



The **CLIMSAVE** Project

Climate Change Integrated Assessment Methodology for Cross-Sectoral Adaptation and Vulnerability in Europe

Report on the new methodology for scenario analysis, including guidelines for its implementation, and based on an analysis of past scenario exercises

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0. Preface

The original aim of this Deliverable was to provide an overview of the participatory scenario development methods as related to WP3, notably those aspects related to organising a series of three stakeholder workshops both for Europe and Scotland. However, since methods and results of those workshops are tightly linked to the development of the modelling platform in CLIMSAVE, a description of a broader methodology is needed. Given a number of discussions between projects partners from various WPs, it became clear that scenarios and scenario development were understood very differently at a practical but also at a more conceptual level. This Deliverable, therefore, starts with an evaluation of the overall approach that CLIMSAVE takes on scenario development. Part of this Deliverable builds on discussions with multiple partners of CLIMSAVE. In particular, I would like to mention the Project Coordinator Paula Harrison, Ian Holman, Martin Dubrovsky, Eric Audsley and Rob Tinch.

1. Deviations from the original plan

Within WP3, more emphasis is being put on the development and finalisation of the new scenario methodology and concrete plans for its implementation. More importantly, it has become clear that no outlet existed for the analysis of the results from the scenario workshops. This led to three deviations to the originally envisioned workplan. As they bear relevance to the content of this Deliverable, they are elaborated upon here:

- A somewhat less all-encompassing evaluation of past scenarios exercises and their role in discussing adaptation options. Rather, the evaluation of past scenarios changed focus from an overview of the content of scenarios to an elaboration of methodological lessons learnt.
- Much more detailed information on the new method. A number of novel elements were introduced, which demand a detailed explanation.
- Commitment from WP3 to provide a detailed analysis of the process and results of all stakeholder workshops. There is a clear distinction between the development of scenarios and the analysis of the products of the stakeholder workshops. The latter is a clear task of WP3 and needs to be reflected in the deliverables that will be produced.

Because of this change in emphasis, the nature of Milestone 3.1 and Deliverables 3.1 and 3.3 have also changed. We therefore propose that:

- Deliverable 3.1 becomes a running report that documents the current state of the new scenario methodology. This includes the original goal of Deliverable 3.1 – report on existing scenario exercises. Deliverable 3.1 will largely replace the original Deliverable 3.3.
- Deliverable 3.3 will become a report in which the results of the workshops are documented and analysed, including lessons learnt.
- In light of the above, the title and nature of Milestone 3.1 was also changed. A meeting took place in Brussels in March 2011. We propose to earmark that meeting as Milestone 3.1. The meeting was pivotal in agreeing on the overall scenario methodology (as opposed to evaluating past scenario exercises) by discussing a zero-order draft of Deliverable 3.1 and the link with the IAP and adaptation options.

Finally, it was decided to shift the deadline of the final version of this Deliverable until after the first European stakeholder workshop in Brugge, Belgium. By doing so, we made it possible to include the final method as was executed during the workshop and the final agenda in this document.

2. Goals and structure of the Deliverable

In light of the above, this Deliverable covers the following main elements:

- Introduction of definitions and terms (Section 3). With this short glossary of terms and definitions, we hope to clarify the perception of WP3 and to facilitate understanding of the subsequent sections of this Deliverable.
- Evaluation of past and ongoing scenario exercises (Section 4). Although this is shorter than originally envisioned, it remains imperative to provide an overview of some of the previously used methods and resulting scenarios.
- Stakeholder selection procedure (Section 5). This is a task from WP1 which was entirely executed within that WP. However, we felt that the method to select stakeholders was best documented here, as it preceded the discussions on the details of the scenario development methods.
- Scenario development method (Section 6). This is the core of the Deliverable, explaining the theory and concepts behind the scenario development methods to be used in CLIMSAVE.
- Practical implementation (Section 7). It was decided to include the actual method and agenda of the first European stakeholder workshop in this Deliverable. With this, we can show how concepts were translated into the practice of a three-day workshop format.

In short, this Deliverable serves a large number of different goals. Yet, all are geared to providing a detailed overview of the background and practical implementation of the scenario method that will be used in CLIMSAVE. For an overview and analysis of the resulting scenarios, we refer to Deliverable 3.3.

3. Introduction of definitions and terms

Key to CLIMSAVE is the notion that decision-makers and other interested citizens need reliable science-based information to help them respond to the risks of climate change impacts and opportunities for adaptation. From this, it follows that the consolidation of such information needs to be founded in a holistic or integrated assessment system's view on the effects of our changing future. We therefore follow the principles of Integrated Assessment (IA), which is an interdisciplinary process that combines, interprets, and communicates knowledge from diverse scientific disciplines from the natural, engineering and social sciences to investigate and understand causal relationships within and between complex systems, providing tools to develop the information resources required.

In the process of scenario development, we translated this into the following set of criteria:

- The *process* is highly transdisciplinary, involving scientists from a range of disciplines but also importantly involving stakeholders in every step of the scenario development process. The process will aim at a two-way iterative process of dialogue and co-

production of knowledge, allowing stakeholders to develop their understanding and test ideas, based upon their own hypotheses.

- The *resulting scenarios* are highly integrated. Although the focus of the scenarios will be on climate change and adaptation options, it is absolutely essential that the scenarios include information on developments of a range of other (climate-related) sectors, actors and factors. This includes policy and adaptation options as well as broad socio-cultural changes that contextualise the adaptation options.
- The *methodology* will be based on the use of a set of different, but complementary, methods and tools that together maximise the possibilities to interact with stakeholders as well as facilitating the link with mathematical models.

It cannot be stressed enough that CLIMSAVE aims at fundamentally integrating stakeholders' perspectives into the project and has made this one of the cornerstones of its approach. The CLIMSAVE consortium underlines that climate change vulnerability and adaptation happens in a societal context. Stakeholders' approaches, compliance and commitment to address and act on the topic are of crucial importance to our society's ability to address vulnerabilities to climate change and other pressures successfully. Due to this, society's action and reaction with its myriad of influencing factors characterising so complex a social system is a key element in the scenario development process. In this process, stakeholders will have an active, driving role in developing and refining scenario storylines for climate impacts and adaptation and linking these, in collaboration with the scientists, to the diverse CLIMSAVE research results. Obviously, this kind of exchange has to bypass classic approaches to stakeholder involvement, as the necessary intensity of dialogue requires highly targeted and specific information exchange and co-creation.

In short, there is a strong emphasis on the integrative potential of scenarios. This potential to integrate across expertise (stakeholders versus researchers), across disciplines (areas of expertise within CLIMSAVE), and across a wide range of factors, sectors and actors is absolutely essential and should be realised. In addition, it should also integrate scenarios (what will Europe look like?) and adaptation measures (what can be done about it?).

The resulting scenarios will contain various elements (see next sections), of which explorative storylines and a set of adaptation options are the two most important aspects. Additionally, methods will focus on the link with mathematical models by employing tools that aim at quantification of storyline elements.

3.1 *Definitions, types of scenarios and concepts*

Scenario types

Scenario development and analysis is emerging as a method particularly well suited to the task of taking a long-term view and attempting to harmonise socio-economic and environmental goals (Raskin et al., 1998). Increasingly, scenario initiatives encourage broad participation of scientists, policy-makers, and citizens in exploring possible future development pathways (Kahane, 1998). By employing participatory methods, policy-makers and other stakeholders can be directly involved in assessing possible futures, and thus be better placed to help shape the future or adapt to changing conditions.

Today, scenario development is used in a variety of different contexts ranging from political decision-making, to business planning, to local community management, and to global

environmental understanding. The broad variety of applications has spawned a large diversity in the type of scenarios that have been developed. Despite recent methodological innovations, the typology of Van Notten et al. (2001) still stands as a good starting point in categorising 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:

- **Explorative**, participatory scenarios, recently often with strong quantitative and qualitative aspects.
- **Normative** scenarios, either participatory or desk research, and often but not exclusively using backcasting methods.

These differ mainly in the project goal – decision support or exploration. Explorative scenarios often strive for e.g. awareness raising, the stimulation of creative thinking, or gaining insight into the way social, economic and environmental processes influence each other. Decision-support scenarios are often used to examine paths to futures that vary according to their desirability. These – often value-laden – scenarios are mostly either preferable and optimistic, or disagreeable and pessimistic.

Crucial to the scenario development methodology employed in CLIMSAVE is the combination of exploratory elements (resulting in narrative storylines) and normative elements (resulting in roadmaps and adaptation options).

Some definitions

Because of the explosively growing number of future-oriented studies, there is also a growing confusion on the terminology that is being used. Scenarios, visions, roadmaps, stories, etc. are increasingly used with a different meaning. It is beyond the scope of this Deliverable to provide an overview of the rapidly growing field of future studies. Instead, we provide a small overview of key definitions of concepts used in this Deliverable, or those otherwise essential to enhance understanding of scenario development¹:

- **Scenario**. A scenario is commonly defined as ‘a story² that can be told in both words and numbers offering an internally consistent and plausible explanation of how events unfold over time’ (Gallopín et al., 1997). In this paper, we accordingly 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. (2001).
- **Narrative**. A narrative is a story that is created in a constructive format (as a work of speech, writing, song, film, television, video games, in photography or theatre) that describes a sequence of fictional or non-fictional events. It is often used as a synonym of story(line). In CLIMSAVE, we will refrain from using this term.

¹ Some of the following definitions – and particularly those of narrative, scenario, and story(line) – refer to each other and therefore seem somewhat awkward. This was impossible to avoid using official definitions. In practice, all these terms can be regarded synonymous for ‘a sequence of events that evolve over time’.

² Note that the use of the word ‘story’ in this definition does not entirely match with the use of the word in CLIMSAVE. Here it indicates a broad concept of any type of sequence of events.

- **Story (or Storyline).** The word story(line) is often used as a synonym of narrative, and thus also refers to a sequence of events. In this Deliverable, the term story is used to indicate a qualitative scenario.
- **Narrative story.** This term is sometimes used in scenario literature, but is pleonastic. Although not factually erroneous, it is more correct to use either narrative or story. In this Deliverable, we use the term story.
- **Robust strategy.** Within the scenario community, a strategy can be defined as a set of (connected) actions serving a particular goal. It is most often used in the context of robust strategies, answering the question: Given a set of ‘forecasting’ scenarios, which set of actions will be effective, irrespective of the scenario that plays out when working towards a specific desired end-point.
- **Backcasting.** Backcasting involves working backwards from a particular desired or undesired future end-point to the present, in order to determine the feasibility of that future and the policy measures that would be required to reach (or avoid) that point.
- **Exploratory.** Exploratory (or explorative) scenarios are created to explore the possible trends in the future, such as the effect of specified measures or drivers (e.g. policies, technological changes) on future development and conditions.
- **Normative.** Normative scenarios focus on descriptions of how a normative (desirable or undesirable) future objective or end-point can be reached.
- **Roadmapping.** A roadmap is a layout of paths or routes that exists (or could exist) in some particular space and/or timeframe. Roadmaps provide essential understanding of proximity, direction and some degree of certainty in travel planning. As a frequently used metaphor within the industry, roadmapping has proved to be a useful tool for technology management, strategic and operational decision-making and action planning. It is a normative and goal oriented method, where attempts are made to achieve a desired future state of development.

Concepts

Section 6 provides a detailed overview of the conceptual framework that will be used within CLIMSAVE. Here we merely want to stipulate the overall goals and methodological consequences of the scenario process in CLIMSAVE. There are three main goals of the overall scenario development process that have consequences for the qualitative storyline development process:

- Analyse impacts of climate change.
- Assess effectiveness and robustness of adaptation options.
- Involve a broad range of scientists, decision-makers and other stakeholders.

The consequences for qualitative scenario development are:

- A strong link between qualitative stories and quantitative models is needed because most of the impacts of climate change are determined in the CLIMSAVE project using model calculations.
- A strong link between qualitative stories and adaptation options is needed because the robustness of adaptation options can only be assessed using a number of (contextual) stories.
- The scenario development method needs to be highly participatory, bringing together a range of stakeholders in a number of stakeholder workshops.

4. Evaluation of past and ongoing scenario exercises

There have been a large and growing number of projects within which scenarios have been developed. It is beyond the scope of this Deliverable to provide an exhaustive overview of the wealth of this literature. For a good example of just how many efforts are being undertaken, we refer to a recent overview on the information available online (Verlaan, 2010). A second excellent example is a recent technical report from the EEA (EEA, 2011), that lists over 500 scenario studies without claiming to be complete. Based on these and other scenario reviews (importantly Rothman, 2008), we selected a small number of scenario sets relevant for CLIMSAVE. The selection differed in terms of the two main aspects that were to be evaluated:

- **Methodological.** It was crucial that the scenarios followed a method very similar to the scenario development method employed in CLIMSAVE, in order to ensure that crucial lessons learnt from previous endeavours were taken into account.
- **Content.** It was equally crucial that we obtained a thorough understanding of the key elements in the scenario sets that were previously developed, together with recommendations of how to use existing material.

4.1 *Methods – lessons learnt from past scenario exercises*

The main criteria for selecting scenario studies that could inform us on methodological issues were the direct or indirect involvement of CLIMSAVE scientists in the study. A personal link ensured access to (potentially sensitive) information on success and failure. Given the expertise of the scientists involved, the list of projects was deemed sufficiently long to ensure coverage across major temporal and spatial scales, topics, and types of stakeholders involved. We limited the list to projects that used some kind of variation on the Story-And-Simulation approach. We furthermore limited the list to studies with a global or European dimension. The list included (for references, see Section 4.2):

- GEO-4
- VISIONS
- MedAction
- SCENES
- PRELUDE
- Millennium Ecosystem Assessment

Below we first present a number of overall key lessons. These are followed by some more detailed conclusions and recommendations for specific issues, methods and tools.

Key overall methodological lessons learnt

The key overall lessons learnt included:

- *Story-And-Simulation was, is and will continue to be the state-of-the-art framework of linking models and stories, and thus scientists and a range of other stakeholders.* Overall, all projects have shown that the advantages strongly outweigh the disadvantages. On the one hand, the Story-And-Simulation approach is sufficiently flexible to allow for new tools to be included, and on the other hand, the approach is

sufficiently strict to clearly separate the roles of stakeholders and scientists and allow for co-production of knowledge.

- *Stakeholder involvement is more difficult at the pan-European scale than when using similar processes at lower or higher scales.* The various projects clearly showed that involving and engaging stakeholders at the local level was relatively easy, while similar success was reported from the global studies. The SCENES project, in particular, clearly demonstrated the ease of involving stakeholders at the Pilot Area level and the difficulties in doing the same at the European scale using the same methodology. This finding might have consequences for the use of workshops as an exclusive means of involving stakeholders.
- *All additional tools that can be used show a large untapped potential that should be explored further.* Most projects have employed the ‘traditional’ Story-And-Simulation approach with qualitative stories and (spatially explicit) mathematical models. More recently, the addition of conceptual models showed their potential in structuring stakeholders’ knowledge and thus facilitating the quantification process. Likewise, Fuzzy Sets proved to be very useful in directly obtaining estimates for model parameters. The potential of using these or other additional tools has barely been touched upon.
- *Using Fuzzy Sets to have stakeholders quantify model parameters have shown potential which should be explored further, yet counterintuitive results do call for research that is more fundamental.* The Fuzzy Sets theory has shown how some parameters can be successfully quantified directly by stakeholders. Some of the results, however, are difficult to explain or different from what was expected. The tool seems to be in an experimental phase, where more fundamental research is needed on how to exactly formulate questions or interpret results. Additionally, the ‘fuzzy’ aspect should be studied in more detail.
- *Using ‘fast track’ scenarios to increase the number of iterations between stories and models had its drawbacks but deserves to be studied further.* As the number of scenario sets is increasing in the literature, new methods need to be explored that use existing material rather than starting from scratch. Importantly, we found that the use of fast-track scenarios is beneficial for the modellers but somewhat limiting for the stakeholders who felt limited in the futures they could develop.

Selected detailed lessons learnt

On Story-And-Simulation

Strengthening the link between stories and models is a balancing act. On the one hand, the use of more tools strengthened the link between stories and models. The application of more tools besides the original stories and mathematical models to facilitate the flow of information works. Several tools have been applied or further developed, e.g. Fuzzy Sets, Conceptual Models, or cartoons. On the other hand, most projects have shown that there is a limit to the number of tools and methods that you can use, particularly during a stakeholder workshop. Our recommendation is to adjust the number of knowledge-brokerage tools and composition to fit the participants’ training and experience as well as available resources (time frame, time step (frequency of meetings allowed), and funding – how much support modelling and analysis is available).

Using fast-track scenarios can increase the number of iterations, but has drawbacks. One of the critical issues with the Story-And-Simulation approach is the iteration between stories and

model output. This number of iterations is usually limited to 1. The use of existing scenarios as a starting point can successfully increase the number of iterations to 2-3, leading to more consistent products. The use of fast-track scenarios, however, comes at a cost in the storyline development. Two issues have been reported as problematic. Firstly, using a set of existing stories as a starting point can obstruct the process of taking ownership of the scenarios by stakeholders. Secondly, fast-track scenarios can lead to a set of scenarios that were termed by some as “boring”. On the other hand, fast-track scenarios were beneficial for the development of quantitative scenarios since they provide a meaningful reference for the iteration process in terms of geographic focus and inclusion of regional perspectives, and they provide a back-up in case of delay in provision of interim results. Our recommendation is to experiment with using other types of short-cuts to speed up the process to draft storylines, for example use fast-track uncertainties, or use existing scenarios without presenting the entire storyline.

The Story-And-Simulation approach has proven its success in practice. Overall, the Story-And-Simulation approach and its two cornerstones (models and stories) and the iterative procedure to increase consistency have been successfully executed a number of times. Below are some of the findings from a smaller set of projects for which detailed information was available (mainly SCENES, the Millennium Ecosystem Assessment and MedAction):

- *Having stakeholders develop storylines led to strong feelings of ownership.* Stakeholders regarded themselves as being the “owners” of the storylines. This feeling increased with each additional iteration.
- *Linking stories and models was a powerful means to bring together scientists and stakeholders.* Stories and models remain the most appropriate tools to engage scientists and stakeholders, and co-produce scenarios.
- *A set of 2-4 consistent, creative, credible, and relevant storylines were developed.* There are indications that the resulting products were believed to be credible, relevant, and consistent.
- *These stories were successfully quantified and translated into model output.* Models varied between a single model (SCENES); a series of linked models (MA); or tailor-made Decision Support Tools (MedAction).
- *Iterating between stories and models is critical and was achieved in most projects.* This is arguably the weakest link in the Story-And-Simulation approach. Beyond any doubt, it has been taken very seriously in all recent scenario projects. Yet, in most cases, more than one iteration proved to be impossible. Particularly interesting is therefore the SCENES project where the number of iterations was increased to three.
- *Stories and model input/output changed after every iteration. The amount of change reduced with every iteration.* It was particularly shown how input from stakeholders through the Fuzzy Set exercise changed with every iteration, and how changes became smaller, indicating an agreement between stakeholders and modellers.
- *This could indicate that stories and models are more consistent with each other than without iterations.*

On stakeholder participation

Engaging stakeholders at the European level is difficult. Organising stakeholder workshops at the pan-European level is very difficult since there is a weak personal stake at the pan-European level compared to the regional and local level. Apparently, these types of projects lack the prestige to make them attractive to institutions and agencies to obligate their representatives to participate. Additionally, a relatively low number of stakeholders are

sometimes engaged, which is somewhat problematic for expertise-driven tools. Our recommendations include:

- To undertake a detailed stakeholder analysis, a comprehensive and serious invitation process as well as to increase the attractiveness of such a process.
- To experiment with other means of involving stakeholders. Semi-structured interviews and a range of other participatory methods should become part of the Story-And-Simulation approach when applied at the European scale. Particularly the newly added tools (Fuzzy Cognitive Mapping, Fuzzy Sets) have the potential to be developed by individuals during interviews rather than during workshops.
- The identification and invitation of stakeholders needs to be a task in its own right.

Engaging stakeholders in a Story-And-Simulation approach is challenging but necessary. It is important to use a flexible methodology adaptable to local circumstances which is also capable of bridging between stories and models. Further, using a range of different tools makes it possible to engage different types of stakeholders that bring different types of knowledge and expertise. Maximising the number of tools that are employed maximises the number of different types of stakeholders that will feel attracted to the process and the results. However, the use of an elaborate Story-And-Simulation approach calls for a long period between workshops, which can lead to a loss of engagement and interest. Whilst using too many different tools can lead to cognitive overload that decreases the effectiveness of the tools.

On simulation

Running a mathematical model application as part of the Story-And-Simulation which includes close collaboration with stakeholders is in its infancy; more empirical studies are needed. Some findings include:

- + *Overall, Fuzzy Sets live up to the promise of quickly delivering stakeholder-based quantification of key model parameters.* Fuzzy Sets have a large untapped potential as a crucial tool in a scenario development toolbox.
- + *The notion of iteratively increasing consistency and plausibility worked for all parameters.* Particularly in the SCENES project, it was noted that for some drivers there was an increase in consistency between the story and the numbers elaborated by stakeholders, but for some additional support from the modelling team was needed. Yet, more iterations clearly led to more credible parameter estimates.
- + *Overall, the quantification and illustration of future development options is important.* Large-scale modelling is an appropriate tool for the pan-European view.
- - *The participating stakeholders represented a limited number of sectors only.* For example, in SCENES stakeholders represented only the water sector, while forestry and ecosystems dominated in MedAction. This selection was very appropriate for the storyline development but caused problems in driver quantification. Due to a lack of expertise, parameter estimations were sometimes very far from any existing and plausible projections. A good example is population growth, where growth rates per year are consistently overestimated compared to numbers found in the literature. SCENES showed that this misjudgement can be corrected in the following round, but that it does result in a delay in the iterative process.
- - *Modelling results can only be meaningfully used by stakeholders in a scenario development workshop when the involvement of scientific experts is high and the*

process is very structured. Projects show that including a sophisticated, complex and complicated tool such as a mathematical model requires the assistance of modelling experts that help stakeholders (and thus influence) stakeholders to a large degree.

Recommendations related to the use of Fuzzy Sets:

- More research is needed to provide better insight into the weak points as identified above. Importantly, the results of the Fuzzy Sets exercise substantially changed the model output, making additional Story and Simulation exercises even more necessary.
- Experiment with asking for information on less parameters, providing more time for discussion and ensuring that sufficient time is spent on the group discussion.
- Be realistic in the number of parameters that need to be quantified. The list of model parameters is much longer and more detailed than stakeholders can estimate in any reasonable amount of time.
- Limit the geographical specificity that is required. Stakeholders can provide information for a few large regions (i.e. Western Europe), not for every nation state in the EU-27. If national level projections are required, other methods need to be employed, possibly involving sectoral experts.
- Make sure that sufficient time is allocated to execute the exercise. This is partly related to the amount of parameters, but even if the list is short ample time needs to be allocated to allow for discussion among group members.

4.2 Content – usefulness of existing scenario sets

This Section is included to provide an overview of the resulting scenarios that have been developed, partly using similar methods. See Section 6 and Section 7 for more details on how this information is used in CLIMSAVE.

A large and growing number of global and continental scenarios have been developed that are potentially useful to consider in CLIMSAVE. A very good and rather recent overview is given by Rothman (2008). With respect to assessing the usefulness of existing scenarios, two aspects are of importance. First, the evaluation of a small set of potentially relevant scenarios will provide guidance on if and how they may be used within a fast-track approach. Second, a presentation and short discussion of four scenario archetypes that can be distilled from the large variety of existing scenarios. Both will be discussed briefly below.

Potentially relevant existing scenarios

A set of criteria were formulated to meaningfully rank sets of scenarios. The criteria cover a variety of aspects ranging from presence of elaborate stories and presence of mathematical models, to relevance of time horizon, and acceptance by scientists and policy-makers. Our starting point were eight sets of scenarios, including four global sets (IPCC, Millennium Ecosystem Assessment, GEO-4 and Shell), and four European sets (VISIONS, SCENES, PRELUDE and Four Futures for Europe). These eight studies were chosen to maximise the range of potentially relevant topics (climate change, ecosystems, water, etc.), time horizons, and type of scenarios.

Global scenarios:

- 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 used as the starting point for many continental and national scenario sets. Its strong points are acceptance by policy-makers, relevance for CLIMSAVE and availability of model results. The lack of elaborate stories and specificity for Europe are weak points.
- Millennium Ecosystem Assessment (MA; MA, 2005). Focus: ecosystems and ecosystem services. Its strong points are topic, elaborate storylines and models. Weak points include acceptance and lack of specificity for Europe.
- 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.
- Shell scenarios (Shell, 2008). Focus: energy. The lack of specificity for Europe and the minimal use of quantitative models are important drawbacks. Currency is a strong point.

European scenarios:

- VISIONS (Rotmans, et al., 2000). Focus: integration and social issues. Somewhat dated, but with an interesting method and strong set of European ‘visions’.
- SCENES (Kämäri et al., 2008). Focus: freshwater. Very recent with four elaborate and detailed socio-economic stories.
- PRELUDE (EEA, 2007). Focus: land use. Very creative scenarios with elaborate stories and a solid quantitative exploration, but with a low degree of acceptance by both scientists and policy-makers.
- Four Futures for Europe (Mooij and Tang, 2003). Focus: economy. Solid economic analysis, but somewhat dated and a rather low detail in stories.

Table 1 shows both the criteria that were used and the values that were given to the eight sets included here. It is clear from the short descriptions and the data in Table 1 that all studies have their strong and weak points. For example, Shell – the lowest scoring study – scores highest on currency, while the IPCC – the highest scoring study – is lowest in that category. Overall, however, the scores allow us to determine which studies are overall more useful to be considered in CLIMSAVE. PRELUDE and VISIONS can both be excluded because of a combination of lack of quantification, low scientific acceptance, and rather poor information on relevant sectors. The lack of specificity for Europe is a crucial limiting factor for both Shell and the MA scenarios. The Four Futures for Europe is somewhat dated and lacks information on relevant sectors. Comparing the remaining studies, SCENES is clearly preferable over GEO-4, mostly because GEO-4 served as the starting point for the SCENES scenarios. The latter can thus be regarded as an ‘improved’ version. Perhaps not very surprisingly, however, the IPCC Special Report on Emission Scenarios got the highest score, despite the low score for currency. Additionally, a new set of scenarios is being developed at the time of writing. It is beyond any doubt that this new set of scenarios will have by far the highest score. The conclusion is, therefore to use, or link to, the existing IPCC scenarios or – if possible – the new set of scenarios that are being developed. We therefore provide more detail on these scenarios in the subsequent section.

Table 1: Criteria used to rank sets of scenarios, together with the scores for eight scenario studies.

Criteria	IPCC	MA	GEO-4	Shell	VISIONS	SCENES	PRELUDE	Four Futures for Europe	Weighing factor
Degree of detail in stories	5	8	6	6	8	8	8	6	1
Specificity for Europe	4	2	5	2	8	8	8	8	3
Time horizon	6	8	8	8	8	8	8	8	1
Degree of quantification	9	7	6	4	3	6	3	6	1
Scientific acceptance	9	8	8	5	5	5	4	6	2
Acceptance by policy-makers	8	6	6	6	5	4	5	6	2
Information on relevant sectors	8	7	5	6	6	4	5	5	3
Degree of 'currentness'	4	7	6	9	4	9	6	5	2
Availability	5	8	8	7	7	8	4	7	1
Total Score	103	100	98	89	96	102	92	100	

The IPCC method

As we speak, a new set of scenarios is being developed for the 5th Assessment Report (AR5). Specifically, local and regional scenario developers are being asked to help shape the socio-economic scenarios. Here, could and should be a role for CLIMSAVE. A discussion on the specific role of CLIMSAVE is beyond this Deliverable or even WP3. Below is an overview of what the IPCC method entails, and the potential consequences for the implementation of the scenario development process.

What does the IPCC method entail?

The IPCC's upcoming 5th Assessment Report (AR5) intends to inform stakeholders about the options they have in order to manage climate change. To do so, a coherent analysis of adaptation and mitigation options should be carried out in order to inform them about the costs, benefits and risks of these options. An essential prerequisite is an improved coherence across the IPCC Working Groups in assessing projected climate change, its impacts, the degree to which adaptation and mitigation policies can reduce climate change and its impacts, and the costs of action and inaction.

The IPCC has decided not to carry out its own scenarios. Instead the IPCC intends to benefit from the scenario processes designed and carried out by the scientific community. This is a consequence of the IPCC's intention to be policy relevant without being policy prescriptive. If it is to avoid policy prescriptions the IPCC must explore a wide range of relevant options of adaptation and mitigation. The costs and risks of different options hinge on facts but also on societal choices. Therefore, the IPCC has to be explicit not only on facts (i.e. parameters, model structure) but also on the underlying value systems determining mitigation and adaptation options. In addition, policy-makers want to understand the intended and the unintended consequences of their choices. Without a consistent scenario process, the IPCC cannot provide these crucial insights.

Box 1: IPCC terminology/acronyms

RCP: Representative Concentration Pathways
SSP: Shared Socio-economic Pathways
SPA: Shared Climate Policy Assumptions
CM: Climate modellers
IAM: Integrated Assessment Modellers
VIA: Vulnerability, Impact, Adaptation community

The new scenario process began with the creation of Representative Concentration Pathways (RCPs); scenarios designed to help climate modellers explore the range of potential future greenhouse emissions and concentration pathways. Following the development of the RCPs, Moss et al. (2010) calls for a "parallel phase" in which the climate modelling community uses the RCPs to develop ensembles of climate change scenarios while the IAM and VIA communities jointly develop new scenarios that could be used for mitigation/adaptation studies. This is where CLIMSAVE could play a role.

In principle, the IPCC AR5 proposed scenario development approach is highly compartmentalised. Table 2 shows the basic lay-out: The **rows** represent four RCPs that correspond to certain greenhouse gas concentration developments. These will be used by the CM community to link them to certain ranges of temperature, sea level and precipitation. As such, the rows represent the biophysical system dynamics and the effect of climate change. In the **columns**, there are four socio-economic pathways (SSPs). These represent four distinct paths of development of the socio-economic system, focusing on mitigation and adaptation potential. The SSPs will *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 integrate. Note that this approach assumes that SSPs and RCPs can be developed independently, while shared climate policy assumptions (SPAs) will always be in response to both a certain RCP and a certain SSP. The exact approach of developing SSPs is still being discussed. At the time of writing, it was being announced that decisions were going to be taken in July 2011.

Table 2: IPCC AR5 proposed scenario development approach showing the connection between RCPs, SSPs and SPAs.

RCP (W/m ²)	Climate (T, P, sea level)	SSPs			
		SSP1	SSP2	SSP3	SSP4
2.6					
4.5		SPA			
6.0					
8.5					

In short, the IPCC is specifically addressing “the VIA community” and their approach to new scenarios bears large similarities with CLIMSAVE. In fact, the stories as described here are synonymous with the SSPs from the IPCC, while their SPAs are very closely connected to the adaptation options. There are thus large possibilities to link to the IPCC process. It was decided that the most logical link is to first conduct our first series of workshops and develop our stories independently. After the first outlines of the stories, IAP, and adaptation options are known, we should revisit the question of how to establish the link.

Scenario Archetypes

Several authors have attempted to classify the large number of different scenario sets into so called scenario archetypes. Rothman (2008) provides a good overview of a number of archetypes that in general agree with other studies (e.g. Busch, 2006; Zurek, 2006; Westhoek et al., 2006). Figure 1 places the eight scenario studies used in Table 1 on two axes that represent the two main uncertainties that determine the main developments in the scenario archetypes. The first axis represents uncertainty about whether the world will further globalise, or whether globalisation will stop and regional development will become prominent. The second axis represents uncertainty about whether we are moving towards a world where economic development is leading with ongoing privatisation and trade liberalisation, or a world with increased solidarity, more interest for environmental issues and a stronger role for the government and the public sector.

The four resulting scenario archetypes (the four quadrants in Figure 1) can be described as follows:

- I. **The Global Market** (Figure 1, top left quadrant). Global developments steered by economic growth result in a total dominance of international markets with a low degree of regulation. Environmental problems are only being dealt with when solutions are economically interesting.
- II. **Continental Barriers** (Figure 1, lower left quadrant). A regionalised world based on economic developments. The market mechanism fails, leading to a growing gap between rich and poor. In turn, this results in increasing problems with crime, violence and terrorism, which eventuates in strong trade and other barriers.
- III. **Global Sustainability** (Figure 1, top right quadrant). A globalised world with an increasingly proactive attitude of policy-makers and the public at large towards environmental issues and a high level of regulation. Three main variations can be discerned. One where the global solution is in technological change (Techno Garden, Knowledge is King), one with strong governance structures (Policy First, Policy

Rules), and one with a broadly supported paradigm shift (Big Crisis, Sustainability First).

IV. **Regional Sustainability** (Figure 1, bottom right quadrant). A regionalised world, where most – broadly supported – initiatives to improve the state of the environment and move toward sustainable solutions are bottom-up with a major role for NGOs and multi-level governance structures.

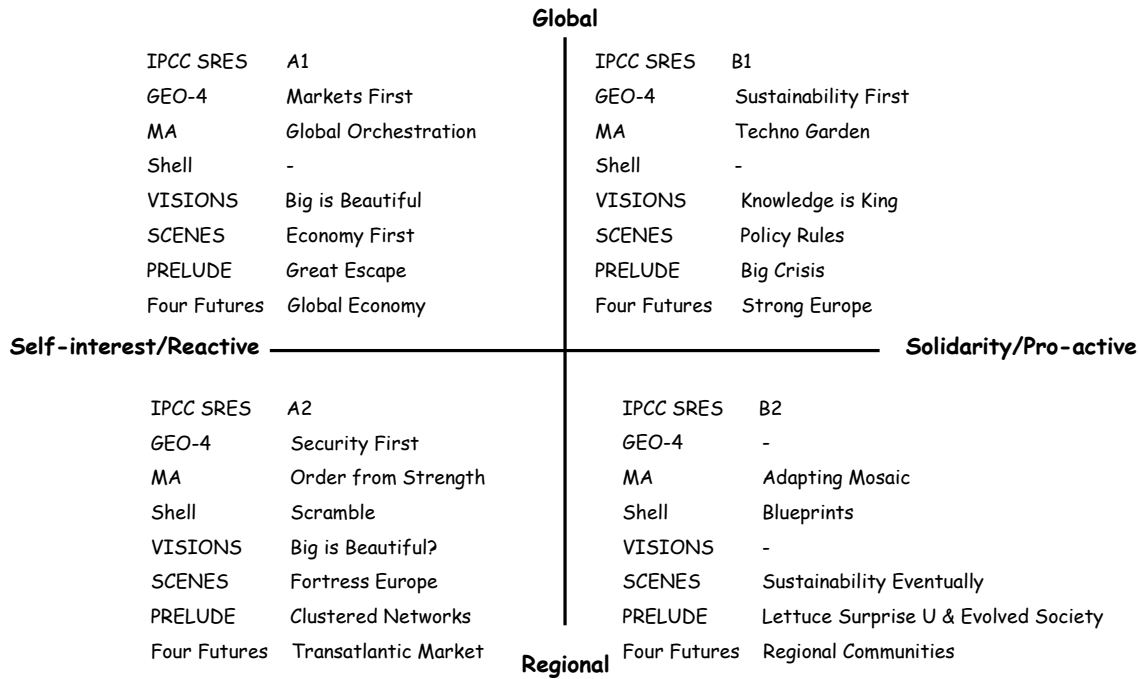


Figure 1: Eight scenario sets positioned along two axes of main uncertainties. See text for explanations of scenario studies.

In conclusion, the bulk of the existing scenario studies can be categorised into a small number of scenario archetypes. This has important practical implications. Most importantly for CLIMSAVE, it is possible to link scenarios that will be developed to other sets of scenarios (e.g. the IPCC scenarios) and use additional information from other studies, provided that scenarios can be categorised in similar archetypes. For example, a scenario developed in CLIMSAVE that assumed globalisation and economic development could be linked to e.g. Global Orchestration from the MedAction, the A1 scenario from the IPCC, or Economy First from SCENES.

5. Stakeholder selection procedure

The input by stakeholders is seen as a critical element for many foresight and scenario processes. In the exploration of plausible futures, the inclusion of perspectives from stakeholders provides not only important information for the process, but also creates the potential for higher relevance of the process results for stakeholders. In a participatory stakeholder involvement process, the purpose is to maximise the inclusion of stakeholder’s perspectives and hence stakeholder’s uptake of process results. In projects at the science-policy interface, this also has the potential to increase the policy relevance of process

outcomes; stakeholder inclusion increases potentially the legitimacy of resulting policy proposals.

The selection of stakeholders for a participatory scenario development process such as undertaken in CLIMSAVE is an important factor in realising the above potential. The process of combined qualitative and quantitative scenario and option development as in CLIMSAVE demands highly specific input by stakeholders through intensive and direct interaction. Within the budgetary and process limits of the project such interaction can only be achieved by the intensive involvement of a relatively small group of stakeholders - in CLIMSAVE through a series of three workshops, at both the European and regional scales, with each involving between 20 and 25 stakeholders participating in the panel. With such a small number, the selection of individual stakeholders for the panel thus needs to be made with special care, enabling the intended effects to be achieved by ensuring a balance of the stakeholder perspectives included.

5.1 Categories for stakeholder identification and selection in the CLIMSAVE project

The selection of stakeholders for the scenario development workshops needs to ensure a balance of societal perspectives on the subject. The absence of a complete model of societal perspectives on climate change adaptation in Europe makes it impossible to choose participants on such a model basis. Moreover, as the project intends to establish close links to policy-making and to contribute to it, the selection cannot be based on political considerations. Instead, a structural, non-normative approach to differentiating perspectives on the subject is needed. The approach applied in CLIMSAVE differentiates according to the following structural elements as categories.

Societal structure

Differentiating between the sectors of society that are concerned with the topic enables different perspectives from the main systems and subsystems in society which are affected by climate change to be captured. After analysis of the different systems and subsystems, the following differentiation was made. Given the focus of input to policy-making in CLIMSAVE, *Government and public authorities* (1) are a first important sector to include in the project. The *economy* (2) strongly affects society's ability to adapt to climate change - its diverse actors form a second important sector to be included. As a research project, the sector of *research* (3) is a key stakeholder in the project and hence a third sector to include. Finally, *civil society* (4) will have a key role in the successful implementation of any adaptation to climate change in Europe. These four main categories of societal structure were subdivided on two further levels, specifying for civil society, for instance, environmental NGOs and NGOs active in various other fields such as recreation, cultural development, human rights, etc. Similarly, the economic sector differentiates, for instance, between social partners (trade unions and employers/business organisations), business sector associations, professional associations and representatives of private companies and enterprises.

Geographical structure

The effects of climate change are, and will be, significantly different depending on the geographical location - hence, the project needs to cover different perspectives from stakeholders from the variety of geographical and territorial locations. For CLIMSAVE, this translates into covering all main geographical areas - at the European scale for the European case, and at the regional scale for the regional case (Scotland). For the European scale, a

difference was made between *Southern Europe, Northern Europe, Eastern Europe and Central Europe*. For the regional case, the differentiation was made between *Central Belt, Highlands, Islands and East Lowlands*.

Topical structure

CLIMSAVE covers a series of themes and vulnerabilities. The group of stakeholders involved needs to be able to give input to these themes and vulnerabilities. In terms of themes, CLIMSAVE differentiates between six thematic sectors: *Urban, Coasts, Water, Agriculture, Forests and Biodiversity*. Furthermore, for the analysis of vulnerabilities and for the definition of the range of possible action, CLIMSAVE applies the concept of capitals. It differentiates between *social, financial, natural, human and manufactured* capital. Perspectives on all thematic sectors and all capitals need to be present in the group of stakeholders involved.

Gender and age structure

CLIMSAVE's focus and approach does not give rise to the need to exclude one of the genders in its stakeholder involvement. On the contrary, the focus of this stakeholder involvement is to include the perspectives of both genders. In terms of age, different generations will face different levels and consequences of climate change. Moreover, the experience and knowledge perspectives of different generations may lead to different input relevant for CLIMSAVE. A differentiation between age groups *20-30 years, 30 to 65 years and 65 years and older* was applied.

5.2 *Setting quotas for stakeholder involvement in the CLIMSAVE workshops*

Based on the above mentioned category structure, minimum quotas for each category and in some cases subcategories were set. The quotas refer to both scales (European and regional).

Societal sectors

A minimum of four participants are to come from each of the four main societal sectors identified: hence a minimum of four participants from government and authorities, a minimum of four participants from economy, a minimum of four participants from research, and a minimum of four participants from civil society.

Within the sector government and authorities, a minimum of one participant is to come from international organisations; a minimum of one participant is to come from European institutions, a minimum of one participant is to come from national governments and authorities, and a minimum of one participant from regional or local government and authorities. Within the sector economy, a minimum of one participant is to come from employer and trade union organisations, a minimum of one participant is to come from business sector organisations, a minimum of one participant is to come from professional organisations, and one participant from an enterprise. Within the sector research, a minimum of one participant is to come from the fields of economics or business management, a minimum of one participant is to come from technology or cross-cutting research, a minimum of one participant is to come from law, sociology, political sciences or communication sciences, and a minimum of one participant from an affiliate or support institution. Within the sector civil society, a minimum of one participant is to come from an environmental NGO (non-governmental organisation), a minimum of one participant is to come from a cultural or

youth NGO, a minimum of one participant is to come from a humanitarian or human rights NGO, and a minimum of one participant is to come from the media.

Geographical balance

The following quotas were set for the geographical balance for the European Union level case study: a minimum of three participants are to come from southern EU, a minimum of three participants are to come from northern EU, a minimum of three participants are to come from eastern EU, and a minimum of three participants from central EU. For the regional (Scottish) case study, the following geographical quotas were set: a minimum of three participants are to come from the Central Belt, a minimum of three participants are to come from the Highlands, a minimum of three participants are to come from the Islands, and a minimum of three participants from East Lowlands.

Topical balance

For the topical balance, the following quotas were set: a minimum of two participants are to come from each of the six thematic sectors (urban, coasts, water, agriculture, forests and biodiversity). Furthermore, a minimum of two participants are to come from each of the capital backgrounds (natural capital, human capital, social capital, manufactured capital and financial capital).

Gender and age

For the gender balance, the following quotas were set: a minimum of eight female participants, and a minimum of eight male participants. Finally, for the age balance, the following quotas were set: a minimum of two participants from the age group 20-30 years, a minimum of twelve participants from the age group 30-65 years, and a minimum of two participants from the age group 65 year and older.

5.3 Enabling a balanced selection of stakeholders

By fulfilling this set of quotas for the categories as defined above, the selection of stakeholders to participate in the CLIMSAVE stakeholder workshops enables a minimum balance of perspectives to be captured - the goal of the approach. The next step was to fill this empty database. Key persons from the CLIMSAVE consortium helped to identify individual persons that fit the categories. The selection of the first set of invitees was to fulfil all quotas defined. In the identification process of individuals, specific attention was given to avoid the “professional stakeholder” phenomenon - meaning to avoid selecting persons that are more interested in participating in as many stakeholder processes as possible rather than in contributing to the specific stakeholder process and content in question.

The identification and selection of invitees took specific care of identifying persons with a clear link to the topic of climate change adaptation in Europe (as defined by the categories above). While CLIMSAVE partners were invited to make proposals, separate research was undertaken to find additional candidates for invitation. Experience in previous stakeholder engagement activities such as in the SCENES project shows the difficulty of engaging stakeholders over a longer period and in several workshops/meetings. In CLIMSAVE, candidate invitees were made aware of the need to participate over the course of the project, rather than for a single workshop.

With the defined elaborate process, the project takes a conscious and planned approach to stakeholder identification - which contrasts with more *ad-hoc* approaches, where stakeholder involvement is handled as a separate add-on to an otherwise stakeholder-remote project. CLIMSAVE targets the involvement of stakeholders as an intrinsic part of the project - stakeholder input in CLIMSAVE delivers essential information to the scientific work and influences outcomes significantly - including but not limited to the provision of explicit qualitative assumptions and model inputs and the link to policy-making. The stakeholder selection process of CLIMSAVE supports these ends through a conscious, planned and elaborate approach.

6. Scenario development

6.1 Overall scenario development framework

Concept

Figure 2 illustrates the various components in the CLIMSAVE scenario development approach. It shows the three products with their three main linking mechanisms as will be developed within CLIMSAVE. Out of these, the main products discussed here are the socio-economic stories and adaptations options as perceived by stakeholders. This Deliverable furthermore provides details on the Story-And-Simulation approach used to link the stories to the climate change impacts produced by the Integrated Assessment Platform (IAP), and on the roadmapping method that will be used to develop adaptation options within the context of the stories. Note that the third connection between the IAP and the adaptation options is equally important, but this work on adaptation metrics is described in Deliverable 4.1.

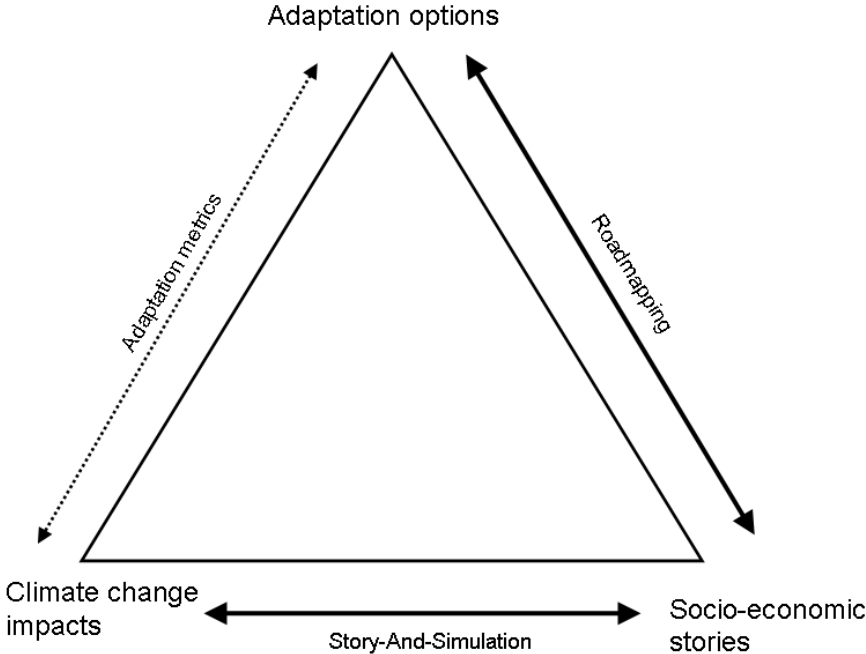


Figure 2: Components of the scenario development approach as adopted in CLIMSAVE.

Practical implementation

The overall scenario methodology was discussed during the kick-off meeting in Oxford in February 2010 and later during a WP1/WP3/WP5 meeting in Kassel in May 2010. The results of this meeting were presented and discussed in the Steering Committee meeting in Barcelona in September 2010, where the concept was accepted by relevant partners. Figure 3 shows the practical implementation of Figure 2 by illustrating the flow of information particularly during stakeholder workshops.

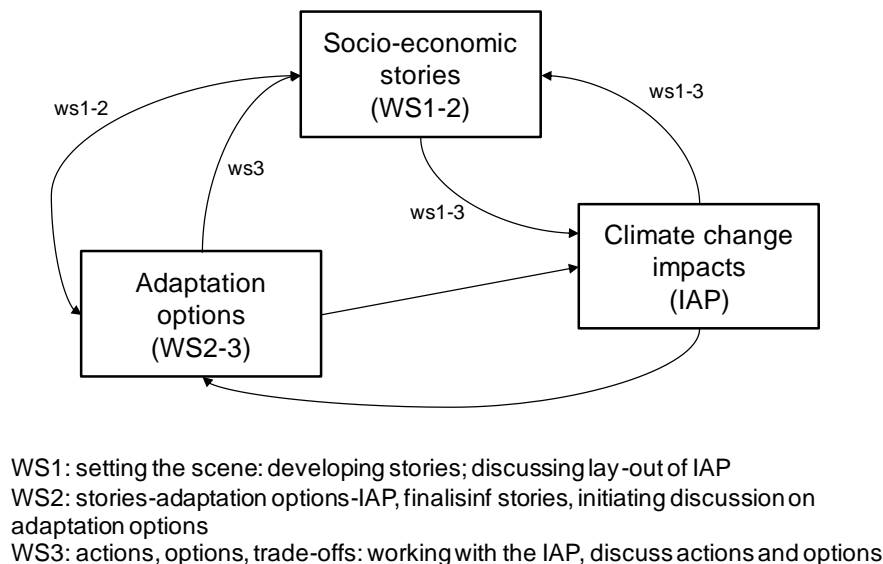


Figure 3: Flow of information between stories, the Integrated Assessment Platform (IAP), and adaptation options, and the role of stakeholder workshops (WS).

Figure 3 shows how a first draft of the socio-economic stories will be developed during the first scenario development workshop (WS1). This workshop will also be used to discuss with stakeholders a first mock-up version of the IAP. Additionally, stakeholders will be providing quantitative estimates of a small selection of parameters for the IAP. Feedback on the lay-out of the IAP and parameter estimates will be provided to WP2. During the second workshop (WS2), stories will be revised and refined based on the first draft but importantly also on the model runs of the IAP, which will illustrate the impact of the stories and climate change for a number of sectors. Based on this, a first draft will be made of a list of adaptation options. The third and final workshop (WS3) will focus entirely on adaptation options, actions, and strategies, through a roadmapping exercise, again using the IAP as an important source of information.

In general, the methodology will be as follows:

1. Develop scenarios separately for climate, other sectors of CLIMSAVE (through models), and socio-economic/institutional aspects (through stories). The Story-And-Simulation approach is a very good starting point.
2. Integrate those separate parts to one set of CLIMSAVE scenarios.
3. Integrate adaptation options, using roadmapping.

The remainder of this section is structured following the structure and terminology of Figure 2.

6.2 Exploratory scenarios - Stories

By and large, the methodology adopted to develop exploratory stories during stakeholder workshops followed the procedure as used for the Millennium Ecosystem Assessment and described in detail in Chapter 5 of the MA methods manual (Henrichs et al., 2010). Broadly three stages are discerned, including a first stage geared towards identifying the main concerns about future developments; a second stage focusing on discussion of key uncertainties and driving forces; and a third stage during which the actual scenarios are developed. The specifics of the steps are given in the section on methods.

Below are three crucial aspects of the CLIMSAVE scenario development method, focusing on the innovative aspects.

Input: fast-track scenarios

The approach of starting with a set of existing scenarios to increase the number of iterations between stories and models has been attempted before. In the literature there are ample examples of using a set of higher-level scenarios that were subsequently downscaled using the starting scenarios as boundary conditions (see e.g. Kok et al., 2006; Rounsevell et al., 2005). Recently, using a set of scenarios at the same (European) scale was attempted, with mixed results (see Kok et al., 2011).

The use of fast-track scenarios to kick-start the process of scenario development has a number of advantages and drawbacks as described in Section 4. Because of the potential drawbacks, it was decided to not use a set of existing *scenarios* (stories and model results) as a starting point for the CLIMSAVE exercise. Yet, starting from scratch was also decided against. Instead, we decided to start from another step in the scenario development process. The following steps can be discerned (see subsequent section for details):

1. Set boundaries (define area, time horizon of scenario, etc.).
2. Define key dimensions (main variables that are important at present).
3. Describe current situation (historical developments).
4. Determine main driving forces.
5. Define critical uncertainties in future development of drivers.
6. Write story.

In CLIMSAVE, we decided to start with Step 5, by presenting a number of key uncertainties to the stakeholders rather than discussing drivers and uncertainties from scratch. The list of key uncertainties was based on two elements: A mix of worldviews and myths of nature, and a number of megatrends as identified by the European Environment Agency (EEA). Below the two elements are introduced; a detailed overview of how they were transformed into a list of (un)certainties is provided in Section 7.

The EEA Megatrends

A recently published list of global ‘megatrends’ (see EEA, 2010; <http://www.eea.europa.eu/soer/europe-and-the-world/megatrends>) was selected as an

appropriate set of drivers that could kick-start the discussions within the CLIMSAVE workshops. Below the list of 11 megatrends is given:

1. Increasing global divergence in **population** trends.
2. Living in an **urban** world.
3. Disease burdens and the risk of new **pandemics**.
4. Accelerating **technological** change: racing into the future.
5. Continued **economic** growth?
6. From a unipolar to a **multipolar** world.
7. Intensified global **competition** for resources.
8. Decreasing stocks of **natural resources**.
9. Increasingly severe consequences of **climate change**.
10. Increasing environmental **pollution load**.
11. Environmental regulation and **governance**: increasing fragmentation and convergence.

Note that the list serves as a set of trends that can be considered. The final list of drivers and trends is ultimately determined by the workshop participants and can (strongly) differ from the list above.

Worldviews, Cultural Theory, and Myths of Nature

Recently, there has been a growing body of literature on the relationship between scenario sets and a fundamental set of ways in which the current situation of the world is perceived. Cultural Theory was developed by Douglas and Wildavsky (1982) using two axes ('Grid' and 'Group'), thus creating four types. Swartz and Thompson (1990) attempted to link Cultural Theory and the Myths of Nature (see Dake, 1992). Figure 4 shows this connection.

Various authors have since attempted to link these four 'rationalities' to sets of four scenarios, particularly the IPCC SRES scenarios. The most elaborate case is for a downscaled set of IPCC scenarios for the Netherlands (see MNP, 2006; Goetheer, 2009). Goetheer (2009), for example, describes four worldviews for the Netherlands that map 1:1 onto the rationalities and that carry the names of the IPCC scenarios (e.g. "The A1 worldview"). The concepts have also been tested in practice elsewhere (e.g. Lima and Castro, 2005). Importantly, a scenario development exercise in the UK using the Myths of Nature showed the ease with which stakeholders understand the concepts and could potentially use it in the scenario development process (Vervoort et al., under review).

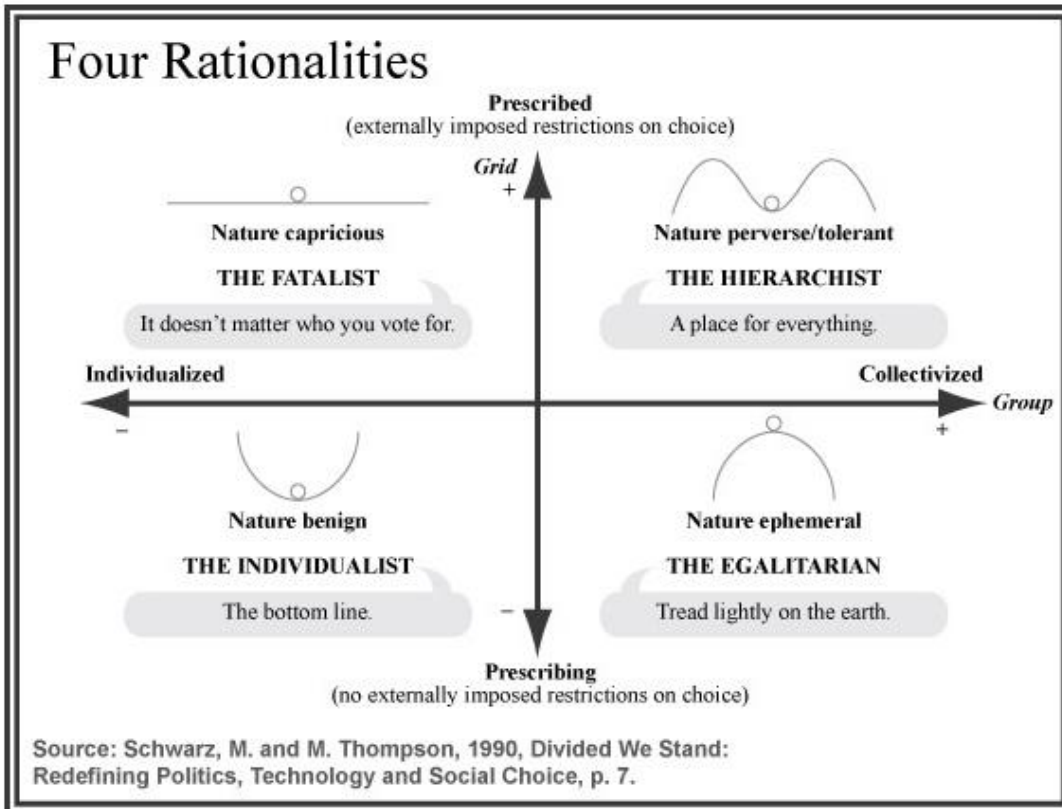


Figure 4: Four rationalities. Combining Cultural Theory and Myths of Nature.

We concluded that there are multiple potential advantages of using rationalities as a starting point rather than an actual set of scenarios:

- We will not start from scratch, thus not abandoning the added values of using a fast-track product.
- Worldviews can be explained quickly and can be understood easily by stakeholders.
- Worldviews are sufficiently broad to stimulate thinking about the future without being prescriptive and limiting.
- Worldviews can be linked to scenario sets, thus maintaining a link between the stakeholder-driven stories and the model-based quantitative scenarios and ensuring a level of consistency.

Note that the translation to uncertainties can be done in various different ways. The procedure followed in CLIMSAVE is explained in Section 7.

Methods – story development in six steps

As said, the starting point of the scenario development method adopted in CLIMSAVE is the one described in the Millennium Assessment Handbook (Henrichs et al., 2010), within which we will highlight six steps:

1. Define the boundaries of your scenarios. Scenarios will be developed until the 2050s, with an earlier time slice in the 2020s. The time horizon of 2055 is sufficient to include the impact of climate change and the effect of (part of) the adaptation options. The methodology will be developed for the European case study and tested in the Scottish case study.

2-4. Define key dimensions/Describe current situation/Describe key drivers and short-term trends. The idea behind these steps is that there is a discussion on the main factors relevant for climate change and adaptation options and on how the different factors connect. In the MA method, these steps are used mainly to arrive at a list of key drivers of the system, based on their importance in the system and the expected short-term changes. Recently, other tools have been employed mainly to determine the perception of stakeholder's understanding of the system. Good examples include Fuzzy Cognitive Mapping, a group model building tool, (see Kok, 2009), with which ample experience was gained in a previous project (see van Vliet et al., 2010). Other available tools and methods include Causal Loop Diagrams or the Syndromes Approach. The CLIMSAVE project team decided that developing a system dynamics model during a stakeholder workshop would be worthwhile but too time-consuming. Although using such participatory models could facilitate the link with the IAP, it would not contribute towards identifying adaptation options. Yet, it was also decided that developing a flow-chart after the first stakeholder workshop by the project team to describe the sequence of events in each of the stories might be useful. This product would thus be less stakeholder-driven, but it would not be developed at the expense of other elements. The usefulness of such a product will be discussed in Deliverable 3.3.

5. Identify critical uncertainties. There is a difference between the factors that drive the system ('certainties') and the factors that drive the system but for which the future situation is highly uncertain ('uncertainties'). This last group of drivers are the most important and will determine to a large extent which scenarios should be developed. As in the MA method, it was assumed that two critical uncertainties will be identified, resulting in four stories. We will start this step by presenting a list of certainties and uncertainties. Note, however, that the process is entirely stakeholder-driven and the outcome in CLIMSAVE might be different. Note that the number of four stories is often used irrespective of the use of uncertainties, because 2 is too narrow, 3 often leads to singling out one as the most likely or most relevant, and more than 4 is simply too many.

6. Develop stories. The actual development of stories is the most important and most time-consuming step. A large part of the first workshop will be devoted to groups of stakeholders sitting down and actually drafting the text for the stories.

Results – Stories: form and content

Form

The basic format is a story, of which the basic elements will be developed during the workshops. It is foreseen that stories will be about 4-6 pages, depending also on the scenario and the stage of the process. Again, the exact shape and form will depend partly on the initiatives of the stakeholders present. For the sake of communication, however, long stories are not the best type of output. The workshop products will be analysed and the CLIMSAVE project team will produce a number of additional outputs that will help communicate the main output of the stakeholder process. These will include:

- a ½ page summary in words,
- a flow-chart showing the sequence of events and the main factors and processes,
- cartoons, pictures etc. for a graphical representation.

Content – stakeholder-led versus stakeholder-determined stories

In principle, the content of the story will be determined by the stakeholders present during the workshops. In this process we want to prescribe as little as possible. Any influence from our side bears the risk of influencing stakeholders. However, the second objective of combining stories with adaptation options and with mathematical models will put some constraints on what the stakeholders will be “allowed” to include and which details need to be provided. Below is a wish list of aspects that we would like to specifically address in the stories:

1. Two time periods. Stories will have information on two time periods that coincide with the time slices used by the modelling teams in CLIMSAVE: short and medium term (until 2025) and long term (until 2055).
2. Stories will as much as possible contain information on socio-economic, institutional and cultural changes, as much as they are relevant for climate change. As much as possible, (climate) policies and climate change will be included in the models (climate change) or the adaptation options (policies). We realise this split is artificial, but nevertheless it seems both useful and doable. This is also relevant given the IPCC process and potential links (see Section 4.2).
3. Stories will need to specifically address the five capital forms as used in the vulnerability framework and a qualitative indication of the dynamics over time.

6.3 Normative scenarios - Adaptation options, climate policies and other actions

The second main output of the participatory scenario development process is a list of actions, policies, and particularly adaptation measures. These actions will both be scenario specific and generic. The latter is referred to here as ‘robust’ actions, defined as actions that will be successful independent from the scenarios, i.e. it will be effective in all scenarios.

Methods

The list of actions, policies and adaptation options will mainly be developed during the second and third workshops in the context of the stories, most likely using a roadmapping technique. It is likely that, again, a fast-track procedure will be followed, using an existing list of potential adaptation options as a starting point. This list will be based in part on adaptation options that have already been selected as relevant to the models and to become part of the IAP. The exact method will be discussed after the results from the first stakeholder workshop are analysed.

Results

The list of actions and adaptation measures will be available at two levels:

1. Scenario specific. For each of the stories, there will be strands of related actions (“strategies” or “highways”) that need to be taken to reach a desired objective. These will be as specific as possible (answering questions such as: When, Who, What, How long, How, Why etc.). It is important to stress the importance of temporal dynamics. Crucial to a roadmap is its time specificity.
2. All these strands of actions developed for one story will be ‘tested’ in the other stories, resulting in a list of actions or strategies that might be valid for multiple scenarios.

Crucial in this process is the fact that a full and running version of the IAP will be available, in order to directly evaluate the impact of taking an adaptation measure. Thus, an assumed effect can directly be verified.

The type of adaptation measures that will be included, depend on a number of factors:

- Selected by stakeholders; relevant for the stories.
- Possible to include in the IAP; quantifiable.
- Availability of capital, which might limit options that can be executed.

Of these, the selection will first and foremost be determined by stakeholders during the workshops. However, where needed for consistency among WPs the other factors can be of some importance.

6.4 Models – the Integrated Assessment Platform

For most of the information on the IAP we refer to the various Deliverables of WP2. The only relevant aspects in the context of the stories are the ability of the meta-models in the IAP to include wishes from stakeholders regarding adaptation options and the functionality of the interface, and the runtime which should be in the order of seconds rather than minutes. The latter enables a real-time feedback between stories and models, thus operationalising the Story-And-Simulation approach.

6.5 Story-And-Simulation – linking models and stories

Basics of the Story-And-Simulation approach

Figure 5 shows the graphical representation of the Story-And-Simulation approach as described by Alcamo (2008).

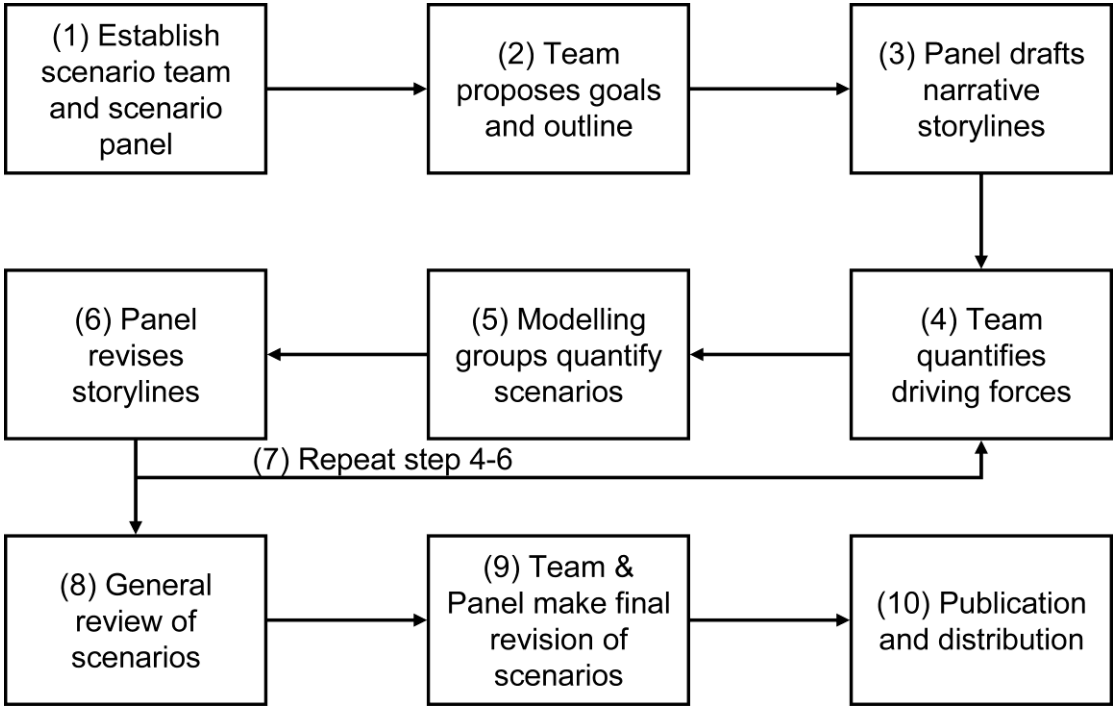


Figure 5: The Story-And-Simulation approach.

Basic procedure

The Story-And-Simulation approach accounts for all steps considered essential to develop scenarios at a single scale. Important steps include the establishment of a scenario panel and scenario team (1); construction of storylines (3) that are quantified and revised (4-6) in an iterative procedure; and publication and distribution (10). The scenario team is a selection of 6-8 experts responsible for the coordination of the scenario development process and most steps in parameter quantification. The scenario panel is a small core group of key stakeholders that is assembled at the start of the project and that are responsible for the actual development of storylines. The composition of the scenario panel should be unaltered as much as possible to ensure continuity. Stakeholder workshops will take place at regular intervals, in this case 3 at approximately 9 month intervals. All members of the scenario panel will be invited to each workshop complemented by a number of additional stakeholders depending on the purpose of the workshop, and a number of scientists from CLIMSAVE. Examples of global exercises that have used an approach similar to the Story-And-Simulation approach include the Millennium Ecosystem Assessment (Carpenter et al., 2005); the Global Environment Outlook (UNEP, 2007); European studies such as PRELUDE (EEA, 2007); and a growing number of regional and local studies (e.g. Kok et al., 2006; Kok and Van Delden, 2009).

Strong and weak points

The text below is taken largely from Kok (2009). See also Section 4.1 for a more detailed and concrete overview of the advantages and drawbacks of using the Story-And-Simulation approach.

Alcamo (2008) lists a number of strong and weak points of the methodology that all still stand today. The approach is costly – both in terms of money and time – but direct stakeholder participation ensures that scenarios are relevant and credible to end-users, while models provide state-of-the-art scientific input and consistency checks.

Although it has only been hinted towards in the published literature (see Kok and Van Delden, 2009), experiences with linking qualitative and quantitative scenarios have uncovered an additional weak link in the Story-And-Simulation method. To understand the nature of the problem, it is important to grasp the fundamentals of constructing stories and dynamic models. Table 3 lists some of the (archetypical) characteristics of dynamic models and stories. There is a high degree of potential complementarity between stories that involve stakeholders and stimulate creative thinking, and models that are quantitative and rigorous. In fact, this is the very reason that the Story-And-Simulation approach has been suggested and successfully adopted. However, the large degree of complementarity might also be the largest drawback of the method. On the one hand, not all assumptions of the stories could be incorporated in the models, while on the other hand, models require quantitative information on a wealth of parameters that it is often difficult to extract from storylines. In other words, there is a mismatch between storylines and model parameters (Step 3 to Step 4 in Figure 5), as well as between model output and revised stories (Step 5 to Step 6). In practice, the translation of stories into quantified model input is often *ad-hoc* and does not do justice to either the richness of the stories or the quantitative complexity of the models. The weak link between the qualitative and quantitative scenarios might well be the most problematic aspect of the Story-And-Simulation methodology.

Table 3: Key characteristics of qualitative (stories) and quantitative (mathematical models) scenarios.

Stories	Mathematical models
Credible	Internally consistent
Not implausible	Plausible
Creative, out-of-the-box thinking	Dependent on model architecture
Developed by stakeholders during workshops	Developed by scientists
Qualitative	Quantitative
Based on perception of stakeholders	Based on scientific state-of-the-art thinking
Not limited by data availability	Data-driven
Focus on social changes	Focus on biophysical data

Application within CLIMSAVE

The application of the Story-And-Simulation approach within CLIMSAVE will make use of these previous experiences, particularly in trying to improve the link between models and stories. Based on the conclusions drawn in Section 4, the following methodological improvements are suggested:

1. Use a technique called **Fuzzy Sets** in order to have stakeholders directly estimate parameter settings for the meta-models in the IAP. This has been tested in an earlier project, with varying success (see SCENES project, www.ymparisto.fi/syke/scenes, Deliverable 2.6). The key improvement is to integrate the method in the story-writing process, rather than undertaking it in a separate session. This will ensure that both products are consistent, while more time can be devoted by workshop participants to discussing numbers.
2. Use a **system dynamics** (qualitative) description to support the story writing. Similarly, this was attempted in a previous project (see SCENES project, www.ymparisto.fi/syke/scenes, Deliverable 2.8 and Deliverable 2.9). The key improvement is to complete the model (IAP) description early in the project, in order for stakeholders to make use of it during and in between stakeholder workshops. These would then also serve as a means of communicating the qualitative scenarios.
3. Have a **real-time interaction** between the meta-models in the IAP and the stories. The short runtime of the IAP provides a unique opportunity to have stakeholders immediately test their (qualitative) assumptions. Within the context of the Story-And-Simulation approach, this has not been attempted before, even though online modelling applications do exist. The added value is in improving the consistency between model and story assumptions.

In short, we will adopt the current state-of-the-art of combining stories and models where possible, and improve the method where necessary.

6.6 Roadmapping – linking stories and adaptation options

Key to understanding how adaptation options and stories can be linked is in the understanding that they are part of a different type of scenario. As said, stories will be *explorative* scenarios addressing the question ‘what could happen?’. Adaptive measures can only meaningfully be

studied when addressing the question ‘what can we do about it?’, which is part of *normative* scenarios. Here we draw heavily from experiences in an earlier project of combining explorative and normative scenarios (see Kok et al., 2011). From these experiences we drew several conclusions, among which were:

- The combination of exploratory and normative scenarios was very fruitful.
- A rather long list of robust actions was compiled.
- The use of backcasting as a method for normative scenario development was not ideal, mostly because of difficulties for stakeholders to understand and work with the method.

It was thus decided to use the same overall concept of combining exploratory stories and normative scenarios. However, on certain aspects the methods will differ. Related to the adaptation measures, we will not use backcasting but rather employ the (related) roadmapping technique (see McDowell and Eames, 2006). Whereas backcasting is specifically designed to reason backwards from a desired vision, roadmapping reasons forward, thus differing less from the explorative stories. The great strength of the roadmapping approach over backcasting is the identification of barriers and solutions to them, and generation of shared targets. The final roadmap itself provides a measure against which progress can be measured (McDowell and Eames, 2006).

Given that this work will take place in the course of 2012 and given that the exact details of the method will also depend on the results of the first and second stakeholder workshops, it is premature to provide details on the method that will be employed.

6.7 Innovative elements

The previous subsections of Section 6 describe the basic concepts, methodology, and specific tools and methods to be employed. In this subsection we summarise the innovative elements in the overall scenario development process, focusing on the methods used to link the adaptation options, models and stories.

Linking stories and models

We demonstrate the innovative elements by using the four problems as identified in the DoW of CLIMSAVE. Although the participatory and qualitative-quantitative approach has its clear advantages, a set of problems continuously arise that takes away from its usefulness for decision-making and integrated assessment. These problems can be summarised as:

- The *reproducibility problem*: qualitative scenarios are largely non-reproducible.
Analysis: the development of stories causes the products to be non-reproducible.
Innovation: use a number of additional (structuring) tools (Fuzzy Sets, Conceptual Models) that yield reproducible results that will complement the stories.
- The *conversion problem*: it is difficult to convert from qualitative to quantitative scenarios, and back again.
Analysis: stories often contain vague words (“strong increase”), while addressing partly unquantifiable factors.
Innovation: The use of Fuzzy Sets and conceptual models will facilitate conversion, by focusing on direct parameter quantification by stakeholders, who thus provide all information for the link between vague words and numbers.

- The *consistency problem*: it is difficult to maintain the consistency of qualitative scenarios and the consistency between qualitative and quantitative scenarios.
Analysis: past projects using the Story-And-Simulation approach have suffered from long runtimes of the models, limiting the interaction between models and stakeholders.
Innovation: use an online Integrated Assessment Platform that runs near real time, and increases the number of iterations and thus the consistency between both products.
- The *engagement problem*: the level of stakeholder engagement in the scenario process is very mixed.
Analysis: more effort has to be put into selecting and inviting stakeholders, while keeping them engaged for the duration of the project.
Innovation: within WP1, a protocol for selecting stakeholders has been developed (see section 5) which helps maximise representativeness and engagement.

Linking stories and adaptation options

The key issue in linking adaptation options and stories is in the combination of exploratory elements (“what could happen?”) and normative elements (“what would we do about it?”). It goes without saying that over recent years much research has tackled precisely this issue – for example within the IPCC with its specific Working Groups that explore climate change and evaluate how mitigation and adaptation can do something about it. Yet, the direct and close link between (stakeholder-determined) stories and adaptation options has not been undertaken in this manner. Note that techniques such as roadmapping and backcasting analysis – which often include explorative elements – are common in the fields of energy and for individual businesses (see Kok et al., 2011). In SCENES, backcasting was used. Compared to that project, the innovation is in:

- Using roadmapping rather than backcasting to increase **engagement** of stakeholders.
- Linking much more closely with those engaged in the link between adaptation and the IAP, increasing **consistency**.
- Using partly prescribed options to increase possibilities of **conversion**.
- Linking with the dynamics of the five capitals and thus with the vulnerability framework to increase **reproducibility**.

An important final innovative element is the focus on the production of a set of guidelines for implementation of the various concepts and frameworks. Practice has shown that the actual implementation when dealing with stakeholders is far from straightforward and can lead to unexpected outcomes. In CLIMSAVE we will document a number of more practical recommendations on how to conduct stakeholder workshops.

7. Scenario development workshops – towards a preliminary program

At the time of writing the final version of this Deliverable (June 2011), the first workshop at the European level has taken place, while the agenda for the first regional workshop in Scotland has been decided upon. Thus, this section provides a detailed overview of the implementation of the concepts outlined above for the first workshop. For the subsequent workshops, it is premature to provide much detail.

All workshops will ideally last two full days or three days, which in practice translates to about 2.5 day of interaction with stakeholders. Usually, a workshop will start around 12:00 on Day 1 and last until 16:00 on Day 3. Past experiences have shown that it is not realistic for any given workshop to have more than 1-2 main goals, and maximally 2-3 secondary goals.

7.1 First workshop

Conceptual outline

The first workshop will mainly focus on the development of stories, following the methodology as described in Section 6.2, with important steps being:

- Discussion of certainties and uncertainties.
- Discussion of key factors.
- Drafting a story.

There are, however, a number of additional goals that need to be satisfied in order to make progress with the Story-And-Simulation approach and linking with the adaptation options. The secondary goals include:

- Quantifying a subset of parameters using Fuzzy Sets.
- Discussing a (very general) set of adaptation options.
- Testing a mock-up version of the IAP and discussing necessary changes.

Practical implementation - Europe

The first European workshop took place on 10-12 May 2011 in Brugge, Belgium. Around 30 people participated. For an analysis of the process and the results we refer to Deliverable 3.3. Here we will present an overview of the actual agenda and program, in order to show the practical implementation of the conceptual methods. Below is a general overview of the agenda of the first workshop:

Day 1 – May 10, 14:00-18:00 – introductions and uncertainties

Welcome and introduction to CLIMSAVE
Presentation and discussion on uncertainties
Initial group discussions

Day 2 – May 11, 9:00-18:00 – development of stories

Group discussions – what are important events?
Group discussions – how do events play out over time?
Group discussions – story writing
Plenary presentations of stories

Day 3 – May 12, 9:00-15:00 – quantification and next steps

Fuzzy sets – quantification of key parameters
Preview of the Integrated Assessment Platform
Next steps and evaluation

In the practical implementation, parts of the conceptual outline were changed to some extent. Below some of the most important changes are briefly discussed.

Goals of the workshop

When drafting the programme, it became clear that developing stories and quantifying parameters would take most of the available time. It was decided to refrain from discussing the adaptation options. Besides a lack of time, we agreed that introducing both types of scenarios (exploratory and normative) in the first workshop would be a cognitive overload for stakeholders. We thus limited the goals of the first workshop.

Uncertainties

As discussed in Section 6.2, a list of uncertainties was drafted and presented to stakeholders during the workshop. Originally, we envisioned separate lists with the uncertainties taken from the EEA megatrends document, and a few uncertainties distilled from the Myths of Nature / World Views. Ultimately, it was decided to join these two groups of uncertainties into one list. This resulting in a long-list containing about 30 uncertainties, where both the megatrends and the Myths of Nature were ‘translated’ into uncertainties. From this a short-list with 15 uncertainties was produced. The shortening was undertaken according to the following criteria:

- Relevance for climate change.
- Relevance for the six sectors covered in CLIMSAVE.
- Even spread to cover: environmental, social, economic, institutional, political, and cultural factors.

This led to the following list of 15 uncertainties that were presented to the stakeholders to be used as fast-track to kick-start the process of scenario development:

1. Geopolitical stability	high – low
2. Dominant decision-making level	European – national – local
3. International cooperation	strong – weak
4. Social and env. responsibility of non-state actors	high – low
5. System shocks	many – few
6. Population/migration	within regions – between regions
7. Technological innovation	pervasive – patchy
8. Economic growth	gradual – ‘rollercoaster’
9. Choice	restricted – free
10. Impact of CC on human society	high – low
11. Response of natural systems	fragile – resilient
12. Attitude towards nature	instrumental – respect
13. Social behaviour	individualised – collectivised
14. Globalisation	global – regional
15. Environmental regulation	integrated, soft - sectoral, hard

Parameter quantification

For the Fuzzy Set exercise to quantify parameters, a list of parameters needed to be drafted. This list needed to be limited in view of the time available for stakeholders to discuss every item, be accompanied by background material in order for stakeholders to gain some understanding of the quantitative dynamics in the past, and be discussed in the context of the storyline. The following list of 12 items was decided upon:

1. Population dynamics
2. Gross Domestic Product
3. Arable land used for biofuel
4. Extent of protected areas
5. Food import ratio
6. Oil Price
7. Household size
8. Natural capital
9. Human capital
10. Social capital
11. Manufactured capital
12. Financial capital

Practical implementation - Scotland

The first Scottish workshop will take place on 27-28 June 2011 in Edinburgh, Scotland. The workshop will take two full days, thus effectively being only slightly shorter than the European workshop. Consequently, the agenda will by and large contain the same elements as the European workshop with roughly the same amount of time available for story development and parameter quantification. Note that the list of uncertainties will differ from those used for the European workshop, while the list of parameters to be quantified is the same.

7.2 Second and third workshop

The exact goals and agenda of the second and third workshops will depend on the analysis of the results of the first workshop. After the execution of the first European workshop, which successfully met its goals, we have no reason to deviate from the conceptual implementation as described in Section 6.2.

The main goals of the second workshop will be to finalise the stories and to draft a list of scenario-specific adaptation options. An important additional goal is to test the IAP. The main goal of the third and final workshop will be to use the IAP and test the impact of stories and the effectiveness of adaptation options.

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