatened by an Earth system tipping point, balancing the costs and benefits to identify the most efficient outcome. Yet it is difficult to plan for such extreme levels of threat under uncertainty and with limited resources. In response, scenarios can be used to undertake stress testing and planning exercises to identify key linkages, exposures, and

[23] https://www.ukclimaterisk.org/wp-content/uploads/2021/06/Effect-of-Potential-Climate-Tipping-Points-on-UK-Impacts.pdf
[24] https://spiral.imperial.ac.uk/bitstream/10044/1/100870/8/Full_text.pdf

vulnerabilities. These can educate priorities for increasing the resilience of key system components. They can also help map the possibilities for how existing adaptation policy can be expanded to incorporate tipping point risks while managing limited resources. Similarly, scenarios can help identify priorities for interventions that trigger positive tipping points, including in resilience and adaptation action.

4. **Escalating climate and nature risk assessment and management to a central priority across government**. The triggering of some Earth system tipping points would profoundly affect all areas of UK society and its interests and connections internationally. They present threats that are the concern of all government departments, regardless of a given department's connection to or perception of existing climate change policy agendas. These are ultimately national security concerns. As such, tipping points lend credence to the argument that the escalating climate and nature crisis should urgently be treated as a fundamental condition of government strategic planning and action at the highest levels, particularly on national resilience issues. Similarly, consideration of the huge potential benefits of triggering positive tipping points should be at the heart of government industrial policy. Across both areas, consideration and mitigation of derailment risks is critically important if the world heads to and beyond 1.5ºC of warming. Overall, the growing possibilities of tipping points – including those directly threatening the UK, like the collapse of convection in the North Atlantic subpolar gyre – should be an impetus to accelerate UK adaptation and resilience action.
5. **Empowering local communities and exposed groups**. The cascading consequences of tipping point dynamics, both constructive and destructive, are best assessed and managed with the input of those with local knowledge. Moreover, the perception of communities as to who is responsible for acting on the consequences of tipping points will itself be a key systemic dynamic that determines the UK's response to the climate and nature crisis in the coming decades. A highly unequal distribution of the costs and benefits of these dynamics will drive further cascading instability, hampering mitigation and adaptation of climate change and nature loss in general, which could trigger other tipping points.

In general, the threats from tipping points confront elements of the existing culture around the risk assessment and management of climate change and other systemic environmental problems.[25] This culture can often be concerned, directly or indirectly, with false positives. This leads to a reflex to underplay the potential existence of extremes lest an estimate, scenario, or warning be dismissed as unrealistic or even proven wrong. Such an approach is not suitable for application in risk assessment, particularly of extreme threats like tipping points. Instead, risk assessment and management of systemic environmental threats should be founded on a concern for false negatives: to avoid missing something that does occur. This is general practice among risk assessment and management in a wide range of sectors and contexts. The potential impacts of tipping points and their growing likelihood urge us to apply similar approaches.

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[ii] https://www.un.org/en/climatechange/net-zero-coalition#:~:text=More%20than%20140%20countries%2C%20including,about%2088%25%20of%20global%20emissions.

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[viii] https://assets.publishing.service.gov.uk/media/5b5182ede5274a732fa155a2/pb13942a-nap-annex-economics.pdf

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[xii] https://www.theccc.org.uk/wp-content/uploads/2023/01/Investment-for-a-well-adapted-UK-CCC.pdf

[xiii] https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2021/03/Saving-lives-and-livelihoods_the-benefits-of-investments-in-climate-change-adaptation-and-resilience.pdf

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