



ACCREU
Assessing
Climate Change
Risk in Europe



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ACCREU

Assessing Climate Change Risk in Europe

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Changes with respect to the DoA

The deliverable follows the Description of Work. The reflexive workshop was delayed to April 2026 to allow the meeting to be held back-to-back with the broader stakeholder workshop, but this delay did not affect any other deliverables or milestones, or the completion of D1.5.

1. Dissemination and uptake

This deliverable reports on the activities undertaken in the reflexive co-creation activities across the ACCREU project, and the formulation of a research agenda for the economics of transformation.

2. Short Summary of results (<250 words)

The ACCREU project is centred on a co-creation approach that goes beyond stakeholder consultation and seeks to actively engage stakeholders in the design and delivery of research activities of the project. This includes work on reflexive co-design, focusing on the economics of transformational adaptation.

This reflexive approach was advanced through a multi-disciplinary, reflexive workshop that encouraged discussion and debate on the subject of the economics of transformational adaptation. The aim was to open up dialogue around existing economic orthodoxies, and to critically engage with the ways these may be hindering adaptation, identifying research priorities to expand knowledge in this field.

This deliverable sets out the key insights from the workshop and sets out a research agenda on the economics of transformational adaptation. This includes the following priority research areas:

- Defining the role of economics in transformational adaptation / framing the economics of climate-resilient societal change;
- Improving the evidence on the economics of transformational adaptation and what works, with learning from the past, as well as evidence gathering priorities for the future;
- Understanding how different preferences affect the framing and attractiveness of transformational adaptation, including time-preference, justice, distributional and equity, and societal willingness to pay/accept and cost sharing mechanisms;
- Improving microeconomic tools and methods for the appraisal of transformational adaptation;
- Developing macroeconomic tools and methods for the assessment of transformational adaptation;
- Enhancing political economy analysis, including institutional and behavioural economics;
- Considering the financing of transformational adaptation and the role of the private sector;
- Opening up a discussion on the economics of catastrophic global climate change and the implications for society.

3. Evidence of accomplishment

The evidence of accomplishment is shown from the successful reflexive workshop that was held and the associated research agenda produced.

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1. Research framework and objectives

This deliverable reports on the reflexive co-creation activities in the ACCREU project. This is the main summary of Task 1.5 of Work Package 1, see task description below.

Task 1.5, Reflexive co-creation of new adaptation research [M26-37] (Lead: PWA, ECOLOGIC, Participants: Fondazione CMCC, IIASA, GRAZ, Stichting VU, Deltares, PIK, PBL, GCF see D1.5 and Milestone 1.4) will organise a forum-based co-design meeting to discuss the economics of transformational adaptation. The focus is to hold a critical/ reflexive debate with experts and policy makers to jointly challenge existing norms and develop new paradigms. A reflexive forum (Month 30) will be held to bring together academics and policy makers to debate the topic of the economics of transformational adaptation. Transformational adaptation, which is a focus of the Adaptation Mission, involves system level change, and therefore is different to the incremental adaptation which is the focus of T1.4. The forum will create an open intellectual and social space, to invite conscious reflection while exploring transformative ways to challenge existing narratives. The forum will produce a research agenda for the economics of transformation, and also produce a review paper and a policy briefing note.

The objectives of the co-creation protocol are related to a number of key ACCREU objectives, notably:

O1: Co-deliver a comprehensive, integrated, updated and co-designed assessment of climate risks across sectors, countries, sub-national regions under different climate and socio-economic scenarios while considering distributional consequences across households and business types, fiscal and financial implications.

O3: Co-create ready-to-implement Adaptation Decision procedures and strategies together with public and private actors to address decision makers at multiple level of governance.

2. ACCREU Reflexive co-creation approach

Co-creation is a structured science-practice interaction, focused on joint working and knowledge production that informs policy and decision-making processes. It involves a number of steps (McGlade et al., 2021).

Co-design is the first phase of the co-creation process, in which researchers and non-academic partners jointly develop a research project and define research questions that meet their common interests and needs. This is followed by **co-production**, in which the research programme is advanced together with stakeholders, for example working together on chosen case studies or policy decisions. Finally, **co-dissemination** develops strategies to communicate the project results in discussion with stakeholders and involves them in this dissemination process. This process is undertaken with iterative **monitoring, evaluations and reflections**, so that lessons can constantly emerge and be incorporated at each research stage.

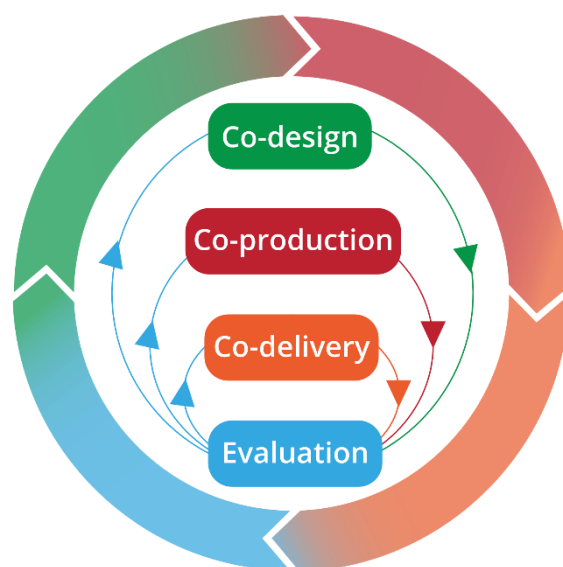


Figure 1 The overall co-creation process and steps.

There is a well-advanced literature on the process of **co-creation** (Dilling and Lemos, 2010; Beier et al, 2016; Moser, 2016), and its application in climate adaptation (Hegger et al. 2012; Hegger et al., 2014). These process centre on **co-design** (cooperative design), which is the participatory design of a research project with stakeholders to jointly develop and define research questions that meet collective interests and needs. This can also extend to **co-production**, which is the participatory implementation of a research project including case studies with stakeholders, and the joint production delivery of research outputs (knowledge production) and exploitation of results.

However, as identified by Harvey et al., (2017) there are different types of co-creation activities:

Co-creation approaches can have different **objectives** with:

- Instrumental co-design - sometimes termed utilitarian or prescriptive co-design. This is focused on creating useable knowledge (to inform decision making); and
- Reflexive (emergent/critical or descriptive) co-design which challenges existing norms and proposes new narratives and ways of thinking.

The use of different **approaches** for the process of co-creation:

- A brokered process, with use of intermediaries or knowledge brokers to mediate the process;
- An assembly, which brings together academic and non-academic actors to debate worldviews in an open intellectual and social space, to invite conscious reflection.

These can be mapped on a matrix, as in Figure 2.

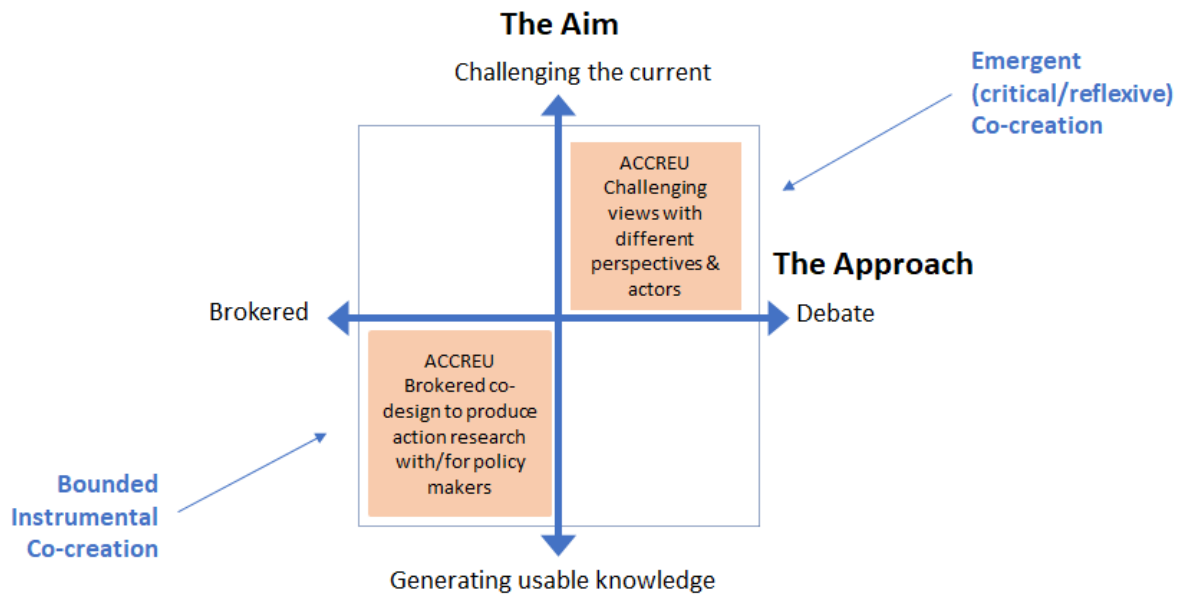


Figure 2. ACCREU codesign on the Co-Creation Matrix (Adapted from Harvey et al. 2017).

Previous work has taken forward the use of instrumental, brokered co-design for the economics of climate change and adaptation (see McGlade et al., 2021). This is also a theme of the ACCREU project (see bottom left of Figure 2) which is providing information on the costs of inaction and adaptation costs and benefits in Europe. This is considered in ACCREU WP1.3 on bounded co-design and associated deliverables.

However, ACCREU is also undertaking **reflexive / emergent co-creation** (critical or descriptive) (see top right of Figure 2). This has been applied to a specific topic, the economics of transformational adaptation.

A review of the literature related to reflexive co-creation (e.g., Moser, 2016; Page et al., 2016; Lotz-Sisitka et al., 2016; Byskov et al., 2021; Chambers et al., 2022; Ziervogel et al., 2022; Jarzabkowski et al., 2024) was used to develop a set of co-design principles and a protocol for a reflexive workshop on the economics of transformational adaptation. These were included in Deliverable 1.2. In summary:

- 1) Participatory framing of the problem and objectives is needed.
- 2) There is a need to bring diverse stakeholders with different views.
- 3) A transparent and inclusive forum for debate is needed, that challenges existing norms.
- 4) It is important to consider governance, power dynamics and agency, not just technical options.
- 5) Researchers are co-creators not knowledge or solutions providers.
- 6) Case studies and tools can help make it real.
- 7) An innovative and open workshop environment is needed.
- 8) Distributional issues, rights and justice are important.
- 9) There should be an iterative process with continuous monitoring, evaluation and learning.

The principles were operationalized into a research protocol, again set out in D1.2. In summary, this included four phases:

Phase 1: Establish a framework for the emergent co-creation discussion and identify relevant stakeholders. Participants in the process will be selected to represent a wide range of perspectives with the potential to design and contribute to transformational adaptation in practice. These activities are set out in Deliverable 1.2, with the stakeholders reported in Milestone 4.

Phase 2: Produce a ‘think piece’ on the economics of transformational adaptation. This was produced and distributed to stakeholders in advance of the reflexive workshop. This is reported in section 4 of this deliverable.

Phase 3: Hold a reflexive co-creation workshop on the economics of transformational adaptation. This was held in April 2026 and is written up in the meeting notes as Milestone 4.

Phase 4: Use the workshop findings to develop a research commentary for publication, alongside a policy brief with a series of insights for policy makers. This deliverable summarises the research agenda. A separate policy brief 4 is produced and the analysis has fed into an article, in preparation.

3. Framing the research agenda on the economics of transformational adaptation

There is an increasing recognition of the need for transformational adaptation in Europe, as set out in the Adaptation Mission (EC, 2021), with a similar call for action at the global level (IPCC, 2021a). There are also an increasing number of academic and grey literature publications on this topic (for example, Kates et al. 2012; Mustelin and Handmer, 2013; Lonsdale et al., 2015; Termeer et al., 2017; Fedele et al., 2019; Biesbroek et al., 2025; UNFCCC, 2025; Biesbroek et al., 2026).

However, almost none of this literature captures the **economics of transformational adaptation**. This has been identified as key gap (Van Hinkel et al. 2025), but at the same time, recent papers identify that conventional economic appraisal and standard cost-benefit analysis can act as a barrier to anticipatory adaptation (e.g., Bonjean Stanton and Roelich, 2021) and are inadequate for transformational change (Mercure et al., 2021).

This economic framing is critical because in Europe, welfare economics is the defining paradigm for government policy. It forms the foundation of public policy intervention and public investment management in the European Commission and national government. Therefore, unless a strong economic case for transformational adaptation can be made, it is unlikely to deliver at scale. Related to this, this economic information also informs financial appraisal and is the basis for private financial decisions and investment.

Against this background, ACCREU undertook a framing exercise to understand the economic dimensions of transformational adaptation, to help understand how to develop a future research agenda. To do this it used the co-creation process and protocol set out in the previous section. The aim was to open up dialogue around existing economic orthodoxies, and challenge these where they may be acting as a unnecessary barrier to transformational adaptation, then identify associated research priorities.

To help frame the reflexive debate at the workshop, we identified **three key research questions** relevant for a discussion of the economics of transformational adaptation. These were written up in a “think piece” that was distributed to stakeholder participants before the meeting.

1. What is transformational adaptation and can its characteristics be captured in economic analysis?

The first question is what is transformational adaptation and how can it be defined? This takes the perspective of the adaptation community and the existing adaptation literature. In practice, the notion of transformation has not been well defined, but some recent publications (e.g. Biesbroek et al. 2026) have identified and synthesised some key characteristics of transformational adaptation. This research question aims to understand whether these characteristics align to, and can be assessed with, conventional economic thinking and methods, or if more innovative approaches are needed.

2. What is the economic case for - and the economic challenges - associated with transformational adaptation?

The nature of transformational adaptation means that it is unlikely to happen autonomously: it is likely to require some form of public intervention and even public investment. Justification of such investments routinely takes place through economic analysis (e.g. analysis of market failures) and then to compare options, through economic appraisal. The second question thus looks at the issue from the perspective of the economic community. The key question was what the economic case for transformational adaptation, and whether transformational adaptation would pass conventional economic appraisal. If not, this leads to a question on whether there is convincing evidence that conventional analysis is missing some critical aspects of transformational adaptation, and thus whether a rethink on approaches might be needed.

3. Re-thinking adaptation economics for transformational change – how and when will we know?

Conventional economic appraisal is focused on marginal changes, however, there have been historic shocks that are so big that normal economic approaches are set to one side. There are potential future climate change risks that could involve similar sized shocks, which would require much greater and earlier implementation of transformational adaptation. These include rising impacts associated with 1.5°C and 2°C overshoots, which could be exacerbated by: accelerated warming; a new normal of (unprecedented) extreme events or persistence

of anomalies; and climate tipping points. This research question asks how big a climate stress or a shock might need to be to justify a step change towards transformational adaptation, including potential threshold levels. It also considers if these shifts can happen in advance of climate impacts (anticipatory), noting that to date these major changes have occurred reactively within the crisis itself.

To support the discussion of these research questions, the project team developed a set of case studies exemplifying different types of transformational adaptation, highlighting challenges and potential solutions and applicability.

4. Workshop discussion and reflections

This section presents the background material from the think piece and draws on the key insights from the discussion at the workshop. The full workshop minutes are included in Milestone 4. The material was structured according to the developed research questions in the previous chapter.

4.1. What is transformational adaptation and can its characteristics be captured in economic analysis?

While there is a growing literature on transformation adaptation, and some general definitions (see Box below), the exact definitions vary significantly and the concept is not well defined in practice. Similarly, while there are case studies of transformational adaptation cited in the literature (see Chu et al. 2019; Ziervogel, 2019; Zografos et al, 2020; IPCC, 2022; Engbersen et al., 2024) these vary widely in terms of their scale and nature.

Box 1. IPCC WG II Glossary definitions (IPCC, 2022).

- Incremental adaptation. Adaptation that maintains the essence and integrity of a system or process at a given scale.
- Transformational adaptation. Adaptation that changes the fundamental attributes of a social-ecological system in anticipation of climate change and its impacts.
- Transformative change. A system-wide change that requires more than technological change through consideration of social and economic factors that, with technology, can bring about rapid change at scale.
- Transformation. A change in the fundamental attributes of natural and human systems', which can be deliberate or societal (social).

To organise these disparate ideas, several studies in the literature have sought to define the potential **characteristics, elements, dimensions or attributes** of transformational adaptation (examples include Kates et al., 2012; Mustelin and Handmer, 2013; Pelling et al., 2015; Fazey et al., 2017; David-Tàbara et al., 2018; Fedele et al., 2019; Zografos et al. 2020). In turn, reviews of this literature have tried to synthesis common characteristics (e.g., Lonsdale et al., 2015; Watkiss and Cimato, 2021; Engbersen et al., 2024).

The most recent example of this literature, Biesbroek et al. (2026), used a Delphi study with experts to identify the key elements (characteristics) of transformational adaptation. They found broad agreement on 13 elements that are important in a definition of transformational adaptation. These are shown in Table 1 below. These include both process- and outcome-related elements. The paper also developed two definitions¹, which capture these elements.

As highlighted in the Biesbroek et al. paper, *clarifying what transformational adaptation entails is crucial for developing effective policies and strategies, ensuring meaningful progress in addressing climate change*. This also applies to the economics of transformational adaptation, and in turn its financing.

This list therefore was used as the basis for the first session of the workshop, which was centred on taking these 13 elements, and examining them from an economic perspective. Note that a 14th element has been added, relating to governance (power). This was included as an element in the Biesbroek et al. paper, but was omitted as it was not selected by all experts.² Despite this, governance and power are potentially highly

¹ Definition 1 (D1): TA to climate risks fundamentally restructures socioecological systems by addressing root causes of vulnerability, ensuring climate resilience across several scales and considering the long-term future. It is context-specific, prioritizes distributive justice and is informed by diverse knowledge systems. TA entails profound change in societal norms and values and recognizes the systemic nature of climate risks and responses. It secures persistent commitments and avoids maladaptation and lock-ins. Definition 2 (D2): TA fundamentally reshapes socioecological systems (1) in an inclusive way (2) to address underlying drivers of climate risk (3), enhance the capacity to cope with and recover from future impacts (4) and prevent unintended consequences now and in the future (5).

² The Biesbroek et al. paper highlights that for shifting power, experts from normative positions emphasized that TA at its core should involve shifting decision-making power to marginalized actors to ensure they have larger roles in transformation. However, others with a more empiricist view remarked that although shifting power is important, it is not always a necessary attribute of TA.

relevant to some forms of transformational adaptation in Europe, and indeed are seen to be critical in some frameworks (e.g. see Watkiss and Cimato, 2021: MACC, 2026).

Table 1. Elements that meet the minimum criteria for being included in the definition of transformational adaptation to climate risks (Biesbroek et al. 2026)

Label	Description
Root causes	Identifies and tackles the underlying environmental, societal, economic, political and/or legal conditions that create or sustain vulnerability and risk within a certain system
Climate resilience	Leads systems and communities to withstand and recover from future climate impacts
Time-horizon	Includes long-term (intergenerational) needs and future climate scenarios and socioeconomic pathways
Diversity of knowledge	Considers a diverse set of knowledges in the process, including scientific knowledge, local knowledge and Indigenous Knowledge
Depth of change	Leads to profound change in the societal norms, values and worldviews
Distributive justice	Ensures fair and equitable allocation of resources and opportunities, ensuring that those most affected by climate change, particularly vulnerable and marginalized communities, receive sufficient support and compensation
Context specificity	Tailors adaptation to the unique conditions and needs of specific contexts
Multiscale	Impacts of change occur across different types of scale (for example, trophic, spatial, jurisdictional or sectoral scales)
Restructuring	Alters the core properties, functions or interactions within the existing social, ecological or socioecological systems
Persistence	Secures long-term commitments and impacts, recognizing that these may not always be irreversible
Maladaptation	Avoids actions that inadvertently increase vulnerability to climate impacts
Avoid lock-ins	Prevents long-term commitments that limit future adaptability and flexibility
Systemic	Takes into account the interconnected nature of the system as a whole, acknowledging that root causes of vulnerability are embedded within broader systemic structures and dynamics
Governance#	<i>The institutional structures and arrangements and governance processes affecting decisions. This can include formal mandates, policy, laws and regulations but also the wider political economy, and actors and power dynamics.</i>

not included in Biesbroek et al. (2026), but identified in some other mappings, and important for some forms of transformational adaptation.

A few specific examples were highlighted for potential discussion at the workshop in the think piece, and were elaborated on through expert presentations at the workshop (see milestone 4). These focused on systemic change and climate justice.

Systemic Change. The scale of the change is a consistent theme across the literature on transformational adaptation, with an emphasis on system wide or systemic change. Systems thinking is a long-established concept, that has been applied to support decision-making in complex and multi-objective policy issues (Stewart and Ayres 2001). It can provide a better representation of a complex system, and allow decision makers to see the bigger picture and to identify underlying drivers of vulnerability or key leverage points. In turn, this can lead to more innovative or integrated (cross-cutting or cross-sectoral) solutions. In simple terms, systems thinking often involves: i) bounding the system of interest; ii) exploring and understanding its components and connections; iii) eliciting different stakeholder and problem owner perspectives, then iv) exploring possible intervention points. This often uses some form of system map to start, e.g., network diagrams, systems mapping or system of systems approaches. These can extend to include feedback loops, actor or stakeholder maps (including social network analysis) and issue maps.

Economic analysis can use these mapping processes of a system, but the more challenging aspect is the quantification and economic analysis of system-level adaptation. It is possible to use more formal modelling methods, including network analysis, to describe complex systems and show interactions and well as the

effects of interventions. Examples exist for road networks (Oh et al., 2020) which use economic analysis to identify the priorities for adaptation at the network level, based on key pinch points and hotspots for greatest and earlier action. A case study example from ACCREU (see D3.2) looks at adaptation costs and benefits at the road and rail network level in Austria. Integrated modelling tools, which connect multiple models and integrate or feed these into economic models, for example, partial equilibrium and computable general equilibrium models, are also a form of systems-based approach. A further ACCREU case study taking a systems-based approach is the examination the food-water-environment nexus in Spain and the Czech republic by combining GLOBIOM suite of models with an economic land use model (D3.2). There is also the potential for agent-based models to capture some of the network elements and interactions between actors.

Climate justice including distributive justice. A common attribute in the literature is that transformations should be equitable and just. While definitions vary, the term climate justice was defined by the AR6 (2021) with respect to a set of different principles: distributive justice which refers to the allocation of burdens and benefits among individuals, nations and generations; procedural justice which refers to who decides and participates in decision-making; and recognition which entails basic respect and robust engagement with, and fair consideration of, diverse cultures and perspectives. The ACCREU case studies on heat and health in the Bremen region (see D3.2) explicitly included a climate justice framework, assessing policies in terms of recognition, distribution, participation and restorative justice. Interestingly, the Biesbroek et al. paper only includes distributive justice.

Economic analysis routinely assesses distributional issues (including in cost-benefit analysis) with an analysis of distributional effects, and how costs and benefits accrue to different people (i.e. winners and losers, patterns across income levels, etc). As examples, EU Impact Assessment requires an analysis of who will be affected by the initiative and how. Similarly, national equivalent (e.g., HMT, 2022) require an analysis of distributional effects (whether these are a direct objective of a policy, or merely a collateral consequence). This often involves a quantitative or descriptive assessment of distributional impacts. It can, however, extend to in-depth appraisal and detailed calculation of distributional effects, and even to the use of distributional weights. These are based on the principle that the value of an additional (Euro) of income will be higher for a low-income than a high-income recipient. These weighting factors can be used to increase the monetary value of benefits or costs that accrue to lower income individuals or households (HMT, 2022) and can be included in cost-benefit analysis, altering the BCR or NPV. For example, values can be adjusted by weighting factors reflecting incomes (with lower-income individuals tending to get larger weights), or other welfare-relevant attributes such as health, life expectancy, or environmental quality. There are numerous examples of the use of distributional analysis. The ACCREU case study in Austria includes a way of capturing distributional objectives depending on the framing (efficiency versus egalitarian) and found this had a large impact on policy. However, in practice, the challenging nature of applying distributional weights, means that this is not a common practice. This is due to the difficulty in assigning weights, as well as the assumptions needed in relation to the groups these are applied to. A further issue is that the use of distributional weights could be considered too narrowly focused on income, and may exclude other elements of equality and social inclusion.

4.2. What is the economic case for - and the economic challenges - associated with transformational adaptation?

Adaptation is generally considered to be inhibited by market failures. These include information failures, positive externalities, and imperfect financial markets (Pauw et al., 2021) as well as policy failures and coordination failures (Frontier Economics and Paul Watkiss Associates 2022). As a consequence, public policy decisions about adaptation are usually normatively driven (Fankhauser, 2017). This is likely to especially be the case for transformational adaptation, which is unlikely to happen autonomously and will require some form of public intervention and most likely public investment (public spending).

There are a standard set of **public policy frameworks** in use in Europe, which provide guidance on policy development in such cases, and these (currently) form the setting in which transformational adaptation will be assessed and prioritised. These are centred on welfare economics. This is concerned with social or public value and not simply market efficiency: it includes all relevant costs and benefits that affect wellbeing, not just

market costs and benefits, and thus includes environmental, cultural, health, social, and justice effects. These economic approaches are different to financial analysis, see Box 2 below.

A good example at the national level is the UK Green Book: Central Government Guidance on Appraisal and Evaluation (HMT, 2022), which sets out guidance on appraisal and the delivery of public value, and which is based on the principles of welfare economics. The first step in this appraisal guidance is to provide the economic rationale for intervention. This includes the consideration of market failures, and thus why it is appropriate for government to intervene, as well as how it might best intervene, i.e. to address these failures. It then progresses to the economic appraisal (impact assessment) of policies.

A similar process is in place at the EU level, where new policies are subject to an EC [Impact Assessment](#) (EC, 2025). Impact assessments examine whether there is a need for EU action and analyse the possible societal (welfare) impacts of available solutions. These are carried out during the preparation phase, before the Commission finalises a proposal for a new law.

Similarly, when it comes to project appraisal, public investment management and project investments typically use social **cost-benefit analysis** to justify investment and help in the selection of options. This approach is used by the European Investment bank, where projects must pass a certain economic return threshold to proceed towards financing (EIB, 2023), though they will also need to undergo a financial analysis to check on financial viability (see Box 2).

Understanding this economic context is critical because if transformational adaptation is going to be advanced by governments, and especially if this requires public policy or public finance, then it will be subject to these approaches. There will be a need to 1) justify the broad economic case for transformational adaptation, 2) transformational adaptation policies will need to be pass impact assessments, and 3) transformational adaptation project investments will need to pass a social cost-benefit analysis (and pass the relevant economic internal rate of return or economic benefit to cost ratio thresholds).

These concepts also are relevant for the financial analysis and appraisal of adaptation, to ensure that transformational adaptation is financially viable; to ensure the public finances can afford it and/or the private sector can be encouraged to invest in it.

Box 2 Economic and Financial Returns

Although closely related, economic and financial appraisal are different:

- *Economic appraisal*, as used by governments and development banks, is based on the principles of welfare economics, and aims to assess the ability of a policy, program, investment or project to improve social welfare or wellbeing. It is therefore conducted from the perspective of society and includes the economic valuation of nonmarket effects, such as environmental benefits and costs. This enables assessment of the socioeconomic costs, benefits, and other dimensions of alternative choices.
- *Financial appraisal* is different and considers the incremental revenues and costs generated by an investment, and the ability to generate cash flows that might be used to repay any financing. It is therefore conducted from the perspective of an investor (not society, as above). A financial analysis excludes environmental or social benefits except where these are reflected in financial cash flows. It will also consider the cost-recovery objectives and mechanisms, and it will often also undertake a financial and fiduciary analysis of the implementing and executing entity.

Economic and financial analysis both involve the identification of benefits and costs and convert these cost and benefit streams/cash flows to present values using discount schemes. Both generate net present value (NPV) and can be used to estimate the internal rate of return (IRR) indicators.

Many of the 13 elements of transformation adaptation (see Table 1) are challenging in relation to conventional economic appraisal (see UNEP, 2024), not least because benefits often arise in the future (time preference), and involve high uncertainty. These issues are exacerbated when considering transformational adaptation from

a financial perspective, because adaptation benefits often do not generate obvious benefit streams, and action involves complex decision making and multiple actors.

Further, there is increasing evidence that transformational adaptation may not pass conventional thresholds of welfare-based economic appraisals, i.e. they may not lead to net social benefits. The ACCREU project has developed a set of case studies that undertook economic analysis of adaptation (D3.2, summarised in Figure 3 below).

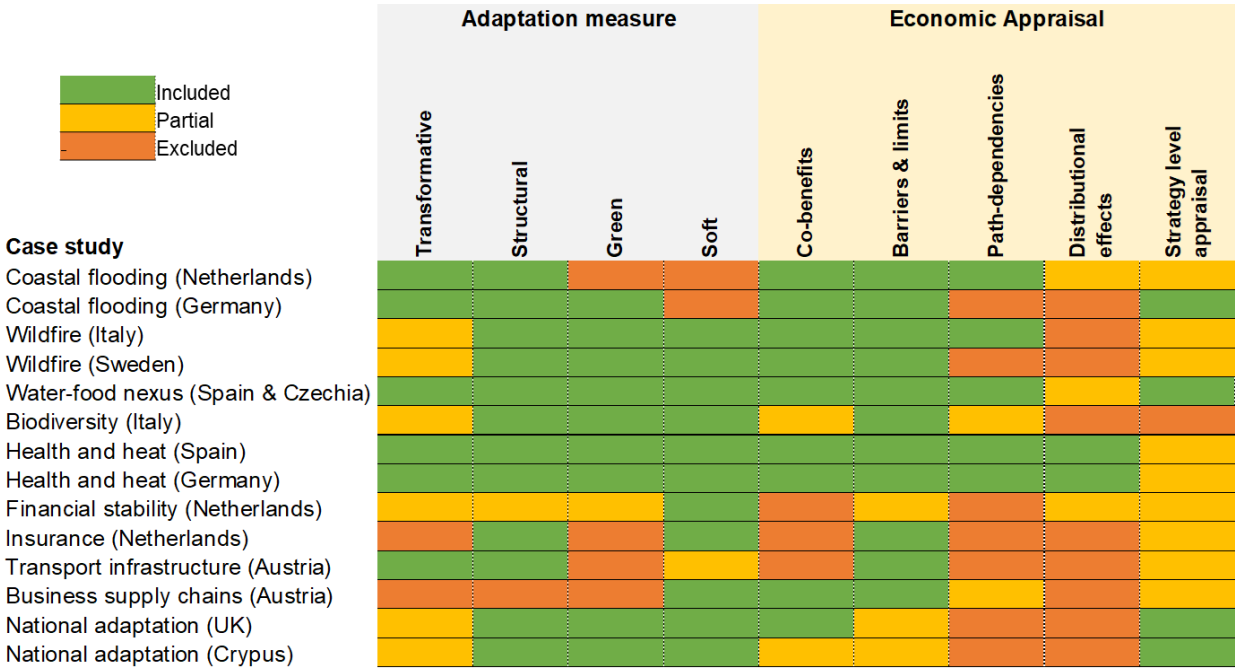


Figure 3. ACCREU adaptation case studies, showing adaptation measures and economic appraisal elements.

The ACCREU case studies found that adaptation often involves co-benefits, in addition to reduced climate change damages. When comprehensive economic appraisal was undertaken, including these co-benefits, the economic case for adaptation was generally positive. Many of these were environmental or social benefits (non-market). Further, when these non-market benefits were included, the relative attractiveness of various options shifted, leading to different priorities. This highlights that capturing these benefits is critical for the economic appraisal of adaptation. This is important to ensure the total economic benefits of adaptation are captured (and reported in benefit to cost ratios), but also that options are compared fairly. The methods used in economic appraisal, and the level of comprehensiveness, influence appraisal results. The inclusion of environmental benefits is routinely in European and national impact assessment and project cost-benefit appraisal guidance, though it can often still be difficult to capture all benefits.

A key conclusion of the ACCREU analysis from these case studies was that the economic appraisal of adaptation requires a more diverse and comprehensive approach, and conventional CBA can act as a barrier: conversely, **transformational adaptation requires comprehensive and even extended CBA frameworks**.

Some particularly important issues are discussed below.

Time preference and discounting. In public economic appraisal, the timing of costs and benefits matters (time preferences). This is routinely captured through the use of social discount rates³. These assign lower

³ While social discount rates can be derived using different approaches, a common approach in Europe is the use of the Social Discount rates. These normally are based on some variation of the Ramsey formula. As an example (HMT, 2022) this is based on the formula $r = \rho + \mu g$ where: " r is the STPR, ρ is time preference comprising pure time preference (δ) and catastrophic risk (L), μg is the wealth effect, derived from the marginal utility of consumption (μ), multiplied by expected growth rate of future real per capita consumption g . The Green book cites evidence for a value for ρ of around 1.5 per cent a year for the near future, an expected annual (growth) rate of g at 2 per cent per year, an elasticity of the marginal utility of consumption (μ) of around 1, leading to a STPR of 3.5 per cent.

weight to benefits that accrue in the future (in present value terms), reflecting the principle that people (and societies) generally prefer to receive goods and services now rather than later. This makes it harder to justify proactive transformational adaptation in net present value terms, as upfront costs are high when compared to benefits that are realised in the future. For example, with the typical Social Time Preference Rate (STPR) used in Europe (4%), future benefits beyond 30 years are very low in present value terms. There are, however, alternative discount schemes that can help to address this, if such schemes can be justified. This includes the use of declining discount schemes, which reduce the STPR in future periods (though these normally only kick in after 25 years or so, and thus do not help significantly unless there is very high future value). These declining discount rates are already included in some national government economic guidance (e.g., HMT, 2022). There is also the potential use of inter-generational discount schemes, which involve much lower rates reflecting a consideration of future generations. These were originally recommended by the Stern review for mitigation, though these were the subject of considerable controversy⁴. There are examples of such schemes published by government for sensitivity analysis (e.g., HMT, 2008). In most cases, inter-generational discounting schemes would not be appropriate for incremental adaptation, as this is generally short-term and local. As an example, when climate proofing a road, it would not make sense to use a different discount rate (DR) for the adaptation components of the project as compared to the main road project appraisal⁵. However, a different DR might be justified for transformational adaptation, for example, major coastal realignment, that would affect the young and future generations very significantly. Indeed, declining or even intergenerational discount schemes might be needed to actually allow transformational adaptation to pass an economic appraisal. The ACCREU case study on superdikes (See D3.2) provides an example of different discount schemes and how these can affect the attractiveness of more transformational adaptation.

Equity and distributional analysis. The issue of distributional and equity weights strongly influences who benefits from adaptation (see ACCREU case studies on heat and health and also on road transport, above). This is also reflected in the literature, for example, Kind et al. (2017) highlight that the diminishing marginal utility of money implies that income differences should be taken into account while calculating the social welfare benefits of flood risk management. This is especially important when social vulnerability is high, damage compensation is incomplete and the distribution of income is regarded as unfair and income is not redistributed in other ways. Further, Kind et al. identify three alternative frameworks to the conventional use of expected values in flood risk management: certainty equivalents, equity weighted expected values and social welfare, all of which use risk premiums or equity weights. When these are applied, they change the results of a flood cost-benefits analysis, regarding not only which groups to target, but also affecting the options put forward.

With respect to both time preference and equity, the discussion at the reflexive workshop highlighted that all economic appraisals involve making choices, such as the discount rate used, or not to apply distributional weights, even if these choices are not transparently decided upon and communicated. Further, these choices have a large impact, but are generally accepted without question. This raised the question of who should have the role of making these choices. Without further discussion, these value judgements will automatically fall to economists, who may make different judgements to non-economists. This therefore led to discussion around a research agenda to better understand preferences, and to be more explicit and transparent about the basis of these when applying to more transformational adaptation. A particular issue was raised around climate justice and equity. If this is over-instrumentalised, or if it is just limited to a check box within a CBA, this can be problematic. One interesting idea that was raised was the trade-off between efficiency and resilience. If value was given to resilience, this would be likely to alter the ranking of adaptation measures, and might also support more transformative action.

There was also a discussion that it might be useful to use narratives or storylines to help discuss what choices mean in practice, i.e. the development of decision support tools to guide economic analysis. Finally, there was an interesting discussion around the links between the political economy and political agendas and transformation including equity, i.e., political mandates can lead to shifts towards equity-oriented approaches,

⁴ Note that while the PRTP value used by Stern was close to zero, the overall social discount rate was not, as future impacts were still discounted for growth (g) to account for the extra wealth of future generations.

⁵ Some discount rates use the opportunity cost of capital, rather than the STPR and viewed from this perspective, marginal adaptation investments should be appraised using the same rate used as for other infrastructure projects.

but noting that these are subject to political cycles and priorities. There was also a discussion on the right tools, e.g., many decision makers ask for analyses of the costs and benefits of adaptation, while it may actually be more pertinent to ask for tools to support decision making under uncertainty e.g. robust decision making.

Decision making under uncertainty (with economics). Future climate change involves deep uncertainty, from the combination of different emission and socio-economic scenarios, variations in climate model projections, differences between impact models, and adaptation effectiveness (Wilby and Desai, 2010). Existing economic decision support tools such as cost-benefit analysis do not work well for a lot of adaptation decisions because of this uncertainty. As a result, the literature is moving from a classic application of cost-benefit analysis and identification of the best or optimal adaptations towards extended cost-benefit frameworks (see Chambwera et al., 2014). This has produced a strong body of literature on decision making under uncertainty (DMUU) for adaptation, which extends to economic analysis (Watkiss et al., 2014; Ditttrich et al., 2016; Kwakkel and Haasnoot, 2019; Bonjean Stanton and Roelich, 2021; Watkiss, 2025). This includes techniques such as robust decision making, decision scaling, real options analysis, portfolio analysis, dynamic adaptation pathways, any of which can be used in an extended cost-benefit analysis framework. Some of these techniques are explicitly focused on economic analysis, notably real options analysis and portfolio analysis. Others can extend to include economics, for example, the integration of economic analysis within dynamic adaptation pathways, as for coastal adaptation (e.g., Haasnoot et al., 2020), or the inclusion of relevant economic metrics in robust decision making or decision scaling in the water sector (e.g., Molina-Perez et al., 2019). While these approaches have been advanced in the literature, they are now also appearing in government economic appraisal, for example, see ADB, 2015; UK Defra, 2025. The ACCREU case studies include several examples of DMUU and there is a much wider literature. While this evidence base and the number of applications is growing, however, these techniques are more applicable at the project level, and they do involve considerable data, expertise, time and resources (Bonjean Stanton and Roelich, 2021). This might mean the methodological approaches are already available but there are issues concerning the application of these techniques – noting they are likely to be a minimum requirement for many transformational adaptation projects. Further, there are research issues around which of the DMUU approaches to apply, and which work best for specific types of transformational adaptation.

The discussion at the reflexive workshop recognised that DMUU has progressed from the academic literature towards practical application in recent years. However, this has focused more on the application to individual projects. This led to discussion on how to address time horizons beyond normal policy making cycles, as well as to assessment of large scale, which are of greater relevance for transformational adaptation.

There was also a discussion about some of the economic impacts excluded in analysis, which are important signals for more transformational change, such as compound and cascading effects, and climate tipping points including the slowing or collapse of the Atlantic Meridional Overturning Circulation (AMOC). The research priorities suggested included stress-testing in adaptation pathways, as well as including co-benefits to make a stronger case for adaptation. There was also a broader set of research and action priorities, such as increasing awareness and communicating climate change and risk to society, developing participatory scenarios and building the capacity of stakeholders.

Political economy, governance and institutional and behavioural economics. A further common characteristic in the transformational literature is around social transformation and governance change, i.e., changes in the political economy of how decisions are made. The literature highlights that delivering transformational change is likely to involve challenging existing power dynamics and may require the formation of new structures or systems of governance (Field et al., 2014). This includes the identification of entry or intervention points that can lead to systemic change, in this context for transformational adaptation. The analysis of governance perspectives requires an understanding of different actors in the system and the governance arrangements around decisions. This can be taken forward with social network analysis. Once this has been identified, then potential options to change governance arrangements and could help deliver transformational adaptation can be considered. The adaptation literature also extends to behavioural change and the social learning, which sees transformation as requiring much deeper understanding and engagement with the complex social processes. This includes deeper understanding and engagement with the complex social processes, including culture, religion, ethics, values, governance, and ontologies of the future and

human consciousness (Fazey et al. 2017). These factors can contribute to changing individuals' own perception from being objects to subjects or agents of change who are capable of contributing to systemic transformations (O'Brien 2018). This implies less attention to altering or manipulating people's behaviour, and more on creating the conditions that promote transformational change. Finally, these issues can be assessed with social learning approaches or concepts, such as second order learning (David-Tàbara et al. (2018) or even triple loop learning, quantum social theory (O'Brien, 2016), or social justice (Fazey et al., 2017). These social concepts have been translated into economics through political economy studies, which look at the interaction between politics and economics, institutional economics, which focuses on the role of institutions in decisions, and behavioural economics, which looks at how individuals and institutions make decisions in real-world contexts.

The reflexive workshop included discussion on the transaction costs associated with more transformational projects, as well as the enabling conditions and pressure points for transformational adaptation. There was also a discussion about the power dynamics and the political economy, including in which parts of government are responsible for making decisions on adaptation. The conversation covered the sequencing of actions, and for example how policies move from idea through to action, and in turn through to budgets and financing. It was noted that there are often many layers of institutions within the EU that may make this sequence more time-consuming or difficult. Further, transformational adaptation is likely to require multiple government departments working together, which is likely to be harder in governance terms than if it were to be pushed by a single department (i.e., due to coordination failures). The discussion led to the identification of interesting research priorities around the process of developing and assessing transformational adaptation. There was some discussion around multi sectoral / cross government taskforces to address these issues, and on which overall institution that should lead. Workshop participants stressed that it will be important to think about how organisations work in practice. This should include learning from previous examples of radical change, how these were implemented and who led, etc. A recurring research priority emerged around understanding “what works (has worked)?”. This research should gather positive examples, but also cases where anticipated larger changes (e.g., post-financial crisis) have not materialised. Participants noted that shocks can be a catalyst for change, such as with the 1953 North Sea flood event, but of the importance of being ready with the solutions in the drawer to respond to such events. A central research question was whether economics can help to make the case for planned, proactive transformational adaptation in a way that does not alarm policymakers, and to understand what is politically feasible. It was discussed that institutions change slowly and incrementally and that radical quick deep changes in values are hardly ever found in public policy, noting however that there is an emerging debate about radical incrementalism: transformative change that proceeds through small steps. Given the strong focus in transformational adaptation on governance, politics and society, this area of policy, institutions and behaviours was considered a research priority.

Macroeconomics. The final theme was on the macroeconomics of transformation adaptation. Macroeconomic analysis is by nature much more aligned with systems and large-scale change, and the macroeconomic analysis of climate change impacts has progressed in recent years. This has extended from the use of integrated assessment models (IAMs) to include structural models (such as computable general equilibrium modelling) and econometric (statistical) studies (O'Neill et al. 2022). However, adaptation is poorly represented in these macroeconomic modelling frameworks (van Maanen et al., 2023). At the same time, there are established economic disciplines looking at macroeconomic policy that would be highly relevant for transformational adaptation. This includes the analysis of root causes through empirical studies and particular econometric studies. Macroeconomics also includes the analysis of structural change, as well as shocks, both of which are highly relevant.

A key and recurring theme at the workshop day was that economics is more than cost-benefit analysis, and that project appraisal is probably the wrong arena for transformational adaptation. The discussion highlighted that economic subdisciplines (macroeconomics, finance, environmental economics) typically work in silos, and that some of the tools needed for transformational adaptation may already exist within the discipline of economics but are not being mobilised across these boundaries. While not all aspects of transformational adaptation can be tackled through conventional economic approaches, there is a lot to be learned through engaging with different economic subdisciplines. There was also some discussion around the broader issue of the current economic system and its focus on economic growth and whether such a system can really be

capable of leading transformational adaptation (i.e., if economic paradigms are themselves a root cause of the problem and a barrier to transformational adaptation). There were divergent views on whether or not current economic thinking could deliver transformational adaptation at all, but this highlighted the need for a broad research agenda, including for more radical economics and accounting for catastrophic futures (see next section). The research priorities identified the need for models and paradigms that are really capable of dealing with the emergence of new sectors, reconfigurations of regions etc. that clearly go beyond marginal changes. Such models would need to account for aspects such as: structural change but also disequilibrium scenarios (i.e. where this goes beyond small changes in the equilibrium); transition dynamics; historic analogues on how structural change can play out and how this can be assessed (and modelled). Further, there was a call for a greater empirical knowledge base to support transformational adaptation. This could support understanding of catalysts for transformational adaptation and might be able to draw on econometric and other empirical economics approaches.

4.3. Re-thinking adaptation economics for transformative change – how and when will we know?

The discussion of the third research question considered the issues and research needs that might arise if greater levels of transformational adaptation be needed. These might arise from:

Overshoots. Given current policy commitments (UNEP, 2025) and likely progress, a confirmation is expected in the near future that keeping global temperatures to 1.5°C is not possible without overshoots, and this may be extended to 2°C unless there is a significant shift in mitigation delivery. This will mean a certain level of transformational adaptation / rising loss and damage is unavoidable, with rising (soft) limits to incremental adaptation and thus more transformational adaptation will be needed in key areas, where these limits are exceeded.

Accelerated warming. A recent series of papers (Hansen et al., 2023; Foster and Rahmstorf, 2026) have identified a statistically significant inflection in the rate of warming post 2015. These potentially indicate a much faster pace of temperature change, which would mean that, from this point in time, temperatures that might have been expected at mid-century could arrive as early as 2035. Clearly the world may not continue warming at this pace, but if these warming trends continue, it would imply a much more ambitious, faster and more expensive (as impacts occur within current asset lifetimes) transition, which will clearly involve much more transformational change, much earlier.

A new normal of unprecedented extremes and the persistence of anomalies. There have been a number of large-scale unprecedented extreme events in Europe. In Germany, the flood event of 2021 led to €40bn worth of damage, a large proportion of which was uninsured (Prognos, 2023) and there were similarly large effects in Valencia (Garriga et al., 2024). This might indicate a potential shift to a “new normal” of patterns of unprecedented extremes, and these could be exacerbated by more persistent anomalies, e.g. multi-year droughts, or from compounding effects. These have major implications for the functioning of European insurance, in terms of affordability and coverage, and raise additional questions on whether transformational adaptation to larger extremes will be needed.

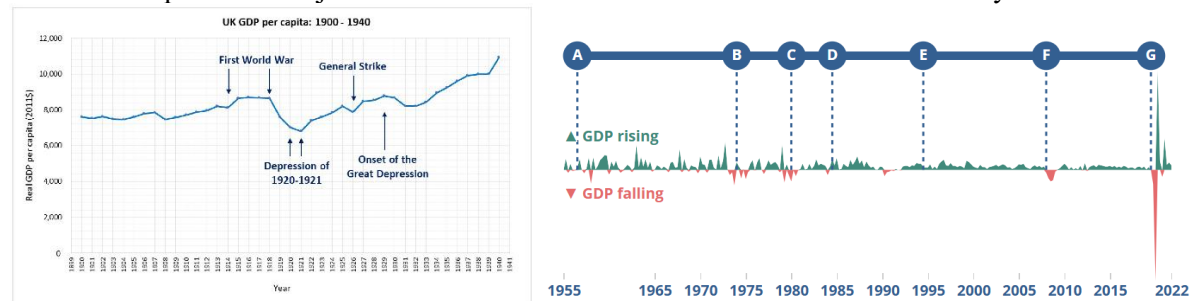
Climate Tipping Points. This is an established literature on responses of the climate system outside of the ranges considered “likely”, such as high values of equilibrium climate sensitivity or carbon cycle feedbacks strength, as well as potential abrupt climate changes and the passing of “tipping points” (or tipping elements) in the Earth System (Lenton et al., 2008; Lenton et al., 2019; GTP, 2023). These are increasingly recognised as an important component of climate change risk assessment, and some economic modelling work has been performed to explore them outside of the mainstream climate projections. These changes have traditionally been seen as beyond the limits of (incremental) adaptation: while the best approach to avoiding these risks is mitigation, there is a rising chance that some of these tipping points may be crossed and would necessitate some form of transformational adaptation.

Socio-economic Tipping Points. While much of the focus has been on climate tipping points, there is a new emerging literature on socio-economic tipping points (van Ginkel et al., 2020), i.e. where the tipping point

arises in the socio-economic system. The evidence on these extremes is more limited, but there are risk assessments which include economic and macroeconomic assessment (e.g., Ranger et al., 2025). Again, these are likely to require more transformational adaptation, and potentially much earlier.

While these larger scale shifts have not yet happened for climate change, there are numerous examples where large shocks have occurred and either conventional economic and fiscal rules were suspended, or else radical new initiatives were introduced. These provide useful analogues for future climate. There is good information on past economic performance in Europe for more than the last 100 years, and this shows that major shocks have led to large scale responses and occasionally policy shifts (albeit sometimes temporary). An example of the influence of shocks on the UK economy is included in Box 3. There was a very large set of shocks associated with the First World War and then the Depression of 1920-21/the Great Depression (see Box 3, left). Since the 1950s, a succession of geopolitical and financial extremes have happened, though the largest of these by some way was COVID-19 (see Box 3, right). Interestingly the range of values from the latest macroeconomic assessments of climate change are similar in nature to these larger events (e.g. see Rising et al., 2026).

Box 3: Example of the major economic shocks to the UK over the last one hundred years



Left. UK GDP per capita from 1900 to 1940 (Wardley-Kershaw and Schenk-Hoppé, 2023).

Right. GDP and events in history for the UK economic, 1955 to current, ONS, 2025.

Based on this literature, the think piece raised a number of related questions for discussion:

How big does a climate stress or a shock need to be to justify a step change towards transformational adaptation, and what might the potential threshold levels be? Most conventional economic appraisal adopts a marginal approach. It does not look at larger shifts, indeed, for such cases, a marginal approach will not be appropriate because there are non-marginal changes (e.g., where there are large impacts on economy, prices, labour markets). A first point for discussion was how big does a shock have to be to justify a change in approach, or even for economic and fiscal rules to be suspended? For example, while it may seem obvious that having to abandon large parts of the Netherlands would be a sufficiently large shock to justify major shifts, this would not be the case for a coastal retreat of a small village of 200 people, but there must be thresholds between these two scenarios that justify increasing levels of change. There is some information based on the non-climate shocks above, which are significant in terms of short-term GDP effects, and these could be matched to the scale of climate change impacts. It might also be possible to relate to economic studies that look at larger structural change, i.e., systematic changes in the sectoral composition of aggregate economic outputs. There are also questions about whether it is only the size of the risk that matters, or other aspects such as the irreversibility.

Can the shift towards transformational adaptation at scale happen in advance of climate impacts (anticipatory), noting to date major changes have occurred reactively? Given what we know already, but also future uncertainty, do we need to act now? The examples above involve reactive responses to major crisis. This leads to the question of whether transformational adaptation – at least to a major climate crisis – can only be scaled-up reactively, or whether it might be possible to do this proactively and anticipatorily. This also leads to potential discussion on evidence of events, e.g., when there is confirmation a tipping point has been reached, would this be sufficient to stimulate more major change? A follow-on discussion from the point above is that if uncertainty cannot be resolved, might it be better to wait? As

highlighted earlier, there are a set of decision making under uncertainty approaches that can help with this, although ultimately anticipatory transformational adaptation will be needed.

What are the changes that might be needed, and are these minor shifts or more radical post economics thinking? What would be needed to encourage more transformational action? While these more major shifts might be a trigger for change, the next issue is how large should this change be. Is this just a move from neo-classical and laissez-faire approaches (for a recent critique see Diesendorf et al., 2024) to a stronger implementation of welfare economics and extended CBA ensuring equity, etc. Or is it a more radical move to ecological economics or post-growth economics⁶. Is this about the art of the possible, or do the shocks involved provide the impetus for more major shifts, and more change is needed, what approaches would be needed to encourage such thinking among policy makers and the public?

Who should pay for transformational adaptation and what should be the cost sharing mechanisms, within and across countries, including considerations of solidarity? There is an emerging issue of who should pay for transformational adaptation, especially as this may involve significantly higher costs, and whether those who benefit should pay or whether cost sharing mechanisms are more equitable. A good example of a government that has explicitly investigated this is New Zealand (NSG, 2025), which in its National Adaptation Framework, sets out that the *expected costs from natural hazards like floods and storms, and the costs of adapting to them, are shared across society and over time*, though it is not yet clear how this will be implemented in practice. These issues will arise for Europe, and are particularly important with regards to solidarity across the European Union, as well as within Member States. Given that climate risks will be unequally distributed across Europe, and transformational adaptation needs will differ, is cross-national cost sharing feasible? This might also extend to alternative approaches for paying for such costs within countries, e.g., wealth taxes (see Advani et al, 2020)

The participants at the workshop also considered why transformational adaptation might not happen to the scale and pace needed. The discussion overwhelmingly attributed the potential failure for transformational adaptation to political and structural barriers rather than technical or knowledge-based limitations. Competing crises (war, geopolitics, inflation), short-term political horizons, vested interests, and the rise of climate-denying right-wing politics (i.e. politicisation of climate research) were identified far more often than scientific or methodological failures. The speed of change was identified as a potential exacerbating factor in failure, i.e. accelerated warming just reduced the time needed for more systemic change. In the European context, this was also associated with a lack of solidarity (across Europe, and within countries). There was also the issue of available finances, including public finances and fiscal pressures, being a limiting factor. A striking feature across all the workshop discussions was that other crises may overtake the focus on longer-term climate impacts and thus the need for transformational adaptation. This included the prominence of potential future events (World War III, war with China/US, AI crashing growth). This identified research that looked at how transformational adaptation might be aligned with or synergistic with other factors, e.g., security.

As well as the macro-economic discussion, the workshop identified the need for complementary research into fiscal (public finances) and financing analysis. The scale of transformational adaptation will have important implications for finance ministries and the public finances, but also among the financial investors that are needed for transformational adaptation, including involve sovereign finance to governments, but also the wider financing of the real economy and the role of the private sector in transformational adaptation. A key enabler –and area where further research is required– was on the finance and funding which was able to deliver transformational adaptation, including from the private sector.

The discussions at the workshop also considered what factors could support the delivery of transformational adaptation. Transformational adaptation was considered to be more likely through a proactive, planned, deliberative approach with strong EU mandates, citizen pressure, de-politicisation, inclusive processes, alignment of financial and economic systems (the mirror image of the barriers to transformational adaptation above). This could be facilitated through a shift in values (beyond GDP) or through better representation of the next generation (who will experience major change) being brought into the decision-making process. There was also discussion that transformational adaptation could be reframed defensively around national

⁶ For example, Jackson [prosperity without growth](#), Raworth [doughnut economics](#).

security/military benefit, or in terms of competitiveness or strategic autonomy, rather than purely in the pursuit of adaptation, i.e. looking to see where it could have benefits against other threat multipliers and issues as part of an integrated solution. An interesting element was also whether the measure of success would be constrained to Europe or whether it would also need to factor in action in the Global South. This involves issues of the cascading effects from outside Europe to the EU, but also equity and solidarity issues at the global level and in the Global South.

4.4 A framework to support research mapping

To help to guide the reflexive discussions, a conceptual framework (depicted in Figure 4 below) was developed that aligned to the three themes above. The top half takes the perspective of the transformational adaptation literature (question 1) and asks where economics can help, while the bottom leads with an economic perspective (question 2). The figure also considers the move from incremental adaptation and conventional economic methods on the left, to transformational adaptation and extended and potentially more radical economic methods on the right (and thus the bigger questions in session 3), noting different actors will have very different views on these issues.

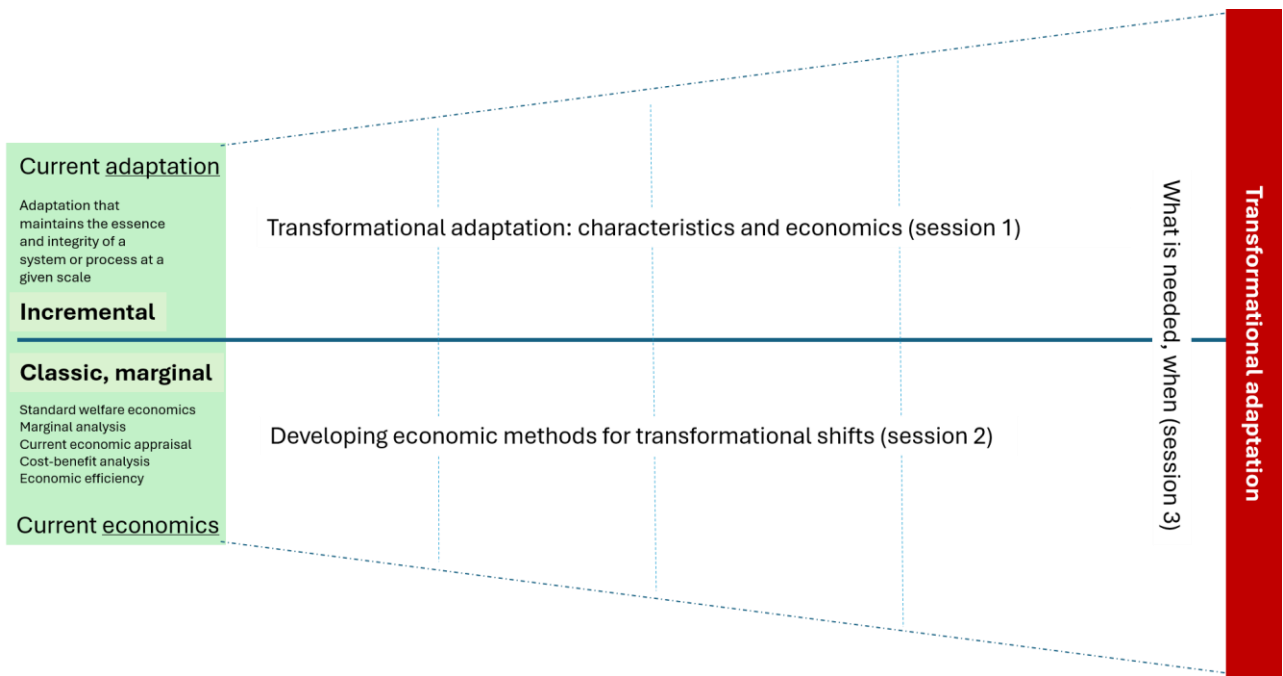


Figure 4. Provisional framework for mapping the issues of the economics of transformational adaptation. Source authors.

5 A research agenda for the economics of transformational adaptation

Based on the literature review, development of inputs for the reflexive workshop and participant feedback, we have produced a research agenda for the economics of transformational adaptation. This is broken down into a set of key research topics:

1. Defining the role of economics in transformational adaptation / framing the economics of climate-resilient societal change;
2. Improving the evidence on the economics of transformational adaptation and what works, with learning from the past, as well as setting out evidence-gathering priorities for the future;
3. Understanding how different preferences affect the framing and attractiveness of transformational adaptation, including time-preference, justice, distribution and equity, and societal willingness to pay/accept and cost-sharing mechanisms;
4. Improving microeconomic tools and methods for the appraisal of transformational adaptation.
5. Developing macroeconomic tools and methods for the assessment of transformational adaptation.
6. Enhancing political economy analysis, including institutional and behavioural economics.
7. Considering the financing of transformational adaptation and the role of the private sector.
8. Opening up a discussion on the economics of catastrophic global climate change and the implications for society.

5.1. Defining the role of economics in transformational adaptation / defining the economics of societal change and transformational adaptation

The most obvious priority to start with is research to define the role of economics in transformational adaptation. As highlighted above, definitions of what transformational adaptation looks like differ, and as a result, there has been more focus on identifying its salient characteristics, as in Table 1. Based on the literature review conducted for the think piece, and the discussion at the workshop, it is possible to map the potential role of economics to these individual characteristics as in Table 2 below.

This mapping identifies that there are multiple areas where economic approaches could support important issues associated with transformational adaptation, which form individual research topics, but also highlights the need to bring these different economic disciplines together in a more structured and comprehensive analysis.

Table 2. Elements that meet the minimum criteria for being included in the definition of transformational adaptation to climate risks according to Biesbroek et al. (2026) linked to potential role of economics (source authors).

Label	Description (Biesbroek et al. 2026)	Current and potential role of economics
Root causes	Identifies and tackles the underlying environmental, societal, economic, political and/or legal conditions that create or sustain vulnerability and risk within a certain system	Welfare economics can capture societal conditions including environmental economics Econometric analysis can assess root causes but may be limited by data
Climate resilience	Leads systems and communities to withstand and recover from future climate impacts	Valuation of adaptation benefits already undertaken, but issue of extending to resilience (and trade-off with efficiency)
Time-horizon	Includes long-term (intergenerational) needs and future climate scenarios and socioeconomic pathways	Captured in economics through time preference and discounting, which reduces future benefits, but potential for declining or intergenerational discount schemes
Diversity of knowledge	Considers a diverse set of knowledges in the process, including scientific knowledge, local knowledge and Indigenous Knowledge	Reliance on quantification in economics likely to prejudice local and indigenous knowledge
Depth of change	Leads to profound change in the societal norms, values and worldviews	Values and norms currently considered through risk preferences and assessed with behavioural economics

Distributive justice	Ensures fair and equitable allocation of resources and opportunities, ensuring that those most affected by climate change, particularly vulnerable and marginalized communities, receive sufficient support and compensation	Can be assessed in economic analysis through distributional analysis and equity weights
Context specificity	Tailors adaptation to the unique conditions and needs of specific contexts	Framing issue on boundary and context - requiring sufficient site and context specificity for economic analysis
Multiscale	Impacts of change occur across different types of scale (for example, trophic, spatial, jurisdictional or sectoral scales)	Partly captured through different analysis from micro -to macro-economic scale
Restructuring	Alters the core properties, functions or interactions within the existing social, ecological or socioecological systems	Economic analysis can look at structural change, but element extends to ecological and social elements which are challenging
Persistence	Secures long-term commitments and impacts, recognizing that these may not always be irreversible	Sustainability of intervention typical part of broader economic assessment, issue of (quasi) irreversibility and can be addressed in some extended DMUU approaches
Maladaptation	Avoids actions that inadvertently increase vulnerability to climate impacts	Economic analysis conventionally assesses risk of perverse outcomes, but issue if too narrow as economic maladaptation only
Avoid lock-ins	Prevents long-term commitments that limit future adaptability and flexibility	Can be included through extended CBA and decision making under uncertainty
Systemic	Takes into account the interconnected nature of the system as a whole, acknowledging that root causes of vulnerability are embedded within broader systemic structures and dynamics	Set of more systemic economic approaches, including input-output analysis, macro-economic modelling Agent based modelling
Governance#	The institutional structures and arrangements and governance processes affecting decisions, both formal and informal.	Political economy analysis Institutional economics Behavioural economics

not included in Biesbroek et al. (2026), but identified in some other mappings, and important for some forms of transformational adaptation.

At the same time, the workshop highlighted that economics should be integrated much earlier into the process of developing policies or interventions that support transformational adaptation, rather than only being used at the level of individual project appraisal later in the process. This builds on the agreement at the workshop that transformational adaptation has strong public good characteristics as it is too systemic and complex to leave to the market, i.e., governments must lead. A research priority is to frame the upstream economic need for transformational adaptation, e.g., traditional policy analysis would ask what is the justification for intervention (including the market failures involved), as well as the nature of the intervention required, including analysis of alternative approach and choices. It would therefore be useful to undertake a more systemic economic policy analysis of the need and justification for transformational adaptation, in line with current economic impact assessment guidance (see earlier discussion). In turn, the analysis of policy intervention should extend to the economics of objective setting for transformational adaptation and the potential trade-offs involved (see also preferences). Such an analysis could include development of a broader economic narrative for transformational adaptation, including its resilience but also the other benefits (see later discussion), as well as comparing alternative approaches, e.g., comparing large-scale transformation with smaller radical incrementalism.

Research Priorities:

- Mapping and analysis of the role of the economic methods to assess transformational adaptation, and consideration of how these could be combined..
- Develop the upstream economic justification for transformational adaptation interventions, including analysis of market failures, and alternative framing (and thinking about how to adapt entire economies).

5.2. Improving the evidence on the economics of transformational adaptation and what works: learning from the past and setting out evidence-gathering priorities for the future;

A common theme across the workshop was that there was insufficient evidence of transformational adaptation in practice. This reflects the low number of transformational adaptation case studies in the literature (see earlier discussion). The analysis of what works (and what does not) could involve a number of research strands.

Participants identified the need for ex-post, evidence-based work to ground transformational adaptation in observed reality rather than normative theory. This included historical case analysis (within the climate context, but also beyond to non-climate examples, with good and bad examples), studies of why progress is slow or fast, and identification of the enablers, archetypes and institutional readiness conditions that have shaped past adaptation. This would provide a counterweight to the more abstract conceptual debates currently around transformational adaptation. The empirical analysis would include the identification of case studies, best practice examples, and early priorities; including public and private sector examples, including in particular an analysis of these through an economic lens.

This evidence could then be used to analysis the potential scaling of transformational adaptation across levels, sectors, different governance levels (project, regional, national, EU) and to synthesis how the case-study findings could inform EU-level decisions.

There will also be a need to establish research methods and protocols for future evaluation (ex-post) of transformational adaptation, as more applications appear, which could be incorporated ex ante during appraisal and project preparation. It would be useful to identify what types of evaluation approaches could be used (e.g., difference in difference, randomised control, econometric analysis) noting the future oriented nature of transformational adaptation may require different approaches to conventional analysis.

Related to this, there will be a need for metrics and indicators to measure transformational adaptation. There is an existing set of adaptation indicators that have been developed as part of Global Goal on Adaptation Indicators, but these would need to be extended to capture more transformational aspects. These transformational adaptation indicators would likely need to include both process-based indicators as well outcome-based indicators, as many of the outcome based indicators would not arise for many years. On the economic side, this would require consideration of effectiveness, benefits and costs, indicators, including relevant issues such as transaction costs.

Research Priorities:

- Conduct review work to identify and assess ex-post, evidence-based analysis of transformational adaptation. This should include historical case analysis (within and beyond the climate context), studies of why progress is slow or fast, and identification of the enablers, success factors, archetypes and institutional readiness conditions that have shaped past transformational adaptation. This should in turn be used to assess how to scale-up and replicate transformational adaptation from individual case studies. This also includes social science analysis of what drives transformational change (see also policy and institutional factors below).
- Development of evaluation methods for transformational adaptation, and potential applicability of different evaluation methods.
- Consideration of transformational adaptation metrics and indicators, for measuring progress, including economically relevant aspects such as effectiveness, costs (including transaction costs) and economic benefits.

5.3. Understanding how different preferences affect the framing and attractiveness of transformational adaptation, including time-preference, justice and distributional preferences, and societal willingness to pay/accept and cost-sharing

Transformational adaptation – where this requires systemic-level change – requires preference elicitation to be extended to contexts that are beyond those usually considered in familiar forms of incremental adaptation. This includes reconsidering time preferences around long-term system change and (intergenerational) discount

schemes, as well as climate justice and distributional preferences (intra-generational equity). It also includes more general issues around societal preferences.

In simple terms, the economics of adaptation can be summarised by the schematic in Figure 5. This starts with growing economic costs of climate change over time, shown left in red. Incremental adaptation reduces these economic costs, producing an economic benefit, working within the existing system. This can be compared to the costs of delivering these adaptation benefits. However, adaptation has low effectiveness, and there is nearly always residual economic loss and damage after adaptation (see D3.4, as well as Rexer and Sharma, 2024), shown in the green line on the right hand side. This leads to a trade-off, between costs, benefits and residual damage, with rising marginal costs (and declining marginal benefits) for progressively greater levels of risk reduction. This means there are choices on the societal objectives for adaptation. A more economically efficient objective might allow for higher levels of residual damage, at least in some areas, while an alternative objective based on notions of acceptable risks would reduce residual levels to similar levels across society. The preferred objectives and level of adaptation/residual damage, will therefore vary with different actors and cultures of acceptance of societal risk – affecting willingness to pay for costs and / or to accept residual impacts.

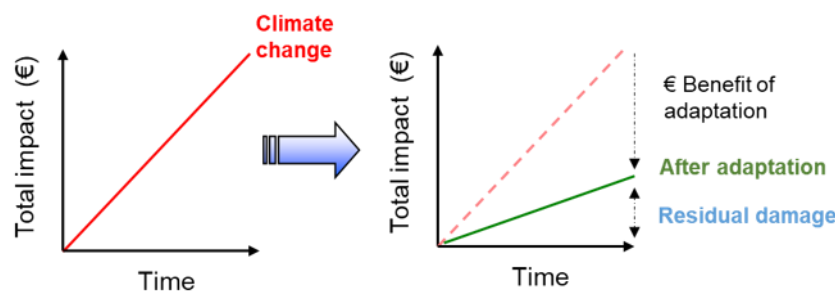


Figure 5. Economics of Incremental Adaptation.

In the case of transformational adaptation, these choices will be more stark. Transformational adaptation may be needed because there is a step change in the impacts of climate change (i.e. a steeper gradient or non-linearity on the left-hand cost side). It may also be needed if there are limits to adaptation that lead to unacceptably high residual risks (on the right-hand side). This will make these choices about societal preferences much more important, because they will be likely to involve higher residual damages or higher adaptation costs. It is also important because transformational adaptation (or lack of it) may lead to stronger differences between winners and losers.

Related to this, there is a question not just about how objectives should be set (and who should benefit) but also cost-sharing mechanisms. The costs of transformational adaptation need to be allocated. It could be that those who benefit should pay, but it is also possible to share costs more equally across society (and in theory, across different generations). This involves important issues of climate justice, especially distributional justice. Governments should be thinking about the costs and benefits of different objectives, and cost allocation methods, as they develop transformational adaptation priorities and financing strategies. In the European context, this includes solidarity principles (and willingness to share costs across Europe).

These trade-offs can be extended to the consideration of efficiency versus resilience in objectives, i.e., the economic trade-offs introduced when resilience is adopted as a criterion that values flexibility, robustness, redundancy and recovery capacity across economic and social systems. This discussion could extend to the trade-offs and synergies with mitigation and transformational adaptation, as well as economic development and transformational adaptation (especially in the Global South).

There are also other elements of transformational adaptation, including biodiversity, cultural heritage, indigenous knowledge, mental wellbeing, landscape and ecosystem services, where preferences will be important. Current revealed preference methods used to value non-market goods and services such as hedonic pricing and travel-cost methods are likely to be of limited use for these, given that they rely on observed behaviour. New methods and applications are therefore required.

As highlighted in the workshop discussion, the choices on objectives, as well as discounting and equity, have a large impact, but are generally accepted without question. A research priority is therefore to identify these preferences. There have been some early willingness to pay studies on adaptation (preference-based evaluation of trade-offs between different forms of adaptation, Ščasný et al., 2016) and current surveys by EUTransform AR project (EU Transform AR, 2025 and OECD have been undertaken or are underway, but these need to be extended to transformational adaptation, as well as wider societal preferences on equity and time preference. For the latter, a key issue will be to consider perspectives across different generations.

Research Priorities

- Analysis of differing objectives and trade-offs for transformational adaptation and surveys to understand societal preferences (risk preferences and willingness to pay/accept), including efficiency versus resilience, as well as cost sharing mechanisms.
- Review of discounting including intergenerational schemes, analysis of what types of transformational adaptation might justify such rates, and surveys to understanding time preferences for transformational adaptation.
- Review of distributional/equity weights (and other approaches) and surveys to understand intra-generational preferences.
- Review of other preferences that are important in transformational adaptation and analysis of whether current methods can assess or if new methods are needed.
- Case studies and guidance on these issues for adaptation economic appraisal.

5.4. Improving microeconomic tools and methods for the appraisal of transformational adaptation.

As highlighted by the ACCREU case studies, and the discussion at the reflexive workshop, transformational adaptation is likely to require extended cost-benefit analysis as a minimum for economic appraisal, such as in project investments (microeconomic analysis). There are some extensions to microeconomic tools and approaches that are therefore identified as research priorities (note macroeconomic priorities are in the next section) as well as strengthening of policy and institutional analysis (also in a later section).

These include a number of different aspects. Expanding from the ACCREU analysis and the discussion at the workshop and above, this includes the inclusion of all societal costs and benefits (including non-market, noting this is standard practice, but these non-market benefits are still often excluded in many economic appraisals, because valuation is more difficult), distributional analysis (and potentially distributional weights) and alternative discount schemes including intergenerational (even if only possible through sensitivity testing). It also includes the integration of decision making under uncertainty. The workshop agreed, however, that these microeconomic practices needed extending rather than discarding, thus moving from CBA to a "CBA++" framework.

Workshop participants also expressed interest in testing alternative frameworks/criteria to those of economic efficiency including to explicitly value resilience or justice.

Participants made many suggestions for complementing extended CBA with other techniques or tools, such as storylines, visioning or narratives. There is increasing use of storylines approaches already in the literature, though these can take many different forms, from extreme outputs from climate models through to qualitative scenarios to help stakeholders imagine different climate futures or undertake stress-testing. These complementary tools to accompany economic analysis include visioning and participatory scenario planning and adaptation pathways that can reduce psychological distance, encouraging long-term thinking and helping to identify robust decisions. These tools can also include narratives that can communicate impacts, personal experience, and adaptation success stories. This can take lessons from other non-climate shocks. Workshop participants also highlighted the need for economic results to be translated into language that is "digestible" for policymakers and that can help transformational adaptation compete with other agendas.

Research Priorities

- Develop an extended cost-benefit analysis framework for transformational adaptation, extending current approaches to ensure consideration of all relevant benefit streams, and inclusion of inter- and intra-generational issues, as well as decision making under uncertainty. This could also extend to new criteria (in addition to economic efficiency) such as around resilience.
- Develop complementary techniques (storylines, visioning, narratives) that can be used in economic analysis, as well as allowing qualitative information to be included.
- Develop narratives and approaches to better communicate with decision makers,

5.5. Developing macroeconomic tool and methods for the assessment of transformational adaptation.

Transformational adaptation goes beyond reducing climate damages and is likely to involve structural changes to the economy that alter patterns of production, labour, trade, finance, and investment. Whereas incremental adaptation aims to preserve existing economic systems, transformational adaptation recognises that climate change may require fundamental economic (as well as societal) restructuring.

There is a general priority to better include adaptation in the suite of existing climate models (IAMs and CGEs) and this extends to transformational adaptation. Transformational adaptation may involve institutional reform, migration, technological change, behavioural responses, and political constraints, which are nonlinear, uncertain, and path dependent. Of course, the inclusion of these issues will be determined by more micro and sector transformational studies, and thus these also need to advance, but there are also questions on how to consider this type of change in macroeconomic model structures.

There is a broader set of macroeconomic assessment methods that could assess what happens to growth, employment and the public finances if some regions become increasingly difficult to inhabit or to insure, and if key sectors experience persistent productivity declines or rising volatility. More traditional macroeconomic analysis could be used, and would then form the basis for assessing the macroeconomic benefits of transformational adaptation.

Existing macroeconomic approaches could be used to look at alternative structural change associated with transformational adaptation, including in long-term development pathways. Dynamic macro models (that look at investment, capital turnover, adjustment costs) could consider short-run vs long-run responses. Investigating the risks of lock-in and stranded assets could help to understand timing and sequencing of policy interventions.

Additional macroeconomic research topic areas include the analysis of patterns of adjustment in labour markets. For example, whilst the economic determinants of migration patterns are now better understood, subsequent effects on sender and receiver regions – and the subsequent role of government – is a research priority. Other macroeconomic topics for further investigation include patterns of adjustment in international trade. For example, climate change may alter agricultural productivity, water availability, shipping routes, and tourism. Subsequent changes in comparative advantage – and their consequences for trade and welfare need to be better understood.

Research Priorities

- Extend the analysis of adaptation in macroeconomic climate modelling (CGE and IAMs) to start considering transformational adaptation.
- Test existing macroeconomic analysis methods and tools (e.g., structural analysis, dynamic models) to the subject of transformational adaptation.

5.6. Enhancing political economy analysis, including institutional and behavioural economics

A consistent theme in the transformation adaptation literature, and in the workshop, was around policy and governance. Current economic models tend to have less focus on the institutional and political conditions that actually determine whether adaptation happens; these will be critical for transformational adaptation given the scale of change.

The analysis of policy and governance can involve a range of approaches, which include political economy analysis and network mapping, through to institutional and behavioural economics. It also includes continued use of co-design and the need to include the values and perspectives of multiple stakeholders. This empirical social science analysis can help to understand what drives transformational change.

Institutional economics research also identifies path dependence as an important factor, where past decisions constrain future options, e.g. in the adaptation context, cities and associated transport infrastructure have been built in coastal areas now at risk from climate hazards such as sea-level rise, erosion and increasing storminess. Despite awareness of risks to these systems and societies, undertaking change is expensive, and so societies become "locked in" as a result of sunk costs, regional industrial specialisms, etc. At the same time, institutional inertia generates new and additional costs through increasing exposure, maladaptation and reduced infrastructure flexibility. Understanding the full range of these costs and benefits – and who bears and gains from them in alternative transformational adaptation contexts - is therefore a research priority.

Workshop participants identified the priority of mainstreaming transformational adaptation (into economic policy and planning), though this involves some potential risks that this might lead to pragmatic incremental progress that dilutes genuine transformational ambition. Relatedly, the use of research and its translation into communication, awareness raising and influencing (even lobbying) emerged as a priority (see earlier research recommendation). This includes identifying effective mechanisms for communication of research results to policy-making structures (noting communicators may not be researchers themselves).

One concern raised at the workshop was that climate-economic models are not absorbing enough of what other disciplines already know. This includes information from non-economic social sciences and humanities, and thus closer science-economics dialogue and genuinely transdisciplinary work with practitioners are important areas of work going forward. Similarly, workshop participants noted that current funding architectures are often too siloed, including by sector, by country, and by mandate. There might be alternative research and cooperation frameworks that cross these boundaries, including between Europe and more vulnerable regions.

Research Priorities

- Application of political economy approaches to transformational adaptation, including network mapping and institutional and behavioural economics.
- Mainstreaming of transformational adaptation into longer-term economic development planning and policy.
- A greater focus on interdisciplinary research to avoid siloed approaches and encourage systemic and integrated analysis (economics and other).
- Analysis of how to maximise research impact, including communication, awareness raising and influencing.

5.7. Considering the financing of transformational adaptation and the role of the private sector

At the workshop the issue of financing transformational adaptation emerged as a new point of discussion. There is a growing literature on adaptation finance (Gautam et al., 2024, Ranger et al., 2024; World Bank, 2025), which includes the use of both domestic public and private sector finance. There is also a recognition that in general, the economic (societal) returns are higher than the financial returns for adaptation (Frontier economics, 2022). This is because many adaptation investments are often in public goods, involve non-market sectors or have non-market benefits, as well as it being difficult to realise commercial returns from the benefits. This means that while adaptation makes sense from a societal perspective, it will still be challenging to attract investment. These issues are amplified for transformational adaptation (UNEP, 2024) because of its typically longer lifetimes and greater complexity.

At the same time, the large-scale impacts that require transformational adaptation, and the costs of this adaptation, will have major fiscal implications and will be important for the public finances. The scale of finance required, and the potential effects on spending and borrowing, may thus require transformational financing, i.e., going beyond conventional approaches (Khosla and Watkiss, 2020). This approach involves a range of financing sources and instruments as well as complementary risk layering approaches, including

financial markets as well as the private sector. This includes the need to look at policy instruments and incentives, and mobilise private capital, as well as changing investment decisions in the real economy. The underlying premise is that the real economy will pay one way or another, so it is better to design that contribution proactively. This will require a consideration of what the business case is for transformational adaptation.

Research Priorities

- Analysis of the potential impacts of climate change on the public finances, and the fiscal benefits of transformational adaptation.
- Analysis of potential financing sources, instrument and models for transformational adaptation, including more transformative finance (including private sector), and including the business case for action.

5.8. Opening up a discussion on the economics of catastrophic global climate change and the implications for society

Transformational adaptation may be needed at great scale, or needed earlier, due to fundamental societal changes induced by the catastrophic consequences of climate change, caused by effects of accelerated warming to irreversible climate tipping points. This leads in turn to a set of further research topics, which range from improved analysis through to potential seismic shifts in current approaches and thinking.

First, it was recognised at the workshop that further work is needed to assess cascading and compounding risks, as well as interconnected, cross-sectoral and cross-crisis risks. This includes cascading impacts (climate and socio-economic), systemic shocks, and the links between climate adaptation and other crises (planetary boundaries, housing, safety, AI, geopolitics). By identifying this research gap, workshop participants implicitly critiqued the limitations of current sectoral and marginal-impact framings.

Complementing this insight, was a discussion on the need to account for the wider benefits of transformational adaptation, beyond risk reduction, to include benefits of competitiveness, strategic autonomy, defence, etc. Demonstrating these links was identified as a key research priority.

Third, it would also be useful to advance some economic analysis of the potential effects of accelerated warming, and the implications for adaptation costs (noting the rate of climate change strongly influences adaptation costs, because more rapid rates of warming involve potentially more stranded assets). This advancement of economic analysis extends to climate and socio-economic tipping points. This could include analysis of the implications of reaching these tipping points, but also analysis of benefits (the value of information) from scaling up analysis and monitoring into these to help inform future decisions. This could also include analysis of positive tipping points that could trigger systemic change toward resilience.

Finally, while views differed, several participants raised the issue of current economic approaches and thinking acting as a barrier to transformational change. This included the consideration of whether transformational adaptation can be achieved within the existing capitalist model of continuous economic growth, or whether climate change requires a more fundamental transformation of economic systems. Whilst it is recognised that capitalism offers important strengths for adaptation—innovation, investment, and resource allocation—it also exhibits market failures, short-term incentives, and unequal outcomes that can undermine resilience. Transformational adaptation -even more so than incremental adaptation- has the characteristics of a public good. This means that many of these market-based strengths may not be realised and market failures may play an even more prominent role. Resilience economics shifts the focus from maximising short-term efficiency to maintaining the long-term capacity of social, economic, and ecological systems to absorb and recover from shocks, though the trade-offs for technological development and growth need to be better understood. This could include the concept of radical solutions that are implemented incrementally. These alternative economic approaches, while controversial, may prove important especially under catastrophic shift, and could (overall or in part) help to support the operationalisation of transformational adaptation.

Research Priorities

- Improved analysis of cascading and interconnected risks and adaptation actions to address these .

- Analysis of the linkages between adaptation and other crisis, and development of the wider resilience and security benefits of transformational adaptation.
- Analysis of the implications for transformational adaptation from accelerated warming and tipping points (climate and socio-economic).
- Exploration of post-growth, post-capitalist or ecological economics for their ability to support transformational adaptation under catastrophic scenarios.

6 Summary and conclusions

Following the workshop, the research framing (see Figure 4) was used to map the findings and insights. This is shown in Figure 6 below. This includes the adaptation perspectives (top) and the economic perspectives (bottom) and looks at the spectrum from incremental adaptation on the left to transformational adaptation on the right. The research priorities were mapped against this framework.

The analysis found that some of the research priorities listed above are already included within existing economic appraisal guidance, such as environmental economics methods for non-market valuation: these therefore only require improved application, rather than new research. This may involve stronger guidance and enforcement of good practice. Others research areas have strong theoretical underpinning, but require more consideration of application, e.g., the use of distributional analysis or weights in project appraisal. This requires more case studies and good practice examples, and practical support and guidance.

A further set offer promise, but are still theoretical and require further development. This includes the institutional and behavioural economics as well as macroeconomics. This requires improved academic (primary) research as well as the early testing for application. Finally, a set of further more radical actions could be interesting, such as resilience economics, but primarily warrant more theoretical analysis and academic debate.

It is stressed that the workshop discussion revealed that various participants placed different research priorities in different places, and had different views on how far from left to right of the figure it would be necessary to move for transformational adaptation.

Top transformational adaptation characteristics

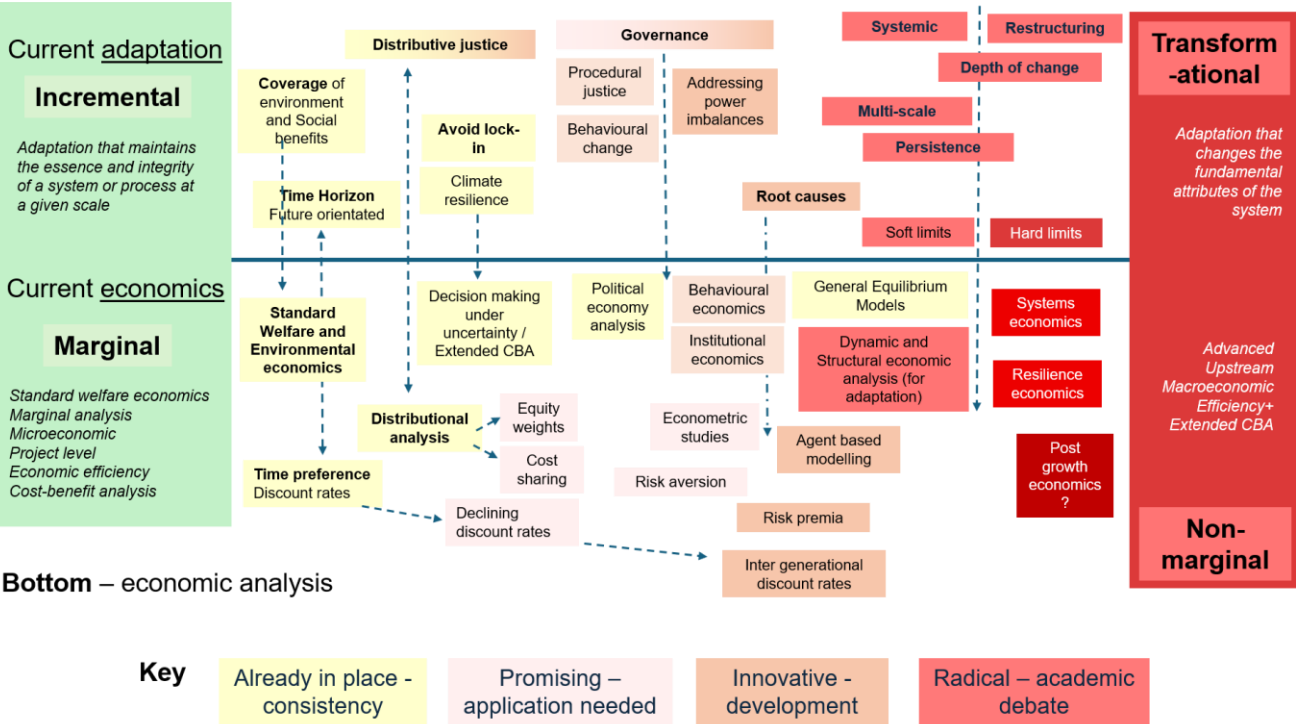


Figure 6. Mapping of transformational adaptation characteristics, economics and research priorities. Source authors.

This research agenda is moving towards an academic publication, and will be shared with relevant research commissioning organisations.

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