Design of Transformative Strategies

Deliverable D5.4

June 2018

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"We can't solve problems by using the same kind of thinking we used when we created them".
Albert Einstein

Collaborative project
FP7 Environment

Project acronym: **IMPRESSIONS**
Project full title: **Impacts and Risks from High-end Scenarios: Strategies for Innovative Solutions**
Start of the project: 01 November 2013
Duration: 60 months
Project coordinator: NERC Centre for Ecology and Hydrology
Project website   www.impressions-project.eu

Document title: Design of Transformative Strategies
Deliverable number: D5.4
Nature of the document: Report
Dissemination level: Public

WP responsible: WP5
Lead beneficiary: J.D. Tàbara

Citation: Tàbara et al. (2018). *Design of Transformative Strategies.* EU FP7 IMPRESSIONS Project Deliverable D5.4.

Milestone date: Month 56 (June 2018)
Actual submission date: Month 56 (June 2018)

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Summary

As the world gets closer to exceeding the 1.5 or 2°C thresholds of the Paris Agreement, it is increasingly recognised that conventional solutions will not be enough either to prevent or to cope with going beyond such targets. To go beyond conventional solutions, this deliverable provides a synthesis of the IMPRESSIONS project results, of its procedural innovations and their implications for the design of transformative strategies under the conditions of high-end climate change.

First we introduce three key concepts - Integrated Climate Governance, Transformative Climate Science and Positive Tipping Points - to frame our analysis and identify the requirements for the design of transformative strategies. *Integrated Climate Governance* (ICG) refers to a conceptual synthesis of science-policy practices that draws insights from multiple sources of knowledge integration and policy practice. The overall purpose of using ICG is to map out the main components that need to be considered in the assessment of transformative solutions and strategies. In particular, we understand that a successful design of transformative strategies ought to:

1. Cover not only the assessment of impacts, risks and vulnerabilities, but also opportunities for institutional innovation and sustainable development; and in particular the required capacities for the emergence of positive tipping points able to reverse the existing trends that lead to a high-end climate change world;
2. Develop and assess specific strategies and pathways of solutions which span different scales of action, sectors and constituencies; and
3. Not only communicate through the (one-way) 'information' of assessments and policy options, but also actively engage with stakeholders so as to help create agents' capacities for transformative change.

The concept of *Transformative Climate Science* (TCS) refers to an open-ended process of producing, structuring and applying solutions-oriented knowledge to fast-link integrated adaptation and mitigation strategies to sustainable development. In particular, TCS can be seen as a novel form of participatory integrated assessment supportive of a sustainability learning process.

The third component in the examination of the requirements for the design of transformative strategies has to do with the question: why and for what purpose do transformative strategies need to be designed? To address this question, we introduce the notion of *positive tipping points* as emergent properties of systems – including both human capacities and structural conditions – which would allow the fast deployment of evolutionary-like transformative solutions to successfully tackle the present socio-climate challenges. In particular, we have provided a simple procedural synthesis to help identify and coordinate the required agents' capacities to implement transformative solutions aimed at achieving ambitious climate and sustainability goals in different contexts. We argue that transformative strategies need to start with the co-production of a desirable vision of the world from which new and different collective capacities to attain a better-off and fairer future can unfold.

After introducing the three concepts, we map out and explore the cross-sectoral and cross-scale implications of high-end climate change and the limits to mitigation and adaptation under these conditions alongside concrete pathways identified within the IMPRESSIONS case studies. The cross-scale implications of high-end climate change are addressed in two ways within IMPRESSIONS: (i) within the integrated climate and socio-economic scenarios; and (ii) in the modelled impacts and vulnerability for each scenario. Model results suggest that for certain impact indicators, some regions of Europe are impacted more negatively by climate change, while others benefit. For example, spatial changes in European land use demonstrate the regional differences in the impacts of climate change on agricultural and forestry productivity. Furthermore, IMPRESSIONS modelling results show that

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impacts in multiple sectors in Europe differ significantly between low-end and high-end climate change scenarios after 2050. This leads to different 'winners and losers' in terms of sectors and regions, with northern Europe gaining in agricultural productivity and potentially biodiversity, the Atlantic region losing in terms of flooding and intensive agriculture, and southern Europe losing in terms of several sectoral indicators (agricultural and forest productivity, water stress and biodiversity vulnerability). The modelling results underline the need to consider climate change adaptation and mitigation actions together. Searching for an appropriate balance between adaptation and mitigation that takes account of cross-sectoral and inter-regional interdependencies will be essential for delivering a sustainable and resilient future for all citizens in Europe and globally.

The synthesis of the capacities in different socio-economic scenarios provides a systematic assessment of what transformative governance and shifts in current systems enable a "proactive" societal change in order to develop transformative solutions to climate change. Overall, transformative strategies across scenarios and case studies emphasise the development of transformative capacities across multiple systems: multi-level, shared and flexible institutions enable participation and the development of a reflexive society, which places sustainability and societal well-being at the core of the economy.

Each of the IMPRESSIONS case studies produced a vision of "where we want to be in 2100". Many vision elements are common across all case studies. For example, there was strong agreement on the importance of health and education and all visions included vision elements on sustainable water use and / or supply. On the basis of a structured discussion with stakeholders a consolidated vision for Europe has been developed that provides ambitious targets for future action. Achieving this vision would require transformative strategies that bring changes to the current system.

Across case studies and scenarios, we identify a nexus of three (groups of) robust pathways to move towards the vision. Each robust pathway encompasses different types of transformative strategies: (i) shift towards sustainable lifestyles; (ii) set up good governance systems for sustainability; and (iii) promote integrated and sustainable resource management. The transformative strategies identify different types of activities and actors to mobilise and create the capacity conditions for delivering the strategy and achieving the vision. The analysis provides a comprehensive picture of 'who is the solution', while the distinct contexts given by the respective socio-economic scenarios equip different types of actors with access to resources to work towards a desired future vision.

In each of the IMPRESSIONS case studies, the stakeholders identified important strategies that could build capacities and help them achieve their vision. All emphasize the need for education in order to achieve their vision. They also underline the need for institutional change and a new economic paradigm. While the Central Asia (EU-external) case study differs from the others in both the process followed and the focus on geopolitical dimensions of dealing with high-end futures, it demonstrates the need for three central elements to realise a sustainable future: cooperation; coordination and connectivity. The strategies in the different case studies also reflect the local contexts in which they were developed. In the face of high-end climate change, both Hungary and Iberia include water management as an important strategy. Scotland looks for bolder and faster action and includes strategies to finance the transition and reshape land use. For Europe as a whole, radical innovation, a new economic paradigm and the bio-economy are the key strategies selected by the stakeholders.

During the IMPRESSIONS case study workshops stakeholders were asked to reflect on what would be the "game-changers" in the scenario that they were working on. What actions would lead to transformative changes that brought them closer to the vision? Building on those results, the complete set of "game-changers" was used to move from `additive', sectoral solutions and strategies to 'multiplicative' ones. The aim was to find positive tipping points to lead to a rapid decarbonisation and rapid 'sustainabilisation' of the world. There are two striking common features of the clusters of

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"game-changers" produced by the stakeholders and project team: (i) changing the economic system; and (ii) supporting local community development. Common game-changers across clusters are environmental fiscal reform, a circular economy, world trade changing to fair trade, and building resilient communities.

Finally, the role of ethics and justice, under the metaphor of the 'moral compass', is underlined as a fundamental way to overcome potential trade-offs between present and future costs and benefits of taking transformative strategies and to support difficult governance decisions aimed at aligning adaptation and mitigation strategies to sustainable development.

Transformative solutions and strategies can be understood as emergent outcomes and processes derived from novel second-order capacities aimed at creating positive tipping points in social-ecological systems configurations. In turn, such capacities can be deliberately built by explicit strategies, such as those identified within the IMPRESSIONS multi-scale case studies. Trying to solve the intertwined problems of climate change and unsustainable development with the existing capacities – e.g., cognitive, normative, technical or organisational – and conventional tools and methods both in science and policy may create even more problems, lock-ins and mal-adaptation, and will make it more difficult to address these issues in the future.

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1.   Introduction

This deliverable provides a synthesis of IMPRESSIONS results and their implications for the design and implementation of transformative strategies under conditions of high-end scenarios. It also shows the potential risks and opportunities of taking a transformative approach to adaptation and mitigation by linking climate strategies to sustainable development. The role of ethics and of decisive normative decisions in governance arrangements is underlined as the most crucial way to overcome potential trade-offs between present and future costs and benefits of implementing equitable transformative actions under high-end climate change.

First, the framework of Integrated Climate Governance (ICG) is introduced in Section 2 with the aim of outlining the main procedural and content requirements, both in Integrated Assessment and in strategic policy-making, to support the building of multi-level governance capacities within the context of high-end scenarios. We argue that a novel mode of science for policy, that we refer to as 'Transformative Climate Science' (TCS) is needed to address the challenge of moving beyond a two-degree global warming world. Moreover, our analysis shows that a novel governance approach based on supporting transformative capacities and agents' cooperation at multiple levels is fundamental in order to achieve potential *positive tipping points* which would reverse the present unsustainable trends that lead us towards high-end scenarios.

Next, Section 3 summarises the cross-scale and cross-sectoral implications of high-end climate change together with an operational definition of transformative solutions and a review of the various kinds of available strategies to support such transformations. In particular, transformative solutions are those which address the ultimate causes of climate change and unsustainability by creating positive synergies between mitigation and adaptation action and sustainability. Thus, transformative solutions change the original system conditions and agency capacities with which the agents operated in the first place and from which innovative patterns of social-ecological interactions and solutions can emerge.

To a large extent, the design followed within the IMPRESSIONS project is representative of such urgently needed epistemological innovation characterised by TCS. This is why in Section 4 the participatory Integrated Assessment process implemented in IMPRESSIONS is briefly described, together with an analysis of the main results of the key strategies and pathways of solutions identified through the consultation with stakeholders across the project's multi-scale case studies.

The growing chances of entering into a high-end climate change world not only raises unprecedented challenges for society and global ecosystems, but also unveils many limitations of existing science and policy capabilities to cope with it. In conditions of high uncertainty and high stakes, it is clear that addressing such challenges has profound moral – rather than simply scientific, technical, or managerial – implications for governance. For this reason, the final section introduces the metaphor of a *moral compass*, developed as a normative tool for providing governance arrangements with guidance in the difficult quest to design just transformative solutions to sustainably navigate high-end climate change.

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2.   Integrated Climate Governance and Transformative Climate Science: Building capacities towards positive tipping points.

2.1. Introduction

This section provides the conceptual framework for the synthesis and analysis of the outputs from the IMPRESSIONS work packages in the design of transformative strategies and solutions in the context of high-end climate change. An innovative analytical framework, based on the concept of Integrated Climate Governance (ICG) is developed in order to assess the opportunities, as well as the synergies and trade-offs between them, to align adaptation and mitigation pathways to sustainable development (SD). Then we introduce the concept of Transformative Climate Science (TCS) to identify the requirements within the domain of research for policy in the design of transformative strategies under conditions of high-end climate and socio-economic change. A procedural synthesis for designing transformative strategies, based on the role of *visions* and the building of *capacities* to support the emergence of *transformative solutions* is also presented at the end of the section under the notion of 'Positive Tipping Points (PTP)'.

2.2. The Integrated Climate Governance framework

Integrated Climate Governance (ICG; Tàbara, 2011; Tàbara et al. 2018c) refers to a conceptual synthesis of science-policy practices which draws insights from multiple sources of knowledge integration and policy practice, and in particular from (Figure 1):

1. Integrated Assessment, and in particular in its transformative orientation of 'Integrated Sustainability Assessment' (ISA; Rotmans et al., 2008);
2. Novel approaches in research and policy practice in climate governance (e.g. Jordan et al. 2018); and
3. Innovative ways for public engagement and knowledge sharing so as to promote societal learning and transformative change for sustainability (Tàbara and Pahl-Wostl 2008; Heras and Tàbara, 2014, Annex 6).
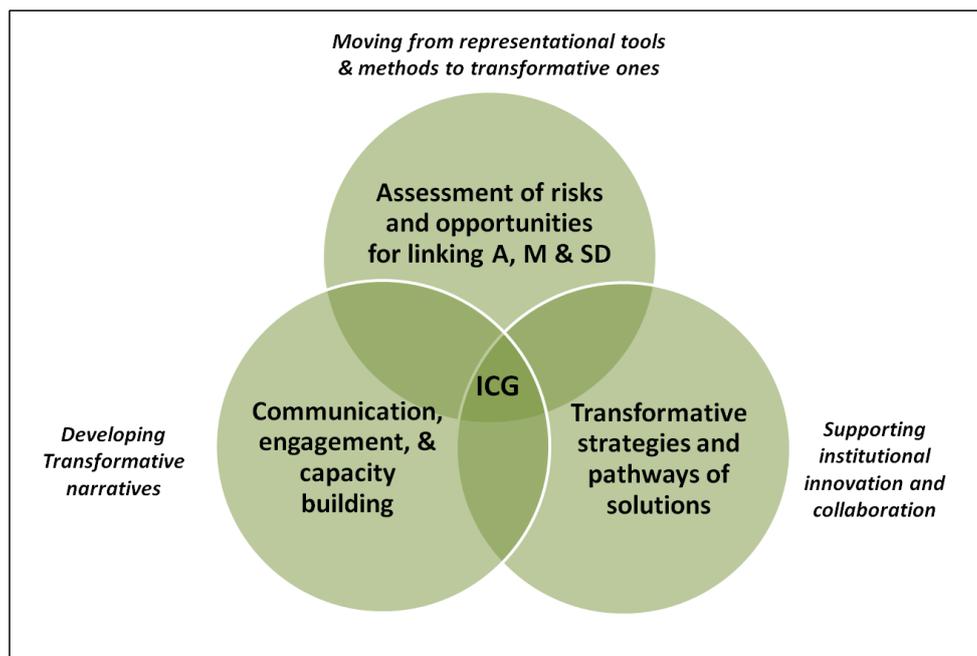

Figure 1: Integrated Climate Governance (ICG) (adapted from Tàbara 2011).

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The overall purpose of using ICG is to map out the main components that need to be considered in the assessment of transformative solutions and strategies. In particular, we understand that a successful design of transformative strategies ought to:

- Cover not only the assessment of impacts, risks and vulnerabilities, but also **opportunities** for institutional innovation and sustainable development; and in particular the required capacities for the emergence of positive tipping points able to reverse the existing trends that lead to a high-end climate change world;
- Develop and assess specific strategies and pathways of solutions which span different scales of action, sectors and constituencies; and
- Not only communicate through the (one-way) 'information' of assessments and policy options, but also actively engage with stakeholders so as to help create agents' capacities for transformative change.

Hence, ICG calls for the development of new tools and methods in science – e.g. from simply being representational towards supporting transformation – so that new forms of public engagement can be created to support institutional and networks collaboration. For instance, a challenge for the IMPRESSIONS project was to introduce economic models that not only represent and analyse risks and vulnerabilities but would also show the implications of the complexity of agent interactions, and in particular that would lead to a positive tipping point in the economy away from the current trends towards the desired targets. As argued in Tàbara (2011), the concept of ICG requires above all deep institutional innovations, which in the context of high-end climate change has been explored with the notion of *transformative climate boundary organisations* (Tàbara et al. 2017). And last but not least, the role of the Arts in developing new modes of awareness, public engagement and knowledge integration in triggering climate transformations was also explored and used in various case study workshops (see Galafassi et al. 2018; Heras and Tàbara 2014; and Annex 4).

2.3. **Transformative Climate Science**

High-end climate change requires transformative solutions, as conventional strategies and solutions will not be enough if major disruptions in social-ecological systems are to be avoided. However, conventional climate assessment approaches and methods show many limitations with respect to providing robust knowledge and support to the design and implementation of transformative solutions in practice.

To this end, we have introduced the concept of *Transformative Climate Science* (TCS) (Tàbara et al. 2018a) as the open-ended process of producing, structuring and applying solutions-oriented knowledge to fast-link integrated adaptation and mitigation strategies to sustainable development. In particular, TCS can be seen as a novel form of participatory integrated assessment, supportive of a sustainability learning process, which:

- Focuses on solutions, not only on problems and trends;
- Integrates and promotes reflectivity on individual motives, beliefs, values, human nature and agency, e.g. via normative visions;
- Focuses on deep causes and social-ecological interactions (mainly global systems unsustainability), not only on symptoms;
- Links local/situated integrated solutions of multiple problems to global processes;
- Supports the coordination of 'global systems of solutions' to support sustainable development;
- Moves from a sectoral, incremental approach about solutions to an integrated, multiplicative, non-linear approach;

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- Aims to understand and support agents' transformative capacities;
- Helps to redistribute rights and responsibilities and addresses institutional, behavioural change and fundamental equity issues;
- Responds to two central questions:
  - *In transdisciplinary research*: understanding 'Who is the solution?', rather than 'What is the problem?'
  - *Specifically for modelling*: how to represent (heterogeneous) agent interactions, multiple rationalities, cumulative/recursive effects, leverage points, systems learning (as an emerging property) and ethical considerations?

Furthermore, 12 dimensions have been identified which scientists and practitioners can use as a checklist to design transformative-oriented climate assessments and strategies (Table 1).

Table 1: Contrasts between conventional versus transformative approaches in the assessment of pathways, strategies and solutions to high-end climate change.

Dimension\approach	Conventional	Transformative
1. Representation of agency in economic modelling	Single rationality, single representative agent	Heterogeneous agency, multiple rationalities
2. Assessment of options for change of institutional, behavioural and social-ecological systems interactions	Weak	Strong
3. Systems of systems approach & coordination	Not necessary or minimal; only dealing with one system or sector or very few at a time	Fundamental; dealing with multiple systems or sectors at a time, e.g. nexuses between food, energy, finance, health, mobility…
4. Assumptions about the future attainability of the existing systems goals	The present system goals are believed to be still attainable in the future without profound reconfigurations	The present system goals are no longer believed to be attainable in the future, and hence require profound reconfigurations
5. Role of visions and normative futures	Without visions: only exploratory/descriptive (non-normative, non-directional) scenarios	Including visioning processes which co-produce desirable futures within the assessment process (to trigger and orient change)
6. Representation of system dynamics. Role of multiple feedbacks, cumulative processes and irreversibilities, including tipping points, phase transitions, bifurcations…	Linear representation of system dynamics; multiple feedbacks, cumulative processes and irreversibilities, including tipping points, phase transitions, bifurcations, rarely or not considered (or weakly so)	Non-linear and complex (e.g. multiple kinds of non-linear interactions; assessing emergence); multiple feedbacks, cumulative processes and irreversibilities, including multiple tipping points, phase transitions, bifurcations, strongly considered
7. Time and space scales considered at the same time	Single; cumulative effects scantily addressed	Multiple; including cumulative effects of past and present actions at various scales

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Dimension\approach	Conventional	Transformative
8. Uncertainty (assumptions & treatment)	Low/medium; probability distributions assumed to be known (e.g. as risks). Probabilism.	High and very high; probability distributions mostly unknown, (e.g., as indeterminacies). Possibilism
9. Kind of learning required	First-order (doing the same better and more)	Second-order (doing something different under a different paradigm)
10. Expected outcomes of the assessment	Single optimal solutions based on a single equilibrium; win-lose solutions (e.g., burden sharing)	Multiple win-win solutions, multiple winners, based on multiple equilibria; integrated strategies for addressing multiple interconnected problems
11. Assessment of equity and distributional issues	Weakly considered (e.g., only intra-generational equity)	Strongly considered (including both intra & inter-generational equity)
12. Criteria tools and methods used in the design and assessment of solutions and strategies	One or very few criteria considered, mostly profitability or/and (Eco)efficiency;	Multi-criteria tools and methods promoted, to consider multiple criteria besides profitability. These include (eco and/or social) efficiency + sufficiency + sustainability.

While it is possible to talk about both *transformative adaptation* and *transformative mitigation*, we make the case that societal transformation does not depend on mitigation or adaptation policies and actions, mostly because they are related to sustainability innovations, which are endogenous developments derived from deliberate social learning. That is, and in contrast to conventional adaptation and conventional mitigation, 'transformative adaptation' and 'transformative mitigation' would be purposefully oriented to modify fundamentally the attributes and global conditions in which particular agents and systems interactions occur and align such climate actions to sustainable development (Figure 2).

Moreover, it can be argued that, as we move to a more high-end climate world (represented in red in Figure 2), the urgency of assessing and implementing transformative solutions is greater, although such solutions will not necessarily be implemented because of the climate threat – but only if societies want to achieve an improved world situation. Hence, the most innovative, robust and *persistent solutions* to high-end climate change are likely to be those which contribute to building the appropriate *conditions and capacities* to support sustainable development. After all, climate change may better be understood not as the ultimate cause of socio-environmental problems – but mostly as an amplifier – and simply as a symptom of unsustainability. Narrowing the framing of global warming to a problem of GHG emissions leaves too many issues aside that must be addressed if more transformative and long-lasting solutions are to be found to cope with high-end climate change.
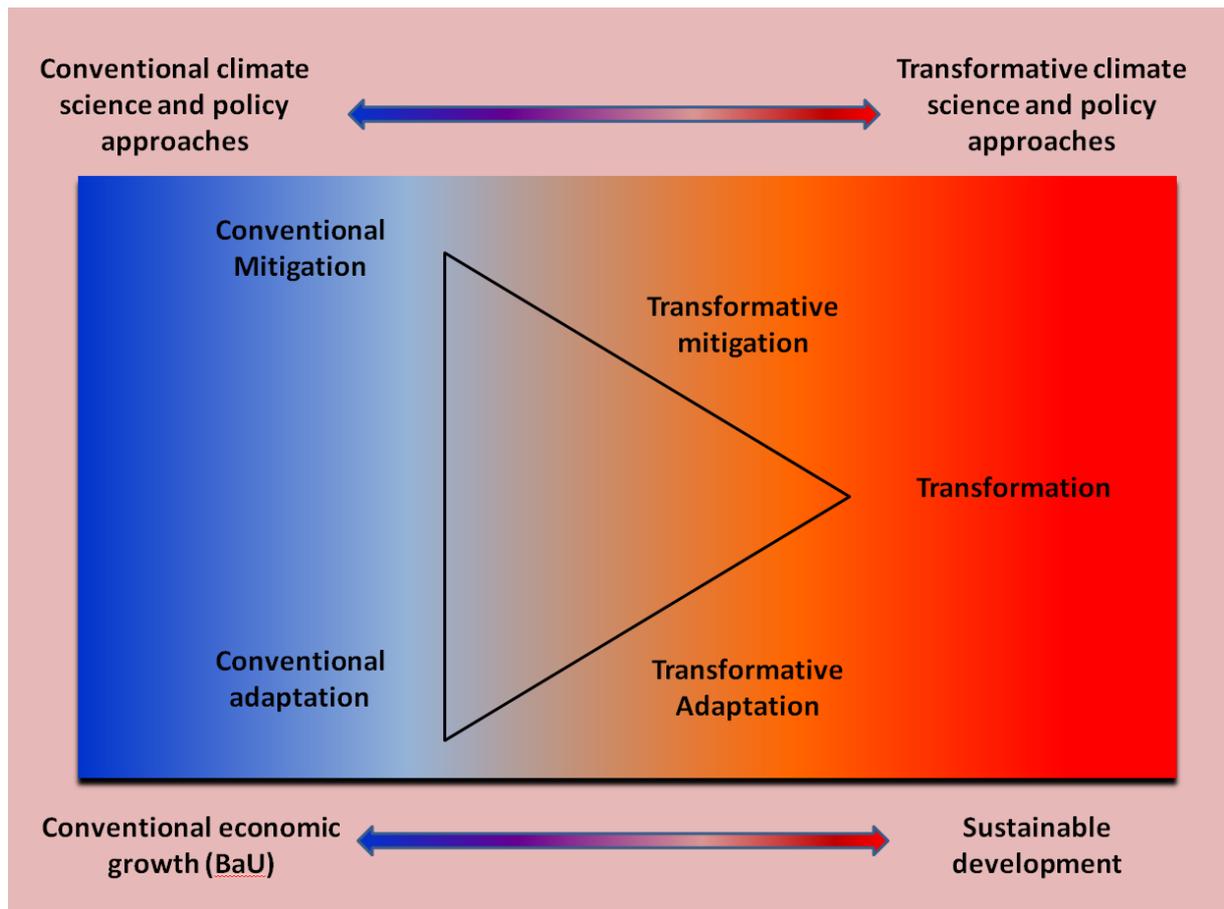
Figure 2: Mapping out different approaches to adaptation, mitigation and transformation (from Tàbara et al. 2018a).

2.4. Towards positive tipping points in a rapidly warming world.

A third component in the examination of the requirements for the design of transformative strategies has to do with the question: why and for what purpose do transformative strategies need to be designed? To address this question, this section introduces the notion of *positive tipping points* (Tàbara et al. 2018b) as emergent properties of systems – including both human capacities and structural conditions – which would allow the fast deployment of evolutionary-like transformative solutions to successfully tackle the present socio-climate challenges. In particular, we have provided a simple procedural synthesis to help identify and coordinate the required agents' capacities to implement transformative solutions aimed at achieving ambitious climate and sustainability goals in different contexts (Figure 3).

Given the large complexity and non-linearity in the dynamics of social-ecological systems, it is simply not possible to forecast the whole array of potentially transformative solutions that need to be implemented globally and which may contribute to the achievement of the 1.5 or 2°C policy targets. Instead, a more pragmatic approach can be formulated which focuses on identifying and characterising the kinds of concrete and distributed capacities to implement these solutions. Required capacities will vary according to different people, needs and interests in their own contexts of action. In this regard, the above simple procedural framework can be used to underline the importance of linking desirable visions of the world, the building of agents' capacities and systems of transformative solutions. Our perspective is based on the premise that transformations in social-ecological systems may be

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accelerated and purposefully brought about by social action. We make the case that in policy-making a *vision is a main driver of transformations* rather than the awareness of an impending catastrophe, and that positive tipping points may be induced by the cascading, feedback and cumulative effects of multiple interlinked actions - or interlinked systems of transformative solutions - which eventually push a system towards a new desired configuration, which we refer to as a Positive Tipping Point (PTP).
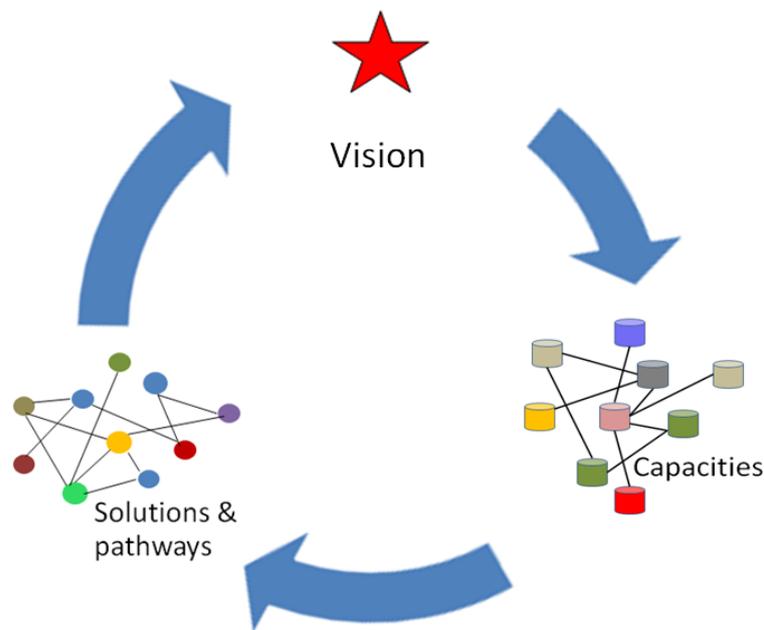
Figure 3. A procedural synthesis to link agents' capacities, pathways of solutions and visions to support systems' transformations (from Tàbara et al. 2018b).

In particular, a PTP occurs when the original conditions of a system of reference are substantially and irreversibly transformed in a way that matches or exceeds a particular desired (normative), better-off configuration or *vision* (Figure 4). Examples of PTPs in some countries are the abolition of slavery, the universal access to education and granting political rights and ownership to women. This moment is likely to happen fast only when agents have been able to build the required *capacities* to implement transformative solutions to do so. In this sense, tipping points will appear as emergent properties derived from the capacities that have been acquired when agents engage in applying their own systems of solutions to solve their problems according their own needs and priorities (often in trial-and-error and learning mode). The implementation of transformative solutions may also lead to shifts in perception, the reconfiguration of social networks and of institutional arrangements. Visions serve as a cognitive, emotional and normative reference for orienting and qualifying radical system changes as positive developments in a given system of reference. They also help to introduce the intersubjective nature of agents' motivations in collective action which lies at the base of social transformations; and in this way, visions play an important role in identifying the potential agency capacities needed to implement transformative solutions. However, visions are not static, and therefore they ought to be reframed as new conditions and ambitions change. A vision does not provide a single 'end-point' in systems trajectories, but only an open-ended desirable state that demands continuous improvement and reframing.

This procedural synthesis has been used to identify and analyse the required capacities, conditions and potential policy interventions which could eventually lead to the emergence of positive tipping points in various social-ecological systems to address the 1.5 and 2°C policy targets as will be shown in the next section.
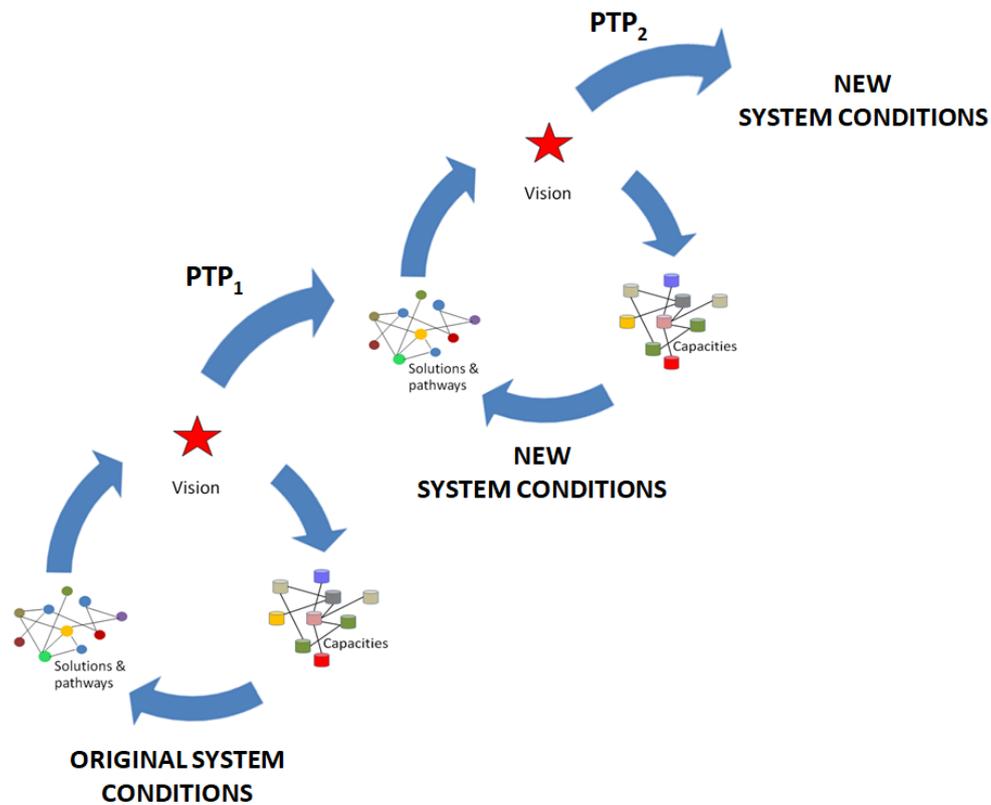
Figure 4: A Positive Tipping Point (PTP) may be induced by boosting agents' capacities to implement pathways of solutions to achieve a transformative vision of the world (from Tàbara et al. 2018b).

In IMPRESSIONS, the potential emergence of PTPs in the economy has been explored. Lamperti et al. (2017) introduced the first agent-based integrated assessment model (DSK) and analysed the impact of heterogeneous, individual-level climate damages on economic dynamics in line with the recent climate econometrics literature (see Deliverable D5.2 – Lamperti et al. 2016). The analysis showed the potential for a rapid transition towards a greener growth pattern and renewable sources of energy and that this transition produces substantially higher growth and employment. In the new system conditions, there is a relative increase in competiveness of green technologies, which self-sustain the growth pattern through the new system dynamics, which help the economy rapidly abandon fossil-fuel-based modes of consumption and production.

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3.   Defining and mapping transformative strategies under high-end climate change

3.1.   Cross-sectoral and cross-scale implications of high-end climate change

All IMPRESSIONS case studies have highlighted the strong inter-connectedness of social-environmental systems and the importance of cross-sectoral interactions under high-end climate change (Berry et al., 2017). These have been particularly centred around: (i) impacts of climatic and socio-economic changes; and (ii) trade-offs between agriculture and forestry for land; between agriculture/forestry and biodiversity for habitat availability; between agriculture and other water users (including the environment) for sustainable water resource management; and between extreme events (flooding and heat stress) and human systems (farming and heat-related deaths, respectively; see Deliverables D3B.2 and D3C.2 - Holman et al., 2017 and Clarke et al. 2017, respectively). Figure 5 shows an illustrative example of the cross-sectoral interactions within the European case study, whereby high-end climatic and socio-economic changes lead to changing competition for limited land and water resources with resultant impacts on landscape and biodiversity.
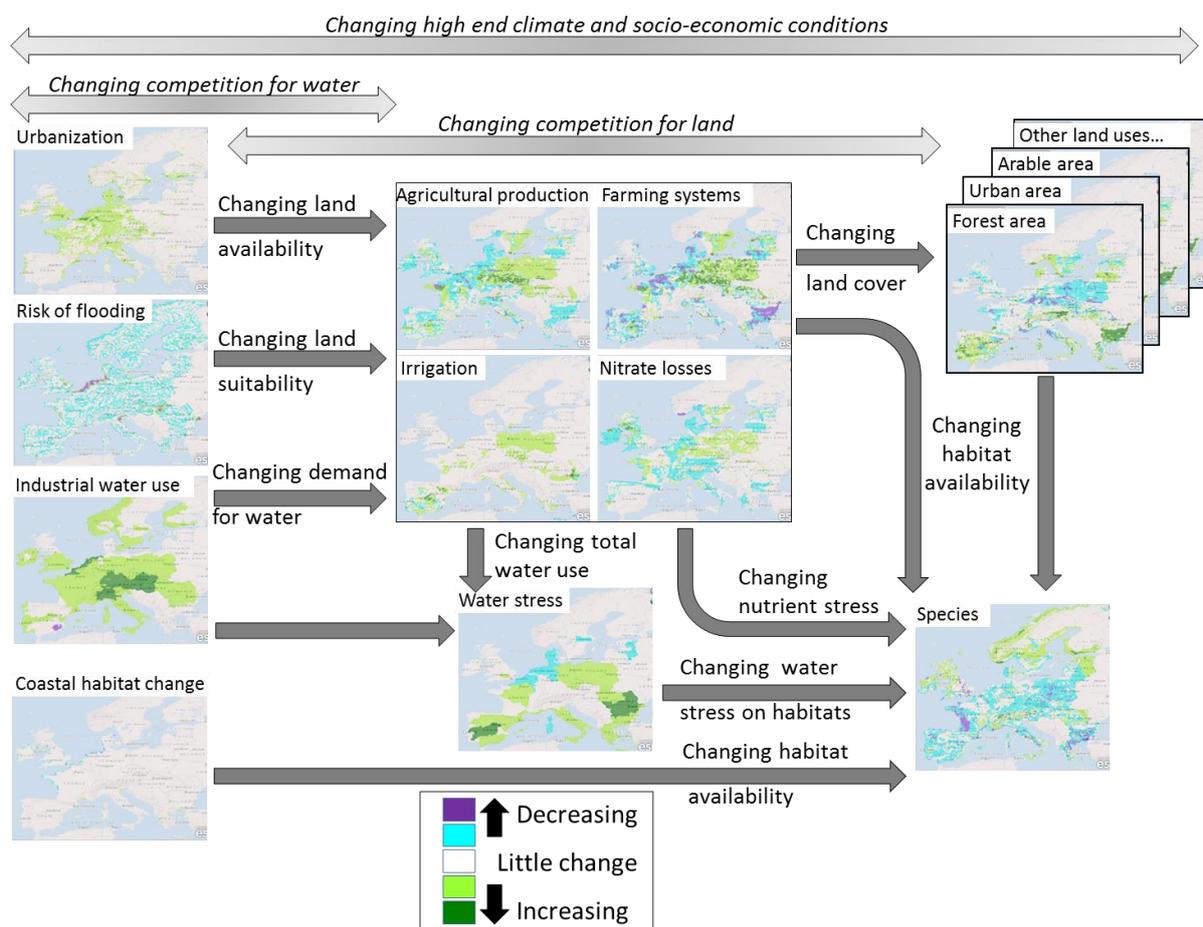
**Figure 5: Illustrative cross-sectoral interactions and competition within the IMPRESSIONS Integrated Assessment Platform 2 that lead to complex trade-offs and synergies across Europe.**

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The cross-scale implications of high-end climate change are addressed in two ways within IMPRESSIONS: (i) within the integrated climate and socio-economic scenarios; and (ii) in the resultant modelled impacts and vulnerability. The IMPRESSIONS European Shared Socioeconomic Pathways (SSPs) were developed to be equivalent to the global SSPs of O'Neill et al. (2015). However, they were also designed to serve as the starting point for the regional scenario development in the Iberian, Hungarian and Scottish case studies, so that there was a reasonable degree of cross-scale consistency in scenario assumptions without compromising the ability to reflect regional issues (Table 2, see Deliverables D2.2 and D2.4 – Kok and Pedde 2016 and Kok et al. 2018, respectively). This resulted in cross-scale coherency in the directions of change in the four forms of capital considered in the scenarios - human capital (health, education etc.), social capital (networks, relationships, families etc), manufactured capital (human constructs such as houses or roads) and financial capital (Table 3).

The IMPRESSIONS cross-scale comparison of modelling results (see Deliverable D3.2 - Nowak et al. 2018) also highlighted the benefits of looking at different scales within one project, as it reveals important spatial and temporally variability in impacts. Model results suggest that for certain impact indicators, some regions of Europe are impacted negatively by climate change, while others benefit. For example, cross-scale impacts are evident in D3.2 where spatial changes in European land use reflect the regional differences in the impacts of climate and socio-economic change on agricultural and forestry productivity.

The IMPRESSIONS scenario and modelling research is summarised in other deliverables: integrated, cross-scale scenarios (Deliverable D2.4 – Kok et al. 2018); multi- and cross-sectoral impacts modelling within the European (Deliverable D3B.2 - Holman et al. 2017) and regional/local case studies (Deliverable D3C.2 - Clarke et al. 2017); and a comparison of modelling results across scales (Deliverable D3.2 - Nowak et al. 2018). This work has demonstrated that the mounting risks and challenges of high-end climate change are unlikely to be adequately addressed by conventional and additive responses focusing on single sectors, scales or on either adaptation or mitigation, without considering long-term sustainable development. The interconnectedness demonstrated between sectors and scales creates opportunities for the implementation of innovative systems of solutions.

Table 2: Key elements in the socio-economic narrative across all case studies. Main entry points are taken from the global SSPs (from Kok and Pedde 2016 – Deliverable D2.2).

Global SSPs Element	Europe	Central Asia	Scotland	Hungary	Iberia
Economic growth	Economic development	Economic development	Economic development	Economic development	Employment
Population	Population and migration	Regional conflicts	Well-being and lifestyle	Migration	Migration
Energy	Renewables versus fossil fuels	Fossil fuels	-	Energy provision	Energy production
Technological development	Technological efficiency	Agri-technology	Technological innovation	-	Technological development
Governance structures	Effective governance and international cooperation	Geopolitical stability and regional governance	Scottish independence, multi-level governance	Multi-level governance, subsidies	Coordination between Spain and Portugal
Environmental change	Water and biodiversity	Transboundary waters, Food security	Countryside	Agriculture, food security	Transboundary rivers

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Table 3: Examples of changes in capitals across all IMPRESSIONS case studies for (a) SSP1 and (b) SSP3. Signs refer to direction and strength of change in three time slices (2010-2040; 2041-2070; 2071-2100) (from Kok and Pedde 2016 – Deliverable D2.2).

(a) SSP1:

SSP1	Europe	Central Asia	Scotland	Hungary	Iberia
Human capital	Strong increase (0, +, ++)	Strong increase (+, +++, +++)	Strong increase (+, ++, ++)	Increase and levelling (++, ++, ++)	Strong increase (+, +++, +++)
Social capital	Strong increase (0, +, ++)	Strong increase (+, +++, +++)	Strong increase (+, ++, ++)	Increase and levelling (++, ++, ++)	Strong increase (++, +++, +++)
Manufactured capital	Steady increase (0, +, +)	Strong increase (+++, ++, ++)	Increase (+, +, +)	Decrease (0, -, -)	Decrease, increase (-, +, ++)
Financial capital	Steady increase (0, +, +)	n.a.	Steady increase (+, +, ++)	n.a.	n.a.

(b) SSP3:

SSP3	Europe	Central Asia	Scotland	Hungary	Iberia
Human capital	Decrease (0, -, -)	Strong decrease (-, --, ---)	Decrease (-, -, -)	Decrease (0, -, -)	Strong decrease (-, ---, ---)
Social capital	Increase, decrease (0, +, 0)	Decrease (-, -, -)	Decrease (-, -, -)	Increase, decrease (+, -, -)	Strong decrease (-, ---, ---)
Manufactured capital	Decrease (0, -, -)	Level, decrease (0, 0, --)	Decrease (-, -, -)	Increase, decrease (+, -, --)	Strong decrease (--, ---, ---)
Financial capital	Strong decrease (-, -, --)	n.a.	Strong decrease (--, -, -)	n.a.	n.a.

3.2. The limits of adaptation and mitigation under high-end scenarios

Under high-end climate scenarios, several of the identified (negative) tipping points in the climate system are challenging if not prohibiting mitigation and/or adaptation options. This is because the resulting consequences either become unavoidable, i.e. mitigation becomes irrelevant or so large and/or fast that traditional/linear adaptation strategies will become irrelevant. Two such elements are well documented in the literature, including in the IPCC 5th Assessment Report: (i) the collapse of the West Antarctic Ice Shelf could take place within a few hundred years if global warming exceeds a certain threshold, which could turn out to be not much above 2°C, resulting in sea-level rise which will likely exceed several meters; and (ii) widespread permafrost thaw with resulting large-scale release of methane and other greenhouse gases. The latter would not happen over a short time interval, but once a certain temperature threshold is surpassed for a sustained period, this may be realized. Paleo-records suggest that this threshold would be well above 2°C. The resulting positive climate feedback may trigger (largely) unknown amounts of additional warming that in a worst case scenario could lead to warming levels that will instigate the event mentioned under (i). For further information, see Deliverable D2.4 – Kok et al. (2018).

Impacts modelling work in IMPRESSIONS using the Integrated Assessment Platform 2 (IAP2) shows that impacts of climate change are clearly greater under high-end scenarios (>4°C) compared to low-end scenarios (<2°C) (Harrison et al. 2018). For example, for the 2080s mitigation consistent with the Paris Agreement would reduce aggregate Europe-wide impacts on the area of intensive agriculture by 21% (on average across climate models), on the area of managed forests by 34%, on water exploitation index by 14%, on people flooded by 10% and on biodiversity vulnerability by 16%. In particular, land use change is considerably greater under high-end compared to low-end scenarios, with large reductions in productive land and increases in unmanaged or abandoned land as currently suitable

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tree species and existing agricultural practices struggle to cope with the extreme climatic conditions. Furthermore, there is a significant increase in the magnitude of impacts after 2050, when differences between low-end and high-end climate change become more apparent. These results demonstrate the adaptation challenges posed by high-end climate change.

Including changes in socio-economic conditions, in addition to low-end or high-end climate change, results in considerably greater variation in the magnitude, range and direction of change of the majority of impact indicators than climate change alone. For example, all indicators (except biodiversity) show changes in excess of ±50% of baseline values in at least one integrated climate and socio-economic scenario. Only three impact indicators show a consistent positive direction of change relative to baseline (irrigation usage, water exploitation index, urban land use), while only two impact indicators show a consistent negative direction of change (biodiversity, extensive grassland). All other indicators (arable land, intensive grassland, very extensive grassland, managed forest, unmanaged woodland, unmanaged land, food production, carbon sequestration, number of people flooded in a 1 in 100 year event) show a mixed direction of change depending on the assumptions within the socio-economic scenario. In particular, socio-economic factors much more strongly drive changes in land use and food production than changes in climate, sometimes overriding the differences due to low-end and high-end climate change. This underlines the challenges to adaptation posed by socio-economic scenarios, with mitigation being more easily achieved in a sustainability-oriented world (SSP1) than in a fossil fuelled work (SSP5), for example.

Thus, Harrison et al. (2018) show that impacts in multiple sectors in Europe differ significantly between low-end and high-end climate change scenarios after 2050. This leads to different 'winners' and 'losers' in terms of sectors and regions, with northern Europe gaining in agricultural productivity and potentially biodiversity, the Atlantic region losing in terms of flooding and intensive agriculture, and southern Europe losing in terms of several sectoral indicators (agricultural and forest productivity, water stress and biodiversity vulnerability).

The results of this analysis show the importance of political and societal choices in determining the consequences of climate change. They also emphasise the need to consider climate change adaptation and mitigation actions together. Searching for an appropriate balance between adaptation and mitigation that takes account of cross-sectoral and inter-regional interdependencies will be essential for delivering a sustainable and resilient future for all citizens in Europe and globally.

3.3. Integrated solutions to high-end climate change

As global warming gets closer to exceeding the 1.5 and 2°C thresholds of the Paris Agreement, it is increasingly recognised that conventional and incremental solutions will not be enough. What is needed are fast, substantive and coordinated actions that simultaneously reduce emissions, vulnerabilities to climate change and contribute to the achievement of the Sustainable Development Goals (SDGs). Transformative solutions address the ultimate causes of climate change and unsustainability by creating positive synergies between different domains of action through linking climate actions with sustainability. Transformative solutions are mostly profound changes in social, economic and political processes. They entail the creation of enabling conditions and capacities able to coordinate multiple interests and often challenge existing arrangements by providing valid and robust alternatives.

Innovative solutions able to address high-end climate change materialise in new patterns of socio-economic interactions in individuals, social organisations, as well as in the overall global systems dynamics. Transformative solutions adopted by individuals can yield almost immediate effects, for example, shifting from a beef-based diet to vegetarian diet can reduce the greenhouse gas footprint by a factor of 11 per meal (Carlsson-Kanyama and Gonzalez 2009). Other solutions may take years or

even several generations to be implemented and work, as they can only be the result of slow, long-term institutional developments, such as restoring large ecosystems or creating a fair and effective democratic system aimed at ensuring climate equity among generations (Figure 6).
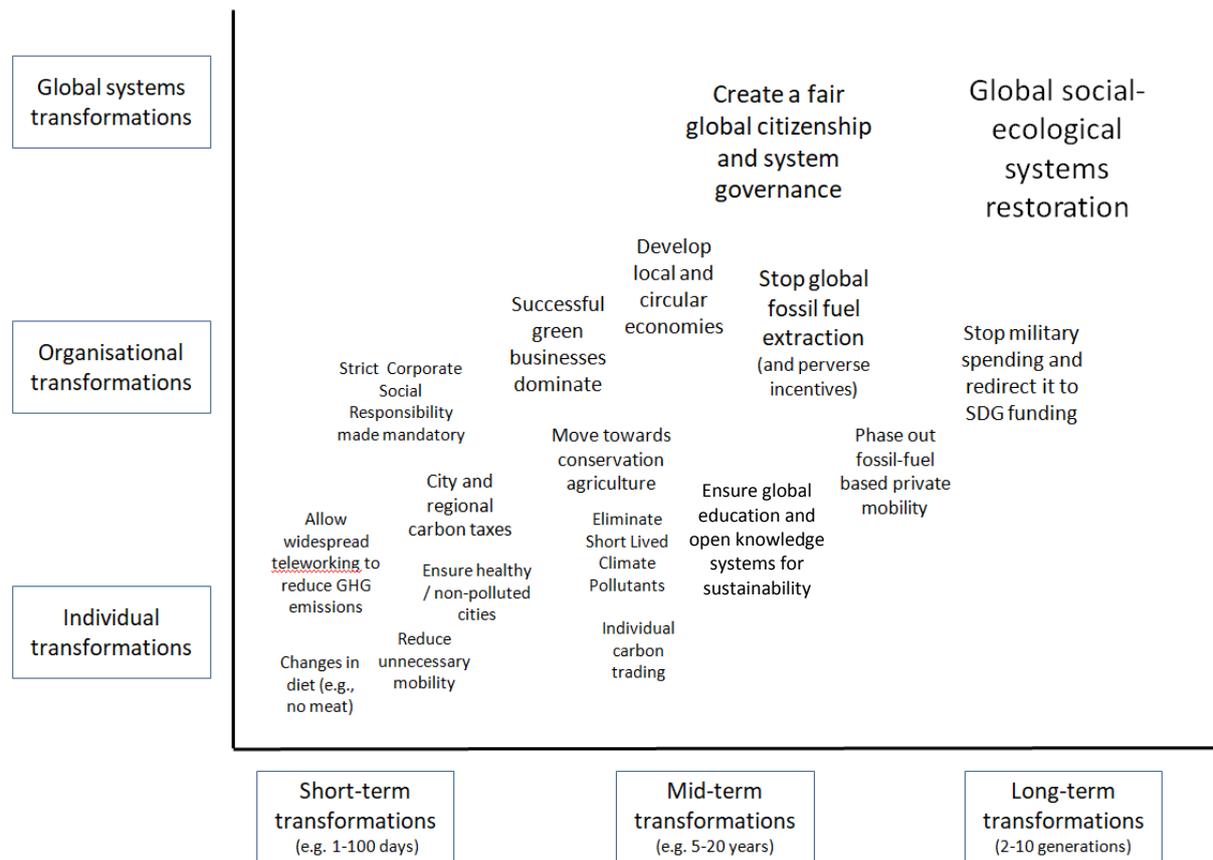
Figure 6: A landscape of potentially transformative solutions. The y axis shows whether they mainly relate to changes in individual behaviours, organisations or global system dynamics, while the x axis refers to whether they can be taken up quickly and at a personal level or they would take more time or organisational capabilities and resources to be implemented (small/larger fonts).

The development of transformative solutions for high-end climate change entails being able to (simultaneously) connect various mitigation and adaptation actions and create positive synergies between them, creating various clusters or nexuses of action leading towards the vision. These clusters include, for instance: (i) urban mobility, health and quality of life; (ii) water, biodiversity, and land use/soil management; and (iii) energy, global trade, agriculture and food systems. Transformative systems of solutions need to be able to overcome multiple trade-offs (in time and space) between environmental integrity and socio-economic goals. Such systems of solutions entail profound changes in the systems of individual and collective responsibilities towards present and future generations, as they also need to consider the extent to which present patterns of production, consumption and public policies address the real needs of the global population or on the contrary exacerbate global inequalities and the unsustainable use of resources. Notably, there are many different kinds of actions which, when combined in an integrated and synergistic way, can help the development and implementation of transformative solutions. These can range from economic, financial and regulatory policy measures to changes in organisational and corporate strategies, as well to the development of new technologies and changes in behaviours and lifestyles (see Jäger and Tàbara 2017).

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In fact, multiple positive transformations towards a more sustainable world are possible and many are already underway. These can be classified according to the SEIC model (see Figure 7) into those which have to do with innovations in institutional arrangements and norms (S), deep modifications in the use of biophysical resources (E), transformations in information and knowledge systems and education (I), and positive abilities in the way to manage and harness current climate and global environmental change (C). Transformative change entails actions that affect all these systems at the same time. For instance, approving a regulation (S) allowing the widespread use of teleworking to reduce GHG emissions (C) could be made possible by innovations in internet services (I) and would also reduce the need of energy use (E) now directed to commuting while improving urban quality of life (SDG11).
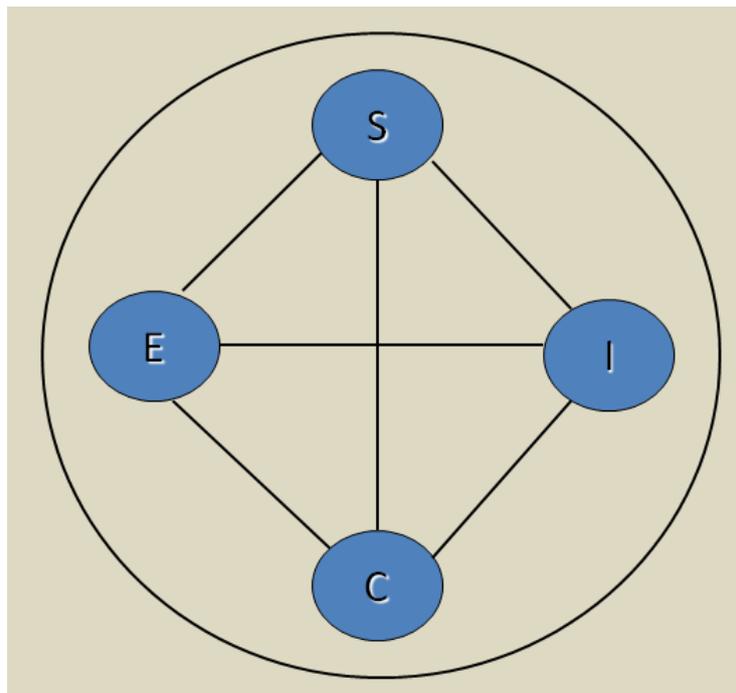
Figure 7: The SEIC model - integrating complex systems interactions for sustainability learning and innovation (from Tàbara & Pahl-Wostl 2008).

Further examples of positive transformations related to the different components of the SEIC model are given below:

- **Transformations in institutional arrangements (S):** create independent sustainability knowledge integration and management agencies (transformative boundary organisations); support transnational cooperation for multi-level climate governance; support new green business models, implement regional and local CO_2 taxes; implement urban tolls for private vehicles; change labour legislation to reduce unnecessary mobility (e.g. teleworking); support widespread adoption of Payment for Ecosystems Services; implement the polluter-pays-principle at all levels of economic activity (e.g. from industry to consumers and public interventions) to combat environmental 'free-riders'; stop much of the current funding of military research and reorient it toward sustainability research and SDG implementation; move towards a global fair citizenship and governance system to balance global environmental and climate rights and responsibilities.

- **Changes in the use of energy, resources and biodiversity (E):** move towards 100% renewable energy in the electricity sector; harness food systems including stopping the global

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unsustainable trade of cash crops (e.g., palm oil) that is destroying vital global ecosystems' functioning; promote widespread conservation agriculture; keep most of the remaining fossil fuels in the ground; eliminate fossil fuel subsidies and reinvest public money in renewable energy research and development and SDG financing.

- **Innovations in information and knowledge systems and education (I):** support cultural changes in perception about the impacts of global consumption, production and trade; stimulate sustainable lifestyles (e.g. change diets to reduce meat consumption, mobility, use of time); internalise negative externalities in price systems (e.g. via carbon taxes); support financial innovation (green crypto-currencies and the democratisation of the monetary system); support civic sustainability sciences (e.g. Transformative Climate Science); and adopt new indicators of well-being for policy beyond GNP to couple and integrate information and knowledge systems with environmental change.

- **Harnessing climate and global environmental change (C):** address negative emissions and CO_2 extraction from the atmosphere through sustainable afforestation and reforestation; deploy further research to assess the safety and sustainability of carbon capture and storage; implement Ecosystem-based Adaptation + Ecological Restoration approaches to support global social-ecological system restoration; reduce short-lived atmospheric pollutants (e.g. methane, particles, hydrofluorocarbons); support urban energy efficiency.

Therefore, transformative strategies and solutions to high-end climate change include any integrated combination of policy measures, technological innovations, economic and information instruments, as well as other different types of conscious actions, either at the individual or collective level, which successfully address both the problems of climate change and unsustainability in concrete contexts of action. Thus, solutions are always situated solutions, taken by specific agents in particular places in a dynamic learning mode.

At this stage it would be naïve, if not incredibly pretentious, to believe that we already know the most suitable, effective and fair solutions or strategies to cope with high-end climate change. However, we can see that innovative solutions are already being combined and implemented by front-runners all over the world in a synergetic mode – as win-win solutions, no-regrets options, or integrated planning interventions.

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4. Synthesis of innovative solutions and strategies from the IMPRESSIONS case studies

4.1. Introduction

This section describes the transformative strategies developed within the IMPRESSIONS case studies, within the range of climate and socio-economic scenarios and pathways that were co-created with stakeholders. As any transformative action on climate change needs to be embedded within broader, long-term visions of a more sustainable world, the transformative strategies were developed within the context of high-end scenarios with the aim of achieving and ensuring societal and environmental well-being. Additionally, the IMPRESSIONS approach builds upon the premise "that transformations in social-ecological systems may be accelerated and purposefully brought about by social action" (Tàbara et al. 2018b: p. 122). Thus, the transformative strategies identify not only what needs to be done, but also how and by whom it is to be done so as to generate the agents' capacities to avoid or cope with high-end scenarios while promoting sustainability.

4.2. Process and stakeholder involvement within the IMPRESSIONS case studies

There are five case studies in the IMPRESSIONS project: Europe as a whole; Scotland; Iberia (focusing on the Tagus river basin; Hungary (focusing on two municipalities); and Central Asia (focusing on the indirect effects on Europe from high-end climate and socio-economic change in Central Asia, also referred to as EU external (EUx)). The EUx case study differs from the others through its geopolitical focus rather than the development of pathways to achieve a vision.

In general, and as shown in Figure 8, the case studies in Europe, Scotland, Iberia and Hungary followed the same pattern:

- Elaboration of four socio-economic scenarios (narratives and quantification, see Deliverable D2.2 - Kok and Pedde 2016) [Workshop Set 1, see Deliverable D6A.2 – Zellmer et al. 2016];
- Development of a vision for the world in 2100 (narratives and visualisation, see Deliverables D4.1- Frantzeskaki et al. 2015 and D4.2 - Hölscher et al. 2017) [Workshop Set 2, see Deliverable D6A.3 – Faradsch et al. 2017];
- Development of pathways within the context of the socio-economic and associated climate scenarios (see Deliverable D4.2 - Hölscher et al. 2017) [Workshop Sets 2 and 3]
- Identification of robust pathways (see Deliverable D4.2 - Hölscher et al. 2017) [Workshop Set 3, see Deliverable D6A.4 – Faradsch et al. 2018];
- Identification and analysis of potential game-changers (see Section 4.7 below) [Workshop 3].

In Scotland, Iberia and Hungary this work was carried out in three workshops roughly one year apart. In Europe, two workshops were needed, since the socio-economic scenarios were first developed by the project team based on the scenarios developed in a previous project (www.climsave.eu). Further information about the workshops is provided in Annex 1.
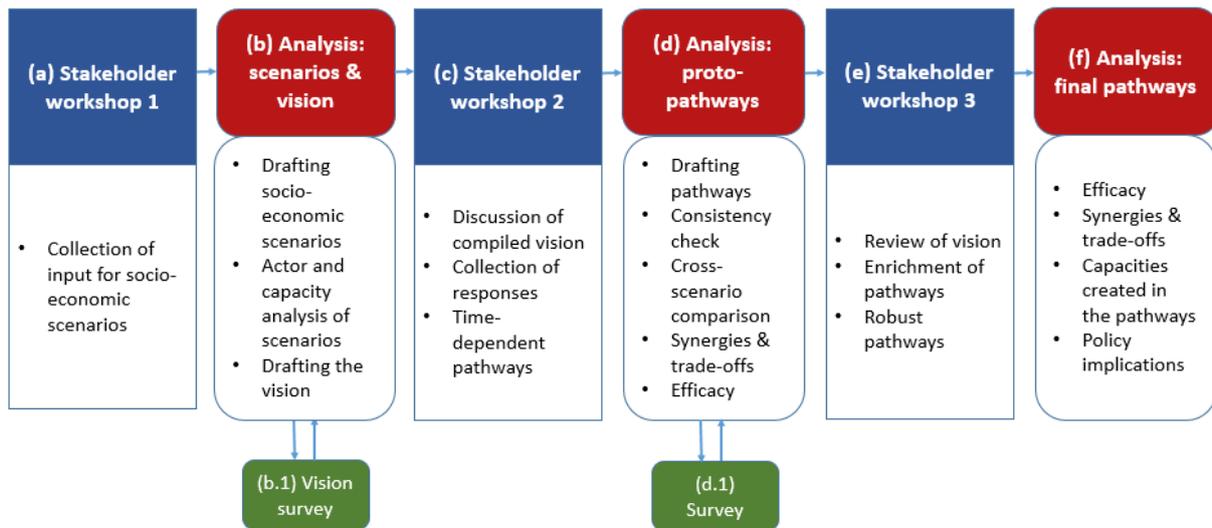
Figure 8: General design and tasks carried out for the development of transformative strategies within the IMPRESSIONS case studies.

In addition to the case study workshops, a final cross-scale workshop with a selection of stakeholders from each case study was held in April 2018. This workshop compared scenarios, visions, pathways and strategies across scales and provided final inputs for this Deliverable on Transformative Strategies (see Figure 9).
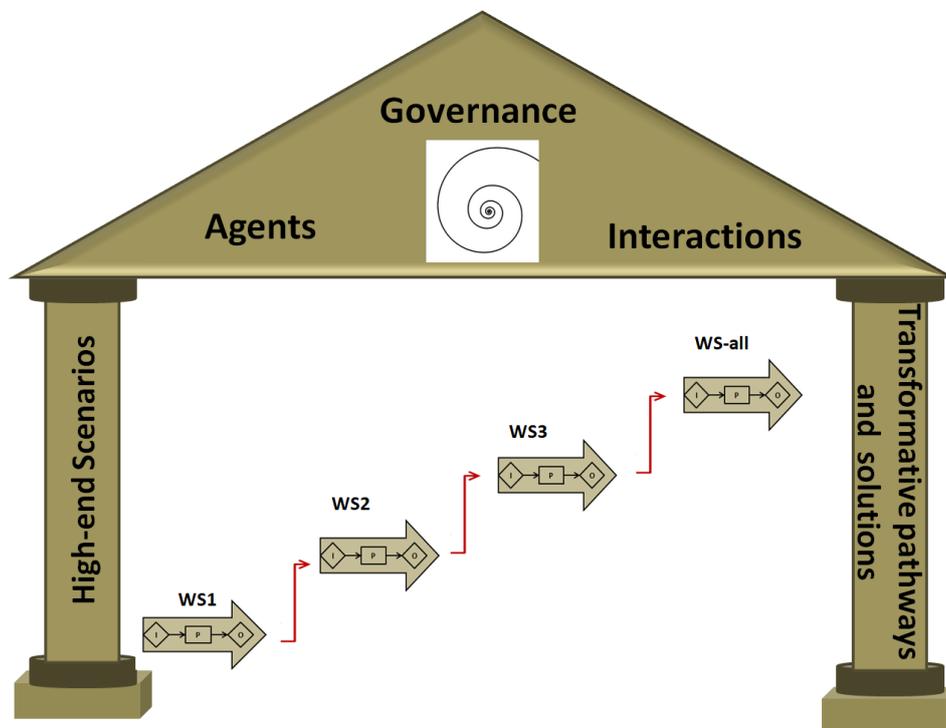
Figure 9. Moving from scenarios to transformative pathways and solutions within IMPRESSIONS the case studies. WS = workshop; WS-all refers to the final cross-scale workshop.

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4.3.   Transformative strategies within scenario narratives

The potential for transformative strategies is highly dependent on local capacities and capitals (see Figure 3). The synthesis of the capacities in the different scenarios is therefore a systematic assessment of what transformative governance and shifts in the current systems enable a "proactive" societal change in order to develop transformative solutions to climate change.

The magnitude of societal change is also emphasised differently in the case studies. For example, in the Hungarian and Scottish case studies, the scenario narratives tend to emphasise gradual changes in transitions to new governance, technological, economical and energy systems across scenarios. In contrast, the Iberian case study emphasises strong and rapid changes across all systems in all scenarios, strengthening the hypothesis that local factors, such as culture, worldviews and perception of the current system strongly affect the changes in the scenarios, irrespective of the direction of change. Nonetheless, similarities across case studies emerge with respect to capacities of actors, strongly linked to the overall scenario logic.

In SSP1, transformative strategies are enabled by high capacities and capitals developed by strong multi-level governance, with synergies among actors at both international, national and local scales. This shift finalises early in the scenarios and therefore amplifies capacities for strong governances in multiple sectors. Crucial is the balance between market systems and the different strengths of regulation across case studies. In all SSPs, however, the increase in trust and participation in governance facilitate the transition to a more sustainable and equitable future.

In SSP3, capitals and capacities decrease due to increased conflicts and the collapse of current institutional and governance systems, which in turn leads to shifts in energy and technology systems in all case studies. During the first time slice (2011-2040), top-down strategies with national and international scale policies still promote empowerment of local solutions. However, as international cooperation crumbles, the transition to the enabling of local actors emphasises the development of local and circular economies with a shift towards less-resource intensive lifestyles. Bottom-up networks and decentralised collaboration is focus of SSP3 strategies.

Almost opposite to SSP3, in SSP4 the capacities are different for different layers of societies, which maintains the status quo, without improvement nor worsening overall. In this scenario, the crucial element is the balance and self-organisation of the different groups: on one hand, the socio-economic and political elites are able to implement strong policies, especially given the dominance of the green-technology sector. On the other hand, especially from the second time slice (2041-2070), other local actors connect locally according to the different context and opportunities, and find synergies for resource access and land management across regions. This approach builds on a new type of process-based governance system that builds on continuous monitoring and learning.

In SSP5, the capacities and capitals are highly different in the case studies. The underlying logic of market-based economic development promotes an increase in human and social capital, especially in Europe and Scotland, where economic laissez-faire is unusually combined with state redistribution mechanisms and centralised governance. Transformative strategies across scenarios, however, leverage on the need of private business to protect natural capital as an asset as well as strong developments in green technology to generate income. Crucial is the development of innovative institutions that can integrate the socio-economic and environmental systems for long-term innovation, prosperity and environmental protection.

Overall, transformative strategies across scenarios and case studies emphasise the development of transformative capacities across multiple systems: multi-level, shared and flexible institutions enable participation and the development of a reflexive society which places sustainability and social

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wellbeing at the core of the economy. Long-term planning also looks at increasing synergies across sectors to boost sustainable development, also through green technology and low-tech infrastructure, while developing context-dependent potential in energy sources.

4.4   Towards a common vision for Europe

As described in IMPRESSIONS Deliverables D4.1 (Frantzeskaki et al. 2015) and D4.2 (Hölscher et al. 2017), each of the IMPRESSIONS case studies produced a vision of "where we want to be in 2100". These visions act as a motivation for transformative action. The visions for Europe as a whole, Iberia, Scotland and the municipalities in Hungary are presented in narrative form and as a summary figure in Deliverable D4.2.

During the cross-scale workshop held in April 2018, these visions were compared with the aim of developing a consolidated vision for Europe. Some vision elements are common across all case studies. For example, there was strong agreement on the importance of health and education and all visions included elements on sustainable water use and / or supply. In other cases, vision elements were included in three or four of the cases (e.g. full employment), so a discussion with stakeholders was necessary in order to agree on whether this vision element could be included in an overall European vision. This discussion also led to a rewording of some vision elements. For example, all case study visions emphasised **equality** in terms of access to services, resources and decision-making – relating to age, gender, race, ethnicity, religion, etc. The stakeholders reached an agreement that the overall vision should focus on **equity and access.**

Table 4 presents the overall results of this discussion. There is agreement among the four case studies on a wide range of vision elements that provide ambitious targets for future action. Achieving most of these vision elements would require transformative strategies that bring changes to the current system.

Table 4: Elements of a common vision for Europe developed with stakeholders at the cross-scale workshop in April 2018.

Equity	Equity among all citizens and societies
	All people have an income adequate to satisfy their basic needs
	All have access to education, health services, resources and infrastructure
Quality of life	High quality of life
	Basic human needs met
Health	Active and healthy lifestyles and a sustainable healthcare system for all
Community life	Self-sufficient communities
	Community and local cultural life are strong and diverse
	Local communities are self-sufficient with circular economies
Urban and rural life	People live in medium-sized cities that use a minimum of space and ensure a maximum of livability and access to culture, green space, jobs, education and zero-emission mobility
	Rural life is attractive and supported and there is a harmonious relationship between urban and rural communities
Education	Advanced and affordable education, including education on sustainability and skills for a sustainable way of life
Energy	Energy is produced and consumed in the most intelligent, sustainable, non-polluting ways with no environmental impact and with zero CO_2 emissions. Europe is energy self-sufficient, with a high dependence on renewable energy sources

Sustainable agriculture and food	Sustainable agriculture and fisheries
	Food security for all
Sustainable water use	Sustainable use of water
	Ample supply of clean, healthy potable water
Land-use	Planning for sustainable land use (urban and rural, coastal and inland)
Ecosystems	Balance in using and preserving ecosystem services
Resource use	Preservation and conservation of Europe's (and the world's) natural resources and environment
	Sustainable management of natural resources within a circular economy
Waste and pollution	Chemical, biological and other (e.g. solid waste) pollution is almost non-existent in water, air and soil
Good governance	Transparent, accountable, democratic and participatory governance
	Many local civil initiatives, decisions on a local scale are made locally
	Europe is strong, peaceful and cohesive
	Respect for national and regional diversity
Employment & work-life balance	Flexibility in employment
	Jobs available for all who want one
	Availability of meaningful employment opportunities that allow people to fulfil their (social) potential
	Reduction of working hours and an increase of volunteering, job sharing and other contributions to society

4.5   Transformative strategies in the pathways within and across scenarios

Across case studies and scenarios, we identify a nexus of three (groups of) robust pathways that each encompasses different types of transformative strategies (Table 5): (i) shift towards sustainable lifestyles; (ii) set up good governance systems for sustainability; and (iii) promote integrated and sustainable resource management. These groupings of strategies allow a comparison of the results across case studies, despite some differences in sectoral focal areas and needs (e.g. drought and heat resilience in Iberia and Hungary, and environmental protection and regeneration in Europe and Scotland). A detailed description of the transformative in these pathways is given in Annex 2. This information is summarised in this section.

As shown in Table 5 and Annex 2 the transformative strategies identify different types of activities and actors to mobilise and create the capacity conditions for delivering the strategy and achieving the vision. Looking at the transformative strategies across scenarios and case studies, we obtain a comprehensive picture of 'who is the solution', while the distinct contexts given by the respective socio-economic scenarios equip different types of actors with access to resources to work towards a desired future vision. Consequently, the strategies start from the opportunities and constraints that actors face in a given scenario, expand their capacities and create new ones as the pathways unfold.

The SSP3 pathways commonly build on the abilities of civil society actors to self-organise in decentralised and regionally-networked local communities in the face of weak and fragmented governmental institutions. The SSP1 and SSP4 pathways focus on top-down strategic planning and coordinated multi-level governance implementation. The SSP5 pathways use the dominant market-based orientation of the scenario by integrating environmental and social protection into production and consumption practice, while remaining economically efficient.

Table 5: Robust pathways and strategies across scenarios and case studies.

Pathways and strategies		Europe				Scotland				Hungary				Iberia			
		SSP1	SSP3	SSP4	SSP5	SSP1	SSP3	SSP4	SSP5	SSP1	SSP3	SSP4	SSP5	SSP1	SSP3	SSP4	SSP5
Sustainable lifestyles																	
Promote shifts towards sustainable lifestyles	Induce and trigger behavioural changes to sustainable lifestyles	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
	Support well-being focus for equity and social capital development	✓	✓	✓	✓		✓						✓	✓	✓	✓	
	Establish new education models for sustainability and solidarity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	Empower local communities and economies	✓	✓			✓	✓	✓	✓		✓	✓	✓		✓	✓	
	Set up new health systems									✓	✓		✓				
Sustainability governance																	
Good governance systems for sustainability	Foster good governance with high levels of participation and transparency	✓	✓		✓	✓				✓	✓	✓	✓	✓		✓	
	Strengthen and stabilise cross-sectoral multi-level governance institutions and collaboration	✓		✓													
	Set up and experiment with learning-based governance models	✓		✓													
Global sustainability leadership	Strengthen and implement global vision for sustainability	✓				✓		✓	✓								
	Establish international collaboration and markets	✓		✓				✓	✓		✓						

Pathways and strategies		Europe				Scotland				Hungary				Iberia			
Integrated and sustainable resource management																	
Integrated and sustainable water management	Implement adaptive and integrated water management across Europe				✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
	Shift to water sensitive infrastructure for water efficiency and adaptation	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓	✓
	Build resilience and prepare for extreme events	✓															
	Set up a water monitoring system									✓			✓	✓		✓	✓
	Set up trans-boundary and problem-based governance institutions and partnerships															✓	
Sustainable agriculture	Develop regulatory frameworks for sustainable and climate-resilient agriculture	✓				✓								✓		✓	✓
	Shift to organic and climate-adaptive farming practices	✓	✓		✓	✓					✓		✓				
	Support local community-based agriculture and rural development	✓	✓		✓		✓					✓	✓				
	Innovate sustainable agriculture technology and technology transfers	✓			✓	✓					✓		✓		✓	✓	
Low carbon economies	Develop local and regional smart energy within a European energy grid			✓	✓	✓								✓		✓	
	Establish mobility infrastructures for low carbon mobility and peripheral connectivity					✓			✓								
Environmental protection and regeneration	Mainstream nature protection into policy frameworks and economic activity	✓			✓	✓	✓	✓	✓			✓		✓			✓
	Enable integrated and ecosystem-based land use and infrastructure planning	✓		✓				✓	✓								
	Protect and restore nature with mainstreaming nature-based solutions and conservation networks	✓	✓	✓	✓		✓	✓	✓								
	Put in place an environmental monitoring system								✓								✓
Green and comfortable cities	Promote green urban development for climate adaptation									✓		✓					

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4.6   Transformative narratives from the five case studies

In each of the IMPRESSIONS case studies, during the third set of workshops (held in 2017), the stakeholders were asked to look at the work they had done during the workshop series and identify important strategies that could build capacities and help them achieve their vision. The results of the stakeholders' discussions in each case study have been summarised in the form of five short transformative narratives to inspire action in the face of high-end climatic and socio-economic change. The full narratives per case study are provided in Annex 3. The narratives are summarised following the vision-capacities-solutions procedural design as outlined in Section 2.4 (Figure 3), are shown in Table 6 and further developed in Annex 3.

Table 6: Summary of the case study transformative narratives based on stakeholder discussions at the third set of workshops of each case study.

Case Study	Europe	Scotland	Iberia	Hungary	Central Asia (EUx)
Narrative	**A New Economy with High Quality of Life**	**"Bolder and Faster"**	**Taking Responsibility**	**A Central Role for Communities**	**A Strategic Partnership Between the EU and Central Asia**
Needed to support change	Education	Education; Institutional Change; Broad Dialogue Process	Education; Transparent, independent and accountable institutions	Education; New healthcare system; Communication	Cooperation; Coordination; Connectivity
Strategies	(Radical) innovation; New economic paradigm; Bio-economy strategy	Bolder and faster actions by communities, business and government; New approaches for financing the transition to sustainability; Reshaping of land use	Ambitious plan focussing on water, energy and the circular economy	Top-down and bottom up actions to support the transitions in energy, water management and the economy	Needs assessment conference dialogue; Energy diversification; Private sector development; Transboundary water agreement; Technical assistance

With reference to the capacities needed the European, Scottish, Iberian and Hungarian narratives all emphasise the need for education in order to achieve their vision. They suggest that education is needed in all age groups, to increase awareness about the interlinked problems that need to be tackled, but also to provide the knowledge and skills to find and implement solutions. The narratives also emphasise the need for institutional change and a new economic paradigm. While the Central Asian (EUx) case study differs from the others in both the process followed and the focus, it demonstrates the need for three central elements to realise a sustainable future: cooperation; coordination; and connectivity.

The strategies in the different case studies reflect the local contexts in which they were developed. In the face of high-end climate change, both Hungary and Iberia include water management as an important strategy. Scotland looks for bolder and faster action and includes strategies to finance the

transition and reshape land use. For Europe as a whole, radical innovation, a new economic paradigm and the bio-economy are the key strategies selected by the stakeholders.

4.7 Game-changers, multiplicative synergies and nexuses of solutions

4.7.1 Introduction

There is obviously not one perfect, "one-size-fits-all" solution for each scenario. Any one solution is also not "better" than another as some solutions will work in some contexts, but not others. Hence, there are multiple solutions – and they are context/scenario dependent. However, different solutions will tend to emerge because of the different socio-economic conditions, and therefore may also be more representative of certain scenarios but not of others. This context dependency means that overall we can present different kinds of solutions for each scenario. As shown in Table 7, the kinds of solutions that fit with the four scenarios can be broadly categorised with one main organising principle. The table also includes examples of these solutions from the pathways.

Table 7: Kinds of solutions for each scenario, organising principle and examples from the pathways.

Scenario	SSP1	SSP3	SSP4	SSP5
Kind of solution	Systemic solutions within "a new kind of governance"	A diversity of experiments and opportunities where weak governance prevails	Green technology on a large scale	A green growth strategy – using fossil fuels while building a basis for the following era
Main organising principle / criteria (not exclusive from each other)	Integrity of systems	Self-sufficiency	Strong environmental awareness	Market-based solutions
Example solutions from the pathways	- Encourage reflexive society to include new governance vision (Europe) - Inform every citizen of his/her ecological footprint, including water and energy footprint (Hungary)	- Have-nots band together for community owned agriculture (Scotland) - Communities of interest for growing, building etc. (Scotland) - Improve self-sufficient communities (Europe) - build social capital through virtual communities around topics (Europe)	- Increase water efficiency in agriculture (Iberia) - Develop green cities, urban gardening, roof gardens (Scotland)	- Create demand for sustainable healthy products and good communication marketing of them (Europe) - Invest in improving and developing health care (Hungary)

However, transformative responses within high-end climate change contexts will ultimately require multiple combinations and different kinds of solutions that may be partly representative / illustrative of more than one of the scenarios.

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During the IMPRESSIONS case study workshops in 2017, after the participants had enhanced their pathways within scenario groups and also looked at the extent to which the modified pathways would get them towards their vision, they were asked to reflect on what would be the "game-changers" in the scenario that they were working on. What actions would lead to transformative changes that would bring them closer to the vision? In some cases, the participants found "game-changers" in the pathways they had developed. In other cases, inspired by input from the project team, they identified "game-changers" that had not been considered in the pathways development process, but which they felt would be consistent with the scenario.

Annex 4 (Table A4.1) presents the game-changers identified by the stakeholders for each scenario and the four case studies: Europe, Scotland, Hungary and Iberia. A brief analysis is presented in the following section.

4.7.2 Brief analysis of game-changers per scenario

SSP1: Local currencies and time-banking were seen to be a game-changer in three of the case studies with the exception being Hungary. Europe and Iberia both proposed greening of cities. Scotland and Iberia proposed a carbon tax. There is some similarity between the Scottish proposal of participatory democracy and the Hungarian proposal of increased public interest in decision-making.

SSP3: The role of local communities is highlighted in Europe, Scotland and Iberia. Scotland, Hungary and Iberia all proposed time-banking, with Scotland and Iberia also both proposing local currencies. Hungary and Iberia both proposed education as a game-changer, whilst Europe and Iberia proposed a bio-economy /circular economy approach.

SSP4: Europe and Scotland both proposed a Master Plan / Investment Framework and Brand Scotland. Land management was seen as a game-changer in Europe and Iberia. Scotland, Iberia and Hungary each have a focus on local communities/civic initiatives. Hungary and Iberia included a shift to environmentally-friendly transportation.

SSP5: Not surprisingly for this scenario, each case study included changes in the energy sector as a game-changer. The only other common proposal is a tax on beef (Scotland) and higher taxes on food (Hungary).

4.7.3 Synergies between game-changers

At the IMPRESSIONS cross-scale workshop in April 2018, the complete set of game-changers was used to move from the design and thinking of `additive', sectoral solutions and strategies to 'multiplicative' ones. The aim was to find positive tipping points to lead to a rapid decarbonisation and rapid 'sustainabilisation' of the world. The focus was on identifying and assessing the most feasible and fit-for-purpose combinations of game-changers for the next two years.

In four groups, the participants (stakeholders and project team members in a co-creation process) made clusters of game-changers that would **create systemic transformative synergies** by being implemented together / in combination with other game-changers. The results are presented in Figures 10 to 13.

The first cluster focuses on promoting green growth (Figure 10). An environmental fiscal reform supports investment in green technologies and a shift of world trade to being fair and sustainable. Investment in green technology is a pre-condition for a circular economy. Development of a circular economy and the promotion of green growth reinforce each other, while green growth is also supported by incentives for the rich to support the poor and by investment in green technologies.

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Regulation to limit environmentally harmful activities also supports the development of green technologies.
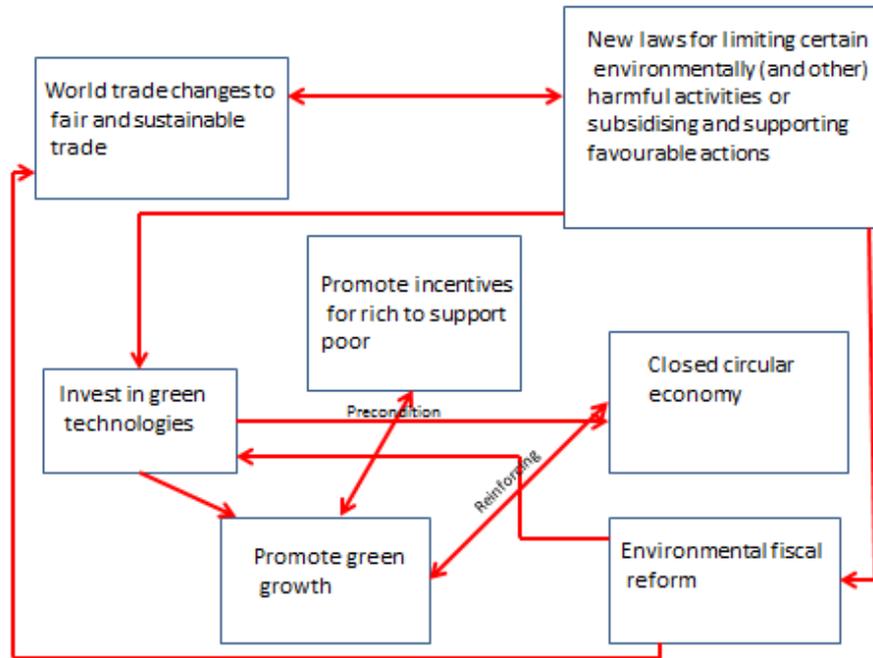
Figure 10: The green growth cluster of game-changer solutions.

The second cluster focuses on full-cost pricing and public investment (Figure 11). The game-changers in this cluster are divided into two groups. On the left-hand side of Figure 11 are environmental tax reform, taxation measures and the inclusion of all costs (i.e. environmental and social costs) into prices. On the right-hand side of Figure 11 the revenues raised by these measures are invested into green technologies, efficient and clean transportation and education and training, which supports innovation and the promotion of green growth. Thus, the environmental fiscal reform is used to lead public investments to support the transition to a more sustainable world.

**Figure 11: Cluster of game-changer solutions based on full-cost pricing and public investment.**

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The third cluster has a mix of game-changers aiming towards a sustainable economy. An environmental fiscal reform triggers other changes in the economy including changing trade to fair trade and promoting cross-border collaboration. There are a number of instruments to deliver this, such as a framework to deliver market liberalisation, subsidising favourable actions and higher taxes on unsustainable goods. Other actions to support the transition to a sustainable economy include the Sustainable Economy Fund. These funds can be used at European, international or even local levels. The reform of the Common Agricultural Policy (CAP) is an example of ways to fund different projects and to use the funds for transformation. Within the context of moving to a circular economy, more enlightened multi-nationals are important actors, and communities inform the multi-nationals on what the priorities should be and how to be responsive to their needs. Communities flourish with more investment in community projects, the use of local currencies and time-banking.

Figure 12: Cluster of game-changers stressing the move towards a sustainable, circular economy.

The fourth cluster focuses on sustaining local economies and resilient communities. Through moving "back to the roots" and abandoning consumerism there is a change of values and the need for money is reduced. Local currencies and time-banking incentivise small changes and support the introduction of new economic models and also restore human capital and access to time and resources within local networks. Transforming the forest together with the local currencies and time-banking increase the value of local resources and increase local self-sufficiency, which improve resilience. Legislation on sustainable communities ensures the trust and transparency needed for time-banking. Governance is also essential for ensuring the safety of fusion energy supply. Affordable energy from fusion powers clean and efficient transportation, which in turn strengthens the local community and eliminates energy poverty.

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Figure 13: Cluster of game-changers underlying the role of local resilient economies.

There are two striking common features of these four clusters. Although the participants had around 90 game-changers to cluster (see Table A4.1 in Annex 4), the clusters that they selected to work on focussed on: (i) changing the economic system; and (ii) supporting local community development. Common game-changers in changing the economy are environmental fiscal reform (clusters 1, 2 and 3), a circular economy (clusters 1 and 3) and world trade changes to fair trade (clusters 1 and 3). The focus on building resilient communities is reflected in clusters 2, 3 and 4.

4.7.4   *What could these combinations of game-changers achieve over the next 24 months?*

The participants were asked to propose what these clusters could achieve in the short-term (24 months). The results are shown in Table A4.2 in Annex 4. The table suggests that three of the clusters could achieve lower emissions or less dependence on carbon in the short-term. Two clusters highlight the achievement of more awareness or even changed mind-sets with quick successes through education. Two clusters suggest that quick results can be achieved through changing consumption patterns.

4.7.5   *What means and resources are needed to implement these clusters of game-changers?*

The participants were asked what capacities would be required to implement these clusters of game-changers and keep them going? The results are shown in Table A4.3 in Annex 4. Over the table as a whole, all forms of capital are required. While three of the clusters refer to the need for investment (financial capital), all of them require changes of social capital in the form of institutional changes (e.g. voluntary standards, reform of the System on National Accounts, tax reform, regulation changes, recognition of community rights, and strong and democratic local governance). All of these changes would be supported by changes in human capital through awareness-raising, education and monitoring. Manufactured capital in the form of green technology is explicitly mentioned in the first cluster on green growth.

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4.7.6   *Who would be the winners and losers under the game-changers?*

Finally, of particular relevance to the next section, the participants were asked about the winners and losers in each cluster of game-changers. The responses are presented in Table A4.4 in Annex 4. Two of the clusters pointed out that over a longer period of time the winners and losers will change, with the "full-cost pricing" cluster suggesting that in the long-term all actors are winners. Resource intensive and inefficient companies are identified as losers together with the oil industry, pension funds and the rich. The winners are local communities and the environment in all clusters.

5. Ethics beyond 2°C: A moral compass to navigate high-end climate change

5.1. Introduction: justice as transformation

Two central components for the robust design and implementation of transformative strategies is the consideration of justice and equity - both between generations (inter-generational) and in every generation (intra-generational equity) and both in terms of distributive justice and procedural justice[1]. As already recognised by the IPCC 5th Assessment Report (Fleurbaey et al. 2014), sustainable development, climate policies and equity are closely interlinked. To a large extent, the role of sustainable development pathways is to be able to identify, and in some cases resolve, the potential synergies and trade-offs between development policies and climate policies through implementation processes which require learning (Figure 14). Here, our conceptualisation aims to move a step forward in this reasoning by arguing that transformative pathways and strategies are required to cope with high-end climate change as the present system may not be able to ensure global climate justice in the long-term and keep the minimum biospheric life support system so as to ensure sustainability.
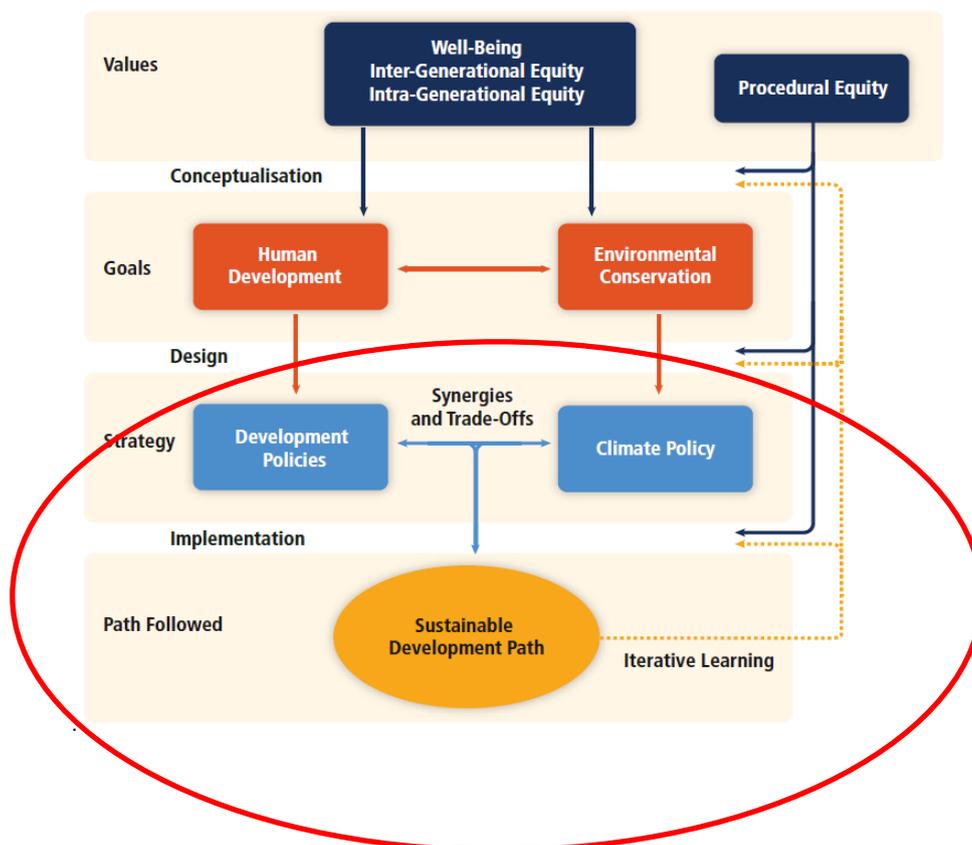

Figure 14: Links between sustainable development, equity and climate policy according to the IPCC 5th Assessment Report (from Fleurbaey et al. 2014; we have added red circle).

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[1] By and large distributive justice in climate change concerns the distribution of the burdens and benefits of addressing climate change, whereas procedural justice refers to the fair participation in the processes of distributing them.

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The growing chance of entering into a high-end climate change world not only raises unprecedented challenges for society and global ecosystems but also unveils many limitations of existing science and policy capabilities to cope with it. In conditions of high uncertainty and high stakes, it is clear that addressing such challenges has profound moral – rather than simply scientific, technical, or managerial – implications for governance. For this reason, in the current situation of 'sustainability anomy' (i.e. not having the necessary moral resources to know what to do once/if we cross the 1.5 or 2°C threshold) this section introduces the metaphor of a *moral compass*, developed as a normative tool for providing guidance for governance arrangements in the difficult quest to design just transformative solutions to sustainably navigate high-end climate change (Grasso and Tàbara, in review). The moral compass can also be used to overcome potential trade-offs between present and future costs and benefits of implementing transformative strategies and to support difficult governance decisions aimed at aligning adaptation and mitigation strategies to sustainable development.

5.2.   **Purpose and structure of the moral compass.**

Defining the kinds of governance arrangements required for navigating a high-end climate change world in a just and sustainable way raises crucial issues. These criticalities are mostly determined by the complexity of impacts and magnified by the uncertainties that surround this unknown and unpredictable future. A high-end climate change world not only exposes existing governance arrangements to their weaknesses and risks, it also generates an opportunity space for the adoption of a challenge-driven approach for shaping such arrangements in different manners. Despite the growing recognition that urgent social-ecological reconfigurations will need to be deployed for sustainably navigating the uncertainties of high-end climate change, explicit moral guidance to support the deep and swift transformations needed to confront the impending future is still lacking.

Consequently, the rationale for using the metaphor of a moral compass lies in the fact that it may not be possible currently to know exactly what kinds of societal transformations are needed in a high-end climate change world; nonetheless it may be possible to anticipate, despite a landscape of high uncertainty – or even indeterminacy – the basic moral constitution to address some of the major threats that humanity and nature undergo if the present unsustainable trends continue. As societies move along such high-end trajectories, comprehension of the positive or negative consequences of taking a particular route may also influence present decisions about continuing along it. However, this adaptive attitude can only be possible if some morally agreed-upon consensus about the directions to be taken is available, a political position which, inevitably, is morally connoted and truly of normative nature. The lack of moral guidance can, in fact, favour paralysis of governance arrangements and worsen moral corruption in engaging sustainably with climate change (Gardiner 2006; 2014).
In contrast to a traditional compass that sets alternative directions, the proposed metaphor of a moral compass normatively provides a set of four pillars grounded in political philosophy – articulated in cardinal directions, moral standards, and moral principles – that governance arrangements could use in order to promote morally-sound solutions aligned with a move towards sustainability under high-end climate change (Figure 15; Table 8):

- *Cardinal directions*: The long-term moral yardstick that governance arrangements should consider in the first place, and gauge their action against, in order to act consistently with sustainability and to avoid falling into unjust and unsustainable trajectories. A cardinal direction is a moral benchmark that allows governance arrangements to act and to reflect upon the implications of their behaviour, learn whether the courses of action taken are sustainable and orient them for (more) sustainably navigating high-end climate change. Cardinal directions should help to interpret the 'moral landscape' in which contemporary societies operate without necessarily providing specific indications on where we should or should not go.

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- *Moral standards*: A second-order foundational moral reference on which basis governance arrangements should orient and shape their behaviours, so that they act consistently with the general references of the cardinal directions. A moral standard provides a more concrete ethical indication for specifying the route for moving sustainably and in a just manner according to the moral mapping provided by the cardinal direction.
- *Moral principles*: The moral features, specific requirements, and conditions in different contexts that need to be satisfied in order for governance arrangements to progress along the selected route indicated by moral standards. A moral principle indicates possible sustainable alternatives, depending on concrete socio-economic and ecological circumstances, for travelling the route indicated by the moral standard towards the relevant cardinal direction.
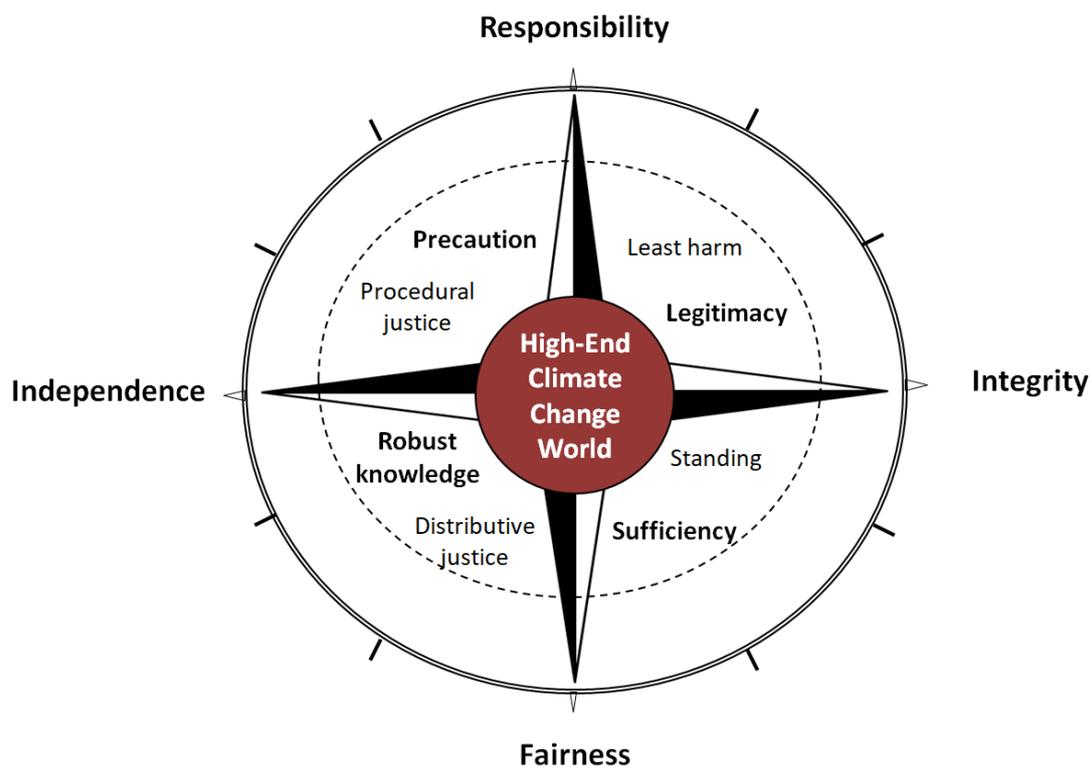

Figure 15: Illustration of the moral compass.

Table 8: The components of the moral compass.

Pillars	Cardinal Directions	Moral Standards	Moral Principles
Pillar I	Responsibility	Least harm	Precaution
Pillar II	Integrity	Legitimacy	Standing
Pillar III	Fairness	Distributive justice	Sufficiency
Pillar IV	Independence	Procedural justice	Robust knowledge

The moral compass should include some overarching and cross-cutting calibration and adjustment mechanisms to facilitate a checking process where openness and broadness are guarantees of the absence of self-indulgency and self-referentiality (North 1991). Such mechanisms need to involve epistemic qualities able to provide the evidence required for the most complete possible understanding of the consistency of conduct of governance arrangements to the political ideal of sustainability and of the consequent implications for present and future generations and for the

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planet. The information basis provided by epistemic qualities can make it possible to carry out the most thorough possible critical review of action of high-end climate change governance arrangements (Buchanan and Keohane, 2006).

Among epistemic qualities, the two most prominent in relation to sustainability in a high-end world are: (i) *accountability*, i.e. the demand that governance arrangements have a certain conduct and the prospect of judging whether they actually conform to that conduct; and (ii) *transparency*, i.e. the possibility of monitoring the performance of high-end climate change governance arrangements (Grant and Keohane 2005). Such epistemic qualities would make it possible to understand and evaluate the consistency between action of governance arrangements and the indications of the moral compass within a sustainability framework. This iterative, integrated learning approach of adaptive governance can truly magnify the governance arrangements potential of providing sustainable solutions for high-end climate change.

5.3. An illustrative application to IMPRESSIONS high-end scenarios

It is not possible to apply the moral compass for providing moral guidance to all the pathways obtained in the IMPRESSIONS project's case studies. Rather, the objective here is to introduce the hypothesis that different socio-economic futures may in fact promote different moral constitutions and therefore the moral guidance provided by the compass for informing and shaping governance arrangements may differ in the different socio-economic scenarios (SSPs).

As Table 9 shows it is highly plausible that in a high-end climate change world defined by low inequality and low carbon intensity, as in SSP1, governance arrangements are already characterised by high levels of Responsibility, Integrity, Fairness, and Independence, and the calibrating and adjustment mechanisms that ensure transparency and accountability are similarly well structured. In this ideal situation, the moral guidance provided by the moral compass would be limited to 'fine-tuning' the governance arrangements associated with the actions within the pathways to the pillars' moral standards and moral principles.

In contrast, in SSP3, where high inequality and high carbon intensity are the norm, special attention should be given to all the various components of the moral compass for steering and reorienting development towards a more morally consistent and socio-ecologically resilient world that is better able to cope with high-end climate change. Therefore, governance arrangements in SSP3 should actively try to orient their conduct along the four cardinal directions suggested by the moral compass. Similarly, the calibration and adjustment mechanisms should be carefully introduced as mentioned above.

In the SSP4 and SSP5 scenarios the possible role of the moral compass is more nuanced, with both scenarios sharing the necessity that governance arrangements consolidate effective calibration and adjustment mechanisms. In SSP4, characterised by high inequality and low carbon intensity, the conditions of such a world could be made a bit less unequal by addressing some of the negative effects of inequality through the use of the moral compass. In particular, it would likely require that governance arrangements pay particular attention to aligning their actions with the cardinal direction related to distributive justice issues, i.e. fairness. In contrast in SSP5, characterised by low inequality and high carbon intensity, governance arrangements would possibly need to ensure conduct inspired by the responsibility cardinal direction in order to lessen/minimize the impact of fossil fuel based development. At the same time, given the very likely powerful carbon lobbies that would characterise a SSP5 future, governance arrangements should aim to acquire and maintain the integrity cardinal direction, as well as autonomy assured by the independence cardinal direction.

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Table 9: Moral guidance provided by the moral compass to governance arrangements in the SSPs.

SSPs	Socio-climatic conditions	Moral guidance
SSP1 Sustainability	Low inequality, low carbon intensity	Fine-tune actions along moral standards and moral principles of the cardinal directions
SSP3 Regional Rivalry	High inequality, high carbon intensity	Orient and shape actions along all cardinal directions
SSP4 Inequality	High inequality, low carbon intensity	Orient and shape actions along the Fairness cardinal direction
SSP5 Fossil-fuel development	Low inequality, high carbon intensity	Orient and shape actions along the Responsibility, Integrity, and Independence cardinal directions

It is worth emphasising also a possible different application of the moral compass, made possible by the broad group of governance arrangements – understood as coordinated patterns of behaviour among multiple agents based on shared beliefs, aspirations, ideologies, and/or political values – to which the moral compass is able to provide moral guidance. We refer to corporate entities, and in particular to the oil and gas industry. According to recent evidence (Heede 2014), two-thirds of the global industrial GHG emissions over the past two centuries can be traced to the activities of 100 companies, mostly belonging to the oil and gas industries. Oil and gas companies have played a critical role in climate change by supplying fossil fuels to the global economic system, and therefore supported unsustainable growth and development of the planet and harmed humankind and ecosystems (Ekwurzel et al. 2017). Therefore, the oil and gas industry has clear responsibilities in relation to climate change. Such responsibilities can be articulated in, at least, two duties: (i) a duty to decarbonise that entails a large-scale transformation that they need to undergo in order to reduce and eventually eliminate carbon emissions from their entire business cycle; and (ii) a duty to support the most vulnerable subjects through provision of funds to compensate for their actions, which resulted in negative climate impacts.

The moral compass may prove extremely useful to structure, articulate, and put into practice such duties consistently with the conditions necessary for navigating a high-end climate change world in a just and sustainable way. In fact, its pillars – cardinal directions, moral standards, and moral principles – can, on the one hand, help steer in a morally sound way the oil industry's transition towards sustainability. On the other hand, they can provide fundamental moral guidance to the oil industry for financially supporting the more vulnerable subjects to cope with a high-end climate change world in a sustainable way.

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6.   Conclusions

As the world gets closer to exceeding the 1.5 and 2°C thresholds of the Paris Agreement, it is increasingly recognised that conventional solutions will not be sufficient either to prevent or to cope with going beyond such targets. To this aim, this deliverable has provided a synthesis of the IMPRESSIONS project results, of its procedural innovations and their implications for the design of transformative strategies under conditions of high-end climate change. Three key concepts (Integrated Climate Governance, Transformative Climate Science and Positive Tipping Points) have been introduced and further elaborated in scientific papers to frame our analysis and identify the requirements for the design of transformative strategies. In particular, we have argued that transformative strategies need to start with the co-production of a desirable vision of the world from which new and different collective capacities to attain a better-off and fairer future can unfold. In this report we have understood that transformative solutions are those that are able to overcome multiple trade-offs between ecological integrity and socio-economic goals in ways which can be turned into positive, multiplicative synergies between climate and sustainable development actions. Clusters of sustainable solutions can be identified, tested and implemented by integrating multiple forms of knowledge and values in concrete places following transformative visions of the kind of world in which we want to live in the future.

This report has also summarised the cross-sectoral and cross-scale implications of high-end climate change and the limits to mitigation and adaptation under these conditions alongside with the concrete pathways identified within the IMPRESSIONS case studies. As shown in Section 4, robust pathways and strategies across scenarios and case studies are related to promoting shifts towards sustainable lifestyles, supporting arrangements for good governance and leadership for sustainability, as well as carrying out substantive actions for integrated management of resources. This explains why the most fundamental game-changers or transformative courses of action, as identified in the final set of workshops of the project, emphasised the need for the reconfiguration of how the whole economy works, including the various underlying ethical principles currently driving its dynamics. In this regard, it is the need to move towards a sustainable, circular economy supportive of local resilient communities in which an adequate mix of policy incentives and investments may play a decisive role. This outcome is consistent with the agent-based modelling results carried out in IMPRESSIONS which identified the potential for positive tipping points in the economy and the role of target public investments to achieve that goal. Last but not least, the role of ethics and justice, under the metaphor of the 'moral compass', has been underlined as a fundamental way to overcome potential trade-offs between present and future costs and benefits of pursuing transformative strategies and to support difficult governance decisions aimed at aligning adaptation and mitigation strategies to sustainable development.

The sustainability of human societies depends on the maintenance and (re)production of certain social-ecological conditions. The damaging of such conditions beyond certain thresholds, e.g. as a consequence of high-end climate change, may jeopardise the survival of humankind. Understanding them is a prerequisite in any attempt to build a fair global society, which also takes into account future generations. However, we still know very little, and empirical evidence is scant, about the nature, evolution and ultimate causes for positive change of these conditions. Sustainability conditions may change, because they have both ecological and social components; conditions and solutions which may have worked for a given society at a certain point in time may not work any longer. Sustainability conditions are always dynamic, relational and hybrid constructs between social and biophysical components. They also include complex interactions between social-ecological system stocks and flows and are dependent on human agency, volition and the capacity to create degrees of freedom for individual choice. Current sustainability conditions do not only become more complex, but also more uncertain.

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Therefore, 'solutions' to sustainability problems, and in particular to high-end climate change, can only be built upon an in-depth understanding of the conditions and the capacities required for building such solutions. Such conditions include both biophysical components and social ones (e.g. related to inequality or social distribution), so a key question for human agency is the following: in which conditions do we want to live? It is precisely such conditions which constitute the various 'scenarios', as those mapped out within IMPRESSIONS which result in the various choices and cumulative decisions taken in the here and now. In practical terms, these reflections entail the need to focus not so much on building trajectories but on the required capacities to build the conditions for those trajectories, e.g. in terms of cultural, moral (e.g. human rights) or structural change conducive to those trajectories.

In short, transformative solutions and strategies to address high-end climate change can be understood as emergent outcomes and processes derived from novel second-order capacities aimed at creating positive tipping points in social-ecological systems configurations. In turn, such capacities can be deliberately built by explicit strategies, such as those identified within the IMPRESSIONS multi-scale case studies. Trying to solve the intertwined problems of climate change and unsustainable development with the existing capacities (e.g. cognitive, normative, technical or organisational) and conventional tools and methods both in science and policy may create even more problems, lock-ins and mal-adaptation, and will make it more difficult to address them in the future.

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Annex 1: Stakeholder participation in case study workshops

	Europe	Scotland	Hungary	Iberia
Stakeholder workshop #1 (a)	-	Mini-workshop September 2015 17 stakeholders	June 2015 27 stakeholders	June 2015 17 stakeholders
Vision survey (b.1)	January 2016 19 responses		Mini-workshop in February/March 2016 45 stakeholders	June 2016 16 responses (9 from Portuguese, 7 from Spanish stakeholders)
Stakeholder workshop #2 (c)	February 2016 23 stakeholders	April 2016 22 stakeholders	June 2016 24 stakeholders	September 2016 23 stakeholders (10 Portuguese and 13 Spanish stakeholders)
Survey (d.1)	January 2017 15 responses	March 2017 6 responses	Mini-workshop in December 2016 10 stakeholders; Survey March 2017, 7 responses	June 2017 13 responses (7 from Portuguese and 6 from Spanish stakeholders)
Stakeholder workshop #3 (e)	May 2017 17 stakeholders	June 2017 12 stakeholders	May 2017 30 stakeholders	September 2017 16 stakeholders (9 Portuguese and 7 Spanish stakeholders)

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Annex 2: Robust pathways, transformative strategies and enabling conditions identified in the IMPRESSIONS case studies

Transformative strategies to shift towards sustainable lifestyles

The pathway to shift towards sustainable lifestyles includes strategies that advocate a cultural change in ways of living, commuting, producing, purchasing and learning for a reflexive and sustainability-oriented society. The shift to sustainable lifestyles is transversal to multiple sectors: it relates to water and energy consumption, food and agriculture practices, trade approaches, production processes and social resilience. The strategies of this pathway create social and human capitals to foster social cohesion and support, as well as to ensure incentives, awareness and knowledge about sustainable lifestyles, production and consumption. They also create (new types of) financial capital by promoting local markets and economies and re-distributing income for more equity.

One transformative strategy in this pathway is to ***induce and trigger behavioural changes for unlocking unsustainability practices*** through decisive regulation and awareness raising. This is because of the need to turn away from practices and lifestyles that drive high emission trajectories and unsustainable resource use – how we consume and produce materials and resources, how we provide for basic needs and how we relate to nature and build social relationships. The pathway includes a suite of strong regulations, taxes and incentives to mandate and incentivise sustainable lifestyles, innovation and economic activities. For example, the Scottish government regulates corporations to tackle environmental damage. The Hungarian government ensures equity by allocating a large share of the GDP to disadvantaged regions and providing energy loans. In Iberia, an annual carbon budget is established and carbon taxes based on real carbon costs are introduced and water taxes and tariffs are enforced for sustainable water use.

Another transformative strategy in this pathway is to ***create a culture of life-long learning for reflexivity on values and behaviours***. A shift to sustainable lifestyles entails deep changes in beliefs, ethics and social morals. This shift is achieved by putting in place new education systems that are accessible for everybody and promote environmental and social values, including appreciation of nature, art and cultural diversity. The system shifts away from performance indicators towards promoting complex thinking, reflexivity, independence and future-oriented and practical skills. Lifelong learning is promoted through formal and informal education services. For example, in Hungary sustainability lectures are made compulsory in primary and high schools. Practical education for a skilled workforce includes training on sustainable and eco-conscious farming, information technology, self-sufficient food production and skills for green technological development and research.

Finally, the pathway includes the transformative strategy to ***empower local communities and economies***. The shift towards sustainable lifestyles also fosters community resilience to enable self-sufficiency and autonomy in resource management and use, and make communities prepared for future shocks. The pathways support local market creation and local democracy by providing incentives for local production and consumption (e.g. for family-based agriculture, local energy cooperatives). The capacities of communities and individuals to participate in decision-making and social networks are strengthened, for example, by ensuring that everybody has access to the internet and international and local information systems.

Transformative strategies to set up good governance systems for sustainability

The pathway to set up good governance systems for sustainability consists of strategies that establish transparent, collaborative, learning-based and accountable governance systems oriented towards ensuring sustainability and resilience in the long-term. New forms of sustainability and climate

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governance involve a mix of governance responses at multiple levels with the foreseen involvement of a wide array of actors to share knowledge and resources, as well as to coordinate and motivate action. The transformative strategies in the pathway create new social capital in terms of new governance institutions and mechanisms for enhanced democracy and transparency at multiple scales, collaboration across sectors and scales, as well as learning and problem-based decision-making. This also involves the generation of human capital to integrate diverse knowledge sources into decision-making.

This pathway includes a transformative strategy to ***establish and defend good governance with high levels of participation, flexibility and transparency***. Good governance for sustainability adheres to high standards of transparency, participation and accountability. The pathway ensures that all actors with an interest, stake and possible impact actively participate in political discourses and decision-making at international, European, national, regional and local levels. For example, in Iberia public participation is increased by establishing participation forums, fostering social networks and political activism.

The transformative strategy to ***ensure alignment towards a long-term orientation for sustainability*** across sectors and scales builds on a long-term and systemic orientation that can motivate and guide the activities of multiple actors across sectors and scales and disclose synergies and trade-offs across multiple policy domains and goals. Across case studies, the pathways build on a common strategic orientation towards sustainability and resilience that aligns diverse goals and guides political, social and economic behaviours. In the European and Scottish pathways, the long-term and decisive pursuit of sustainability is also extended to the global arena, to support global goals and collaboration.

Strengthening cross-sector and multi-level partnerships and institutions for collaboration and coordination ensures coordinated and co-beneficial policy and planning outcomes across scales and sectors in line with the long-term sustainability orientation. Governance strategies and plans are developed with problem-based approaches that transcend individual sectors (for example taking the food-water-energy nexus as a starting point). The European Union oversees the overarching framework conditions. Local and regional governments and partnerships coordinate the regional implementation. The Scottish pathways set up different types of think tanks (internationally, regionally, etc.) that involve diverse actors from civil society and government, that market and research across scales and sectors to promote knowledge sharing and alignment of interests and goals.

Promote integrated and sustainable resource management

The pathway to promote integrated and sustainable resource management includes strategies to set up context-sensitive, multi-functional and efficient resource management for environmental protection and European self-sufficiency. The strategies address diverse sectors from a holistic and problem-based perspective, including water, agriculture, energy, biodiversity and land use. The strategies on integrated resource management create manufactured and natural capital by investing in new technologies and nature-based solutions and environmental services for sustainable resource use. They generate social capital to organise integrated, collaborative and context-sensitive resource management and to develop decisive guidelines and regulations on resource use (e.g. water taxes). Human capital is developed to better understand and monitor the state of the environment, as well as to develop new knowledge about sustainable resource management practices such as organic and climate-friendly farming practices.

The pathways include transformative strategies to ***adopt protected and fit-to-context planning and management approaches within multi-level frameworks***. Planning and management approaches are aligned to overarching European frameworks for self-sufficiency and allow attention to context-specific opportunities and needs. The overarching perspective supports integrated resource and land

use planning, which takes into account synergies and trade-offs between different sectors and policy goals, as well as different context needs and opportunities across Europe and its regions. For example, energy generation and supply are addressed from a European perspective (European self-sufficiency and 100% renewable energy generation) while fostering solar energy in southern Europe, local energy generation and regional energy supply within European energy grids.

The transformative strategies **establish multi-level and cross-sectoral partnerships and networks** to manage resources at local and regional levels in relation to context-specific needs and opportunities. Regions and communities are interconnected to build on each other's assets and support each other. In Hungary multi-level and public-private partnerships for sustainable and resilient water management span local, regional, national and international levels. For example, a regional utility government is established and cooperation on water among micro-regions supported. The Iberian pathways in SSP4 put in place transboundary collaborations between Portugal and Spain to manage their common water bodies, such as a joint agency on all common water bodies and transboundary and transregional water partnerships at the river basin level.

The pathways include strategies to **develop knowledge on natural flows and uses** to ensure that the actions are in line with social and environmental conditions and to prepare for risks, the pathways put in place comprehensive knowledge and monitoring systems. For example, the SSP5 pathways in Scotland include strategies for monitoring and resource mapping by funding solution-oriented research and research on ecosystem service values, developing GIS tools to account for resources and utilising more localised resource maps. The Iberian pathways set up full water cycle monitoring to control water use, quality and quantity.

Finally, the pathways include strategies to **support disruptive innovations for sustainable resource management and use**. This builds on experimentation with and embedding of new ways of doing, thinking and organising to realise sustainable and integrated resource management. Innovations include integrated infrastructure solutions (e.g. regional and international water transportation networks; water-sensitive infrastructure), green technologies (e.g. low carbon energy; water efficiency), practices (e.g. organic farming), nature-based solutions (e.g. river re-naturalisation) and low-tech solutions (e.g. household rainwater harvesting). These innovations are supported by investment schemes for innovation that are especially oriented towards technologies that enable local resource management and markets (e.g. circular economy, vertical farming, local energy generation). The innovations are replicated in new contexts by the creation of conditions for the exchange of best practices and for technology transfer.

Further details on the transformative strategies in the case study pathways are given in Table A2.1.

Table A2.1: Robust pathways with transformative strategies and enabling conditions.

Robust pathways	Transformative strategies	Activities and actors	Capacity conditions created
Sustainable lifestyles			
Promote shift towards sustainable lifestyles	Induce and trigger behavioural changes for unlocking unsustainable lifestyles	Regulations, (dis-)incentives, control and guidelines for sustainable production and consumption (European and national governments)	*Social capital:* regulatory framework for unlocking unsustainable practices
		Awareness raising on sustainable and healthy lifestyles and environment (governments; community organisations)	*Human capital:* awareness of and knowledge about sustainable lifestyles
	Support a well-being focus for equity and social capital development	Develop well-being indicators and social policies (governments; business self-regulation)	*Social capital:* institutions to re-distribute financial resources to urban and rural development *Financial capital:* re-distribution of income
	Create a culture of life-long learning for reflexivity on values and behaviours	Develop integrative education models for lifelong learning on sustainability and social cohesion (governments; businesses; communities)	*Social capital:* social cohesion and support *Human capital:* practice-based knowledge; knowledge for self-sufficiency and sustainable behaviour
	Empower local communities and economies	Support and develop local communities and economies (governments, businesses, communities)	*Social capital:* institutions to re-distribute financial resources to urban and rural development *Financial capital:* local markets and economies
Sustainability governance			
Good governance systems for sustainability	Establish and defend good governance with high levels of participation, flexibility and transparency	Create participatory, transparent and flexible governance institutions (governments)	*Social capital:* good and adaptive governance institutions
		Build capacities for participation (governments; knowledge institutes; communities)	*Human capital:* ability to participate in decision-making at multiple levels
	Ensure alignment towards a long-term orientation for sustainability	Develop shared and long-term goals for sustainability and social cohesion on local to global levels (governments together with business, knowledge institutes and communities)	*Social capital:* shared, integrated and long-term orientation towards sustainability

Robust pathways	Transformative strategies	Activities and actors	Capacity conditions created
	Strengthen cross-sectoral multi-level governance	Create cross-scale and cross-sectoral partnerships for goal integration and knowledge exchange (governments; knowledge institutes; businesses; communities)	*Social capital:* cross-sectoral and multi-level governance institutions for collaboration and coordination
		Assign responsibilities across European, national, regional and local decision-making levels to coordinate resource management on local and regional levels	*Social capital:* polycentric and multi-level governance networks
Global sustainability leadership	Strengthen and implement global vision for sustainability	Develop national, European and global sustainability visions (governments; businesses; communities)	*Social capital:* global alignment towards sustainability
Integrated resource management			
Integrated and sustainable water management	Implement adaptive and integrated water management across Europe	Set up integrated water management framework at multiple levels (e.g. EU water cycle, river basin) (governments) Implement regulation, awareness raising and control of water efficiency and use (e.g. water price) (governments)	*Social capital:* integrated institutions for sustainable water management
	Shift to water sensitive infrastructure for water efficiency and adaptation	Promote and implement nature-based solutions for climate adaptation (governments; businesses) Promote and develop technological innovations for water efficiency and local water infrastructure (governments; businesses; knowledge institutes)	*Manufactured capital:* technologies and infrastructures for climate adaptation and water efficiency *Natural capital:* nature-based solutions
	Set up a water monitoring system	Generate knowledge on ecological flows and water use (governments; businesses; knowledge institutes; communities)	*Human capital:* knowledge on water flows, quality and quantity
Sustainable agriculture	Develop regulatory frameworks for sustainable and climate-resilient agriculture	Develop frameworks for multi-functional, integrated and context-sensitive agriculture (governments) Regulation, (dis-)incentives and controls on sustainable agriculture (e.g. carbon tax, fertiliser ban) (governments)	*Social capital:* integrated institutions for sustainable and multi-functional agriculture

Robust pathways	Transformative strategies	Activities and actors	Capacity conditions created
	Shift to organic and climate-adaptive farming practices	Adopt organic and climate-adaptive farming practices (farmers)	*Human capital:* knowledge about organic and climate-adaptive farming practices
	Support local community-based agriculture and rural development	Incentivise and develop local and sustainable food markets and family-owned, community-based agriculture (governments; communities; businesses)	*Manufactured capital:* technologies and solutions for local markets *Financial capital:* local economies and markets
	Innovate sustainable agriculture technology and technology transfers	Invest and develop sustainable agriculture technology (e.g. indoor agriculture, bio-economy) (governments; businesses; communities)	*Manufactured capital:* sustainable energy and resource efficiency in agriculture *Natural capital:* bio-economy; protect resources *Financial capital:* strengthen Europe's global market position
Circular and local low-carbon economy	Develop local and regional smart energy within a European energy grid	Develop a framework for local and regional sustainable energy generation and provision within national and European energy grids (governments) Regulations and (dis-)incentives for sustainable and community-owned energy (governments) Invest and develop green and smart energy technologies (governments; businesses; communities)	*Social capital:* integrated institutions for sustainable energy provision and generation at local and regional levels *Manufactured capital:* technological innovation for green and smart energy at multiple levels *Financial capital:* local energy markets
Environmental protection and regeneration	Mainstream nature protection into policy frameworks and economic activity	Legislation, taxes, incentives and standards to internalise nature in economic activities and sectoral policies (governments; self-regulation of businesses) Natural capital accounting (businesses)	*Social capital:* integrated institutions for nature protection and sustainable market activities *Financial capital:* internalisation of nature into economic activities and sectoral policies
	Enable integrated and ecosystem-based land-use and infrastructure planning	EU-wide and national-level land reform within regional frameworks for context-sensitive land-use (European and national governments)	*Social capital:* institutions for context-sensitive land-use
	Protect and restore nature through mainstreaming nature-based solutions and conservation networks	Promote and implement nature-based solutions and conservation networks	*Natural capital:* reforestation; biodiversity corridors

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Annex 3: Transformative narratives from the IMPRESSIONS case studies

A3.1 "A New Economy with High Quality of Life"

A narrative based on the European case study of the IMPRESSIONS project.

Vision

In 2100 Europe is a strong, peaceful and cohesive society with a high quality of life, a low carbon economy and a healthy environment. Many actions and actors contributed to the transition towards sustainability. Europeans found that dealing with high-end climate change and its impacts can build on the strengths, diversity and cultures that distinguish Europe from the rest of the world. In addition to the creation of jobs and a resilient society, it has also been possible to value and support the ecosystems that provide the basis for prosperity. New forms of governance (top-down and bottom-up) provide an open, visionary and adaptive governance system that is able to respond quickly to challenges.

Capacities

A key role in the transition towards sustainability was played by the education system. Sustainability learning was integrated into the entire school curriculum. Topics such as system-thinking, leadership, values and social entrepreneurship became an integral part of school life. Young people thus became informed and responsible consumers, while older people were empowered to continue on sustainable pathways. At university level, there was increased funding for student exchange programs to build better understanding and alliances across borders. Sustainability became an explicit learning outcome for universities. The EU provided guidance and coordination and funding for this education transition. The main responsibility for implementation and investment was with the national authorities, but there was innovative support through many initiatives from civil society organisations through social / transformative hubs.

Strategies and solutions

Innovation and often radical innovation was also an essential part of the transformation. For example, there were innovations in the use of urban space; creating spaces that are attractive, valued and economically viable. With a radical rethinking of mobility in cities and a holistic view of the built environment (indoor air quality, water efficiency, energy efficiency in buildings), the resilience of the urban space has been increased dramatically. The important question was: how to stimulate and support innovation? Of course, there were also some conventional policy approaches, such as taxes, fiscal subsidies and regulation. In addition, knowledge exchange and demonstrating new ideas in **pilot projects** supported innovation. Showing what works and then providing incentives through government support for others to implement these solutions accelerated the transition.

The transition towards sustainability in Europe was based on a **shift in economic paradigm** towards a new type of economy combining the bio-based, low carbon and circular economy. With a strong vision and governance, an overarching framework was developed to bring the elements of these approaches together, create positive synergies and deal with trade-offs. Stakeholder communities were closely involved in the dialogue about this overarching framework and how the different concepts could bring benefits in reshaping the economy.

It was recognised from the beginning that changing the economic paradigm to go "beyond GDP" would require a proper **accounting framework**. Without this, it would have been impossible to monitor

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progress. In particular, care was taken to include natural capital in the national accounting system. Credible indicators were developed to support the use of the national accounting framework and also were used to track progress towards the achievement of the sustainable development goals.

As part of the shift in economic paradigm, a **bio-economy strategy** was developed at the EU level. Given the availability of biomass at the regional level, this strategy was also of interest to Member States and for regional policies. A range of stakeholders were involved in the implementation of the bio-economy strategy, including: biomass producers, bio-based industry, NGOs, the financial sector and standardisation bodies. The strategy provided a framework for integrating agriculture, forestry and energy strategies and dealing with both the mitigation of and adaptation to climate change. The underlying aim of the strategy was to stimulate innovation and investments. Bio-based industries were seen as a component of regional development. Awareness-raising campaigns addressed issues like the potential impact of the bio-economy on food supply or biodiversity and were able to allay people's fears. Since some of the products of the bio-economy are traded within the EU and globally, certification schemes were put in place. Biomass resources can be traced and the sustainability of the whole value chain can be monitored. A wide range of biomass from crops, agriculture waste, residues and forestry products is now used to produce a variety of products: feed, food, fuel, electricity, fibre, bio-chemicals and bio-plastics. The bio-economy has reduced greenhouse gas emissions and created jobs locally and regionally.

A3.2 "Bolder and Faster"

A narrative based on the Scottish case study of the IMPRESSIONS project.

Vision

Scotland in 2100 is a country of equality. The population is maintained at a sustainable level with communities living in low density areas. All people have an income adequate to satisfy their basic needs and enjoy personal safety and freedom. The focus of the economy is on producing and consuming what is important in life. With an enhanced process of participatory government, fair democratic governance is characterised by proportional representation and the opportunity to make frequent input to decisions. With a low carbon and climate resilient economy, everybody can enjoy a green environment. Food is produced sustainably with a low carbon footprint. Water use for agriculture is responsible and less energy intensive. Energy is produced locally and owned by communities. There is space for essential environmental services in every catchment. With equitable land ownership, land use is driven by public choices and priorities. A better spread of public services allows people to choose between rural and urban living. Nature is well-integrated into all cities, providing better living spaces.

Capacities

To achieve this vision, three major changes were made: a new and bolder policy-making approach; a sustainable land use strategy; and new approaches for financing the transition to sustainability. This required new or increased capacities in Scottish society. It was necessary to build human capital through education in order to provide the statistics, maps and projections on which to base the new land use strategy and to define minimum ecosystem service requirements for each priority land use. There was a need to introduce institutional changes to give the Finance Minister control over all government programmes. Last but not least, to deal with trade-offs and the need to find workable solutions for individuals, communities and the country as a whole, it was necessary to have well-designed and iterative dialogue processes with broad stakeholder involvement.

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Strategies and solutions

Communities, business and government are "Bolder and Faster"

The old conventional policy approach to finding solutions to high-end climate change was too slow. It was agreed that government, business and community approaches needed to be bolder and faster. Climate change was seen as a national security issue for Scotland. The Paris Agreement of 2015 provided a positive global context for action and stimulated the government to position itself as a leader in climate change mitigation and adaptation. It was decided to scale up existing programmes and provide more funding for them, while continuing to set out the case for more urgent action as a political issue. Importantly, the Finance Minister was given control over all government programmes. This meant that climate change was considered in all activities using public expenditure, which raised awareness and stimulated similar actions in the private sector. Policy action was linked with issues of public concern and grassroots campaigns, such as health and the environment. Bolder and faster actions could also be taken on issues that should not be a partisan issue and that bring multiple and synergetic benefits, such as housing. Climate change was also seen to be a long-term community issue and bold actions at this level included the introduction of personal carbon budgets.

Land use and farming

To achieve the vision of sustainable land use, it was decided to try and incentivise the right activity in the right place. An assessment of the suitability of all land in Scotland for different activities produced a map of priority land uses for different areas of the country (East Scotland and the Shetlands are defined as arable areas; the West coast is given to forestry; the population centres are in the East). Minimum ecosystem service requirements were defined for each priority land use. To do this, a process with broad stakeholder involvement was necessary. The first step in this process was to agree that there was a problem and to reach a consensus on what were Scotland's land needs. People who were being asked to give up land for other purposes would need compensation, through rewards rather than subsidies. The process brought together different types of knowledge to understand the best use of Scotland's land, in the context of needs for food, carbon sequestering, peat bogs, housing/ infrastructure, recreation and tourism, biodiversity etc. It was agreed that game-shooting did not count as a key use, so no prime land was dedicated for this purpose. People became convinced at the beginning that meat production was not the prime purpose of land use and their diets needed to become less meat-heavy. Thus land use was reshaped to provide multiple benefits. Perverse incentives were removed in order to move towards a more sustainable land use and financial disincentives – fines and taxes – were also used. Motivation also came from understanding the contribution of sustainable land use to "Brand Scotland" and to the value added to the economy through protecting and increasing natural capital. Natural capital accounting meant that multi-benefit land uses were recognised and rewarded.

New approaches for financing the transition to sustainability

Scotland recognised that there was a need for a Central Fund to support different charities. This meant that charities would not have to do their own fund-raising and it reduced their administrative burden. Businesses could choose to donate to a charity, a region or a particular cause. Tax breaks were provided for charitable donations. A registered list of sponsorship opportunities for building projects was set up; businesses providing support were named on the building. Later this approach was also expanded to cover other kinds of projects, not just buildings. Charity league tables were published, showing who had donated and how much. This provided a further incentive for businesses to donate. Philanthropy was also targeted towards providing benefits for employees. Seed funding was provided

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through the Central Fund to small businesses in local communities. These businesses paid back into the Central Fund once they were above a certain size.

It was also important to combine crowd-funding with micro-lending. People agreed to lend small amounts of money for a project, including environmental projects. At first, those who donated would get a return on their capital, or at least get their capital back once the project produced a return on investment, or see it as a charity donation. Later, it was agreed that donors would receive an 'environmental return', but not a financial return. These benefits are presented in the form of a report that explains the 'environmental return' on the money that you provided.

A3.3   "A Central Role for Communities"

A narrative based on the Hungarian case study of the IMPRESSIONS project.

Vision

With participatory and accountable local governance, there are also many local civil initiatives. Community and local cultural life grounded in shared values are flourishing. Active and healthy lifestyles are promoted through education and awareness-raising across all levels of society. Using modern and highly eco-efficient technologies, the economy is sustainable and also provides meaningful local employment that helps retain many of the younger generation in the communities. Protection of the environment and climate is a priority. Sustainable food production includes large-scale organic farming and self-sufficiency based on kitchen gardens. Hungary produces all of the energy it needs from sustainable sources, while water management is focused on water retention and floodplains that have regained their natural ecosystem functions.

Capacities

Education, changing mind-sets, a healthy and skilled workforce and strengthening civil society were significant building blocks in creating capacities to achieve the vision.

Starting in kindergarten, a generation emerged with a new spirit and approach. The reformed education system grounded in positive thinking, collective responsibility and a practical, solutions orientation became a priority between 2020 and 2040. These changes led to important innovations in energy and technology after 2040. This was supported by the government. NGOs also launched initiatives on grassroots education, environmental education and local production with support from the state. The healthcare system was improved through cooperation between local and governmental levels, refocused on well-being and the prevention of disease/ill-health through healthy and active lifestyles.

Communication was central to changing the mind-sets of individuals and groups, so that well-being and the search for happiness replaced consumption and money as ultimate goals. Thereby a paradigm shift was achieved. Everybody, from the state-level down to the individual, took responsibility for the consequences of their actions.

Strategies and solutions

Much of the vision was embedded in the globally agreed Sustainable Development Goals, so early action to achieve those goals was an important step in the transition towards sustainability. It was important to participate early on in an internationally agreed initiative that involved making an in-depth assessment of the situation and trends that prevailed at the start of the transition, to stimulate thinking on what was necessary and what was possible.

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In the early years, it was the responsibility of the state to support the transition through the regulation of consumption, taxation policies and providing incentives. NGOs and civil initiatives used this support to accelerate the transition through their actions. The introduction of a water management system was the key to achieving water security by 2040. It was very important to create employment and here communities played a central role. Communities that established a local self-sufficient energy economy and local agriculture and water solutions also created meaningful jobs. Communities were also central in reducing societal conflicts through collaborative actions. Bottom-up approaches in communities also addressed culture, the arts and heritage etc. and contributed to building networks and strengthening collaboration.

A further important step was to replace GDP as a measure of progress. A new indicator was introduced that was based on life-cycle analysis that included food and various products and put well-being rather than income at the heart of societal ambition.

A3.4   "Taking Responsibility"

A narrative based on the Iberian case study of the IMPRESSIONS project.

Vision

With well-coordinated Iberian governmental institutions, Iberia also has a highly politically engaged society and different cultural and regional identities are valued, respected and accommodated. Iberia supports and takes an active role in fostering global cooperation and solidarity, with respect for human rights and social development of people. In 2100, people in Portugal and Spain engage in new lifestyles that fit in more sustainable ways with the special characteristics of the Iberian landscapes and territorial diversity. Natural resources, and especially water and soil, are managed sustainably and biodiversity is strictly protected. Rural areas flourish while cities are smaller than in 2016 and are energy self-sufficient. Land use management and participatory planning promote the socio-economic sustainability of the regions and secure equal development opportunities between different areas. In Iberia, the sustainable economy makes use of their natural resources with minimum impact on ecosystems through maximum reuse, recycling and recirculation of materials. A new welfare model focuses on well-being and quality of life. Everybody enjoys safe food, the consumption of local, seasonal and organic products are prioritised and public policies support more sustainable and locally-based agriculture and markets. With 100% renewable energy, a distributed network of energy production and consumption and no more investment in fossil fuels, Iberia has a low carbon economy. All citizens have full access to clean and safe water. Integrated Iberian water management ensures a balanced use of water for urban supply, agriculture, forestry and energy production. Improved water management helps to adapt to extreme events, such as droughts and floods, and mitigate their negative effects.

Capacities

The vision was achieved by implementing transparent, independent and accountable institutions, together with new solidarity and educational mechanisms, which helped to bring about large-scale behavioural change. A series of decisive regulations based on a new economic paradigm were also necessary. Education, training and civic participation were the key for change. Everybody was encouraged to become engaged in the search for solutions, as well as in their demonstration and dissemination at home, at work and in their various contexts of action - especially in the economy and in politics. This required wide-scale awareness-raising of people's environmental (water, energy, soil, etc.) footprints, and the large-scale deployment of tools, such as lifecycle assessments, green labelling and other ways to support social learning about the efficient use of resources.

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National and regional research and innovation strategies were spearheaded by governments, although research and innovation were carried out jointly by universities and businesses in a long-term process.

Strategies and solutions

An important characteristic of the strategies to achieve the vision was that individuals, the government and business all took responsibility for the implications of their consumption and production actions. With regard to energy, individuals began to produce electricity and hot water at the household level. The government accepted the responsibility to create and foster market mechanisms to establish energy distribution networks. Within a period of 15 years, governments created fiscal and economic incentives so there would be an investment in household-level energy production. Businesses changed their production and distribution paradigm in line with Corporate Social Responsibility. With regard to water, individuals took responsibility for using less water through the introduction of smart metering systems and the use of efficient devices that reduce water consumption. The government taxed water resources to encourage reduced water losses in both urban supply and agriculture. Businesses began to cooperate with each other to reduce water losses through the exchange of best practices.

The need for more efficient use of resources, energy and water in particular, was guided by an ambitious plan. It included a move towards creating compact and self-sufficient cities with integrated and efficient public transport and energy-efficient buildings. To save water, sustainable irrigation systems and water re-use were introduced. Legislation and labelling of the carbon and ecological foot print of produced goods was introduced for lowering footprints. The circular economy encouraged recycling, the use of local products, avoidance of transport and a shift towards environmentally friendly and healthy diets.

A3.5   "A Strategic Partnership between the EU and Central Asia"

A narrative from the Central Asia (EUx) case study of the IMPRESSIONS project.

Introduction

To support both the implementation of the Paris Agreement and the achievement of the Sustainable Development Goals (SDGs), Europe and Central Asia developed a partnership to focus on key issues of mutual interest. This partnership aimed to build stability and security through technical cooperation, education and economic development, with the ultimate goal of a transition towards sustainability. With a combination of formal and informal dialogues, the main needs of countries and communities in Central Asia could be assessed and a coordinated response from the EU was developed. Over the long-term, the Central Asian economy became more diversified as the normative elements of the SDGs were addressed, facilitating the decarbonisation of the energy system.

Needs assessment

Before beginning other initiatives, it was necessary to develop a list of ongoing activities in Central Asia at the EU and national level. Some initiatives were overlapping, with different donors investing in the same kind of projects. The list of ongoing activities allowed a consolidation of effort with coordinated donor action.

At the same time, it was important to make an assessment of needs to ascertain what each of the countries, but also communities, in Central Asia wanted. This was compared with the list of ongoing activities to identify gaps. Identifying concrete needs supported the development of a Central Asia – Europe partnership.

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Vision

EU - Central Asia (EU-CA) Strategic Partnership

The first step in developing a true partnership is to hold an EU-CA strategic partnership conference, in which EU and CA stakeholders discuss and clarify their priorities in view of the needs assessment described above. Some attention needs to be paid to redefining the region in order to include countries that had previously not been considered (e.g. Afghanistan, Mongolia). It was recogniSed that the partnership needed a clear and consistent definition of Central Asia.

The priorities: educational exchanges, environmental issues, good governance, private sector development, investment in trade cooperation and infrastructure development, rural development (including water and gender issues) and health built the capacity of Central Asian states to comply with the Paris Agreement and / or to access climate finance.

The partnership is not just a political strategy. Development aid organisations were also fully integrated and guided the investments made by the EU. Given their important roles in the region, diplomatic channels to both China and Russia were an important part of the EU-CA partnership. In particular, China became an increasingly key stakeholder in the EU-CA partnership, with a clear division of labour emerging between the two external partners in order to avoid conflicts or overlaps and to maximise coordination.

Building strategic relations

The focus of the partnership is on building relationships (increasing social capital) and dialogues at multiple levels. There are several parallel, but interconnected tracks:

- State / official track (Ministries: Foreign, Water, Energy);
- Informal meetings (e.g. Parliamentarians);
- Expert track (academics) working more informally on creating shared knowledge between countries;
- Grass-root / Civil Society Organisation tracks

Each track allowed information exchange and gathering and shared knowledge creation. They also built relationships and the capacity for implementation. Discussions at all levels focused on topics of shared EU-CA interests, such as security and stability, disaster risk reduction, migration, sustainable development and tackling drug trafficking and organised crime.

Capacities

To build the partnership with Central Asia, the EU needed to coordinate sectoral activities and build up a catalogue of activities and expertise that can be offered by European partners. This required increased capacity to coordinate financial support and ensure transparency. Initial actions focussed on technical cooperation in response to demand from within Central Asia; this built capacity for tackling other issues. To build up connectivity - in addition to improving infrastructure - the focus was on removing the barriers to allow educational exchanges and free travel, in addition to trade.

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Solutions

European Energy Diversification Initiative (EEDI)

With the ultimate goal of decarbonisation and meeting the goals of the Paris Agreement, a step-by step approach was taken. Central Asia was able to satisfy its needs for diversification. The step-by-step approach used existing opportunities. For example, the Trans-Caspian pipeline was used in the early stages and opened up a space for discussion on diversification in countries like Turkmenistan. Rather than an immediate stop to the use of hydrocarbons, there was diversification and an incremental shift to a cleaner energy mix. The EU encouraged Member States to promote sector-related activities across Central Asia in small projects based on Central Asian needs and coordinated through a catalogue of activities and providers of expertise and support from the EU. These projects focussed to begin with on the energy sector, but then expanded to other sectors to diversify the Central Asian economies.

Private sector development

In synergy with the European Energy Diversification Initiative and its catalogue of initiatives and with a focus on SMEs, private sector development was supported by the EU in sectors identified by Central Asian countries (e.g. tourism, textiles, irrigation, agriculture, infrastructure, machinery, equipment and green technology). This allowed Central Asia to reduce imports, create jobs and contribute to the climate goals of mitigation and adaptation. The EU provided an essential coordinating role between Member States and also consulted with EU business representatives in Brussels and at the national level. In addition, the EU ensured, via regulation, that the interactions of EU companies with Central Asian counterparts were free from corruption and did not engage in arms trading.

Investments for private sector development were made by the European Investment Bank, and other institutions (e.g. commercial banks). The EU also provided technical assistance and the European Bank for Reconstruction and Development provided business advice (e.g. on developing business plans and access to finance) and development cooperation finance. Technical assistance was used to develop the capacity of the financial sector and service sectors. Expertise was also provided in adjusting the regulatory environment to support private sector development and for promoting exports, investment, quality control, vocational training, education and R&D.

Environment

Taking climate change adaptation and disaster risk reduction as starting points, cooperation on environmental issues developed at multiple levels. Supported by more environmental data and investments in infrastructure and monitoring, this cooperation with regional actors, individual states, local communities, NGOs and CSOs was pursued. At the local level, technical assistance was provided to build monitoring capacity. Solutions were found for local hot-spots of environmental problems. These success stories stimulated national authorities to address similar problems elsewhere. At the regional level environmental strategies were embedded in economic planning and there was an active exchange of best practices in environmental technologies. Cooperation on water issues dealt with all uses of water and also focussed on water quality, framed as a health issue. The financial community provided coordinated, targeted and transparent support to the multi-level interventions on environmental issues.

Transboundary water sharing agreement

A cornerstone of the new EU-Central Asia partnership was the high-level diplomatic investment made by the EU to facilitate water diplomacy in the region. The EU sought to coordinate its support with China, with the EU mediating political dialogues, providing technical support for impact assessments

and support at various levels to the process of engaging communities and stakeholders across transboundary river basins. China supported these diplomatic initiatives and played a lead role in the financial and infrastructure aspects of new dam building, energy grid development and enhanced physical connectivity via its Belt and Road Initiative. The resulting regional agreement on water sharing helped to spur more sustainable agriculture in the region, manage river levels in response to changing climate-related flood risks and provide reliable low carbon energy to previously energy-poor communities, including in fragile neighbouring countries (e.g. Afghanistan and Pakistan), as well as clean energy exports into Xinjiang province, China.

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Annex 4: Game-changers as identified by the IMPRESSIONS stakeholders

Table A4.1: Game-changers per SSP identified by the workshop participants in the final series of workshops. Similar kinds of game-changers are indicated in the same colour.

	Europe	Scotland	Hungary	Iberia
SSP1	Local currencies to enable local production. Greening of cities - new concepts of built environment and mobility. Medical breakthrough to slow down aging. Energy from farm residues – reduce competition for the land and close the loop. Transforming the forest - actively managed and replanting .Use the forest for everything (food, clothes, wood chemical, etc.). Reduce bureaucracy. Streamline actions and decrease barriers.	Time-banking: Everyone's time has equal value. Participatory democracy: the people propose ideas, there are many referendums. Introduction of a high carbon tax, needs to be balanced by a service, e.g. free transport. Integrated public transport system. Increase the flexibility of hours, days worked.	Communities: The communities govern, and demand things, achieving things from the bottom. Decisions at the top levels are reinforced by ideas coming from below. Increase public trust in politics: increase public interest in decision-making, mandatory reporting on actions of politicians, giving more tasks to local decision-makers. Communication and awareness-raising: Calling attention to the danger: we might lose our planet! Transform the human mind and human thinking. Give tools to people, and teach them how to maintain their welfare. International skills bartering system.	Local currency and Time Banks - Incentive new models of exchange, at a small scale. Reconfiguring / densification of cities and infrastructure – Cities energetically self-sufficient; photovoltaics on buildings to feed transport networks. Taxes for carbon and water. Technology to make crops less affected by climate. Reduce commuting. New forms of work. World trade changes to Fair trade.

	Europe	Scotland	Hungary	Iberia
SSP3	Foster and bolster networks to enable more resilient local communities. Environmental fiscal reform. Increasing the carbon tax. Support the transition to greener energy production, with incentives to innovate and create employment Reform the Common Agricultural Policy (CAP) and Cohesion Funds - decarbonise with greater focus on the bio-economy. A new integrated Water-Forestry-Agriculture policy early in the timeline. Champion the bio-economy approach A new political narrative – need for urgency, real costs, getting out of the crisis and avoiding new ones, long-term benefits of change.	Multinationals: self-regulate then shift to working together, they don't have to wait for political cycles or slower government policies. Need for more enlightened multi-nationals/champions (individuals). Communities - Champions from community work at the interface of producers and consumers. Skills transfer. Building the interface between communities and multinationals. Local currency and time credits - using alternative currencies to build the skills. An important element in strengthening communities. Urban areas – opportunities such as electric bikes, urban gardens, moving to more dense living.	Community supported agriculture Time-banking Reducing food waste Promote green growth Protect water reservoirs Promoting incentives for the rich to support the poor to keep social stability Education: volunteering, alternative schools	Local and circular economy - boost the cooperative movement as a tool to make local and circular economy feasible; local currencies, exchange of products, exchange of time. Education and training Enhancement of passive houses (zero emissions). Promote bicycle use, walking, Industry 4.0 Creation of a "Dehesa" label Promote cross-border collaboration to support eco-innovation

	Europe	Scotland	Hungary	Iberia
SSP4	The masterplan with monitoring. Supply/value chains (grid & local/global networks) ensure self-sufficiency for food and energy supply. Investment in green technologies. Protectionism of energy market. Stratified land use planning to ensure unmanaged land use change. Land use planning where local communities are enhanced to work in producing food.	Brand Scotland 2.0 Impact Assessment Tool – long-term assessments. MUSCOs (Multi-Utility Service Companies). Sustainable Scotland Fund. Invest in community projects. Re-establish understanding of community. Framework to manage market liberalisation for re-investment in Scotland & business philanthropy.	Change the mind-sets through education. Reliable communication, independent media, e.g. about extreme weather events. New laws for limiting certain environmentally (or otherwise) harmful activities or subsidising and supporting favourable actions. Environmentally friendly public transport, home office. Use the EU funds for transformation. Civic initiatives: with state support, new solutions (e.g. food waste) can be included as basic values in the charters of new NGOs. Back to roots, abandon consumerism.	Agriculture - land management; urban food production Governance – legislation on sustainable communities. Energy – unusual alternative energies; households without emissions and with biomass TRANSPORT – efficient transportation (no emissions, no pollution).

	Europe	Scotland	Hungary	Iberia
SSP5	Massive afforestation program. Develop program for climate-resilient crop development. Ultra-clean fossil-fuel transport technology (e.g. fuel cells). Other means of transforming mobility & transport-systems. Closed circular economy.	Energy generation and trading between Clantons - supported by major advancement in energy generation and storage technology. Heavy tax on beef. Market-ready fusion Localised governance systems - in Clantons. Heavy investment in education. Education programmes in 'Clanton' leadership.	Taxation - More taxes on all kind of consumption; Instead of taxing labour, place taxes on energy consumption; No VAT taxes on locally grown or produced food; Higher taxes on imported fruits, vegetables and other food. Energy: remove state subsidy of energy costs; basic research for higher efficiency in fossil fuel usage; massive governmental aid for building passive houses or converting the existing buildings; monitoring energy-efficiency on household level; innovation in storing of solar energy; geothermal heating systems; small scale nuclear plants. Food system - reuse of food waste; Food rationing, restrictions of meat consumption per capita; Mobility – Introduce mobility quota, limiting how much you are allowed to travel in a certain time period; Promote domestic tourism; only low-consumption cars are allowed;, promote electric vehicles Community, - highlight role models (e.g. in efficient energy use, alternative	Local energy communities; networks would increase efficiency and diminish costs. Change the way we work; work less hours, to have more work for more people. Desalination technology – need cost-effective technology.

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			agriculture); obligatory working and learning new community-based technologies; 30-day/year community work for high school and university students.	

Table A4.2: What can the clusters of game-changers achieve over the next 24 months?

Cluster	Achievements in 24 months
1. Green Growth	• Clean air and water depending on implementation • New mind-sets – self-propelling effect • Changes in competitiveness for companies that comply -> competitive edge • New regulation (EU and local level) • Risk-rating of industrialised countries will improve -> rating system changes
2. Full-cost pricing to increase public investment	• Better consumption patterns e.g. beef -> chicken • Investments in sustainable solutions • More informed and innovative society • Less dependence on carbon • QUICK SUCCESSES - Education
3. Towards a sustainable economy	• International exchange minimised and sustainable • Demand met locally • Emissions coming from energy reduced
4. Local resilient communities	• Abandoned consumerism -> reduced emissions • Strong communities -> resourcing locally • Community campaigning • Fusion will not be available • Good links between levels of governance

Table A4.3: What means and resources are needed to implement the clusters?

Cluster	Means and resources
1. Green Growth	• Money and investments in green technologies (e.g. green investment fund, green bonds) -> agreement on international level; specific body to establish rules; European policy voluntary standards; offer incentives and benefits • Public awareness and pressure • Mandates • Monitoring and enforcement • Promoting start-up culture -> scale-ups leading to change • Reform System of National Accounts
2. Full-cost pricing to increase public investment	• Tax reform • Also importers taxed – tariffs • Also for export
3. Towards a sustainable economy	• Fund • Regulation changes
4. Local resilient communities	• Strong and democratic local governance • Good knowledge base including on climate change • New values and mind-set • Substantial investment in science and innovation • (Community) champion -> Leadership • Recognition and protection of community rights / structural by national authorities • [Does not work easily in cities]

Table A4.4: Who are the winners and losers?

Cluster	Winners	Losers
1. Green Growth	• Multinationals (embracing potential for development and business model) • Environment • The poor • The rich • Elon Musk • Rural communities • Cities	• Multinationals – resource intensive and inefficient • The rich • Saudi Arabian princes
2. Full-cost pricing to increase public investment	• IN THE LONG TERM ALL ARE WINNERS	• Oil industry • European companies in global competition
3. Towards a sustainable economy	• Local communities everywhere – globally • Producers over longer time scale - 5 years • Environment	• Shareholders • Pension funds • Food / goods exporters
4. Local resilient communities	• Local communities • Nature and biodiversity • Developing countries in the longer term (CO_2) reduction	• Local communities if they are trade dependent • Multinationals • Super rich • Developing countries in the short-term (agricultural economy)

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Annex 5: Exploring new modes of engagement, learning and climate knowledge integration through the Arts.

According to Donella Meadows[2] (1999), out of 10 possible leverage points to intervene in a system, **culture is the most effective place to intervene when we intend to transform it**. Therefore, the design of transformative and engaging strategies should seriously consider the role of the arts in fundamentally transforming taken-for-granted cultural conventions about time, space, as well as the individual and collective interactions in social-ecological systems. Below we describe some of the experiments and performances carried out within the IMPRESSIONS project to explore integrated forms of art-science collaboration to trigger transformations in people's mind-sets, support alternative modes of learning and develop innovative forms of public engagement (See also Galafassi et al. submitted).

Artistic contributions and performances carried out at the Iberian case study workshops and the final cross-scale workshop:

- **The Bond You Hold** (https://vimeo.com/142046379; https://vimeo.com/219431632) is a physical theatre performance overlaid with pattern projections and music embodying the dynamic relation between climate and humans, in a world beyond 2°C warming, played at the first Iberian workshop in Lisbon in June 2016. Directed by Diego Galafassi and Maria Heras. Performance and choreography Maria Magdalona Beky Winnerstram (Långsjö Teater). Music composed by Katherine Young, USA. Scientific direction J. David Tàbara and Kasper Kok. Make-up Flora Velloso (floravelloso.com). Light design Ronald Hessman. Art projections from Tone Bjordam and Marten Scheffer's collaboration "Critical Transitions". For more information see this website: tonebjordam.com. Additional projections Diego Galafassi, Felix Pharand-Deschenes in "Climate Change – The State of The Science" (IGBP and Globaia production). Additional music Marten Scheffer and Arnin Scheidel.

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[2] D. Meadows (1999). Leverage Points. Places to Intervene in a System. The Sustainability Institute.

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- **A-Corda Installation** is a participatory installation created at the third Iberian workshop in Cáceres in September 2017 inviting visitors to imagine the future that may unfold and also the future one would like to create. Transformative visions are required to generate the energy and momentum for change across scales as a response to climate change. Concept and installation by Diego Galafassi and J. David Tàbara with drawings by Tone Bjordam. At the centre of the room, a rope spirals upwards from a table and opens up in mid-air into its four component strands. Each strand shoots out towards each of the four walls of the room. They split up further into their component strands forming a branching structure that connects to four drawings of possible Iberian futures, based on the Iberian Shared Socio-Economic Pathways (SSPs). Each drawing captures the essence of the four possible futures developed within the IMPRESSIONS project knowledge co-creation process amongst scientists and practitioners from various societal sectors. The table at the centre is an interactive space where visitors are invited to contribute their dreams and visions for the future of the Iberian Peninsula. A rope is composed of component strands which are twisted in the opposite direction of the rope. It is through the opposing forces and friction of the different strands that the whole stays together. The rope was used as a metaphor for how different visions and innovative solutions, not always going into the same direction, can work together to create a sustainable future. Presented at Garcia Matos cloister at San Francisco Cultural Complex in Caceres, Spain during September and October 2017. See the news item about the installation at http://www.stockholmresilience.org/news--events/general-news/2017-10-02-dealing-with-climate-change-on-the-iberian-peninsula.html

- **We are knot** is an open-ended participatory performance also designed for the third Iberian workshop in September 2017 exploring the edge of human motivation and willingness to act when confronted with a difficult situation that requires collective action such as the climate knot. The audience was brought up onto the stage where two actors were 'bundled' in an intricate web of knots. Initially the audience was passive and only watched. As the performance developed, following visual cues from the actors, the participants started untangling the knots, until the

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majority of participants became involved in the task. When the actors were 'untangled' they utilised the whole space and by their movement brought the participants together to the centre of the stage. The final act was the projection of images from around the world and natural environments on the ceiling of the Auditorium. This performance gave great insights into understanding some of the inner dynamics of 'human nature' by bringing both researchers and stakeholders to a real scenario and who took action in emergent and unexpected ways.

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- **Di-gestion / Di-gestión / De-management** is a food-art performance exploring the origin and development of visions and climate futures by the experiences in the most bodily, inner and sensorial processes of eating. Carried out at the final cross-scale workshop in Hungary in May 2018, both stakeholders and researchers were asked to sit at four different tables and were served four different menus, each designed in line with the four different SSPs used within the IMPRESSIONS case studies; and after having tasted, experienced and seen different feelings, sensations and reactions they were asked to guess which futures they were 'living in'. The idea of a continuum of the diversity of 'life inside' us and 'outside us' was also stressed ('we're only but one among many in us') by asking people to metaphorically go through a digestive system and be part of a performance in which the digestion and other more cosmic processes related to the idea that from 'digestion come life'. An extract of a poem read during the performance:

  There are 10 times more bacterial cells in my body than human cells
  To be human is to inhabit the world of just about 100 trillion other beings.
  To be human is to provide shelter, to be the carrier, it is to be home.
  To be human is to be humus,
  the soil from which other life grows.
  There is no solid line dividing the life inside and the life outside.

  We move inside a world of digestion
  Bubbling, dynamic, fluid
  a gut feeling sometimes is the best guide
  having the guts to change
  finding the heart of the matter
  emotions create the world, the world create emotions

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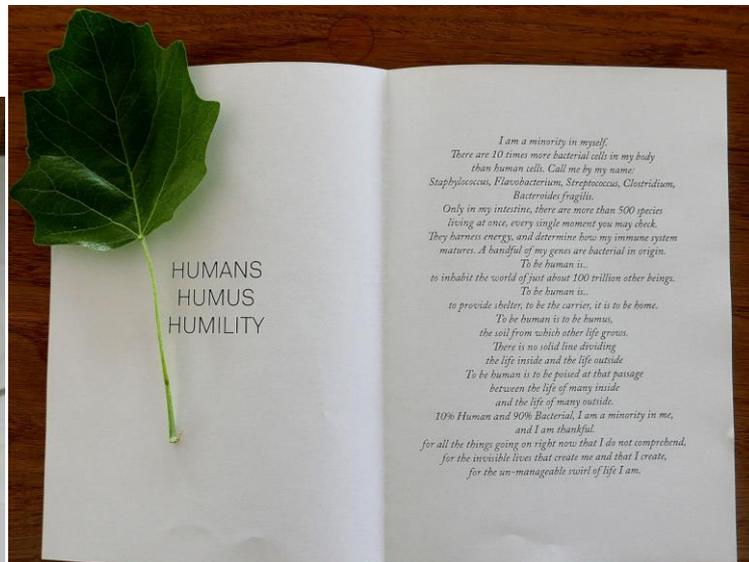
- **The Transformative Solution treasure hunt.** As part of the final cross-scale workshop art-science interface activities, a 'treasure solution hunt game' was designed to support the making of a joint participative installation based on the general conceptual message that *people will only find solutions if they look for them.* Hence, a total of 27 'game-changers' actions were printed, stuck on a variety of objects (mostly on tiles and small wooden planks, but also on others, like an small disused wheel) and hidden in various places of the hotel garden where the workshop took place. The list of solutions were selected from the analysis and synthesis of 'game-changers' actions already proposed by the IMPRESSIONS stakeholders in all the case studies (22) plus some additional ones proposed by J. David Tàbara based on a literature and policy review. Furthermore, about five planks were left blank so participants could add a few more in case they found anything missing. A most surprising and relevant outcome was that **the installation emerged as a spiral form in which at the core of it the solution on supporting a circular economy was placed.** In addition, **insisting on climate justice and implementing education** at all levels were put close to the core of the installation, that is, where the planks on 'Support circular economy, so as to close production-consumption-waste cycles' was placed. The results of the participatory installation seemed to be very similar or aligned with the results which emerged in the parallel and final participatory session on game-changers where four groups selected a few of the most important game-changers derived from earlier workshops and created a storyline on synergies and multiplicative effect among them: **in both cases the key role of changing the economy was underlined.**

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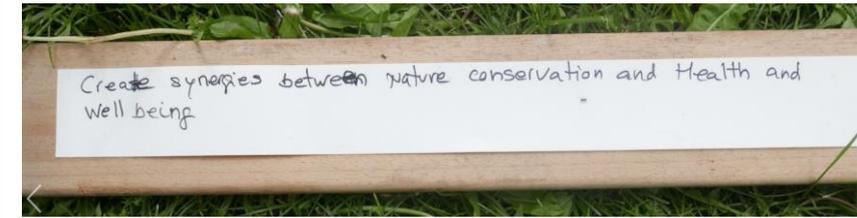
Annex 6: IMPRESSIONS publications on transformative strategies

Here we include the abstracts of the key publications developed in IMPRESSIONS on transformative solutions.

Tàbara, J.D., Jäger, J., Mangalagiu D. & Grasso, M. (2018). Defining Transformative Climate Science in the context of high-end climate change. *Regional Environmental Change.* **IMPRESSIONS project Special Issue. Open access at: https://link.springer.com/article/10.1007/s10113-018-1288-8**

High-end climate change requires transformative solutions, as conventional strategies and solutions will not be enough if major disruptions in social-ecological systems are to be avoided. However, conventional climate assessment approaches and methods show many limitations if they are to provide robust knowledge and support to the implementation of such solutions in practice. To this end, we define *Transformative Climate Science* as the open-ended process of producing, structuring and applying solutions-oriented knowledge to fast-link integrated adaptation and mitigation strategies to sustainable development. In particular, based on our experiences within regional cases in Central Asia, Europe, Iberia, Scotland and Hungary, we have selected 12 dimensions that scientists and practitioners can use as a checklist to design transformative-oriented climate assessments. While it is possible to talk both about *transformative adaptation* and *transformative mitigation*, in this paper we make the case that societal transformation does not depend on mitigation or adaptation policies and actions, mostly because they are related to sustainability innovations, which are endogenous developments derived from deliberate social learning.

Jäger, J. and Tàbara, J.D. 'Policy Insights' In: Berry, P.M., Betts, R.A., Harrison, P.A. and Sanchez-Arcilla, A. (Eds.) 2017. *High-End Climate Change in Europe.* **Available at http://highendclimateresearch.eu/**

Moving beyond the 2°C global warming threshold poses unprecedented challenges as well as new opportunities for societal transformation. High-end climate change requires innovative approaches in science and policy dealing with the ultimate causes of unsustainability. Integrated strategies for these new social-ecological conditions can only be achieved, and ensured in the long run, by linking climate-oriented, practical, systemic solutions to sustainable development.

Sustainable solutions are those that are able to overcome multiple trade-offs between ecological integrity and socio-economic goals in ways which can be turned into positive synergies. Clusters of sustainable solutions can be identified, tested and implemented by integrating multiple forms of knowledge and values in concrete places following transformative visions of the kind of world in which we want to live.

Conventional and additive approaches focusing on single sectors, scales or either adaptation or mitigation without considering long-term sustainable development will not be enough to cope with the mounting risks and challenges of high-end climate change. Innovative approaches entail *combining multiple systems of solutions* that not only solve present problems but also learn how to transform current systems arrangements so as to prevent them occurring again.

Conventional policy appraisal methods are designed for relatively short-term, well-understood policy choices in single sectors and are not feasible for transformative approaches combining multiple systems of solutions. They face severe limitations for assessing the impact of very long-term decisions about adaption and mitigation in the face of strong climate sensitivity and change.

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The most innovative and robust solutions to high-end climate change are those which contribute to the building the appropriate *system conditions and agent capacities* for charting alternative development pathways aligned with sustainability. Appraisal of policy options associated with selecting and implementing such solutions should focus on how they develop societal capacities to adapt to, cope with, but also reduce climate change.

Tàbara, J.D., Frantzeskaki, N., Hölscher, K., Pedde, S. Lamperti, F. Kok, K., Christensen, J.H., Jäger, J., and Berry, P. (2018). Positive tipping points for a rapidly warming world. *Current Opinion in Environmental Sustainability.* **Special Issue on Sustainability Governance and Transformation, 31. Open access at: doi: 10.1016/j.cosust.2018.01.012**

The challenge of meeting the UNFCCC CoP21 goal of keeping global warming 'well below 2°C and to pursue efforts towards 1.5°C' ('the 2°C-1.5°C target') calls for research efforts to better understand the opportunities and constraints for fundamental transformations in global systems dynamics which currently drive the unsustainable and inequitable use of the Earth's resources. To this end, this research reviews and introduces the notion of *positive tipping points* as emergent properties of systems – including both human capacities and structural conditions – which would allow the fast deployment of evolutionary-like transformative solutions to successfully tackle the present socio-climate quandary. Our research provides a simple procedural synthesis to help identify and coordinate the required agents' capacities to implement transformative solutions aligned with such climate goal in different contexts. Our research shows how to identify the required capacities, conditions and potential policy interventions which could eventually lead to the emergence of positive tipping points in various social-ecological systems to address the 2°C-1.5°C policy target. Our insights are based on the participatory downscaling of global Shared Socio-economic Pathways (SSPs) to Europe, the formulation of pathways of solutions within these scenarios and the results from an agent-based economic modelling.

Tàbara, J. D, St. Clair, A. L. and Hermansen E.A.T. (2017). Transforming communication and knowledge production processes to address high-end climate change. *Environmental Science and Policy,* **70:31-37.** http://dx.doi.org/10.1016/j.envsci.2017.01.004

Recent GHG emissions trends are in stark contrast with the Paris Agreement's target to hold the increase in average global warming to "well below 2°C and pursue efforts to stay below 1.5°C" by the end of the century compared with preindustrial times. This disconnect has further unveiled the limitations of current knowledge production and communication processes in Southern European countries, where fast institutional changes are needed to address the potential impacts as well as the opportunities for transformation derived from high-end climate change. The prevailing knowledge deficit-model – aimed at producing 'more knowledge' about climate impacts, vulnerabilities and long-term scenarios to decision makers – has long proven inadequate in tackling the many complexities of the present socio-climate quandary. The growing emphasis on assessing and implementing concrete solutions, demand new and more complex forms of agent interactions in the production, framing, communication and use of climate knowledge; and in particular, explicit procedures able to tackle difficult normative questions regarding assessment of solutions and the allocation of individual and collective responsibilities. To explore these challenges, we analyse the views of 30 Spanish knowledge contributors and users of the latest UN IPCC AR5 report and share the insights gained from the implementation of a participatory Integrated Assessment procedure aimed at developing innovative solutions to high-end climate scenarios in Iberia. Our analysis supports the view of the need to institutionalise transformation, and in particular underlines the potential role that transformative climate boundary organisations could play to address such difficult ethical choices in different contexts of action.

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Galafassi, D., Kagan, S., Milkoreit, M., Heras, M., Bilodeau, Ch., Juarez-Bourke, S., Merrie, A., Guerrero, L., Pétursdóttir, G. and Tàbara, J. D. (2018). 'Raising the temperature': The arts in a warming planet. *Current Opinion in Environmental Sustainability.* **Special Issue on Sustainability Governance and Transformation**, 31: 71–79. https://doi.org/10.1016/j.cosust.2017.12.010

The search for decisive actions to remain below 1.5^{o}C of global temperature rise will require profound cultural transformations. Yet our knowledge of how to promote and bring about such deep transformative changes in the minds and behaviours of individuals and societies is still limited. As climate change unravels and the planet becomes increasingly connected, societies will need to articulate a shared purpose that is both engaging and respectful of cultural diversity. Thus, there is a growing need to 'raise the temperature' of integration between multiple ways of knowing climate change. We have reviewed a range of literatures and synthesised them in order to draw out the perceived role of the arts in fostering climate transformations. Our analysis of climate-related art projects and initiatives shows increased engagement in recent years, particularly with the narrative, visual and performing arts. The arts are moving beyond raising awareness and entering the terrain of interdisciplinarity and knowledge co-creation. We conclude that climate-arts can contribute positively in fostering the imagination and emotional predisposition for the development and implementation of the transformations necessary to address the 1.5^{o}C challenge.

Grasso, M. and Tàbara, J.D. (in review). What ethics beyond two degrees? A moral compass to navigate high-end climate change. Submitted to *Ethics, Policy & Environment***.**

A high-end climate change world raises unprecedented challenges. Such challenges have profound moral – rather than simply scientific, technical, or managerial – implications for governance arrangements. Unfortunately, despite the growing recognition that morally-grounded, urgent social-ecological reconfigurations are needed for sustainably navigating the uncertain landscape of high-end climate change, an explicit moral guidance to support governance arrangements is still lacking. To fill this void, this work, through the metaphor of a *moral compass*, develops a normative tool for providing governance arrangements with the necessary moral guidance for identifying and establishing the transformative solutions required to sustainably navigate high-end climate change.

Galafassi, D., Tàbara J. D., Heras M. (in prep). Restoring our senses, restoring the Earth: Fostering imaginative capacities through Arts for envisioning climate transformations. To be submitted to *Elementa: Science of the Anthropocene***. Special Feature on Imagination and imaginative capacity for transforming to sustainability: Future thinking for a world of uncertainty and surprise.**

Humanity has never lived in a world where global average temperature is above two degrees of current levels. Moving towards such high-end climate change futures involves the need to confront high uncertainties, non-linear dynamics and multiple irreversibilities in global social-ecological systems besides fundamental challenges to current governance structures. In order to face high-end climate change, imaginative practices able to support multiple ways of learning and experimenting about the future are necessary. In this article we developed and analysed a set of art-based activities as part of a visioning process within the context of a five-year research aimed at identifying transformative strategies to high-end climate change. Various exploratory artistic activities were carried out as part of a science-led participatory knowledge co-creation process within the EU-funded project IMPRESSIONS. Our art-based approach combines a range of performative, visual and reflexive practices with the ambition to reach out to more-than-rational, but also practical elements of future visioning processes. We suggest that our art-based approach helped bring new ways of seeing, feeling and interpreting the world more conducive to realising the kind of fundamental transformations, both in subjective and collective sensibilities, needed to address high-end climate change.