ECONADAPT

The Economics of Adaptation

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Documentation of the Socio-economic scenarios and adaptation narratives developed and used in the case study WPs

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To find out more about the ECONADAPT project, please visit the web-site: www.econadapt.eu

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1 Introduction

ECONADAPT is an EC FP7 research project whose purpose is to support adaptation planning through building the knowledge base on the economics of adaptation to climate change and converting this into practical information for decision makers. Numerous participatory activities have been conducted to assess the needs of decision makers from EU, through country to local level. These included the bilateral meetings and interviews held at multiple levels detailed in Deliverable 1.1 as well as two key workshops.

Adaptation planning is complex, multi-dimensional, multi-actor and characterized by high uncertainty. The impacts and consequences of a changing climate on Europe are and will be far-reaching; many specifics of future climate change are still unpredictable and uncertain. Moreover, many other developments, such as economic, social, political, and environmental changes, will determine whether different regions will suffer or be able to adapt in the face of climate change. Developing and appraising climate adaptation policies, pathways and projects can therefore feel very daunting to decision-makers. Tools and techniques that can help adaptation planners cope with multiple dimensions of future uncertainties are sought at multiple levels from EU, through country to local level decision-makers.

1.1 Deviation from original title and content

During the construction of the Description of Work of ECONADAPT and during the early phases of the project, it was foreseen that foresight-related activities and in particular the development of socio-economic scenarios to contextualise adaptations and adaptation narratives would be a crucial part of the project. It was, however, decided to conduct an assessment of stakeholder' needs. This was undertaken during a workshop that was part of a larger OECD meeting (see Del 1.1 and Section 5.1 of this Deliverable). The results of this assessment clearly indicated that there was little need for a forward-looking component in their work. It was therefore decided to refrain from development of socio-economic scenarios and coupled scenario-related activities in WP 1. Similarly, the case study work did not focus on scenarios or adaptation narratives. Consequently, the content of this Deliverable has changed considerably compared to what was originally envisioned, reflecting the work that was done.

The first part of the Deliverable provides a theoretical and conceptual background to what scenarios are and what (global) scenarios sets were available for use in ECONADAPT. In Section 3, the terminology used in "foresight" is introduced and explained, ensuring that there is no confusion of how terms are understood within ECONADAPT. Section 4 presents some existing sets of global and European scenarios, with particular emphasis on the new global scenarios – SSPs and RCPs – and criteria for selection the best possible set of scenarios. The second part of the Deliverable provides an overview of the scenario-related activities undertaken in ECONADAPT. These include two workshops and a survey among ECONADAPT partners to study the use of scenarios in the project. Section 5 summarises and analyses the results of the OECD workshop and the workshop related to the future of the Common Agricultural Policy. Both workshops were documented elsewhere (see Deliverable 1.1 and Deliverable 7.1). Section 6 presents the results of a survey on how scenarios were used in the various WPs. The Deliverable closes with Section 7 that concludes and provides future recommendations on the use of foresight methods in this context.

2 Foresight, Scenarios and Their Usage

2.1 Introduction of terms: Foresight and Scenarios

Foresight
In general, "foresight" is used to describe future looking activities or methods. The European Foresight Platform (EFP) uses the term "forward-looking activities" (FLA) to contain foresight, forecasting, and other methods (horizon scanning, etc.). They are processes which collect future intelligence and build medium to long term visions aimed at influencing present day decisions and mobilising joint actions (Gavigan, Zappacosta et al. 2001, Popper and Teichler 2011). There are a diverse range of approaches to foresight. They can aim to reduce uncertainty by gaining further information on likelihoods, or help people cope with still inevitable uncertainty. Some exercises are focused on statistical modelling, or it can also be "a participatory process which brings together participants from science, industry, government, administration and other areas of society in order to identify and evaluate long-term developments in science, technology, industry and society" (Meissner 2013)(p. 906). Foresight has the potential to help states identify grand societal changes and contribute their development and vision to assist in translating societal challenges into operational realities (Popper and Teichler 2011). Foresight includes both processes which use qualitative or quantitative approaches to the development of futures, or a mix of both; and desk-studies as well as elaborate stakeholder-based processes. Any foresight activity that explores multiple futures produces 'scenarios'.

Scenarios
Scenario development traces back to the 1940s, when this methodology was used in a series of strategic studies for *military planning* purposes (Wack 1985). In the 1970s, the first scientific scenarios were introduced with the edition of the 1972 book *The Limits of Growth (Meadows, Meadows et al. 1972).* Later on, in the 1980s, scenarios were refined by Royal Dutch/Shell, who used scenarios within their approach to *business planning*. The first global environmental scenarios were produced by the Global Scenario Group, convened in 1995 by the Stockholm Environment Institute to analyse future paths for world development in the face of environmental pressures and crises in the twenty-first century. Today, scenario development is used in a large variety of different contexts ranging from political decision-making, to business planning, to local community management, and to global environmental understanding (Kok, van Vliet et al. 2011).

"The world is now moving through a period of extraordinary turbulence; the speed and magnitude of global change, the **increasing connectedness** of social and natural systems at the planetary level, and the growing complexity of societies and their impacts upon the biosphere **result in a high level of uncertainty** and unpredictability" (Gallopin, Hammond et al. 1997). In this context, scenarios become a good tool when: uncertainty is high, and controllability is low, or complexity is high, or causality is high" ((Raskin, Banuri et al. 2002); see Figure 1).

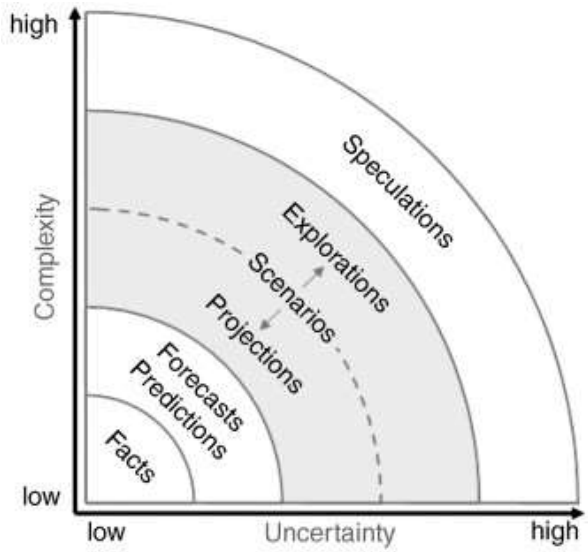


Figure 1. Dealing with uncertainties and complexity (source: Zurek and Henrichs, 2007)

For environmental scientists, interested in results, scenarios are a good tool for an integrated analysis of a complex problem since they provide in-depth insight in complex societal problems. For social scientists, focused on processes, scenarios are a good tool for communication, conflict management, and long-term participation. Scenarios provide an excellent tool for communication.

2.2 Scenarios – definition and use in ECONADAPT

2.2.1 Definition of scenarios

There are many definitions of what scenarios are, with only partial agreement, but all of them coincide in the statement that scenarios are not predictions, but a description of how the future might unfold. It is beyond the scope of this Deliverable to provide an overview of the rapidly growing field of future studies and the general use of 'scenarios'.
A scenario is commonly defined as "a story that can be told in both words and numbers offering an internally consistent and plausible explanation of how events unfold over time" (Gallopin, Hammond et al. 1997). A scenario describes some imaginable future state of the world, generated by tracing out a hypothetical but plausible chain of events. In this paper, we use scenarios as a broad concept, encompassing a range of methods and tools, including both explorative and normative and both qualitative and quantitative scenarios, as well as all other categories as mentioned by van Notten et al. (Van Notten, Rotmans et al. 2001). Scenarios are defined by Van Notten et al as 'consistent and coherent descriptions of alternative hypothetical futures that reflect different perspectives on past, present, and future developments, which can serve as a basis for action' (Van Notten, Rotmans et al. 2001). They can help decision making by providing a range of plausible futures which can be used to challenge assumptions about the future, to test policy and practice and to raise public awareness in the present.

Two additional relevant definitions, according to (Börjeson, Höjer et al. 2006) are:

- Scenarios are plausible descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key relationships and driving forces. (focus on system description)

- Scenarios are credible, challenging, and relevant stories about how the future might unfold that can be told in both words and numbers. (focus on value for end users and other stakeholders)

2.2.2 Scenario Typology

Despite recent methodological innovations, the typology of Van Notten et al. (Van Notten, Rotmans et al. 2001) still stands as a good starting point for categorizing important types of scenarios. They propose a classification based on fourteen aspects, among which are: (i) Inclusion of norms: descriptive or normative; (ii) Vantage point: exploration or backcasting; (iii) Data collection: desk research or participatory; and (iv) Data: qualitative or quantitative. Two types of scenarios have become particularly popular: 1) Explorative, participatory scenarios, recently often with strong quantitative and qualitative aspects. 2) Normative scenarios, either participatory or desk research, and often but not exclusively using back-casting methods. The two can be used in combination where a normative vision is back-cast through diverse exploratory scenarios to test what sorts of actions and policies are required to achieve the desirable outcome across different plausible future contexts. The aim of exploratory scenarios is to systematically explore and address a wide range of uncertainties. Exploratory scenarios can be used as wind tunnels in which to test policies and plans and thus it is important to specify a wide range of alternatives, including those that may at first glance seem unlikely, non-traditional or politically infeasible. The purpose of normative scenarios is to specify what we do and do not want, so we can work out how to steward the system towards desirable and away from undesirable states (system resilience).

2.2.3 Use of scenarios in ECONADAPT

In short, scenarios can be defined in many different ways, with clear differences between the definitions, mostly related to the purpose of using scenarios. There are, however, also clear similarities. Most scenario users seem to agree on the following common aspects of a scenario:

- Scenarios are most useful when facing a situation with an uncertain future outlook, partly caused by the complexity of the system under study
- Scenarios are NOT predictions or forecasts
- Scenarios consist of an endpoint (situation in some year in the future) and some description of how to get there
- Important characteristics of scenarios are qualitative/quantitative; normative/exploratory; expert-based/stakeholder-determined.
- Scenarios can be helpful in guiding action and evaluating the potential future robustness of adaptation options

In this Deliverable, we have used the term scenario rather loosely, including all major types of scenarios, and not limit ourselves to the category of qualitative, participatory explorations referred to in the title. Also, the scenarios reviewed and used in ECONADAPT involve a mixture of exploratory elements (resulting in narrative storylines and model inputs) and normative elements (roadmaps and adaptation options). The exploratory scenarios are given a normative interpretation in that they are perceived as more or less positive from an adaptation perspective. Miser and Quade (1988) provide a set of characteristics of a good scenario, including consistency, plausibility, credibility, rationality, relevance and utility. These characteristics are aimed for in ECONADAPT.

2.3 Foresight in relation to policy and decision-making

2.3.1 An overview of the literature

Many academic organizations, including the European Foresight Network, argue that foresight must impact decisions. For instance, in a study on foresight critical success factors, Calof and Smith highlighted that foresight must provide actionable recommendations which fit with today's policy and project environment (Calof and Smith 2012). Regardless of the foresight's mission statement, the true importance is measured by its actual impact on policy and projects. As stated by Havas et al. "It is crucial to prove the impact of foresight on decision making" (Havas, Schartinger et al. 2010)(p. 12).

In 'the tools of policy formulation: Actors, Capacities, Venues and Effects' (Jordan and Turnpenny 2015) a detailed description of policy formulation processes is given – and foresight/scenarios are analysed as one of a range of policy formulation tools, particularly suitable for the identification of strategic directions and priority setting, in a more transparent and inclusive fashion. Vervoort et al. outline how foresight can be used for the design of concrete and detailed plans, projects and policies through multi-stakeholder processes (Vervoort, Thornton et al. 2014). They argue that foresight can be a strong tool for the formulation and testing of policy and projects but that to be impactful, scenarios should be created or adapted to fit closely with the strategic focus of policies or plans, and used in a continuous, co-designed and co-owned process of policy formulation between policy makers, those facilitating the foresight, and other stakeholders. Rather than creating scenarios and then attempting to have impact through recommendations coming out of the foresight, the use of the scenarios should be fully integrated in policy and project formulation processes. Furthermore, the scenarios should be credible, legitimate and salient (Chaudhury, Vervoort et al. 2012).

There are two main categories for the sources of foresight: initiatives by the executing organizations (for instance, research organizations, civil society), and demand-driven foresight (Gavigan, Zappacosta et al. 2001, Popper 2009). The majority of cases correspond to the first case (individual/organization driven). However, the second case has been more prevalent at national level foresight. These activities tend to be more qualitative, while the regional level sees mixed/qualitative exercises.

According to Popper's European Foresight Platform Mapping Report, a foresight exercise can transform:

- Capacities and skills
- Priorities and strategies
- Paradigms and current visions
- Socio-economic and STI systems
- Behaviour, attitude, and lifestyles
- Knowledge-based products and services

As Major et al. argue, foresight in policy making can be defined as a deliberate attempt to broaden the "boundaries of perception" and to expand the awareness of emerging issues and situations (Major, Asch et al. 2001)(p. 93). Voros, Horton and Slaughter all state that foresight aims to support strategic thinking and decision-making by developing a range of possible ways of how the future could unfold (Slaughter 1995, Horton 1999, Voros 2003). It tries to capture and anticipate potential future developments and to generate visions of how society evolves and what policy and project options are available to shape a desired future. Foresight exercises can contribute to priority setting or recommendation as an input in the policy and project shaping process (Popper 2009)(p. 29)

Over the past years, foresight methods have become more widely used in policy and decision-making processes in some countries. According to Popper, “forward-looking elements have been integrated in several European policy instruments, such as the ERA-Nets Joint Programming Initiatives (JPIs) and Technology Platforms (e.g. in the form of technology roadmaps), and as diverse policy areas as agricultural and energy policy and projects have embarked upon initiatives to better coordinate future sectoral needs and research agendas, at national and European levels” (Popper and Teichler 2011)(p. 22). A detailed investigation on the issue of foresight impact on policy-making has been provided by Da Costa et al (Da Costa, Warnke et al. 2008). They have identified six functions of foresight for policy-making:

1. Informing policy by generating new insights
2. Facilitating policy implementation i.e. enhancing awareness of challenges to be addressed
3. Embed participation in policy-making.
4. Support policy definition i.e. translating outcomes into specific policy options.
5. Reconfiguring policy systems (so that they are more capable of addressing long-term issues).
6. Having a symbolic function, signalling the need for, for instance, an integrated regional approach.

Also, Havas et al. have contributed to foresight impact assessment by redefining foresight concepts to provide assistance in the decision making process (Havas, Schartinger et al. 2010). They have identified three main foresight functions:

1. Informing: Generating consolidated findings concerning the dynamics of change, future challenges and options.
2. Interpreting: Using the insight of foresight and merging those results with perspective on strategic positioning.
3. Facilitating: Fostering implementation by developing shared visions among major stakeholders on desirable future developments, and this implicitly coordinating their actions.

There are six important factors to ensure generating impact on policy through foresight.

These are:

1. Established relationships and networks with user communities.
2. Involvement of research users at all stages of the research.
3. Well-planned user-engagement and knowledge exchange strategies.
4. Use portfolios of research activity.
5. Good infrastructure and management support.
6. Where appropriate, the involvement of intermediaries and knowledge brokers as translators, amplifiers, network providers.

In short, there are a few different conceptual ways in which foresight can be used for/ facilitate/translate into concrete, short-term policy making. These, in turn, have given rise to a large number of methodologies, methods, and tools to operationalise this interaction. Because we have refrained from developing and/or using scenarios and other foresight methods in ECONADAPT such that these methods could be explored or implemented, we do not further elaborate on this potential, apart from highlighting some of the potential obstacles for impact.

2.3.2 Obstacles to impact

Consistent with the above examples of successful policy-focused foresight, a number of studies see the lack of integration between foresight processes and policy formulation in many case studies as a key obstacle to impact. Andersen and Rasmussen argue that many foresight projects have failed to impact policy-making, because they are carried out as stand-alone activities with their results not properly integrated into the necessary policy processes (Andersen and Rasmussen 2014). He suggests that foresight be an integral part of the policy making process with concepts such as adaptive and systemic exercises that encourage foresight to be designed as more tailored for policy. In a review of thirty-eight global, regional and national foresight studies on food-related sectors, namely: agriculture, rural development, energy, and forestry, Bourgeois et al observe that food-related foresight studies are increasingly including policy as an endogenous driver. This represents a shift from past foresight practices, that only considered policy as an external factor, although they included "policy shifts" as recommendations (p. 4-5). Popper, in a review of global foresight exercises, identifies "policy shift" as the most common type of recommendation in European foresight studies (p. 92). Recognizing policy as an endogenous driver of the food and agricultural sector has implications on whether or not policy-makers participate in foresight studies. He finds that typically when policy-makers are involved, there are higher chances of foresight having an impact on policy decisions.

Wengel states that excluding social structures and agencies or agents, which comprise formal institutions like policies, recommendations etc., from scenario exercises obstructs developing socio technically consistent and comprehensive scenarios (Wengel 2011). She also states that by not addressing the questions: *who to change*, *how to change* and *what to change,* foresight exercises underrepresent or only implicitly represent social structures and agencies. This is particularly important in action oriented back-castings that explore how a group of actors can achieve a desired future of some kind or avoid an undesired one. Konnola et al and Cariola et al share a similar view; they identify expectations on the management of foresight processes and final outcomes as important determinants of whether foresight will address societal challenges via policy (Cariola and Rolfo 2004, Könnölä, Scapolo et al. 2011). Similarly, Cagnin et al in their seminal paper on new approaches to Future-Oriented Technology Analyses (FTA) governance for equity, stress the importance of ensuring that FTA processes are inclusive if they are to impact policy making which aims ultimately at equity and governance. Foresight can only facilitate policy-making when there is active *societal* involvement (Cagnin, Loveridge et al. 2011). However, Konnola et al contradict this view; for them, *expert* involvement is the key to successful impact of foresight on policy. Their involvement allows stakeholders to become more aware of signals of change and threats, as well as put in place mechanisms that allow for timely action. Also, the intelligence or knowledge from expert participation contributes to the knowledge base for policy design. For the authors, exclusive participation rather than an extensive societal participation as implied by Cagnin et al. is more effective in shaping policy. Andersen and Rasmussen agree that expertise, which they define as individual's skills and knowledge in the particular area of foresight exercise, is often used to support top-down decisions, provide advice and make recommendations.

Konnola et al, Georghiou and Keenan, and Da Costa et al all claim that it is more difficult to evaluate the impact of foresight focused on long-term developments with emphasis on the system level on policy (Georghiou and Keenan 2006, Da Costa, Warnke et al. 2008, Könnölä, Scapolo et al. 2011). Konnola et al. also claim that policymakers do not refer to the sources used when decisions are made, which also contributes to the difficulty of tracing foresights' impact on policy. Foresight exercises, according to Konnola et al, conducted with the aim of generating information, will not necessarily lead to actions or identification of policy options. Rather, foresight with instrumental outcomes as the goal are more likely to lead to development of actions and therefore useful for supporting policy-making. Interestingly, they

state that positioning a foresight exercise or project as informative and communicating this objective to stakeholders has the tendency to limit the involvement of stakeholders who wish to be closer to decision-making. Therefore, similar to Bourgeios' view, they suggest that alternative forms of participation for decision-makers in foresight exercises be given serious consideration.

Georghiou and Keenan are of the opinion that for foresight to be effective in shaping policy, since policy is influenced by several factors, it needs to be tuned in to the strategic behaviour and cycles of policy and economic actors. Foresight does not always consider the needs of recipients, making it relatively easy for noise to blight its signal, preventing its adoption by policy makers. It becomes important therefore to present foresight in a manner that policy mechanisms can receive and easily absorb. Timing becomes of import here as well, and needs to be aligned with policy cycles. The results of the UK Technology Foresight Programme is a case-in-point; failing to be submitted early enough for the Research Council to implement, its reform capacity was delayed and eventually diminished. However, Georghiou and Keenan go on to state that foresight cannot always work within the status quo, and on some occasions it is the policy structure that will need to change to accommodate foresight's disruptive information. Grupp and Linstone concluded that foresight was more valuable as a communication technique for government and industry (Grupp and Linstone 1999). Considering these various sources of policy influences, such as lobbying, budgetary analyses, historic commitments etc., Georghiou and Keenan are of the opinion that there is the problem of attributing the source of policy to foresight exercise, but in the same vein, taking a more holistic and systemic framework that views foresight as complementary to other policy tools may be advised (Georghiou and Keenan 2006).

Several lessons come out of these reviews. Firstly, for foresight to be impactful, it should be integrated with policy, and co-designed and co-owned to a degree by policy makers. Secondly, it should also be understood that it may be difficult to measure some types of policy impact in less targeted foresight exercises, which might nonetheless be highly useful. Research on the learning effects of scenarios (Schoemaker 1993, Glick, Chermack et al. 2012) provides a promising avenue for documenting impacts in other ways than through impacts on policy. Finally, the integration of policy and foresight is a challenging undertaking which brings up new challenges, including the right timing, trust between actors involved, the fragmented and dynamic nature of policy environments, and other issues (Vervoort, Thornton et al. 2014).

3 Review of relevant scenario activities

This chapter has two main parts. First, the process of selecting the best set of (global) scenarios is described, starting from the assumption that the RCP x SSP scenarios are favourable (Section 3.1-3.4). This is followed by an overview of consideration how to select, within the RCP x SSP scenarios, the most meaningful subset to be used. The second part of this chapter is a short overview of socio-economic scenarios, the SSPs and other sets of scenarios that could be related to these (Section3.5).

3.1 Introduction to the new global scenarios: The RCP x SSP scenarios

This chapter provides a short overview of existing global scenarios and the development process of the new global scenarios, referred to here as the RCP x SSP scenarios, as background to the subsequent chapters on climate and socio-economic scenarios. Additionally, a summarising overview is given of the (combinations of) RCPs and SSPs that are considered most useful. This chapter draws from earlier similar endeavours, notably within another ongoing EC-funded FP7 project, IMPRESSIONS (www.impressions-project.eu; see also Kok et al., 2015).

3.2 Existing scenarios and selection of a best set

A small set of existing global scenarios was evaluated for their potential usefulness within ECONADAPT. We opted for a small set only, given the strong preference for the RCP x SSP scenarios (see Section 5). An evaluation against other existing global scenarios was undertaken in order to better understand the strengths and weaknesses of the RCP x SSP scenarios. Besides the RCP x SSP scenarios, the global scenarios included were:

- IPCC Special Report on Emission Scenarios. (IPCC SRES; Nakićenović et al., 2000). Focus: climate and greenhouse gas emissions. This is the most used and most well-known of all scenario sets in existence. It is global but has been used as the starting point for many continental and national scenario sets.

- Millennium Ecosystem Assessment (MA; MA, 2005). Focus: ecosystems and ecosystem services. This set of four scenarios does not specifically include information related to climate change (impacts), but the socio-economic scenarios are very elaborated and include an unmatched detail on changes in land-based systems.

- Global Environment Outlook (GEO-3, GEO-4; UNEP, 2002, 2007). Focus: integrated view on the environment. An important strong point is the availability of storylines for Europe, as socio-economic scenarios were developed at the continental level.

- Shell scenarios (Shell, 2008). Focus: energy. The lack of specificity for Europe and the minimal use of quantitative models are important drawbacks. These scenarios have been mostly included because of the focus on the energy sector and the distinctly different (business) starting point.

Additional sets of (more recent) global scenarios were included only in an initial screening. Interesting work includes recent initiatives related to the Global Scenario Group (see www.gsg.org); the World Water Scenarios developed and further explored at IIASA; and the OECD scenarios. None were deemed sufficiently useful to include in this evaluation.

Table 1 provides the criteria used for the evaluation and the scores for the global scenarios that were included. From the results, the most important conclusion is that the RCP x SSP scenarios are most useful for adoption in ECONADAPT, although scores differ relatively little. The Shell scenarios scores lowest, mostly based on an overall lower scoring in many important categories, such as scientific acceptance, degree of quantification, and specificity for Europe. In relation to the RCP x SSP scenarios, the following conclusions seem valid.

Table 1: Criteria for usefulness for IMPRESSIONS and scores for existing global scenario sets.

Criteria	**RCP x SSP**	**IPCC SRES**	**MA**	**GEO-4**	**Shell**
Degree of detail in stories	5	5	8	6	6
Specificity for Europe	2	4	2	5	2
Time horizon	9	6	8	8	8
Degree of quantification	6	9	7	6	4
Scientific acceptance	6	9	8	8	5
Acceptance by policy-makers	8	8	5	6	6
Information on relevant sectors	8	8	7	5	6
Degree of 'currentness'	10	2	3	4	6
Availability	6	5	8	8	7
Total Score	*60*	*56*	*56*	*56*	*50*

Arguments in favour of selecting the RCP x SSP scenarios:

- **Only RCP x SSP scenarios are sufficiently recent**. All of the global scenarios sets that were included in the evaluation, except for the RCP x SSP scenarios, are not very recent. As most were developed about 10-15 years ago, this also explains why there was a need for a new set of global scenarios. It is a strong argument against using any other set of scenarios.
- **Only RCP x SSP has a time horizon of 2100**. Most of the global scenarios have a time horizon that is (much) shorter than 2100, although the IPCC SRES scenarios do extend until the end of the century. Although ECONADAPT is not specifically focusing on this very long-term outlook, the possibility to do so in a project related to climate change (adaptation) is an advantage.
- **RCP x SSP is very broad and includes both very low emission scenarios (RCP2.6) and very high-end climate change (RCP8.5).** Particularly the MA and the GEO-3/4 scenarios do not focus on climate change. A possible exception is the SRES A1FI scenario that is comparable to RCP8.5.
- **RCP x SSP is a set of global scenarios that should replace the IPCC SRES scenarios.** The previous points indicate that the IPCC SRES scenarios are most likely the second best choice. Yet, the RCP x SSP scenarios will replace the SRES scenarios as the new IPCC standard.

The main argument against the selection is:

- **The RCP x SSP scenarios are under development**. Using very recent scenarios comes at a price. As can be seen in Table 1, scores for several criteria are lower than for other scenario sets because of its recent completion (e.g. specificity for Europe; degree of quantification; acceptance by scientists). It is expected that this will improve rapid, and indeed the data availability is increasing rapidly.

In short, although using a very recent set of scenarios comes with the risk of using products that might not live up to expectations, the RCP x SSP set is the only sufficiently recent set of global scenarios that extend until 2100, that are directly related to climate change, and that offer socio-economic scenarios of sufficient detail.

3.3 An introduction to the process of developing the RCP x SSP scenarios

A process is under way in the climate change research community to develop a new set of integrated scenarios, the RCP x SSP scenarios, describing future climate, societal, and environmental change (Moss et al., 2010; see Figure 2). This process started with the development of representative concentration pathways (RCPs) that describe a set of alternative trajectories for atmospheric concentrations of key greenhouse gases (Van Vuuren et al., 2011). Based on these, climate modellers produced a number of simulations of possible future climates over the 21st century (Taylor et al., 2012). In parallel, other researchers are producing a new set of alternative pathways of future societal development, described as shared socio-economic pathways (SSPs), and using integrated assessment models (IAMs) to produce additional quantitative elements based on them, including future emissions and land use change. A conceptual framework has been produced for the development of SSPs (O'Neill et al., 2014) and for how to combine IAM scenarios based on them with future climate change outcomes and climate policy assumptions to produce integrated scenarios (Ebi et al., 2014; Kriegler et al., 2014) and support other kinds of integrated climate change analysis.

As is clear from Figure 2, the "parallel process" as proposed and executed to develop the global scenarios is highly compartmentalised. Table 2 shows the basic lay-out of the compartments and how they can be assembled to develop "integrated scenarios": The **rows** represent four RCPs that correspond to certain greenhouse gas concentration developments. These are being used by the climate modelling community to link them to certain ranges of temperature, precipitation and sea level. As such, the rows represent the biophysical system dynamics and the effects on climate change. The **columns** represent five SSPs that correspond with distinct paths of development of the socio-economic system, focusing on mitigation and adaptation potential. The SSPs do *not* include adaptation/mitigation options or climate policies. Finally, the **cells** are the integrated scenarios where assumptions on climate, the socio-economic system and adaptation, mitigation and climate policies come together. Note that this approach assumes that RCPS and SSPs can be developed independently, while shared climate policy assumptions (SPAs) will always be in response to both a certain RCP and a certain SSP. Figure 2 indicates how, with the completion of RCPs, SSPs and earth system model runs, the scientific community is now facing the challenge of how to integrate the separately developed products over a range of scales to assess climate change impacts, vulnerability, adaptation and mitigation.

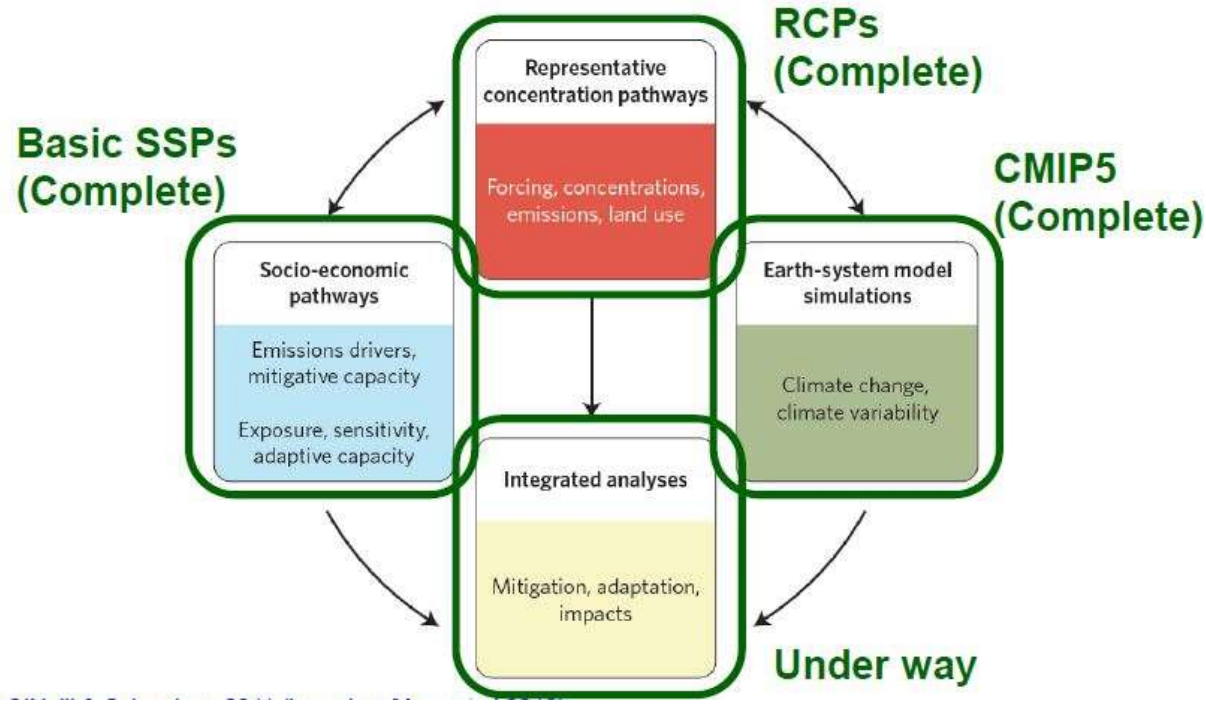


Figure 2. Framework of the new integrated global scenarios. Text in green indicates progress by the end of 2014. Source: O'Neill and Schweizer (2011).

Table 2. Scenario development approach showing the connection between Representative Concentration Pathways (RCPs), Shared Socioeconomic Pathways (SSPs) and Shared Policy Assumptions (SPAs) in the new global scenarios.

RCP (W/m^2)	SSPs				
	SSP1	**SSP2**	**SSP3**	**SSP4**	**SSP5**
2.6					
4.5	SPA				
6.0					
8.5					

3.4 Selection of RCP and SSP combinations

In general terms, it is not advisable to select all possible combinations between RCPs and SSPs. As there are multiple (> 20) climate models, multiple impact models, multiple sets of policies and other actions, the total number of different future outlooks to explore would very quickly become very large. It is therefore always advisable to select a small and manageable set of future scenarios that would still give rise to a rather large set of future impacts and adaptation options to potentially consider.

Here we briefly describe the reasoning for the selection of a set of RCP x SSP scenario combinations as they are being used in the IMPRESSIONS project. Although this project particularly focuses on high-end climate change, the logic of the selection process translates to other projects, and particularly to ECONADAPT similarly studying climate change adaptation as a result of both socio-economic and climatic development.

3.4.1 Selection of RCPs and SSPs

There are four RCPs that cover a very large range of possible greenhouse gas concentration trajectories, ranging from +2.6 to +8.5 W/m^2 (values in the year 2100 relative to pre-industrial values). Given that the overall aim of IMPRESSIONS is to study the impacts of high-end scenarios, it was decided to select RCP8.5 and RCP4.5. However, besides ensuring that high-end climate change scenarios are included, this selection also signifies that:

- A broad range of mean temperature changes (2-6 degree Celsius) is considered; and
- Lower-end climate change scenarios are not excluded

It was decided to select SSP1, SSP3, SSP4 and SSP5 for a variety of reasons:

- These four SSPs capture a very broad range of socio-economic development pathways;
- SSP2 is intermediate between these four SSPs and is the most 'moderate' scenario;
- SSP2 has no equivalent in many other scenario datasets and is therefore difficult to match to existing model runs, databases, or other scenarios.

3.4.2 Selection of RCP x SSP combinations

Out of the eight possible combinations between two RCPs and four SSPs, five combinations were proposed as a minimum set to be used in the IMPRESSIONS as starting point for the participatory scenario development work (see Table 3). This links the SSPs with low mitigation challenges (SSP1/4) to RCP4.5 and those with high mitigation challenges (SSP3/5) to RCP8.5. We also assume that SSP3 matches reasonably well to both RCPs, enabling the effect of a different RCP, under the same SSP, to be analysed. Furthermore, both low adaptation challenges (SSP1/5) and high adaptation challenges (SSP3/4) are confronted with both RCPs. By having a certain amount of flexibility to vary the amount and type of climate change within an RCP, we keep options open to further discuss the exact nature of the combinations as work progresses.

Table 3: Selected RCP x SSP combinations and their characteristics.

	Low adaptation challenges	High adaptation challenges
High mitigation challenges	RCP8.5 x SSP5	RCP8.5 x SSP3
Low mitigation challenges	RCP4.5 x SSP1	RCP4.5 x SSP4 RCP4.5 x SSP3

In more general terms, these conclusions seem valid:

- There is a strong overlap in amount of climate change generated by the emission levels of the four RCPs. Selecting RCP4.5 and RCP8.5 ensures that almost the entire range of temperature changes is covered. This is likely to exclude global warming below 2 degree Celsius, for which RCP2.6 or below is needed

- When stakeholders are to be involved in the process of scenario development, the total set of RCP x SSP needs to be limited to maximally 4. This seems to be the maximum number of distinct futures that any group of stakeholders can meaningfully use.

- When stakeholders will not be involved, the total set of RCP x SSP combinations can obviously be larger, as there is no upper limit to the number of model runs. Yet, the degrees of freedom increase rapidly when considering different climate models, impact models, parameter settings, etc. For model use, it is recommended to at least consider all possible combinations of RCPs and SSPs.

Note that work is underway of the IAM community to attempt to reproduce RCPs, using the SSPs as input. From these analyses it seems that RCP8.5 can only be reached in an SSP5 world, while RCP2.6 cannot be obtained in any socio-economic scenario except SSP1.

3.5 The Shared Socioeconomic Pathways (SSPs)

This section provides an overview of the four global SSPs as deemed most useful for ECONADAPT in terms of a summary of the narrative, trend indications of key elements, and a graphical representation of the scenarios plotted in a diagram with two key uncertainties. Narratives and key elements of the downscaled, equivalent European SSPs can be found in Annex 1. Figure 3 provides an overview of the five SSPs.

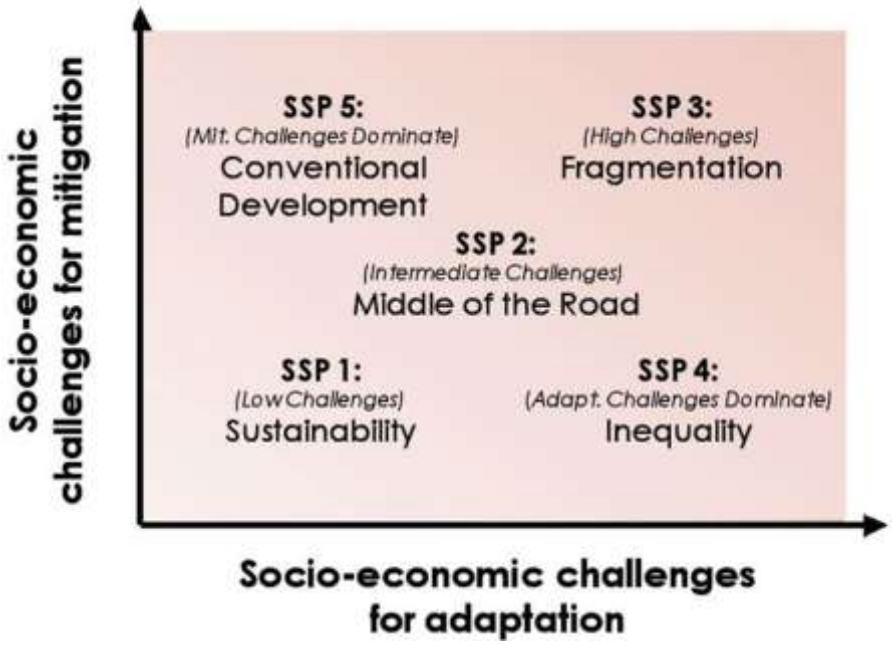
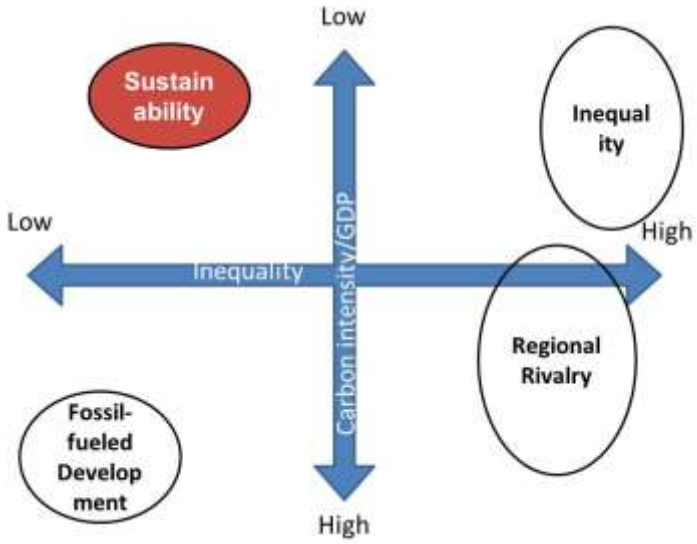


Figure 3. The Shared Socio-economic Pathways (SSPs) of the new IPCC-guided scenario set.

3.5.1 SSP1: Sustainability – The Green Road

Within *Sustainability*, there is a high commitment to achieve development goals, to increase environmental awareness worldwide, and to gradually move toward less resource-intensive lifestyles. The world shifts gradually, but pervasively, toward a more sustainable path, emphasising more inclusive development, driven by increasing evidence of, and accounting for, the social, cultural, and economic costs of environmental degradation and inequality. The shift evolves over time, is not uniform, and is punctuated by periodic tragedies that bring these costs into stark relief. Over time, the initially disparate constituencies become mutually reinforcing, ultimately leading to effective and persistent collaboration. The world is further characterised by a combination of directed development of environmentally friendly technologies, a favourable outlook for renewable energy, institutions that can facilitate international cooperation, improved human well-being, and relatively low energy demand. Overall, it is a bumpy road, but one that eventually moves the world in a more sustainable direction.

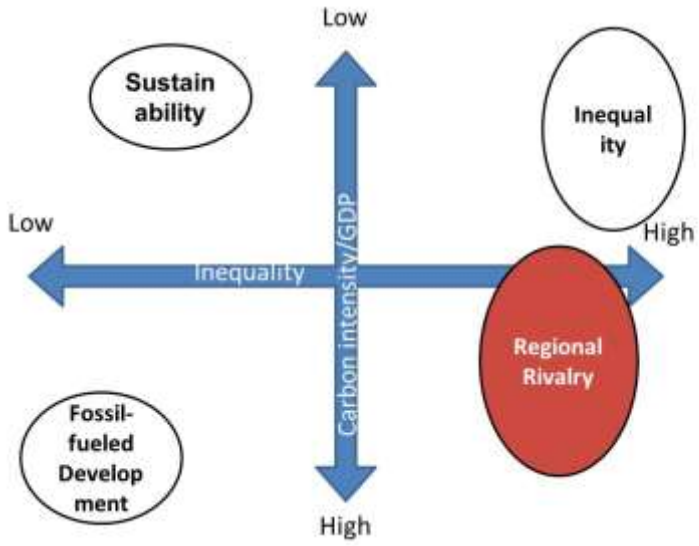
Key assumptions	**Sustainability – The Green Road**
Environmental policies	Improved management; strong regulations
Policy orientation	Towards sustainable development
Institutions	Effective
Education	High
Social cohesion & equity	High
Health investments	High
Inequality	Reduced across and within countries
Globalisation	Connected markets, local production
Consumption and diet	Low growth in material consumption, low meat diets
Population growth	Relatively low
Technology development & transfer	Rapid
Carbon (energy) intensity	Low
Environmental status	Improving conditions



3.5.2 SSP3: Regional Rivalry – A Rocky Road

Sparked by economic woes in major economies and regional conflict over territorial and national issues, antagonism between and within regional blocs increases. This causes a resurgent nationalism, concerns about competitiveness and security, and regional conflicts, which push countries to increasingly focus on domestic or, at most, regional issues. This trend is reinforced by the limited number of comparatively weak global institutions, with uneven coordination and cooperation for addressing environmental and other global concerns. There are pockets of extreme poverty alongside pockets of moderate wealth, with many countries struggling to maintain living standards and provide access to safe water, improved sanitation, and health care for disadvantaged populations. The world is further characterised by growing resource intensity and fossil fuel dependency along with difficulty in achieving international cooperation and slow technological change.

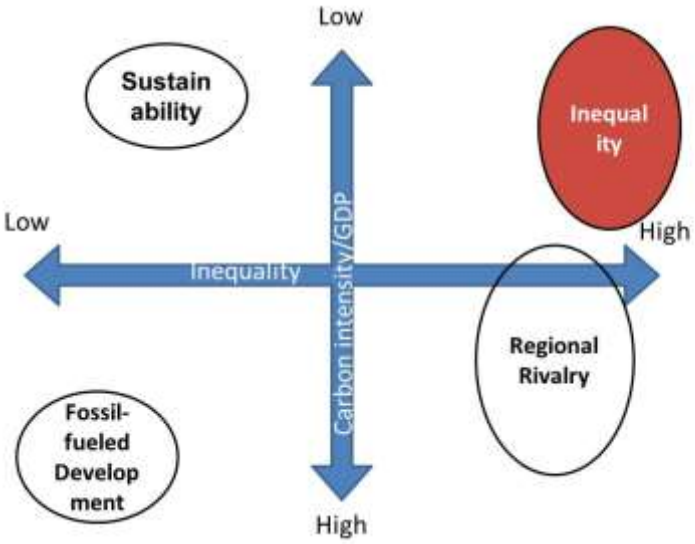
Key assumptions	**Regional Rivalry – A Rocky Road**
Environmental policies	Low priority for environmental issues
Policy orientation	Towards security
Institutions	Weak global; national governments dominate
Education	Low
Social cohesion & equity	Low
Health investments	Low
Inequality	High, especially across countries
Globalisation	De-globalising; regional security
Consumption and diet	Material-intensive consumption
Population growth	Low in OECD; High in high fertility countries
Technology development & transfer	Slow
Carbon (energy) intensity	High, particularly in regions with fossil fuel resources
Environmental status	Serious degradation



3.5.3 SSP4: Inequality – A Road Divided

Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that is well educated and contributes to knowledge- and capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labour intensive, low-tech economy. Power becomes more concentrated in a relatively small political and business elite, which is capable of acting quickly and decisively. At the same time, substantial proportions of populations have a low level of development and limited access to effective institutions for coping with economic or environmental stresses.

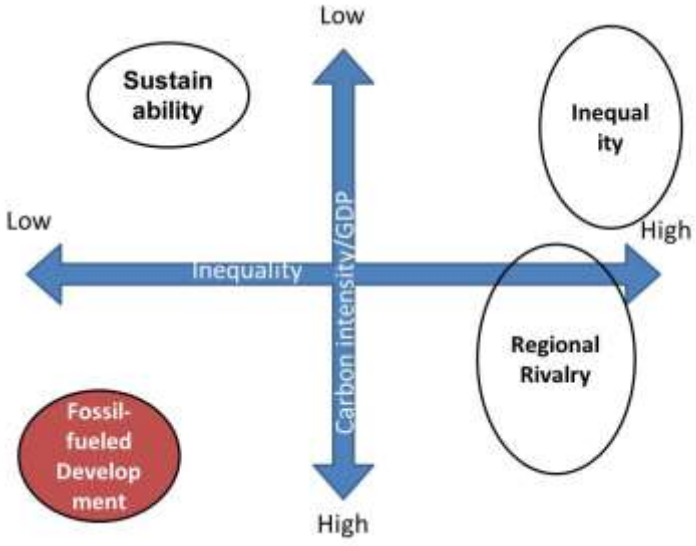
Key assumptions	**Inequality – A Road Divided**
Environmental policies	Focus on local environment in high-income countries; no attention to global issues
Policy orientation	Towards benefit of the political and business elite
Institutions	Effective for elite
Education	Very low to medium, very unequal
Social cohesion & equity	Low, stratified with medium equity
Health investments	Unequal within regions, lower in low income countries
Inequality	High, especially within countries
Globalisation	Globally connected elite
Consumption and diet	Elite: high/material; rest: low
Population growth	Low in OECD, relatively high elsewhere
Technology development & transfer	High in high-tech economies and sectors; slow in others with little transfer
Carbon (energy) intensity	Low/medium
Environmental status	Highly managed near high-income areas; degraded otherwise



3.5.4 SSP5: Fossil-fuelled Development – Taking the Highway

Driven by the economic success of industrialised and emerging economies, this world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated, with interventions focused on maintaining competition and removing institutional barriers. The push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles, linked to a strong faith in the ability to effectively manage social and ecological systems. The world is characterised by a strong reliance on fossil fuels but a total lack of global environmental concern.

Key assumptions	**Fossil-fuelled Development – Taking the Highway**
Environmental policies	Focus on local environment, little concern with global issues
Policy orientation	Towards development and human capital with free markets
Institutions	Increasingly effective
Education	High
Social cohesion & equity	High
Health investments	High
Inequality	Strongly reduced, especially across countries
Globalisation	Strong and increasingly connected markets
Consumption and diet	Materialism, high consumption, meat-rich
Population growth	Relatively low
Technology development & transfer	Rapid
Carbon (energy) intensity	High
Environmental status	Highly engineered approaches



3.5.5 Differences and commonalities between the SSPs

A first and most crucial observation is that there are two pairs of SSPs:

SSP1 and SSP5: The future outlook of both scenarios is, in essence, positive. Low population growth, high levels of education, equity and a sustained economic growth in an increasing globalisation world. In fact, the two narratives are similar in most other characteristics (technological change, institutions) as well. And indeed, together, those aspects results in both cases in futures where challenges to adaptation are low, for similar reasons. Yet, there are crucial differences. Perhaps most importantly, in SSP5 the focus is on improving of human capital, whereas in SSP1 natural capital comes first. In SSP5, quickly improving human well-being is (literally) fuelled by cheap fossil fuels, and without much attention for environmental degradation. Although the seeds are present, society in SSP5 does not transform to a low-input, low-output world which does results towards the end of SSP1.

SSP3 and SSP4: The future outlook of both scenarios is, in essence, negative, except for the upper class. For the vast lower class, population growth is high, education levels remain low, equity is low, as well as economic growth. Additionally, both scenarios assume slow technological development and high resulting environmental impacts. Consequently, both scenarios project high challenges for climate adaptation. However, there are crucial differences, mostly related to the degree to which societies become unequal. In SSP3, there is a growing gap between rich and poor, but without the rich being more than moderately wealthy and not well-connected. In SSP4, the gap between the poor masses and the global elite is huge, with the elite benefiting in every sense of the word, without sharing much with the rest of the population. This gives rise to fundamental differences between SSP3 and SSP4, in which it is assumed that there is an elite that is well organised, globally connected, and with access to new technologies and accompanying low energy intensity. Consequences also include less environmental impacts and a more diversified use of energy sources, as well as high urbanisation rates. Based on a similar starting point and similar initial trends, SSP3 and SSP4 partly develop to similar circumstances by 2100, but they are also very different in some respects, particularly related to challenges to mitigation.

In conclusion, SSP1 is a utopian, sustainable future; SSP3 is a dystopian, doom scenario. Both exist in many scenario sets and mirror in many ways earlier endeavours. In SSP4, a growing and powerful elite successfully escapes the misery; the scenario is a mix between elements of SSP1 (for the elite) and SSP3 (for the masses). In SSP5, trends mirror those in SSP1, but low priorities for environmental protection bend some trends in the direction of SSP3. The scenario is a mix between SSP1 (early stage) and some hints of SSP3 (later stage). As a result, drivers are unique sets for the four SSPs. Impacts, however, may be very similar for SSP1 and SSP5 (because of similarities early in the stories) and for SSP3 and SSP4 (because of similarities in how the masses are impacted).

3.6 Other existing European scenarios

Most of the work undertaken within ECONADAPT relates to developments in Europe. It is therefore essential to also evaluate (other) existing sets of scenarios for Europe. Within the many sets available, two stand out. First and foremost, there is a set of recently completed European SSPs that are readily available and that closely match the global SSPs (see Kok et al., subm.), including downscaled narratives, tables with key elements and quantification of key drivers. These Eur-SSPs, in turn, were partly based on another set of existing European scenarios, developed during an earlier FP7 project, CLIMAVE (http://www.climsave.eu) on the adaption to climate change. Within CLIMSAVE, a set of socio-economic scenarios was developed for Europe and Scotland. The CLIMSAVE scenarios are described in detail in a series of project deliverables, importantly D1.2 (Gramberger et al. 2011a), D1.3 (Gramberger et al. 2012a), and D1.4 (Gramberger et al. 2013a). A short summary of the CLIMSAVE European socio-economic scenarios is provided below (see Figure 4):

Figure 4: Four European socio-economic scenarios positioned along two axes of main uncertainties.

We are the World: Effective governments change the focus from GDP to welfare, which leads to a redistribution of wealth, and thus to less inequality and more (global) cooperation.

Towards 2025: The financial crisis continues to have strong repercussions and EU leaders are forced towards further European financial policies. The crises fuel the feeling that behaviour has to change putting governments under pressure to take ambitious measures, including support for innovative research facilities. This results in a higher quality of life and a growing feeling of security and safety. Trade wars and crises are solved by the increased effectiveness of governments worldwide. By 2025, efforts to transform Europe and the rest of the world into a sustainable environment are now starting to pay their dividends.

Towards 2055: There is a focus on welfare rather than on GDP. The European Union has expanded further and the implementation of global governance advances. This also leads to a much safer world. On a technological level there is a lot more international competition as of 2030. A world constitution is adopted based on values such as equality and equal redistribution of resources for all. In 2050 technology has made it possible to live in a CO_2

neutral society. The redistribution of wealth globally has led to less inequality, more cooperation and a conflict free world.

Icarus: Short-term policy planning and a stagnating economy lead to the disintegration of social fabric and the shortage of goods and services.

Towards 2025: With the economy gradually picking up, the demand for resources increases, which turns out to be a tipping point for the state of the environment with severe ecosystem failures. Extreme weather events become more frequent and further increase the costs of resources, because of which the economy in Europe starts stagnating. In light of increasingly scarce public resources, long-term policy planning becomes rare with hardly any money for education, research or innovation. Eventually the EU breaks down.

Towards 2055: The stagnation of the economy leads to high unemployment rates and the breakdown of the social security system. This widens the gap between the haves and the have-nots. With the disintegration of social fabric, Europeans start to migrate to the BRIC countries, whose economies prosper. The impact of extreme weather events, together with economic decline bring about shortages of essential goods and services. Eventually some counter-movements are starting to take root with some signs of a slight economic recovery and post-modern values becoming more important.

Should I Stay Or Should I Go: Failure to address the economic crisis leads to an increased gap between rich and poor, political instability and conflicts; people live in an insecure and instable world.

Towards 2025: In an attempt to revamp the European economy quickly, policy-makers decide to invest in innovations with a big return on investment in the short run. Meanwhile, the depletion of natural resources continues and natural hazards increase in severity. Commodity prices go up and there is a slowly growing underclass that can no longer afford utility services. Attempts to find innovative solutions to combat the depletion of natural resources are unsuccessful. There is a widening gap in society, which feeds social unrest and triggers migration. Europe has altogether become a more dangerous place.

Towards 2055: Short economic revivals only add to the increasing gap between rich and poor, while most of society cannot adapt to the rollercoaster economy and suffers from health issues, unemployment, and poverty. The divide between the “affected” and “not affected” leads to conflicts over scarce resources, political instability and government failures. Governments start to regulate the use of resources very strictly and instate power cuts and water rationing. People start exchanging goods, work or services rather than paying for them. Organised crime has reached an all-time high and people live in an insecure and instable world.

Riders on the Storm: Strong economic recessions hit hard, but are successfully countered with renewables and green technologies. Europe is an important player in a turbulent world.

Towards 2025: Extreme weather events lead to food shortages and price increases, and suppress economic growth. Yet, the EU is committed to finding innovative solutions to the depletion of natural resources and climate change. Key to this strategy is public-private collaboration. The constructive approach makes the EU stronger and more influential, while global political stability decreases. The lack of a global market for green technology triggers a strong economic recession.

Towards 2055: Counter measures in the EU are successful with high energy efficiency and renewable sources reducing the dependency on natural resources. Additionally, people have become used to a lower standard of living. A new wave of severe climate change impacts

does not affect Europe but hits hard in the rest of the world. Europe displays a steady green GDP growth and an increase in purchasing power, which is reflected in a population increase. The demand for green technology has also grown with the recovery of the world economy. The enormous investments finally pay off. Although the world economy remains turbulent, Europe is an important player.

3.7 Matching existing scenario sets: global SSPs and CLIMSAVE

Increasingly, scenario development relates to the combination of existing sets of scenarios, as the number of foresight studies expands. It is beyond the scope of this Deliverable to elaborate on the many issues when attempting to combine multiple existing sets of scenarios, often developed for different purposes, at different geographical scales and/or with different crucial assumptions. Instead, below is the example of this combination of the CLIMSAVE scenarios and the global SSPs and the some of the methodological decisions that needed to be taken in order to conceptualise the use of two existing sets of scenarios. Table 4 shows the CLIMSAVE scenarios with illustrative examples of three uncertainties as identified by stakeholders, together with the most similar SSP.

Table 4: CLIMSAVE scenarios for Europe with illustrative examples for economic, environmental and social uncertainties, and most similar SSP.

Scenario	Economic	Environmental	Social	SSP
We are the World	Gradual increase	Effective solutions	High social cohesion	SSP1
Icarus	Gradual decline	Ineffective solutions	Decline, then picking up	SSP3
Riders on the Storm	Rollercoaster downwards	Effective solutions	Low social cohesion	SSP4
Should I Stay or Should I go?	Rollercoaster up and down	Ineffective solutions	Low, but growing	No SSP equivalent

An analysis of Table 4 and other elements within the CLIMSAVE and SSP scenarios revealed:

- Three out of four SSPs match to greater or lesser degree one of the CLIMSAVE scenarios.

- The strongest match is with the Utopian SSP1 (We are the World) and the Dystopian SSP3 (Icarus). A fair match is found with SSP4 (Riders on the Storm), mostly in relation to strong economic growth, which spurs consumption and leads to a rapid use of natural resources including fossil fuels. The match with SSP5 is poor, mostly because of the fundamental assumption of strong fossil-fuel dominated energy consumption, in combination with lack of interest in natural capital. This is not assumed in Should I Stay or Should I Go.

- Overall, the SSPs assume a higher economic growth than the CLIMSAVE scenarios. Social sustainability is likewise lower in the European CLIMSAVE scenarios.

In conclusion, the SSPs and the CLIMSAVE match to a degree sufficient to assume that they could be synchronised further and linked. This is particularly the case for SSP1 and SSP3, and to some extent for SSP4. Linking SSP5 and CLIMSAVE is more challenging.

When combining the SSP and CLIMSAVE scenarios, it is necessary to decide which should be leading. In this case, it was decided that, in principle, the global SSPs should be leading, for several reasons:

- The CLIMSAVE scenarios have a time horizon of 2055 whilst the IMPRESSIONS European socio-economic scenarios should have an outlook until 2100.

- The CLIMSAVE scenarios use other main uncertainties to lay out the basic foundation of the scenarios. Using these as a starting point would deviate from scenario development in other case studies and, hence, loose cross-scale consistency.

- The CLIMSAVE scenarios lack a version of SSP5, which in terms of linking with RCP8.5 (see Section 2.3.2) is very important and would need to be added.

This has important additional advantages for use in ECONADAPT and other similar endeavours:

- The Eur-SSP narratives can be combined with the national level quantifications generated as part of the global SSPs.

- The Eur-SSP quantification matches the numbers from the global SSP database.

- The fundamental assumptions of the Eur-SSPs are the same as those of the global SSPs.

However, there are also a number of drawbacks associated with this decision:

- The CLIMSAVE scenarios are much richer and specific for Europe. Some of the detail and richness of the stories cannot be used.

- The SSPs are global scenarios, focusing on aspects that globally lead to highly contrasting scenarios. For Europe, this is not necessarily the case, particularly considering the pairs SSP1/SSP5 and SSP3/SSP4. The CLIMSAVE scenarios are contrasting.

Furthermore, the CLIMSAVE scenarios were developed during a series of three stakeholder workshops and it is important to ensure stakeholder acceptance of using the global SSPs as a starting point. IMPRESSIONS, likewise, uses stakeholder workshops as the main method for developing socio-economic scenarios. A number of steps were taken to help overcome this issue:

- An expert meeting was organised (January 2015 in Wageningen, the Netherlands) during which a foundation was laid for a set of European SSPs, based on the CLIMSAVE scenarios and the global SSPs. The goal of the meeting was to draft a set of scenarios that would serve as a set of extended European SSPs, while maintaining the flavour of the CLIMSAVE scenarios.

- An online discussion with a small selection of stakeholders will be initiated to discuss the set of draft European SSPs.

- The European SSPs will be discussed during the subsequent European stakeholder workshop.

The resulting European SSPs narratives are given in Annex 1; Table 5 lists their key elements.

For ECONADAPT this means that the Eur-SSPs can be used without having to further consult stakeholders as they have been closely involved in the development of the Eur-SSPs and the CLIMSAVE scenarios, ensuring stakeholder buy-in when used within the context of climate change mitigation and adaptation.

Table 5. Key elements of the Eur-SSPs.

	SSP1-WATW (Good)	**SSP3-Icarus**	**SSP4-ROTS**	**SSP5-SISOSIG (based on global SSP5)**
Decision-making level	international/EU leader more than MS	National/Local+ fragmentation	Int`l/Europe	international/EU not a leader on the global scale
Geopolitical stability	high	Low	High	high
International cooperation -	Strong, EU important player	Weak	Strong	Strong (trade)
Social respect	high	Low between countries	Low. Respect between society	High
Net migration- low in-migration	Low in migration	Outmigration	Selected immigration	High- to cities and from poorer countries
Economic development	gradual (not rollercoaster, but some hiccups, particularly at beginning)	Low	High	strong
Mobility	high as globally connected markets and welcoming atmosphere, but actually people don't move, no barriers	Low	High	high
Globalisation	unconstrained	Constrained	Uncontrolled (only controlled in parts)	Unconstrained
Choice	free, but strong regulation on land use	restricted	Free for elites	Free
Social cohesion	high	Low EU/higher within country	low	High
Technology development	lots of technology, but not that rapid to be pervasive	Low	High in some areas\low in labour intensive areas	Major (e.g. geoengineering)
Quality of Governance	High – focus well being	Ineffective	High effective	High – focus business
Human health investments	high	Low	High for elites	high
Education investments	high	Low	High for elites	High
Environmental respect	high	Low	High in pockets Low in forest	Low, but high NIMBY

4 Key ECONADAPT Foresight Oriented Workshops

As discussed in the introduction of this Deliverable, the number of foresight-related activities conducted by ECONADAPT was low, due to low interest levels or alternative priorities expressed by stakeholders during the stakeholder driven needs assessment activities conducted in the first stages of the project. There were, however, a number of activities that did have a forward-looking component. This chapter summarises and analyses scenario-related aspects of two workshops conducted within ECONADAPT.

4.1 OECD Workshop

A workshop was conducted in collaboration with the OECD, on the 18-19th June 2014 in Paris, with attendees from the European Commission, Member State (adaptation leads), International boundary organisations, large private sector organisations, and some city level adaptation leads. In terms of foresight, the workshop had three purposes:

- to expose participants to the utility of foresight activities in policy and program design and decision-making in general: to this end an invited session was given by Dr Angela Wilkinson, OECD Counsellor for Strategic Foresight,
- to map out current practice across participant organisations, to understand which approaches are currently being used and why,
- to identify gaps in in current practice and prioritise the development of decision-support approaches and tools based on stakeholder needs and priorities.

A detailed report of all activities and results exists in ECONADAPT Deliverable 1.1. With respect to foresight this workshop identified:

- Large variability in current practice across participants: few actors use (or are even currently interested in/have capacity for) foresight based tools, though the very few that do, such as the Netherlands, are very advanced.
- Wide demand for basic decision-aiding tools such as multi-criteria analysis and cost-benefit analysis. Those countries not already using foresight tools showed little interest in them preferring support with alternative tools and approaches. Subsequently, a mapping analysis was undertaken to match various stakeholders to the ECONADAPT project work packages in terms of WP5 Disaster Risk Reduction (ECHO, ENV, CLIMA), WP6 project appraisal (EIB, EBRD, CLIMA, REGIO), WP7 Policy Appraisal (CLIMA, OECD), WP8 macroeconomics, WP9 international adaptation finance (DEVCO, DFID), and cross-cutting/tools (CLIMA, EEA, UNDP, UNFCCC).

The primary result of the workshop for ECONADAPT was to shift focus away from foresight/scenario approaches in the near term and focus instead on the requested capacity development, based on a stakeholder driven needs assessment. Since European commission representatives from DG CLIMA and AGRI expressed an interest in foresight and scenarios, they were incorporated into WP7, via a scenario planning workshop. This workshop is covered in the following section.

The results from the workshop indicated a strong preference of those present at the OECD workshop towards decision-support tools rather than scenario development. This was crucial in the decision to change the work in the project. Stakeholders were successfully matched with WPs of ECONADAPT, which resulted in securing a stakeholder-driven approach of the project, with close ties with stakeholders and aiming outcomes that were directly useful.

4.2 CAP Workshop

A European workshop was held on June 1st 2015, in Brussels, with attendees from the European Commission (e.g. AGRI, CLIMA, ENV), private sector European food and agriculture actors (e.g. Fediol), European food, agriculture and environment organisations (e.g. Sustainable food trust, Groupe de Brugge), some national government representatives (e.g. Netherlands Ministry of Economics) and subject matter experts from a host of European Universities (e.g. Wageningen, Bath, Ghent University, Czech University of Life Sciences). A process was facilitated which allowed participants to systematically reflect on the capacity of the CAP to support and enable climate adaptation now and in the future. In order to achieve this, a two stage participatory SWOT analysis was conducted in break out groups. The first stage focused on current performance and the second on future performance. In this Deliverable we focus on the foresight/scenarios component of the workshop. A full workshop report, containing details of all methods and results is included in Deliverable 7.1.

Effective planning for the future requires planners and decision makers are mindful of the context for which plans are being made. Ultimately the success or failure of any policy or other intervention depends on a range of uncertain factors complex that can be systematically considered through scenario testing. Accordingly, a set of diverse exploratory scenarios for linked socio-economic and climate futures for Europe were used to test the future performance of the CAP and develop suggested options to improve its performance in the context of each scenario. Comparison of options across scenarios allows for the development of more robust policies to future uncertainty. If a plan or policy is considered to be feasible under a wide range of challenging futures, it could be considered more robust. Each scenario provides a unique set of challenges and opportunities for participants to work with in order to achieve desirable outcomes.

The scenarios used in the workshop were integrated outlooks until 2100 as developed through the EU FP7 Programs CLIMSAVE and IMPRESSIONS. An initial set of 4 SSPs (SSP1,3,4,5) and 2 RCPs (RCP4.5 and RCP8.5) was put forward in those project as a core set to be further developed and discussed by stakeholders in IMPRESSIONS. In the context of this workshop, a smaller subset of two combinations of the European Shared Socio-economic Pathways (SSPs) and Representative Concentration Pathways (RCPs) were selected to maximize scenario diversity and plausibility. The first integrated scenario consisted of a combination of relatively low GHG emissions and related climate change as represented by RCP4.5. This emissions scenario was combined with SSP1 that sketches a path to a sustainable world (see Section 3). The second integrated scenario consisted of a combination of very high GHG emissions as represented by RCP8.5. This emissions scenario and RCP 8.5 was combined with SSP3. In terms of climate change impacts, the two scenarios can be characterised as follows:

SSP1 x RCP4.5 - We Are The World
The impacts of climate change and extreme events are relatively low, but significant, mostly because of the inertia of the system. It is not until around 2050, that the effects of global efforts to reduce CO2 are visible and global warming starts levelling off.

SSP3 x RCP8.5 - Icarus
The impacts of climate change and extreme events are relatively high, with an increased intensity, duration, and unpredictability of extreme events. The lack of global efforts to mitigate and regional (economic and social) capabilities to adapt is increasing visible in trends of climate change (impacts). These two scenarios provided supporting material for scenario immersion in the introductory sessions of the workshop.

Participants were facilitated to immerse themselves in the scenario using narrative descriptions of each global scenario, combined with illustrations, and climate impact model outputs globally and for Europe. The scenario illustrations for the two scenarios used are provided in Figure 5. During this process participants describe in detail what Europe would look like and what would be happening in that situation.

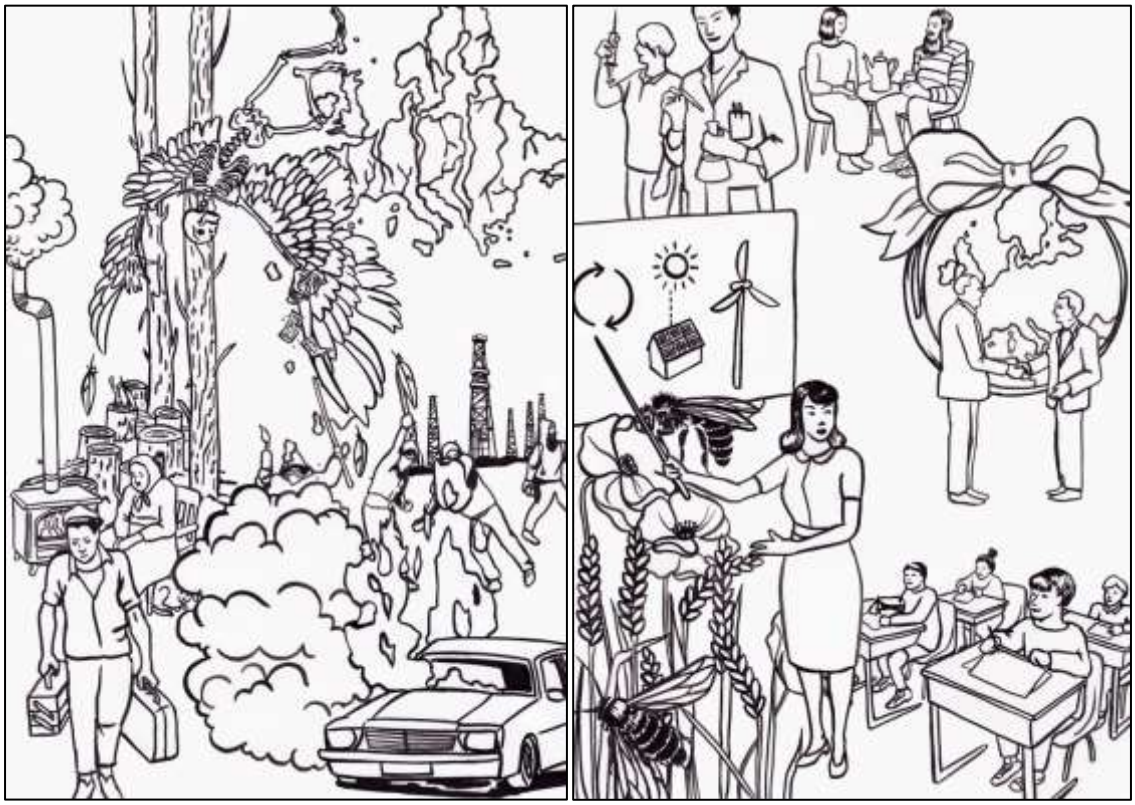


Figure 5. Scenario Illustrations: left Icarus, right We Are The World.

Note that the scenario images developed through ECONADAPT have subsequently been used by a range of other EU projects, including IMPRESSIONS, Transmango, and GLOBAQUA.

Following scenario immersion, participants tested the performance of the CAP in terms of climate adaptation in that situation. Following testing within each scenario, comparison of SWOT analyses generated a list of robust options for improving the capacity of the CAP to enable adaptation to future climate change.

There was strong agreement that adaptation must take place at all levels from local, through national and regional to all of EU and that the principle of subsidiarity should apply.
The main strengths of the current CAP relate to direct and decoupled payments, which provide farmers with safety nets and the financial freedom to experiment with adaptations; as well as an overarching focus on the environment and sustainability.

The main weaknesses of the CAP relate to maintenance and enhancement of diversity (in terms of crops, biodiversity and farming systems) as well as money going to large farmers rather than those that need it most. A major weakness from the adaptation perspective is lack of long term, integrated perspectives and a lack of integration with other policies.

Adjustments to the CAP robust across the scenarios to support adaptation to future climate change are:

- Creation of new opportunities through cooperative approaches.
- Support local networks and cooperatives.
- More community based and farmer based – bottom up approaches.
- Pillar 2 approaches by making contracts between farmers and authorities.
- Links between CAP and other environmental and social policies, on a national, regional or local level (short supply chains and co-operations).
- Learning network between farmers, knowledge building. Support context specific knowledge sharing.

Important challenges exist to mainstream adaptation under the current and future CAP. Although the current CAP already has several mechanisms to enhance adaptation and to pay more attention to sustainability and climate resilience, further strengthening of these mechanisms can be considered. The set of options for mainstreaming climate adaption in the CAP ranges from simple provision of information on climate change and adaptation options in the context of the CAP policies, at one extreme, to a very fundamental revision of the systems, at the other extreme, as such that much larger shares of the CAP payments are directly related to environmental targets and investments in adaptation to ensure that the agricultural sectors in Europe will become more resilient to climate change.

In the context of water quality management the CAP support may currently lead to developments that have a tendency to aggravate the existing problems, e.g. with manure management, nitrogen leakage and eutrophication. This would not be in accordance with the water framework directive, and it produces counter-effective results. For this reason it is important to even further harmonize the impacts of the CAP system with important policy areas such as biodiversity conservation, protection of nature and landscape and water and air quality. Although the current CAP makes efforts through pillar II and cross-compliance to support sustainable management in the agricultural sector, a large part of the budget is simply allocated in terms of income support without providing strong incentives for sustainable development or climate resilience.

Other mechanisms can be used to stimulate and facilitate adaptation such as insurance, capacity building, networks and partnerships and this is certainly advocated under the CAP. However, currently it is not clear how the proposed measures are implemented in practice and whether the speed and intensity of the actions is sufficient to provide for the required resilience in the agricultural sector. To what extent the measures are adequate will also depend on the characteristics of future climate change and the stochastic development in the related weather patterns, both for the temporal and spatial dimension.

4.2.1 Recommendations

The CAP workshop was arguably the activity within ECONADAPT that most closely resembled the originally envisioned role of scenarios in the project. In many ways, the methods employed to involve scenarios and link them to policy making were mirror those describe in earlier chapters. The RCP x SSP scenarios were used, a selection of two combinations was made and within the context of these possible future outlooks (qualitatively and quantitatively) the future of the Common Agricultural Policy was discussed with stakeholders, using participatory methods in a one day workshop.

Perhaps the most important recommendation is to increase the use of the methods such as employed in the CAP workshop. Among the many advantages, there are:

- Buy-in of stakeholders
- Robustness testing of policies to be better prepared for an uncertain future
- Alignment with the manifold ongoing and upcoming studies that use the RCP x SSP scenarios
- Include future uncertainties in current decision making
- Use state-of-the-art conceptual thinking on how to assess effectiveness of adaptation measures
- Link between qualitative stakeholder-generated scenarios and adaptation options and model-based quantitative estimates.

Other recommendations include methodological improvements of the method as employed:

- Increase the length of the workshop. A two-day event increases possibilities to do either more RCP x SSP combinations; increase time available to discuss details of CAP improvement; or increase discussion on quantitative model results.
- Increase the number of workshops. Multiple workshops would allow for iteration between stakeholders and experts.
- Employ other methods. In addition to largely qualitative discussions, methods or tools could be used aiming at, for example, quantitative estimates, group-model building, or Multi Criteria Analysis.
- Include scenario development as part of the workshop. Involving stakeholders in the development of the socio-economic scenarios would increase buy-in and potential use of scenarios beyond the project's lifetime.

5 Use of scenarios within ECONADAPT

Towards the end of the project, a survey was designed and conducted with a number of questions focusing on the use of scenarios within ECONADAPT. Key persons from each WP were asked to complete the survey. In this way, an overview of the use of scenarios across the project could be obtained.

The survey consisted of the following questions:

1. Have you used/will you be using scenarios in your work?
2. Scenarios can be defined in many different ways, and take many forms such as qualitative (stories, mind maps and cartoons) and quantitative (model input and model output, including impact models) and with categories such as socio-economic (population, GDP, governance structures etc.), climate (emissions, T, P, sea-level rise etc.) and policy (specific strategies and policy arrangements or other human actions). Please describe the type of scenarios you have chosen to use in your work package in ECONADAPT and the reasons for this choice.
3. Which existing scenario sets are you aware of, that you consider relevant to ECONADAPT in general?
4. Please explain which scenario sets you have used/will be using in your WP and the reasons for this choice.
5. Please describe how scenarios are used within your work.
6. Have you been involved in the development or use of qualitative scenarios and narratives for policy development? If yes, please mention the context.

Table 6 provides a summary of the results.

Table 6. Summary of survey results

WP	Did you use scenarios?	What type of scenarios?	What existing scenarios are you aware of relevant for ECONADAPT?	What scenarios did you use?	How did you use scenarios?	Have you been involved in qualitative scenario development?
WP1	Yes	Qualitative	CLIMSAVE scenarios; SSPs and RCPs; OECD scenarios	Various SSP x RCP combinations	Qualitative context for adaptation options and assessment of CAP changes	Yes.
WP2	Yes	Quantitative scenarios	CLIMSAVE scenarios	three quantitative scenarios Scenario A: Stable preferences; Scenario B: Green preferences; Scenario C: Materialistic preferences	Assessment of future WTP	Yes. CLIMSAVE narratives.
WP3	Yes	Quantitative emission scenarios, mostly related to CORDEX	First IPCC SRES, now RCPs.	The CORDEX simulations use the RCP scenarios, mainly RCP 4.5 and RCP8.5	CORDEX and RCPs, we do not particularly care about socio-economic scenarios	No
WP4 and WP5	Yes	Quantitative model input	SSPs and RCPs	SSPs, made consistent with global climate change assessment	SSP assumptions (SSP2) were used as model input	No
WP6	Yes	Quantitative model output	SSP and RCP are state-of-the-art	15 climate models forced with three RCPs (2.6; 4.5; 8.5) 3 RCP x SSP combinations: SSP1 and RCP2.6 SSP3 and RCP4.5 SSP5 and RCP8.5	Climate model output and GDP projections from SSP database	No
WP7	Yes	Quantitative model input and qualitative storylines related to policy measures.	SSP scenarios. ISIMIP scenarios	Various SSPs and Impact models	a.Two approaches: 1. deterministic scenario-by-scenario analysis 2. Integrated modelling and policy robustness b. stochastic scenarios of crop yield shocks c. alternative scenarios of new CAP policy measures in GLOBIOM d. risk management model	Yes. Alternative scenarios of new CAP policy measures.

WP8	Yes	- Quantitative scenarios - OECD projections - Output from impact models - Policy scenarios	SSPs for the socioeconomic drivers and several sets of scenarios related to RCPs for different impact models.	The AgMIP output of five crop models for all RCPs and the DIVA scenarios for sea level rise. ICES model and we base our reference scenario on SSP2	SSP assumptions (SSP2) were used as model input	No
WP10	No	n.a.	SSPs and RCPs and scenarios for socio-economic indicators	n.a.	n.a.	n.a.

A number of observations stand out:

- Scenarios have been used in most of the WPs of ECONADAPT. This is remarkable, since the user needs survey indicated that scenarios were not among the main methods than needed to be included. As a result, the toolbox developed in WP10 did not include scenarios, while most of the partners and other WPs did.
- Existing scenarios and model output were considered an input of sufficient quality to carry out the work.
- Almost all partners are aware of the SSPxRCP global scenarios, many consider them state-of-the-art, and most have used them. The survey clearly showed that there was a strong preference to use the most recent global scenarios, that were developed by the international climate change community.
- Scenario use is almost completely limited to quantitative scenarios. Many partners and WPs have used scenarios to provide model input and/or consider model output as scenarios. This is a different use of scenarios than originally envisioned, yet a perfectly valid manner to capture some of the future uncertainty in socio-economic and environmental outlooks.
- In practical terms, most scenarios are related to emission scenarios and climate models or SSPs and impact models. The use of scenarios was mostly limited to the use of existing climate model runs (from CORDEX), extracting socio-economic data from the SSP database (https://tntcat.iiasa.ac.at/SspDb), or model output from impact models mostly through the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) database.

In short, scenarios were a crucial tool in ECONADAPT, having a role in almost all WPs and across all types of activities. Almost exclusively, the new global SSPs and RCPs were considered as only set of scenarios. The use of scenarios was almost completely limited to quantitative model input (climate models, SSP database) or model output (impact models that in turn used the SSPs and RCPs). Scenarios thus mostly served to apply models. Model output in turn was used to discuss adaptation options. As such, scenarios served a similar purpose as originally envisioned, but by using existing scenarios rather than developing or discussing new ones, and by applying models, rather than through a qualitative use. Overall, the importance of scenarios in ECONADAPT was somewhat hidden, which was uncovered by the survey.

6 Conclusions and recommendations

This Deliverable brought together all aspects of ECONADAPT that involved the use of scenarios in the broadest sense. Although the use of (qualitative) scenarios was severely limited compared to the original workplan in the Description of Work, sufficient scenario-related work was carried out to conclude on its use and provide future recommendations.

The results of the OECD workshop seemed to clearly indicate an interest in decision-support tools such as CBA or MCA rather than scenarios, which was subsequently adopted in the project's work. Yet, the survey among ECONADAPT partners equally clearly indicated that scenarios were used in almost all aspects of the work. This apparent contradiction can be explained from the fact that the tools employed often have a model-based, forward-looking component that requires the use of scenarios. So, although rather hidden, the OECD workshop did also include a demand for scenario use. Because this demand was poorly articulated, there was no coordination between activities or any degree of stakeholder involvement. On the one hand, this proved to not be problematic as uniformly the SSPxRCP scenarios were chosen, while these were also singled out as the only recent, appropriate set of scenarios in this Deliverable (see Section 4.2). Although different SSPs and different SSPxRCP combinations were used, the outputs of the various activities within the project were similarly contextualised, potentially also enabling comparison across scale, case study and type of tool. On the other hand, choice of scenarios and future trends and related changes in key drivers has a strong influence on results of, for instance, a cost-benefit analysis. As it is, stakeholders were relatively uninformed on the choice of scenarios and implications for the tools that they were offered. A more stakeholder-inclusive process might have changed that.

The CAP workshop was the only example in ECONADAPT of scenario work as originally envisioned. This included the use of qualitative scenarios, quantitative model input and output, stakeholder-generated, scenario specific future policies changes, and importantly a cross-scenario robustness assessment of these policies. In this way, stakeholders co-produced scenarios used to stress-test CAP adjustments that they listed themselves. This process of knowledge co-production increases stakeholder buy-in, reduces the importance of expert opinions, and increases communication between project partners and other stakeholders. Although such a set-up comes with its own pros and cons, we recommend to put to forward in subsequent endeavours, as a means to complement development of other types of tools. This could be achieved with little extra cost and effort, as the CAP workshop demonstrated.

Perhaps most importantly, we need to revisit the fact that the stakeholder survey on users' needs gave rise to a direction of the research in ECONADAPT that was away from using foresight methods. This points towards a dilemma often encountered in work that is partly stakeholder determined. On the one hand, it is essential to understand the needs of the potential users and stakeholders that are to be involved, as well as of the various project partners. If these give strong signals that scenarios are not useful to consider, it can be concluded to change the research direction. On the other hand, operating at the forefront of scientific progress can also mean that stakeholders might not be totally aware of possible tools as they have not yet been widely used beyond the scientific realm. In other words, stakeholders might not be in the position to fully judge what their needs are. This can be an incentive to maintain certain methods without the mandate from stakeholders. A compromise can be found in an iteration between project partners and stakeholders to identify users' needs in close collaboration. With some success, the so-called Story-And-Simulation approach (Alcamo, 2008) has been put forward as a means to develop scenarios in an iterative procedure between stakeholders and modellers. The approach has been considered in endeavours also including adaptation options and other policies.

In more general terms, we recommend to strengthen the two-way communication and interaction between those advocating the use of scenarios and those that focus on adaptation options and tools to meaningfully assess trade-offs, and effectiveness. In the context of climate, all agree that current variability as well as future changes need to accounted for, and that any tool needs a “forward-looking component”, even if not specifically called for.

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Annex 1. The European Shared Socioeconomic Pathways – Full stories

European SSP1 – We are the World
There is a high commitment to achieve sustainable development goals through effective governments and global cooperation, ultimately resulting in less inequality and less resource intensive lifestyles

2010-2040: The financial crisis continues to have strong repercussions and EU leaders are forced towards further integration of European financial and fiscal policies. The interplay of financial, environmental, and economic crises fuel the feeling that behaviour has to change away from an unregulated market-driven economy to a sustainable development path. This puts governments under pressure to take ambitious measures, including stimulating an energy transition towards renewables and facilitating innovative research, accompanied by investments in health, education, and social support. These investments are at the expense of somewhat slower economic growth and initially meet with some resistance. Eventually, a system of national accounts is put in place that essentially adopts a basket of well-being based performance measures instead of GDP. The resulting higher quality of life and a growing feeling of security and safety are eventually embraced. In Europe and worldwide, trade wars and other economic crises are addressed increasingly effectively by multi-level governance configurations. Investment in green technologies and geo-engineering increases rapidly, focusing on renewables and energy efficiency. By 2040, efforts to transform Europe to a sustainable society are now starting to pay their dividends, reinforced by gradually changing lifestyles.

2040-2070: A decrease in conflicts in Europe's Southern and Eastern border regions leads to higher political stability and moderate but steady economic growth in an increasingly equitable Europe, which allows for the middle class to grow stronger. The European Union expands further and participates in new global governance initiatives. The larger EU takes responsibility for addressing its environmental impacts in the border regions and leads investments that help in the pursuit of sustainable development goals in those regions. As a result, migration towards Europe starts to decline for the first time this century. There is a substantial shift in the European political agenda with a greater focus on well-being than economic growth, driven by human losses associated with climate change combined with positive improvements in accessible education and lifestyle. Advances in green technologies are further stimulated by international competition leading to a CO_2 neutral society by 2050.

2070-2100: Worldwide, consumption is now oriented toward low material growth and low resource and energy intensity. This results from the development of new technologies with radically reduced resource consumption and a strong increase in the use of renewable energy sources, facilitated by new flexible global, regional and national institutions that enhance international cooperation. Supported by a continued steady economic development and the strong middle class, economic and social inequality further decrease. By 2100, Europe is characterised by a high level of sustainability oriented political and societal awareness, focusing on renewable energy and low material growth in a strongly regulated but effective multi-level governance structure. International cooperation is strong, particularly with Asia.

European SSP3 – Icarus
Sparked by economic woes in major economies and regional conflict, antagonism between and within regional blocs increases, resulting in the disintegration of social fabric and many countries struggling to maintain living standards. Ultimately, a high-carbon intensive Europe emerges with high inequalities predominantly between, but also within, countries.

2010-2040: With the economy gradually picking up, the demand for resources increases, which turns out to be a tipping point for the state of the environment with severe ecosystem failures. At the same time, the world economy does not perform as expected with new crises across the European Union that stress the structural differences across and within Member States. Populist movements become increasingly mainstream and are further fuelled by increasing riots in multicultural neighbourhoods. The persistence of conflicts and decline in trade also substantially increases energy and food prices, while initiating a massive build-up of the defence sector, which is resource hungry but not resource efficient. Extreme weather events become more frequent and further increase the costs of resources, damage control and defensive measures; this causes the economy in Europe to start to stagnate. This, in turn, increases unemployment rates and leads to the phasing out of the social security system. In light of increasingly scarce public resources, long-term policy planning becomes rare with hardly any money for education, research or innovation. Eventually the EU breaks down.

2040-2070: Continuing negative social, environmental, and economic developments widen the gap between the poorer countries and regions particularly in the periphery of Europe and the richer, larger, countries that maintain a decent level of social, economic, and political stability. With the disintegration of social fabric, Europeans in the poorer regions increasingly migrate in search of jobs, and are employed in countries that are somewhat better off, for relatively low wages. Most migration is within Europe. Eventually, new regional blocs are formed in the north and in the south of Europe, while new alliances with other countries are forged to ensure sufficient energy supply. By 2070, social counter-movements appear with some signs of a slight economic recovery and increased social cohesion. Yet, these signs are temporary and do not take root in a fragmented and divided Europe with strong regional rivalry and conflict. The general lack of economic resources and means to afford new technologies, coupled with weak institutions and governance structure, leads to an increasing resource intensity and fossil fuel use.

2070-2100: In the absence of strong (inter)national institutions, criminal organisations and corruption take hold, in the aftermath of failed counter movements. Europe has lost its leading position, reinforced by difficulties to re-establish effective collaborations. The far-reaching fragmentation and cultural diversity have triggered a brain drain with the well-educated migrating to regions outside Europe that offer (slightly) better possibilities. Eventually, Europe is not worse off than the rest of the world, but struggles not to become the world's backwater as new clean technologies are increasingly developed elsewhere and affordable only for the richer Member States. These ensure clean water, clean energy and health for those countries. However, the majority accept political instability and social injustice and learn to live with less.

European-SSP4 – Riders on the Storm
Globally, power becomes more concentrated in a relatively small political and business elite, accompanied by increasing disparities in economic opportunity, leading to substantial proportions of populations having a low level of development. However, Europe becomes an important player in a world full of tensions due to successful green technologies, despite the growing inequalities both across and within countries.

2010-2040: Sparked by the economic crisis and extreme weather events, the EU increases commitment to find innovative solutions to the depletion of natural resources and climate change. In combination with current relatively high levels of social cohesion, energy efficiency and environmental policy-making this initiates a shift towards a high-tech green Europe. This transformation is strongly supported by large businesses that successfully seek collaboration with the increasingly powerful European government. Eventually, average wealth starts to increase as crises are successfully combatted. At the same time, the centralised public-private partnerships and related policies result in increased social disparities within countries.

2040-2070: Technology development is strong in the high-tech economy and sectors. Energy companies hedge against price fluctuations through diversifying their energy sources, with investments in both carbon-intensive fuels like coal and unconventional oil, but also low-carbon energy sources. New high-tech sectors are growing in importance and gradually become the backbone of an economically strong Europe. At the same time, however, inequalities are rising because of a number of simultaneously acting factors. These include skill-based technology development; highly unequal investments in education; and less affluent groups having increasingly weak political power and limited access to credit. Together, these increasing disparities in economic opportunities and political power lead to increasing inequalities and stratification both across and within countries. The traditionally strong middle class decreases in influence but only slightly in numbers. By 2070, there is a large and widening gap between an internationally-connected society that is well educated and contributes to knowledge- and capital-intensive sectors of the global economy, and a more fragmented collection of lower- income societies that work in a labour intensive, low-tech economy, mostly in the service sector for the benefit of the elite. Despite a strong EU, power becomes increasingly concentrated in a relatively small political and business elite, while vulnerable groups have decreasing representation and influence. Among others, this results in increased conflicts in poorer regions of Europe and migration flows to safer areas, which become protected and clean `islands'. Migration flows into Europe are highly controlled by the elite, but Europe increasingly attracts illegal immigrants competing for decreasingly available low-skilled jobs.

2070-2100: Europe has become a market leader in (green) technologies, because of long-term under-investment in new resources in many other regions of the world related to uncertainty in fossil fuel markets. Protected by a strong elite, the small "connected" upper class benefits with high-skilled workers moving easily across countries to tap into new business opportunities. The elite becomes increasingly separated from other social classes, importantly from the now quickly dwindling middle class. A large share of the population, however, does not benefit from technological breakthroughs and does not profit from alliances between big business and the political elite. This results in deepening inequalities within and among countries across Europe. With decreasing public funding, good education is only accessible to those who can afford it. Technological development has not resulted in reduced energy prices, but has instead established an oligarchy of green business developers that control energy supply and reduce resource availability for the majority. As a governing body, the European Union is strong with strong ties with the lobbying industry. Social cohesion, however, is now low and stratified, while human health has decreased for most. By 2100, Europe is an important player in a world full of tensions, but with growing inequalities across and within European countries.

European-SSP5 – Fossil-fuelled Development
Globally, driven by the economic success of industrialised and emerging economies, people in this world place increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. A lack of environmental concern leads to the exploitation of abundant fossil fuel resources. In Europe, innovations likewise lead to a large return on investment and increased social equity and health, also through overuse of non-renewable resources. Resulting environmental degradation is of secondary importance, but partly addressed by technological solutions.

2010-2040: Global markets are increasingly integrated, with interventions focused on removing institutional barriers to the participation of disadvantaged population groups. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources. In the aftermath of the economic crises in Europe, there is a slow shift towards market deregulation, resulting in a strong labour market and increased purchasing power. This results in a decrease in political unrest. Of particular importance for Europe is the large-scale extraction of shale gas, which further stimulates economic wealth, part of which is used to stimulate the development of (green) technologies. Europe regains its leading position in the global economy, which further contributes towards a focus on economic growth and export markets rather than environmental policies. Nuclear energy is slowly phased out everywhere in Europe, while investments in biofuels are low, in favour of cheaper and more readily available fossil fuels.

2040-2070: Because of decreased energy price volatility and stabilising economies, public trust in political decision making increases which facilitates strategies related to further exploitation of natural resources. Faith is strong in the ability to effectively manage social and ecological systems, including by geo-engineering. High and low skilled immigration and mobility remain high as European economies flourish. Job availability across all market sectors is high and contributes towards a reduction of inequalities and competition. Population across all societal classes, and the strengthening middle class in particular, adopts a very energy intensive lifestyle. Where environmental problems occur, these are tackled locally and reactively with technological solutions. The environment degrades, but the majority of the population is unaware because of successful technological innovation in e.g. food and water production, vaccination availability and climate adaptation, which decrease the dependency on ecosystem services.

2070-2100: In general, Europe continues on its path towards economic and social sustainability through competitive markets; investments in education and health; innovation and a strong focus on technological solutions fuelled by an (over)exploitation of fossil fuel resources, with an ever stronger pressure on natural resources. The continuous high stability of the energy market and economies have changed European policy-making, now predominantly focusing on and investing in policies related to human and social capital, rather than environmental protection. National governments have less political power, which enhances free circulation of services, goods and people. Population continues to grow with many European cities having become economic hubs with efficient transportation means. Towards 2100, the environment is locally seriously degraded as non-renewables are further exploited, which eventually results in a slow re-emergence of investments in renewables, deemed necessary as prices of fossil fuels rise.