The **CLIMSAVE** Project

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

Report on the new methodology for scenario analysis of climate impacts and adaptation assessment in Europe, including guidelines for its implementation

Kasper Kok[1], Marc Gramberger[2], Katharina Zellmer[2], Mark Metzger[4], Martina Flörke[3], Benjamin Stuch[3], Jill Jäger[5], Ines Omann[5], György Pataki[6], Ian Holman[7]

[1] *Soil Geography and Landscape, Wageningen University, The Netherlands*
[2] *Prospex, Keerbergen, Belgium*
[3] *Center for Environmental Systems Research, University of Kassel, Germany*
[4] *The University of Edinburgh, UK*
[5] *SERI, Austria*
[6] *ESSRG, Hungary*
[7] *Cranfield University, UK*

April 2013

Table of contents

1. Introduction

The main goal of this Deliverable is to analyse the results of the full series of stakeholder workshops as documented in a series of reports (Deliverable 1.2, 1.3, and 1.4), accompanied with detailed recommendations to improve the scenario development methodology as documented in Deliverable 3.1, as well as a set of practical guidelines for other scenario practitioners. In order to document the entire process and all results, this Deliverable has been a running document with a new draft after every set of workshops (WS), intended to provide input for the exact methods to be followed in the subsequent workshop. This final version emphasises the *novel aspects* of the scenario development method; reporting on the execution of the state-of-the-art will be relatively short. The following aspects will be analysed:

- Storyline development (Section 2; WS1&2)
- Fuzzy sets (Section 3; WS1&2)
- Interacting with the CLIMSAVE Integrated Assessment Platform (IAP) (Section 4; WS3)
- Adaptation options – listing, categorising and testing their robustness (Section 5; WS2&3)
- Cross-scale interactions (Section 6; WS3)
- Stakeholder satisfaction (Section 7; WS1-3)

We have tried to structure every section such that the first entry point is related to the product that was derived, or the process/tool that was used, and the second is the scale being discussed. The process was executed at two scales, Europe and Scotland. As explained in Deliverable 3.1, conceptually the method was designed and applied for Europe and then tested at a lower scale for Scotland. In practice, both can be considered the practical application of the method described in Deliverable 3.1, with modifications as were seen fit.

Sections 2-7 of this Deliverable start with an analysis, followed by a set of specific conclusions and recommendations. Section 8 summarises the main conclusions, and Section 9 offers a set of more practical guidelines of how to organise a participatory, multi-scale scenario development exercise.

1.1 Basic data of workshops

Below, a general overview is given of the dates, locations, number of participants, main goals, and Deliverables that document the results.

1.1.1 Europe

Workshop 1	10 - 12 May 2011, Bruges, Belgium
	19 participants
	1. Scenario development: - *identification and analysis of main drivers and uncertainties* - *developing scenario logic* - *developing storylines* 2. Quantification of selected key variables and capitals
	Results described in D1.2a

Workshop 2	6 - 8 February 2012, Prague, Czech Republic
	11 participants
	1. Scenario development: - *Refinement and finalisation of preliminary storylines* 2. Reviewing quantified values for set of selected variables 3. Adaptation options: - *Identification of adaptation options per scenario* - *Determining importance of a set of adaptation options included in the IAP*
	Results described in D1.3a

Workshop 3	3 - 4 December 2012, Edinburgh, United Kingdom
	12 participants
	1. Working with the IAP to analyse the impact of adaptation options 2. Developing climate change adaptation strategies per scenario 3. Identifying workable adaptation options across scenarios 4. Comparative analysis of process and results for Europe and Scotland (together with regional level participants) 5. Discussing learning points from CLIMSAVE (together with regional level participants)
	Results described in D1.4a

1.1.2 Scotland

Workshop 1	27 - 28 June 2011, Edinburgh, United Kingdom
	27 participants
	1. Scenario development: - *identification and analysis of main drivers and uncertainties* - *developing scenario logic* - *developing storylines* 2. Quantification of selected key variables and capitals
	Results described in D1.2b

Workshop 2	27 - 28 February 2012, Edinburgh, United Kingdom
	19 participants
	1. Scenario development: - *Refinement and finalisation of preliminary storylines* 2. Reviewing quantified values for set of selected variables 3. Adaptation options: - *Identification of adaptation options per scenario* - *Determining importance of a set of adaptation options included in the IAP*
	Results described in D1.3b

Workshop 3	3 - 4 December 2012, Edinburgh, United Kingdom
	15 participants
	1. Working with the IAP to analyse the impact of adaptation options 2. Developing climate change adaptation strategies per scenario 3. Identifying workable adaptation options across scenarios 4. Comparative analysis of process and results for Europe and Scotland (together with regional level participants) 5. Discussing learning points from CLIMSAVE (together with regional level participants)
	Results described in D1.4b

1.2 Goals, objectives, and overall methods

1.2.1 Objectives and concept

Below are some of the main elements of the scenario development method as developed prior to the first series of workshops, and as documented in Deliverable 3.1. For more details on the method, as well as the changes made to the original plan during the process, we refer to the above Deliverable. This short summary is intended to provide an overview of the concepts that underlie the scenario development methods as applied in the CLIMSAVE project. The methods were applied at two scales, Europe and Scotland. All elements of the overall concept are presented, but with an emphasis on the participatory aspects. The concept and main elements of the scenario development process are visualised in Figure 1. The 'corners' of the triangle depict elements; the arrows represent the main methods employed.

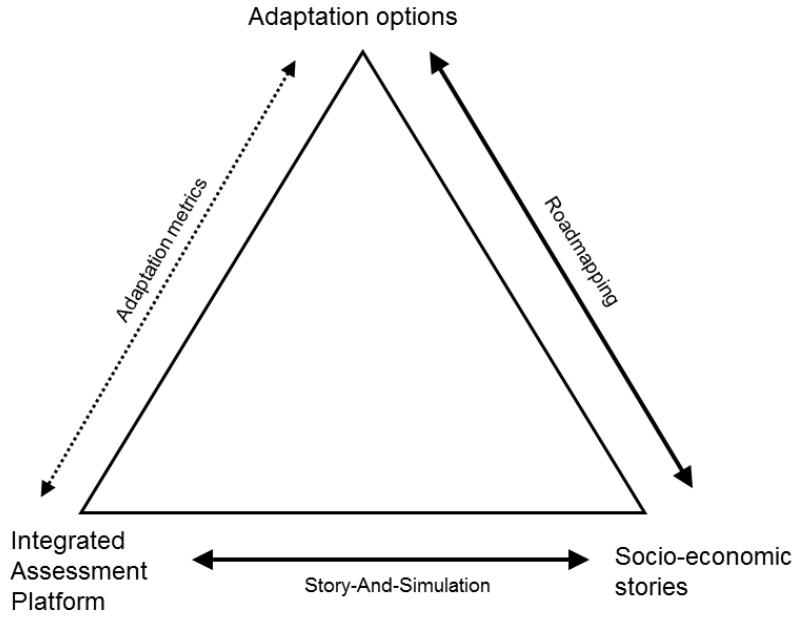


Figure 1: Main elements of scenario development in CLIMSAVE.

1.2.2 Main elements

Integrated Assessment Platform (IAP)

The online IAP is a collection of mathematical models that together provide quantitative data (maps and graphs) of climate scenarios, socio-economic scenarios, and a range of impacts. Additionally, the effects of adaptation options can be simulated, as well as the effects in terms of vulnerability and costs.

Socio-economic stories

A set of four qualitative socio-economic scenarios is developed using participatory methods. A broad set of stakeholders is selected that participate in the development of socio-economic stories. The aim is to bring together scientific methods and stakeholder knowledge. Stories cover a range of aspects including social and economic developments, but also cultural, institutional and political aspects in a set of integrated future outlooks. Stories are developed during a set of three stakeholder workshops. Additional to the stories, flow-charts, graphs

depicting temporal developments, and quantitative estimates of a number of main drivers (e.g. population and GDP) are produced. Together, these stakeholder-determined products depict a picture of possible futures.

Adaptation options

Lists of adaptation options are generated and discussed by stakeholders in the context of the set of socio-economic scenarios and by CLIMSAVE experts, based on an extensive literature review (see Deliverable 4.2). A selection of these options, partly based on stakeholder opinions, is incorporated in the IAP.

1.2.3. Overall methods

Story-and-Simulation approach

An essential part of the scenario development method is the so-called Story-and-Simulation approach in which qualitative stories are developed by stakeholders and linked to quantitative models in an iterative procedure (see Figure 2). Crucial is the notion that the final set of integrated scenarios is co-produced by scientific experts and stakeholder views. The method consists of ten steps that clearly define the role of stakeholders and modelling experts in the process. In practice, the Story-And-Simulation approach is translated into a set of three workshops of 2-3 days during which around 20 stakeholders developed stakeholder-determined scenarios using expert-determined methods and guided by professional facilitators.

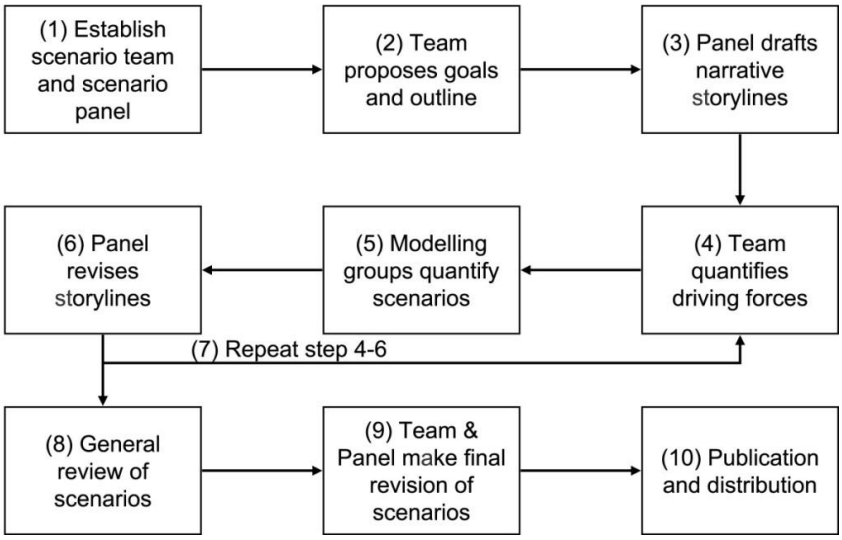


Figure 2: The Story-And-Simulation approach.

Roadmapping

The socio-economic stories address the question "what can happen?", while the adaptation options provide an answer to the question "what can we do about it?". Roadmapping is a method to link these normative options and the explorative stories. First, the adaptation options are related to each other, forming broader strategies. The effectiveness of these strategies in the four different socio-economic futures can subsequently be evaluated. In this way, adaptation options can be identified that would work in all of the socio-economic futures.

Adaptation metrics

This step quantifies the list of adaptation options as discussed by stakeholders in order to examine them using the IAP, and to enable a quantitative evaluation of impacts and costs. These metrics are not discussed with stakeholders.

2. Development of qualitative scenarios

As said, the main aim of this Deliverable is not to analyse all results in full detail, but to focus on those parts that had innovative aspects. Although the methods to develop qualitative scenarios were relatively standard, three more innovative elements stand out:

- **Fast-track uncertainties**. We used a set of existing uncertainties rather than starting from scratch in the first workshop. This list was revisited in the second workshop.
- **Storyline development**. The fact that the initial set of stories was not entirely satisfactory, this called for a special method to be developed during the second workshop to minimise overlap between the 4 European stories.
- **Constructing tables with qualitative information**. Tables with information on about a dozen additional model parameters were constructed based on the storylines.

2.1 Uncertainties

In both workshops, a list of 'fast-track' uncertainties was presented to the stakeholders as a starting point for drafting a long list of uncertainties. These uncertainties are to be understood as key driving forces, for which fundamentally different future outlooks can be defined. Part of every uncertainty was thus an indication of 2-3 polarities, and these were briefly introduced to stakeholders. This was followed by a plenary discussion during which uncertainties were altered, added or deleted. This discussion resulted in a final list of uncertainties.

2.1.1 Europe

A list of 15 uncertainties was presented to the stakeholders:

	Uncertainty	**Polarities**
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 climate change 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

The following alterations were agreed upon:

- The uncertainty "System shocks" was eliminated.
- Technological development was further refined into the driver "Solutions by innovation to depletion of natural resources". The uncertainties associated with this driver were defined as "non-effective to effective".
- Social behaviour was eliminated in favour of the newly introduced uncertainty "Social cohesion".
- The uncertainty "Ability of natural systems to deliver ecosystem services" replaced "Response of natural systems".
- Environmental regulation was eliminated and became part of the uncertainty "Decision-making level". The uncertainties associated with the "decision-making level" driver were also updated to four uncertainties (international dominant, Europe dominant, nation-state dominant, local dominant).
- "Impact of climate change on human society" was further refined to "Impact of climate change and other natural hazards". Its polarities were changed from "low to high" to "fragile and unstable to resilient and stable".
- "Attitude towards nature" was further refined to "Attitude towards human and natural health". The polarities were changed from "instrumental to respect" to "influential to respectful".
- "Social belief systems" was added to the list. Its polarities were defined as "plural to dominant".

The final list of uncertainties is presented in Table 1 (see also Deliverable 1.2a).

A number of observations can be made based on the two lists:

- **High level of diversity**. The final list of uncertainties has a high level of diversity. Partly this is a result of the list of 15 uncertainties that was used as a starting point, but importantly it also reflects the opinion of the stakeholders. This can be concluded from the refinements and additions that stakeholders made. These include technological development, policy regulations, the impact of climate change, human health, and social factors. This clearly indicates that a broad variety of uncertainties were labelled as important.

- **The final list has untapped potential**. The final list of 14 uncertainties tells a rich story about the multiple challenges that the European future will face. Of those, only two were selected and taken further in the set of scenarios. Most of the remaining 12 were not discussed further during the first workshop. However, they were discussed again in the second workshop to enrich the storylines where appropriate.

- **Specific focus on environmental issues.** A number of the uncertainties as present in the final list specifically address environmental factors. This is particularly true for the 'impact of climate change', but also for 'depletion of natural resources'. Although in itself this is not surprising, it does pose potential issues concerning the overall CLIMSAVE method. As also discussed in Deliverable 3.1, the overall assumption is that the *socio-economic* context will be provided by the qualitative stories, while the models provide a quantitative description of the *environmental* system. By including environmental uncertainties in the qualitative stories, potential inconsistencies are introduced. This issue did not surface, but was closely monitored in subsequent workshops.

- **Low interest for uncertainties related to 'conceptual issues'.** Three uncertainties were deleted from the list. Two of those related to the 'Myths of Nature'; one related to worldviews and the Cultural Theory. In other words, the CLIMSAVE Scenario Team provided a list that combined uncertainties in existing trends (population, GDP, etc.) with these more conceptual uncertainties. It was clear that the European stakeholders did not relate strongly to the more conceptual uncertainties and either deleted or rephrased these.
- **Fast-track uncertainties partly worked.** Using fast-track uncertainties ensured a highly diverse starting point, which probably contributed to the high level of diversity in the final list. On the other hand, introducing an already prepared list did not save time, as explaining all items was time consuming.

Table 1: Main uncertainties related to climate change adaptation in Europe and the main polarities as identified and agreed by the European stakeholder panel.

Polarity	Driver/uncertainty	Polarity
Europe dominant	International dominant Decision-making level Local dominant	Nation-state dominant
Low Stability	Geopolitical stability	High stability
Strong cooperation	International cooperation	Weak cooperation
Low responsibility	Social and environmental respect of non-state actors	High responsibility
Migration within regions	Population and migration	Migration between regions
Gradual	Economic development (growth)	Roller-coaster
Unconstrained	Globalisation	Constrained
Restricted	Choice	Free
Influential	Attitude towards human and natural health	Respectful
Low	Social cohesion	High
Non-effective	Solutions by innovation to depletion of natural resources	Effective
Plural	Social belief systems	Dominant
Fragile and unstable	Ability of natural system to deliver ecosystem services	Resilient and stable
Low	Impact of climate change and other natural hazards	High

Recommendations:

- **Rethink the use of fast-track uncertainties.** It might be worthwhile to consider using a shorter, but equally diverse list. Additionally, more conceptual uncertainties should perhaps be avoided. It might also be feasible to survey the participants before the first meeting to find out what they think the main uncertainties are.
- **Make use of the information provided by all uncertainties.** This is a collectively decided upon list containing a wealth of information, that deserves to find its way into the storylines. It is recommended to have a session in WS2 that addresses this aspect of storyline enrichment. This would additionally ensure that a high level of diversity is introduced/maintained.
- **Treat carefully the information on fundamental uncertainties on environmental factors.** At all times, stakeholders should be encouraged to discuss all types of factors and uncertainties. As such, information on reactions of the environmental system cannot and should not be limited. Yet, to avoid potential inconsistencies in assumptions on the behaviour of the natural system, it should not be encouraged.

2.1.2 Scotland

The list of fast-track uncertainties included:

	Uncertainty	**Polarities**
1.	Influence of local communities	high – low
2.	Social behaviour	individualised – collectivised
3.	Economic growth	gradual – 'rollercoaster'
4.	Food and energy security	import – self-sufficiency
5.	Adaption of technological innovation	pervasive – patchy
6.	Environmental regulation	integrated – sectoral
7.	Population/migration	out-migration – in-migration
8.	Threat of war, crime, or violence	high – low
9.	Social and env. responsibility of non-state actors	high – low
10.	Lifestyle	'green' – unsustainable
11.	Impact of climate change on human society	high – low
12.	Globalisation	global – national

The following alterations were agreed upon:

- The uncertainty "Influence of local communities" was eliminated from the original list.
- The name of the uncertainty "Food and energy security" was further refined to "Resource security".
- The uncertainty "Social and environmental responsibility of non-state actors" was eliminated from the original list.
- The uncertainty "Lifestyle" was further specified to "Well-being and lifestyle". Hence, its polarities changed from "green and unsustainable" to "equitable and disparate".
- The uncertainty "Consumption" was added to the list. Its polarities are "accepted limits and no limits".
- The uncertainty "Globalisation" was eliminated from the original list.
- The uncertainty "Power level of decision-making" was added to the list. Its polarities are "local and central".

The final list of uncertainties is presented in Table 2 (see also Deliverable 1.2a).

Table 2: Main uncertainties related to climate change adaptation in Scotland and the main polarities as identified and agreed by the Scottish stakeholder panel.

Polarity	Driver/uncertainty	Polarity
Individualised	Social behaviour	Collectivised
Gradual	Economic growth	"Rollercoaster"
Surplus	Resource security	Deficit
Pervasive	Adoption of technological innovation	Patchy
Integrated	Environmental regulation	Sectoral
Out-migration	Population/migration	In-migration
High	Threat of war, crime and violence	Low
Accepted limits	Consumption	No limits
Equitable	Well-being and lifestyle	Disparate
High	Climate change impact on human society	Low
Local	Power level of decision-making	Central

A number of observations can be made based on the two lists:

- **High level of diversity.** Similar to the list of European uncertainties, there is a large variety of factors, ranging from environmental regulation, consumption and migration, to the threat of war.
- **Discussion focused strongly on the 'human factor'.** Both the alterations and deleted factors were less diverse. Contrary to Europe, the additions and refinements were less varied focusing much more on 'human' factors such as consumption, lifestyle and the level of decision-making. Similarly, the deleted factors were those which dealt with the social system (role of local communities, social responsibility). There are no straightforward conclusions to be drawn from the differences in focus on social factors between Europe and Scotland. It could be hypothesised that at a more regional scale, the larger variety in environmental and other factors leads to more discussion on a broader range of uncertainties. Be it as it may, the final list in both cases is very heterogeneous.

- **The final list has untapped potential**. See Europe: this is equally true for Scotland.

Recommendations:

- **Use the untapped potential.** See Table 1 for Europe and Table 2 for Scotland.

2.1.3 Comparison of lists between Europe and Scotland

- **Equally diverse but different.** Although both lists of uncertainties are equally diverse and cover all capitals, the overlap between them is remarkably small, despite the commonalities in the list of fast-track uncertainties. There are five uncertainties that appear on both final lists:
    - Economic development
    - Technical innovation
    - Population patterns
    - Impact of climate change
    - Level of decision-making

2.1.4 Revisiting uncertainties

Acknowledging the untapped potential, the list of uncertainties was revisited in the second workshop series, adding information on how the uncertainties play out in all eight specific scenarios. This is documented in Deliverables 1.3a and 1.3b. In this way, a complete and sometimes detailed set of tables was produced. A summary of the results is presented in Table 3 (Europe) and Table 4 (Scotland). These provide a nice and structured overview of some of the main thrusts underlying all scenarios, and in that sense are highly complementary – rather than overlapping – with the information available in the storylines.

Table 3: Uncertainties in Europe.

Uncertainty	We are the world	Icarus	Should I or Should I Go	Riders on the Storm
Decision-making level	- 7 cultural blocks - Subsidiarity - Bottom-up initiative	Nation-state dominant: EU fragmentation	Start: EU, but fading out; splits End: Nations-state/ local	-
Geopolitical stability	Low → high	Low: First EU not stable, then conflict	Low: Many pressures and conflicts	First low, then medium; important for economic development
International cooperation	Weak → strong	Rather weak cooperation	Weak: weak regulation specifically for long-term issues	Competition and integration, later on more cooperation which influences innovation and policy-making

Uncertainty	We are the world	Icarus	Should I or Should I Go	Riders on the Storm
Social and environmental respect of non-state actors	High due to regulation	In the end they begin to take responsibility	Generally low; can be high in selective communities	-
Population and migration	Within: strong Between: highly skilled and the very poor	Both: migration to BRIC's	Movement within regions; some niche brain-drain from EU	-
Economic development (growth)	Gradual	Gradual	Rollercoaster	Rollercoaster
Globalisation	Ideas flow, with constraints	Flows not restricted Some protectionism by the end	Unconstrained, but with selective break-downs due to instability	Unconstrained; markets for innovation and economic development
Choice	Free within blocks on the individual level, open society	Starts free, becomes restricted in EU as of period II	Free choice for some, much less for the rest	-
Attitude towards human and natural health	Respectful	Not respectful anywhere	Not many options to be respectful, but some communities are	Awareness and education lead to more respect
Social cohesion	High, with differences	Declines in phase II, starts picking up by end of III	Low, yet high in some communities	Growing
Solutions by innovation to depletion of natural resources	Effective	Non-effective	Non-effective	Effective
Social belief systems	Plural, respectful	Plural	Plural; possibility for extremists; strong religious systems	Moving towards plural
Ability of natural system to deliver ecosystem services	Resilient, under proper management	Fragile and unstable	Fragile and unstable; strong pressure for land, water and food; not priority; danger of fatalism and cynicism	Fragile and unstable = key driver
Impact of climate change and other natural hazards	High	High	High: feeling of incapability	High = key driver

Observations from Europe:

- There are number of uncertainties that do not vary across the scenarios, and that should in fact be considered certainties.
    - Impact of climate change is always high
    - Social belief systems are always plural
    - Globalisation continues.

- There is only a small number of uncertainties that correlate with those selected to shape the archetype scenarios, both related mostly to natural capital:
    - Fragile ecosystems
    - No respect for human and natural health.

Table 4: Uncertainties in Scotland.

Uncertainty	**Tartan Spring**	**Mad Max**	**The Scottish Play**	**MacTopia**
Social behaviour	Collective – individual – collective: (driven by privatisation)	Early on individualised, later collective within strata	Collectivised: working together, not individual	Collectivised: not absolute, not all nationalised; yet strong societal approach with shared benefits
Economic growth	Gradual – wealth goes away	Rollercoaster - volatile	Gradual with blips	First gradual, then also rollercoaster
Resource scarcity	Surplus	Deficit	Deficit	Surplus
Adoption of technological innovation	Pervasive technology for exploitation of natural resources	Patchy and stratified	Not pervasive, but widespread	Pervasive
Environmental regulation	Governance weak No EU	No relevant topic	Integrated – not always controlled by Scotland	Integrated
Population/ migration	2020: in-migration of low- and high-skilled 2050: out – high-skilled Scottish; in-migration of economic migrants	Strictly outwards	Both ways:	In-migration, but comes to halt
Threat of war, crime and violence	Increases	High: general social unrest	Stable – equality	Low in Scotland, medium elsewhere
Consumption	No limits: driven by necessity	No limits:	Accepted limits: less money, repair rather than buy new, tax	Individual limits, sustainable as a country

Uncertainty	Tartan Spring	Mad Max	The Scottish Play	MacTopia
Well-being and lifestyle	Disparate	Disparate	Equitable	Equitable
Climate change impact on human society	Low – only by external	High, but only cause/effect	High: we have options, adaptive capacity	Very high danger, very low impact
Power level of decision-making	External: driven by multinationals	Corporate HR Trumptower vs. community strata	Coordination - subsidiarity	Strong centre and high community empowerment

Observations from Scotland:

- There is one "certain" uncertainty in Scotland:
    - Social behaviour is collective (in Mad Max it is, however, collective in two layers of society).

- Mad Max, as the most "negative" scenario often differs from the other three, and stands out as the most gloomy future:
    - Migration is strictly outwards
    - Adoption of technology is patchy
    - Economic growth is rollercoaster.

In summary, asking stakeholders to specifically discuss all uncertainties that were listed before in the context of their scenario, yielded in a rich source of information. This structured, tabular information complements the information present in the stories.

2.2 Selection of two main uncertainties and defining the skeleton scenarios

2.2.1 Selection of main uncertainties

The main uncertainties were selected by a voting system based on two characteristics, namely 'Importance' and 'Uncertainty'. All results can be found in Deliverables 1.2a and 1.2b. Below only the top five is reproduced (between brackets the total number of votes for importance and degree of uncertainty; in bold the two that were selected).

Europe:

1. **Economic development** (21)
2. Ability of natural systems to deliver (18)
3. **Solution by innovation** (15)
4. Impact of climate change (12)
5. Attitude to human health (8)

Scotland:

1. **Resource scarcity** (27)
2. **Well-being and lifestyle** (15)
3. Level of decision making (14)
4. Economic development (12)
5. Social behaviour (10)

A few key observations:

- **There was a high correlation between votes for importance and votes for uncertainty**. This was particularly the case for Europe. In Scotland, there were a few uncertainties with differences in votes, notably 'war and crimes' (0 for importance; 5 for uncertainty) and 'consumption' (5; 2).
- **The procedure of selecting the top two uncertainties was fairly smooth in both workshops**. In both workshops, the procedure was similar. The most important uncertainty was clear, and the second most important one was selected based on the fact that it needed to be as independent as possible from the first. This caused no problems in either workshop. Despite the fact that others have warned that it is easy to misuse the axes (Van 't Klooster *et al.*, 2006), these workshops showed that this 'classic' method continues to be effective.
- **The top two in Europe reflected the main discussions, but leave out important aspects**. Economic development (in the middle of a global crisis) and technological innovation as a means to fight unsustainable use of resources were clearly two of the main topics during the discussion. These two issues do not relate very strongly to social or human capital. In fact, these were not deemed to be important or uncertain. Most 'social' uncertainties did not receive more than 3-5 votes.
- **The top two in Scotland reflected some of the main discussions**. There was no disagreement on the main uncertainty (resource scarcity, which was deemed all-deciding), but fairly equally distributed votes on a number of other uncertainties. Importantly, the level of decision-making (i.e. UK or Scotland) was not focused on.
- **Overall, the four selected uncertainties cover a broad range of factors**.

Recommendations:

- Make sure that the discussion on the selection of the two main uncertainties focuses on 'future uncertainty' rather than 'future importance'. As it happened, in both workshops, the uncertainties with most votes for 'degree of importance' were selected. This deserves attention, since it indicates a focus on (current) importance rather than on future uncertainty.
- Consider spending slightly more time on the selection of the top two uncertainties. It is here that the backbone of the scenarios is decided upon, and not all stakeholders seemed equally aware of the importance of this step.

2.2.2 Skeleton scenarios

Figure 3 show the two sets of skeleton scenarios (see Deliverables 1.3a and 1.3b).

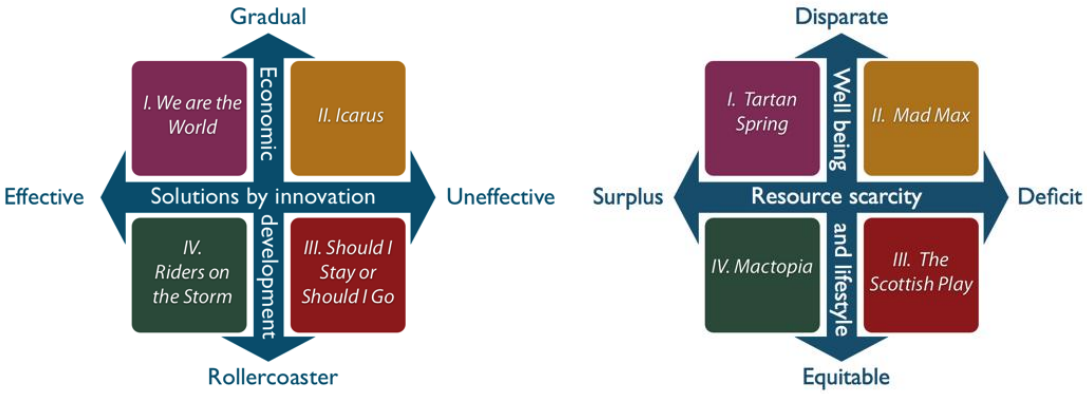


Figure 3: Skeleton scenarios as developed during the European (left) and Scottish (right) workshop.

Analysis:

- **By and large, there was a widespread consensus among stakeholders on the scenario skeletons that were selected**. In both workshops, the plenary session ended with an agreement that the set of four skeleton scenarios was one which provided opportunities to develop a set of clearly distinct stories that would include important information on the future outlook of the region. This was in great part a result of the lengthy discussions on the long list of uncertainties. However, the actual consideration of roles that other important factors would play in the scenarios was rather brief. It was somewhat unclear if this was a true consensus or based on the fact that stakeholders were happy to have a concrete result after a long day of discussions.

2.2.3 Overall conclusions on the development of skeleton scenarios

Conclusions on the procedure leading up to the selection of the chosen skeleton scenarios can be drawn on the process and method, as well as on the resulting scenarios.

Process and method:

- The method used was fairly standard and proved to be effective.
- Including fast-track uncertainties was successful, but not in saving time.
- Including fast-track uncertainties was very successful in ensuring diversity.
- The long list of uncertainties deserves to be revisited in subsequent workshops.

Results:

- The lists of uncertainties were long and diverse. The same holds for the top five most important uncertainties, as well as the top two that were selected to form the skeleton scenarios.
- Skeleton scenarios consequently cover a broad range of issues. In both Europe and Scotland they seem to represent the most important and most uncertain issues. These differ substantially between Europe and Scotland.

2.3 Storylines

2.3.1 Characteristics of the final storylines

This section analyses all results, including headlines, dynamics and storylines. Stakeholders were asked to identify important events that would take place in their story ("headlines"), place them on a timeline ("dynamics"), and link them in a series of events ("storyline"). Note that headlines and dynamics were produced by stakeholders, while the stories were written by CLIMSAVE scientists. The stories come in three versions, one produced after each workshop.

Table 5 provides a summary of the eight qualitative scenarios as produced after WS1 and WS2. The final versions of the stories are given in Deliverable 1.4a/b.

Table 5: Characteristics of storylines as produced during WS1 and WS2.

Scenario	Number of headlines	Representation of dynamics	Number of words in story (WS1/2)
Europe			
We are the World	42	Full conceptual model	636 / 1426
Icarus	34	Some connections and non-linear curve with three phases	742 / 1328
Rollercoaster to Armageddon[1]	41	Multiple graphs to show non-linearities	692 / 1554
I-ticket to Ride[2]	32	Conceptual model; connections; and non-linear curve	578 / 1408
Scotland			
Tartan spring	43	No indication of dynamics	945 /1508
Mad Max	67	No indication of dynamics	990 / 1592
Scottish Play	51	No indication of dynamics	758 / 1317
Mactopia	51	Full conceptual model	764 / 1690

2.3.2 Analysis:

Methods and process:

- **Method was very inviting to be creative.** The creation of headlines in particular generated many surprising and creative ideas. It is a simple and effective way to structure a brainstorm on elements of a scenario. It also ensures that all individuals contribute to the product.

[1] Rollercoaster to Armageddon was renamed "Should I Stay or Should I Go" in WS2, and will be referred to as so from now on.

[2] I-ticket to Ride was renamed "Riders on the Storm" in WS2, and will be referred to as so from this point onwards

- **Method was very diverse** with 'headlines', connections between factors (i.e. flows and conceptual model), and 'temporal dynamics'. Although all groups of stakeholders were asked to go through all the steps, they were flexible in what they focused on. The results clearly indicate differences between scenarios and between Europe and Scotland.
- **Large differences between groups and the dynamics of the parallel sessions were observed**. This was good and bad:
    - Good: groups could put more emphasis on what they related most to. This was reflected in the results.
    - Good: high buy-in. Almost all groups reached consensus on the product that they created.
    - Bad: lack of very highly structured and closely facilitated sessions led to difficult discussions in some groups. Individuals that were more sceptical tended to dominate some group discussions, which severely slowed down the process.
    - Bad: differences in focus led to differences in results, which somewhat limits their comparability.
- **Group work needed to be carefully facilitated.** In Europe, we attempted to have a less systematic facilitation, with facilitators changing groups every once in a while. This did not work and was not repeated in Scotland. The group work process in the second workshop was smoother as a result.
- **Not all individuals were equally satisfied with the task of developing creative, long-term stories. This was difficult to change.** In both Europe and Scotland, there were a few individuals who did not think that the skeleton scenario they chose to be part of was plausible or credible. This underlines the need to provide clear information on the consequences of the choice of the skeleton.

Results:

Two sets of four rather rich qualitative scenarios were developed. As can be seen from Table 5, at least 30 headlines were created, that translated into initial stories of about 600-1000 words, which were later expanded to stories of 1300-1700 words. In many cases, this was accompanied by a system description and/or an indication of non-linearities.

All scenarios had imaginative titles. Good examples are Mad Max (after a long discussion, the group voted against using the name Mad Macs) and Icarus (combining mythology, non-linearity and summary of the scenario). Besides, all Scottish scenarios had specific references to Scotland in the title. These are additional indications of stakeholder involvement, buy-in and a highly creative process. Note that the discussion on titles continued for the duration of the process – particularly at European scale, resulting in new titles for two scenarios. Titles were changed to be more comparable (all song titles).

There were remarkable differences between Europe and Scotland. Despite similarities in methods, stakeholder composition and length of workshop, there were relatively large differences between Scotland and Europe after the first workshop. From Table 5, it can be deducted that all qualitative scenarios in Europe were shorter, using less headlines, but with a strong focus on non-linearities. Differences are relatively strong, as the longest story after WS1 in Europe (742 words) is shorter than the shortest story in Scotland (758 words). The same holds for the number of headlines. Similarly, all scenarios in Europe focused strongly on conceptual models, feedbacks and descriptions of non-linearities, while all but one scenario in

Scotland gave no indication of this at all. It is highly speculative to conclude anything from this. Potential reasons include the following:

- The polarities of the axis of economic development in Europe specify temporal dynamics (rollercoaster versus gradual), which triggered discussions on dynamics in all groups. More time was devoted to this discussion, which limited the time available to create headlines.
- The European stakeholders were more diverse culturally and the Scottish stakeholders were generally much more familiar, through previous engagement, with the issue of climate change adaptation.
- The large diversity of factors, actors and sectors across Europe, gave most stakeholders a feeling of being a lay person on future developments, which may have inhibited the generation of headlines somewhat.
- When brainstorming about the future of a smaller region (such as Scotland), imagining future developments was easier and the number of headlines consequently larger.
- Evaluating the order in which a larger number of events takes place limited the amount of time available to discuss connections and (non-linear) dynamics.
- Note that based on these preliminary drafts, it can NOT be concluded that the future of Scotland consists of more elements, or that the future of Europe is more complex.

In Europe, at this point of the scenario development, the axes did not lead to four clearly separate distinct stories. In the storylines, stakeholders had a similar interpretation of 'economic development' in various groups. The stories 'We are the World' and 'Riders on the Storm' are very similar in this regard. The same holds for 'Icarus' and 'Should I Stay or Should I Go'. In other words, the axis 'effective/ineffective solutions by innovations' was a good uncertainty to separate stories, while the axis 'gradual growth versus rollercoaster economic development' did not lead the groups to strongly separate stories.

In Scotland, the four stories depict four distinct futures. The two axes proved to be sufficiently independent to provide a skeleton for four distinct qualitative scenarios.

<u>Recommendations for WS2:</u>

- For Europe, carefully re-evaluate with stakeholders the set of four scenarios and their similarities. The following are options to make scenarios more distinct:
    - Merge the four existing scenarios to two, and create 1-2 additional scenarios based on the additional uncertainties.
    - Maintain the four scenarios, focus on differences, and flesh those out during the scenario enrichment.
    - For Icarus it was assumed that while solutions to innovation were ineffective in Europe, they were effective elsewhere and especially in BRIC countries, whereas in Should I Stay or Should I Go it was assumed that they were ineffective everywhere.
- For Europe, focus the enrichment on providing more meat on the bones, potentially working from the conceptual models.
- For Scotland, focus the enrichment on providing a mix of more text and conceptual models.
- Up front, check if all individual stakeholders are comfortable with the scenario group they are in. It is not advisable to drastically change the composition of groups, but some shifts are possible if needed.

2.3.3 Separating the European stories

As noted above, the two axes that were selected in Europe do not nicely separate into four distinct stories, because of a similar interpretation of the axis 'economic development'. This was discussed prior to the second workshop, and it was decided to undertake a specific effort to give all four stories their own identity. Specifically, it was decided to try to better relate the two "rollercoaster scenarios" (Riders on the Storm and Should I Stay or Should I Go) to the ups and downs of economic development than in the first version. There are a few clear indications that this attempt was successful:

- Exactly those two scenarios changed their name, indicating that their character also changed.
- Besides added text, we also documented how much text was deleted. The two rollercoaster scenarios deleted more text than any of the others, while Should I Stay or Should I Go is the longest story of the four European scenarios.
- Stakeholders themselves indicated that they were happier with the set of scenarios that emerged out of the second workshop.

2.4 Qualitative information on additional model parameters

During the course of the model quantification that took place during the second half of 2011, a number of additional model parameters were identified as being important to link qualitative scenarios and models. A total of 14 additional parameters were identified that could not be related to the quantitative information available from the fuzzy sets approach for 7 parameters. All qualitative scenarios were checked for information on those 14 parameters by CLIMSAVE members. Results are presented in Tables 6 and 7. Note this analysis of the stories took place after WS1, but despite the enlargement of the stories, the analysis also holds for the final stories.

Table 6: Qualitative information present in storylines on 14 additional model parameters for European scenarios.

Variable	We are the world	Icarus[1]	Should I Stay or Should I Go[2]	Riders on the Storm[3]
Technological effectiveness	Much higher (for green technologies)	Decrease ("no scientific breakthroughs")	Strong decrease ("technology failure"; "unsuccessful")	Much higher (for all technologies!)
Labour cost	Very indirectly, unemployment is low	Unemployment is very high, many 'poor'	Indirect: increase, since "all costs are increasing"	Indirect: increase: " investments go down"
Yield change (due to plant breeding)	Strong increase (pressure on the land + green technologies boosted)	None (technologies are ineffective)	None (technology failure)	Strong increase ("drought resilient", innovations)
Policy pressure to reduce ruminants	Very high (restaurants vegetarian + strong government)	None (no political interest)	Some (only towards 2050: regulation of land use)	No indication, so no pressure is likely
Policy pressure to reduce consumption of white meat	Very high (restaurants vegetarian + strong government)	None (no political interest)	None (no apparent actions)	No indication, so no pressure is likely
Crop yield potential reduction due to reduced inputs	Strongly reduced (indirectly: sustainable lifestyle = organic farming)	Reduced (depletion of oil)	Strongly reduced (high costs of inputs and energy)	Reduced (Peak oil in 2025)
Irrigation efficiency	Increase (as part of Green Technologies)	Decrease (tech. ineffective; no maintenance)	Decrease (technology failure)	Strong increase ("new irrigation techniques")
Set-aside land	Decrease (there is "pressure on the land")	??	Indirect: Increase due to high costs and later regulations	Decrease because of food shortage
Water savings due to technological change	Increase (as part of Green Technologies)	Decrease (no tech. improvements)	Decrease (technology fails)	Strong increase (strong focus of scenario)
Water savings due to behavioural change	Strong decrease (behavioural change)	Increase (no behavioural change)	No change (no priority of government or people)	Slight decrease (no specific focus; only after 2030)
Electricity production	??	Indirect: decrease due to resource scarcity	Decrease (increased costs and/or availability)	Strong increase (fusion; new energy sources, etc.)
Strictness of planning regulations	Much higher ("many measures are imposed")	Much lower (political structure fail)	Higher (more limitations, regulations)	Lower (strong private sector)
House preference for proximity of green space	??	??	??	??
Attractiveness of the coast	??	??	??	??

1: Note on Icarus: highly non-linear changes! (stable increase, stagnation, decline). Most changes can be assumed to start in the second time slice only.
2: Note on Should I Stay or Should I Go: positive twist around 2040 changes the story slightly and is ignored here.
3: Note on Riders on the Storm: changes take time to take off. Changes here can be assumed for the second time slice only.

Table 7: Qualitative information present in storylines on 14 additional model parameters for Scottish scenarios.

Variable	Tartan Spring	Mad Max	The Scottish Play	Mactopia
Technological effectiveness	Higher ("Innovation")	Somewhat higher (mostly in agriculture)	Lower (indirect: focus is on social adaptation)	Much higher (boost of renewable technology)
Labour cost	Lower (tech innovations leads to less jobs)	Somewhat lower (more 'poor' that are paid less)	??	??
Yield change (due to plant breeding)	Increase (innovation and efficient use of resources)	Strong increase (intensification of agriculture)	No change (indirect: no investment)	Slight increase (renewable technologies)
Policy pressure to reduce ruminants	??	??	High (reduced meat diet)	Probably very high: sustainable and highly regulated society
Policy pressure to reduce consumption of white meat	Probably some pressure	Probably very low	High (reduced meat diet)	Probably very high: sustainable and highly regulated society
Crop yield potential reduction due to reduced inputs	No reduction (indirect: tech. innovations and energy use efficiency)	??	High (fertiliser limited)	??
Irrigation efficiency	Higher (tech. innovation)	Much higher (intensification of agriculture; water shortage: high prices)	Slight increase (indirect: reaction to droughts)	No change (no issues with water)
Set-aside land	Higher (indirect: more efficiency: less land necessary)	Lower (higher land prices)	Higher (marginal land becomes more productive)	Lower (share of agriculture increases)
Water savings due to technological change	Higher (Scotland exports water)	Much higher (high prices; water shortage)	Somewhat higher (indirectly: droughts)	Somewhat higher (some tech. change; reuse)
Water savings due to behavioural change	Somewhat lower (indirect: from other green measurements)	Lower (water shortages)	Much lower (adaptation to water shortages)	Somewhat lower (habits become more sustainable)
Electricity production	Much higher (Uranium producer; maximise energy sources)	Higher (energy is sold to the highest bidder)	Much higher (greater use of electricity)	Somewhat lower (indirect: prices for electricity go up)
Strictness of planning regulations	Higher (land use dictated by central organisation)	Lower (more privatisation)	Much lower (greater personal responsibility)	Much higher (strong government approach; "harsh penalties")
House preference for proximity of green space	Higher (more gated communities)	??	Somewhat higher ("some people move to the countryside")	??
Attractiveness of the coast	??	??	??	??

A few observations on all parameters are given below:

Parameter	**Comment**
Technological effectiveness	Information always present. Usually technological change refers to specific type of technologies.
Labour cost	No information at all. Note that there is a lot of information on (un)employment.
Yield change (due to plant breeding)	Almost never direct information. Mostly related to technological change.
Policy pressure to reduce ruminants	Explicitly mentioned in a few stories. High potential to get more information, because of link with 'green' behaviour.
Policy pressure to reduce consumption of white meat	Explicitly mentioned in a few stories. High potential to get more information because of link with 'green' behaviour.
Crop yield potential reduction due to reduced inputs	Almost no direct mention of relation with inputs. Abundant indirect information linked to oil price or cost of inputs.
Irrigation efficiency	Directly mentioned in two scenarios. Often assumed to go up in relation to green technologies.
Set-aside land	Not mentioned directly. Assumed to be related to intensification, pressure on land or land prices.
Water savings due to technological change	Not mentioned directly (water is not an issue in most scenarios). Assumed to be linked to green technologies.
Water savings due to behavioural change	Not explicitly mentioned. Link with behavioural change is assumed to be strong.
Electricity production	Energy was an important topic in Scotland; not in Europe. Assumed to be related to resource scarcity, energy source availability, etc.
Strictness of planning regulations	Information always present. Assumed to be related to regulations, measures, political structures, etc.
House preference for proximity of green space	Virtually no information present in the stories. Even indirectly, there are no hints in the stories.

Attractiveness of the coast	Virtually no information present in stories. Even indirectly, there are no hints in the stories.

Analysis:

- The modellers identified a rather large number (14) of additional parameters.
- Some information could be extracted from the stories, but mostly it concerned indirect guestimates, rather than direct statements from the stories. Information was present in some cases on:
    - Planning regulations
    - Electricity production (through energy assumptions)
    - Technological effectiveness

3. Fuzzy sets

3.1 Introduction

This section is about how quantitative iteration of socio-economic key variables by stakeholders has affected the final results of a fuzzy set approach as part of the Story-And-Simulation (SAS) methodology. While the process of fuzzy set quantification is described in more detail in Deliverables 1.2a/b, 1.3a/b and 3.2, here we analyse the change in six[3] socio-economic key variables within the iteration process framed by the SAS methodology and its implications for the scenario development. The iteration process between the workshops (WS) was driven by the evaluation of questionnaires filled out by stakeholders during WS1 and WS2, which was again attributable to the storyline development. As the fuzzy set numbers of key driving variables formed the basis of the CLIMSAVE IAP sliders, these are of importance for the impact, adaptation and vulnerability assessments. Therefore, all slider values are listed according to the different storylines, from the first round of stakeholder quantification during WS1 as well as the final set of slider values after iteration during WS2, and given in Tables 11 and 12 in the Annex. This enables a direct comparison of variable-specific effects between scenarios in more detail. In the following, we provide an overview about iteration effects for all European and Scottish scenarios separately as well as across the case studies, i.e. a cross-scale comparison between the European and Scottish scenarios.

3.2 Effects of iteration on quantification output

3.2.1 Europe

The analysis of the iteration process accounts for the changes in six key variables of the four scenarios and two time slices. In total, the fuzzy set iteration was required 27 times across the four European scenarios whereas the key variables changed 14 times for the 2020s and 13 times for the 2050s. Frequent changes become evident for the "Should I Stay or Should I Go" scenario (9) followed by "Riders on the Storm" (7), "Icarus" (6), and "We are the World" (5). Over all European scenarios, every variable was revised in total between 2-6 times (2-3 times for the 2020s and 0-3 times for the 2050s). The "household size" variable is noticeable

[3] Initially a list of seven variables was defined. After WS1, the variable "protected area" was removed from the list. It is now considered as an adaptation option rather than a socio-economic driver. Similarly, the initially used geographical regions were removed. The final list thus contains six variables, for which fuzzy stakeholder-based boundaries were defined, without any geographical separation for either Europe or Scotland.

because it was rarely revised (2); with 2 revisions in the 2020s and 0 revisions in the 2050s. Most revisions were required for the variables "population" (6) and "food imports" (6); each for 3 scenarios per time period. "Oil price" ranked second (5); with 2 revisions for the 2020s and 3 for the 2050s. Besides the variables "household size" and "oil price", all variables were revised an equal number of times for both time periods.

3.2.2 Scotland

For the Scottish scenarios we carried out the same analysis as described for the European case. Revisions of key variables were made in total 21 times (8 times for the 2020s and 13 times for the 2050s). Most revisions of key variables were made in Mad Max (7), followed by MacTopia (6), Tartan Spring (5), and The Scottish Play (3). All variables were revised in total between 2-5 times among the scenarios and time periods (0-2 times for the 2020s and 1-3 times for the 2050s). Here again, "household size" underwent very few revisions (2), only for 1 scenario per time period. The most revisions (5) were made for "population" (2 for the 2020s and 3 for the 2050s), and the second most (4) for "food imports" (2 per period) and "oil price" (1 for the 2020s and 3 for the 2050s). "GDP", "population" and "oil price" had higher revisions for the 2050s than for the 2020s. Only "arable land for biofuel" had higher revisions for the 2020s (2) than for the 2050s (1). "GDP" had no revisions for the 2020s, but 3 for the 2050s.

3.2.3 Cross-scale comparison and interpretation

When comparing revisions made during the quantification process of key variables in the European scenarios with those of the Scottish case study, both similarities and disparities can be analysed. Overall, the revisions were less pronounced for the Scottish case study (in total 21) compared to the European case study (in total 27). Scotland had stronger revisions for the later period (13) compared to 8 for the earlier period, which may indicate that the long-term vision gives rise to difficulties. The revisions made during the European scenario development are not polarised with regards to the two time periods. Only one more change was made for the 2020s (14, compared to 13 for the 2050s). Here, it seems that visions of future developments in both the short- and long-term are in general more diverse in the European than the Scottish case study. At the European scale, this could have been initiated by the assumed economic instability.

Another relevant outcome of this analysis is the number of revisions related to the dynamics of the scenarios. It is apparent that most changes in key variables are counted for the scenarios with rollercoaster dynamics in the field of main uncertainties. This applies to Should I Stay or Should I Go (Europe) as well as for Mad Max (Scotland), with 9 and 7 revisions, respectively. Both scenarios are characterised by a rollercoaster of economic development. Moreover, it seems to be challenging to develop a scenario including a rollercoaster of economic development and its implication on different sectors in combination with ineffective solutions (Should I stay or should I go) or disparate well-being and lifestyle (Mad Max).

By far the lowest number of revisions of key variables were made for the We are the World (Europe) and The Scottish Play (Scotland) scenarios, each with 3 revisions. We are the World is characterised by gradual economic development and effective solutions by innovation to the depletion of natural resources. It seems to be easier for stakeholders to develop a scenario within a framework of gradual and positive developments compared to rollercoaster dynamics. The Scottish Play scenario is characterised by an equitable well-being and lifestyle,

and a resource deficit. Although this scenario includes a resource deficit and the Scottish population may be poorer than a few decades ago, they are also greener and happier. This idea of the future may stimulate stakeholders' agreement on key developments and thus also on key variables. As said (see section 2.3.1), in Europe, the axes did not nicely separate four distinct stories after WS1. During WS2, the storylines were further developed to increase disparities between gradual and rollercoaster scenarios. This agrees well with the higher number of quantitative revisions for rollercoaster scenarios. Moreover, in Scotland, the four stories already depicted four distinct futures after WS1. Here, only few changes to the storyline were performed to increase scenario separations during WS2. This also contributes to, and explains, the lower number of quantitative revisions in the Scottish case study compared to the European case study.

The key variable "population" was revised most often for both case regions (6 times for Europe and 5 for Scotland), which shows the difficulty of quantifying demographic trends by stakeholders even at the regional scale. This also confirms conclusions drawn with respect to the 'fast-track' uncertainties (see section 2.1.3). Population development is one of five overlapping uncertainties between Europe and Scotland. It seems that the estimation of population patterns is generally uncertain, which is not necessarily related to specific scenarios. This finding also contributed to the high overall revisions. The key variable "household size" was the least often revised for both regions (2 times each), suggesting not only that stakeholders' agreed, but also that they had a certain amount of familiarity with this variable. Furthermore, when sorting all variables regarding their total number of revisions, the order is basically the same for the European and Scottish case studies. The highest number of revisions given first, the order is as follows: "population", "food imports", "oil price", "GDP", "arable land for biofuel production", and "household size".

The different number of revisions can be explained with a higher/lower agreement among stakeholders with respect to the quantitative values for each qualitative class (e.g. what does medium change mean in percentage changes?). These values were analysed according to the individual fuzzy set spreadsheets that were filled out by the stakeholders during WS1. Quantitative associations for the applied qualitative classes seem to be similar among stakeholders for variables that were less often revised; dissimilarity seems to be higher for the more often revised variables. In this case, iterations of key variables would be driven by different stakeholder perceptions of the meaning of qualitative wording in numbers. However, this does not account for new groups of stakeholders during WS2. The participation of new stakeholders was higher for Europe than Scotland, which could have contributed to the higher number of revisions for the European case study. Additionally, the qualitative storyline revisions during WS2 led to storyline changes; hence, key variables needed quantitative revisions accordingly. In particular, there is new information on population in all European stories and some stories in Scotland; all provide new information related to the uncertainty on population. For this variable, the stories seem to have been driven by the fuzzy sets exercise. For the other variables, a direct link could not be established.

3.3 The use of documented discussions during the fuzzy set exercise to enrich stories

During both the European and Scottish scenario development process the fuzzy set methodology provided quantitative model drivers and, as a side effect, enriched qualitative stakeholder discussions. Concerns about future states of socio-economic key variables were essentially storyline driven. However, during the quantification exercises, stakeholders were automatically checking the storyline for consistency. The fuzzy set exercise supported

systematic thinking of the socio-economic scenario development process, such as how changes in one sector could potentially affect (changes in) other sectors. It increased stakeholder engagement and led to complex qualitative discussions. Hence, not only the storyline drives the quantification of key variables (and thus model drivers), but also the quantification drives storyline development. Finally, there are two important effects closely linked to the fuzzy set iteration that need to be mentioned: first, the improvement of quantified drivers and scenario content creation, both embedded in the SAS methodology; and second, the systematic stakeholder discussions which promoted the CLIMSAVE team in documenting reconstructive causal consequences and relationships. Certain socio-economic scenario characteristics became more reasonably documented due to records made during the discussions of the quantification exercise. Both effects were realised during the fuzzy set exercises of WS1 and WS2.

3.4 Recommendations

- More research is needed to provide better insight into the weaknesses of using fuzzy sets. The tool has untapped potential that has not fully been explored.
- Experiment with e.g. asking information on fewer parameters, and ensuring that sufficient time is spent for the group discussion. The list of model parameters is much longer and more detailed than stakeholders can consider in any reasonable amount of time. In other words, it may be better to aim for what was asked in WS2 (6 variables without geographical separation) rather than what was asked for in WS1 (7 variables for 4 regions).
- 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.
- Strengthen the link between stories and fuzzy sets. This would open the possibility to analyse whether changes made during the fuzzy set sessions are incorporated in the storylines, and (thus) whether iterations structurally change stories.
- The analysis shows that it is easier for stakeholders to develop a scenario within a framework of gradual and positive developments compared to rollercoaster dynamics.
- Over all case studies, the variables "population", "food imports" and "oil price" were more often revised than "GDP", "arable land for biofuel production" and "household size".
- Fuzzy set quantification is storyline driven, but quantification also drives storyline development.
- An iterative process is needed to agree on common key variable quantification.

4. Interaction with the IAP

4.1 Important results of the IAP

Most of the architecture and functionality of the IAP is documented elsewhere (see Deliverable 2.3). Yet, because the IAP is currently still being further developed and because therefore the stakeholders were using a preliminary version, it is important in the context of this Deliverable to shortly present some of the main functionality present in the version of the IAP that was used during WS3 (i.e. the beginning of December 2012). In this section we present some maps (as screenshots) from the various screens, particularly from the scenario settings screen; the impacts screen; and the adaptation options screen, i.e. those that were available to the workshop participants. The images shown are screen dumps from the IAP as used during WS3.

4.1.1 Scenario settings

Figure 4 and Figure 5 show the change in annual mean temperature and annual precipitation in the 2050s, relative to the 1961-90 baseline. The workshop used outputs from the CSMK3 Global Circulation Model (GCM) with a 'middle' climate sensitivity and an A1 emissions scenario. CSMK3 was selected as it is the 'central' GCM (the GCM whose climate change scenario is the closest to the mean scenario over all 16 GCMs available from the IPCC-AR4 database). Only one climate change scenario was used in WS3 due to time constraints, but the importance of exploring several climate change scenarios, and the flexibility of the IAP to do so, was stressed.

Selection of key socio-economic scenario settings was based on a set of sliders with three colours: green, yellow and red (Figure 6). Values included within the green area of the slider are within the range of the qualitative scenario; yellow is outside the range provided by the storyline, but inside the possible range (the scenario becomes named as "user defined"); red is outside of the possible range.

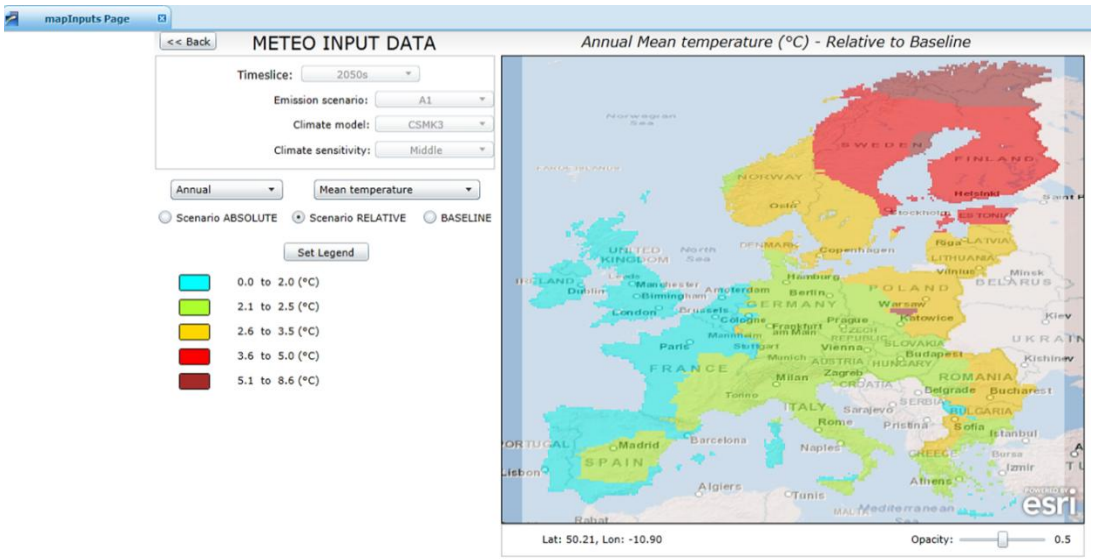


Figure 4: IAP input data used in WS3. Change in annual mean temperature, relative to baseline, for the CSMK3 Global Circulation Model (GCM) with a 'middle' climate sensitivity and an A1 emissions scenario.

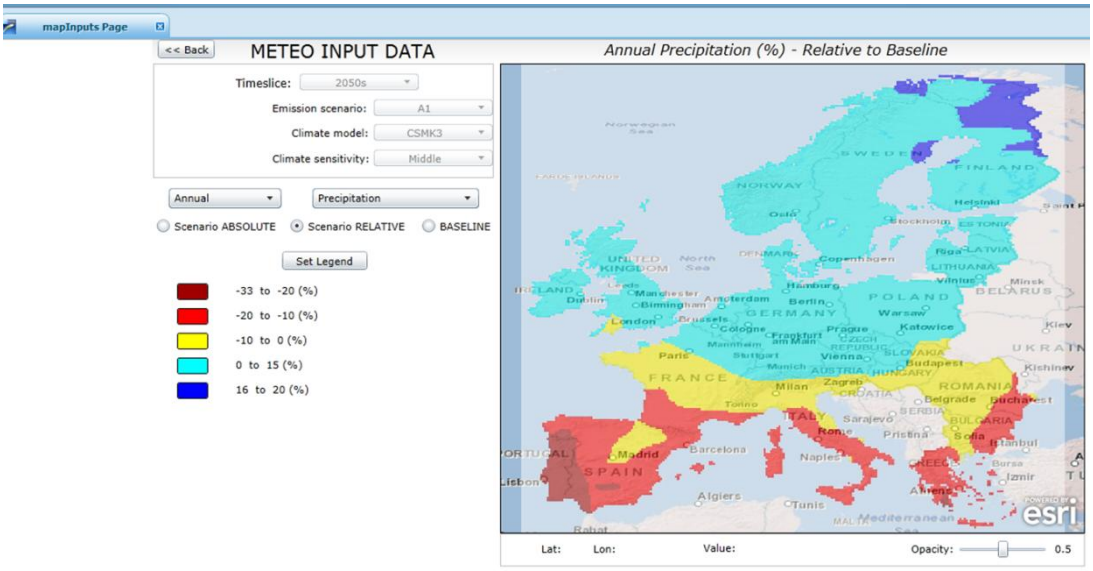


Figure 5: IAP input data used in WS3. Change in annual precipitation, relative to baseline, for the CSMK3 Global Circulation Model (GCM) with a 'middle' climate sensitivity and an A1 emissions scenario.

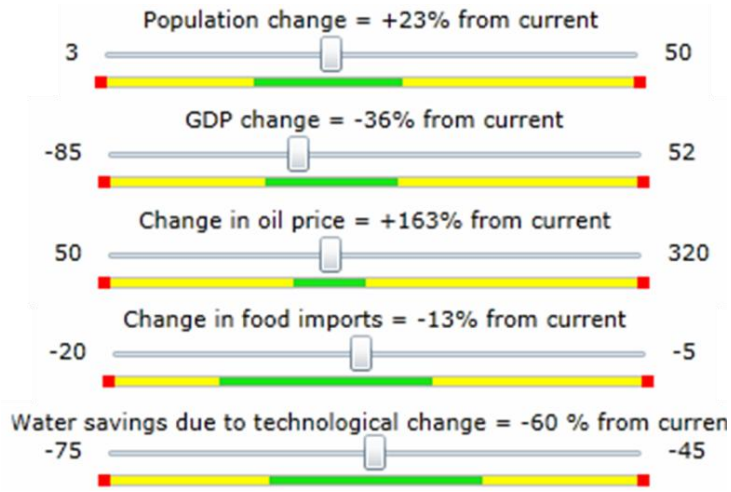


Figure 6: IAP input data used in WS3. The sliders allow the user to change the default values for a number of variables (related to the fuzzy sets; see section 3). Green: within the range provided by the storyline; yellow: outside the range provided by the storyline, but inside the possible range; red: outside of the possible range.

4.1.2 Impacts screen

The "Should I Stay or Should I Go" scenario settings led to a range of impacts. For example:

- Artificial surface area (see Figure 7): very slight increases (<2%) in artificial surfaces in eastern Europe, but larger decreases (<4%) in western Europe, with some cities decreasing by up to 8% in artificial surfaces. Changes are small in both cases due to the major declines in GDP growth cancelling out the effect of strong population growth. Low spatial planning regulations lead to relatively dispersed patterns of artificial surfaces.

- Water Exploitation Index (WEI): this shows the balance between water availability and water demand and indicates water stress at WEI>0.4. A number of catchments are simulated as water stressed, due in part to the increases in population and water demand due to reduced water savings as a result of technological change.

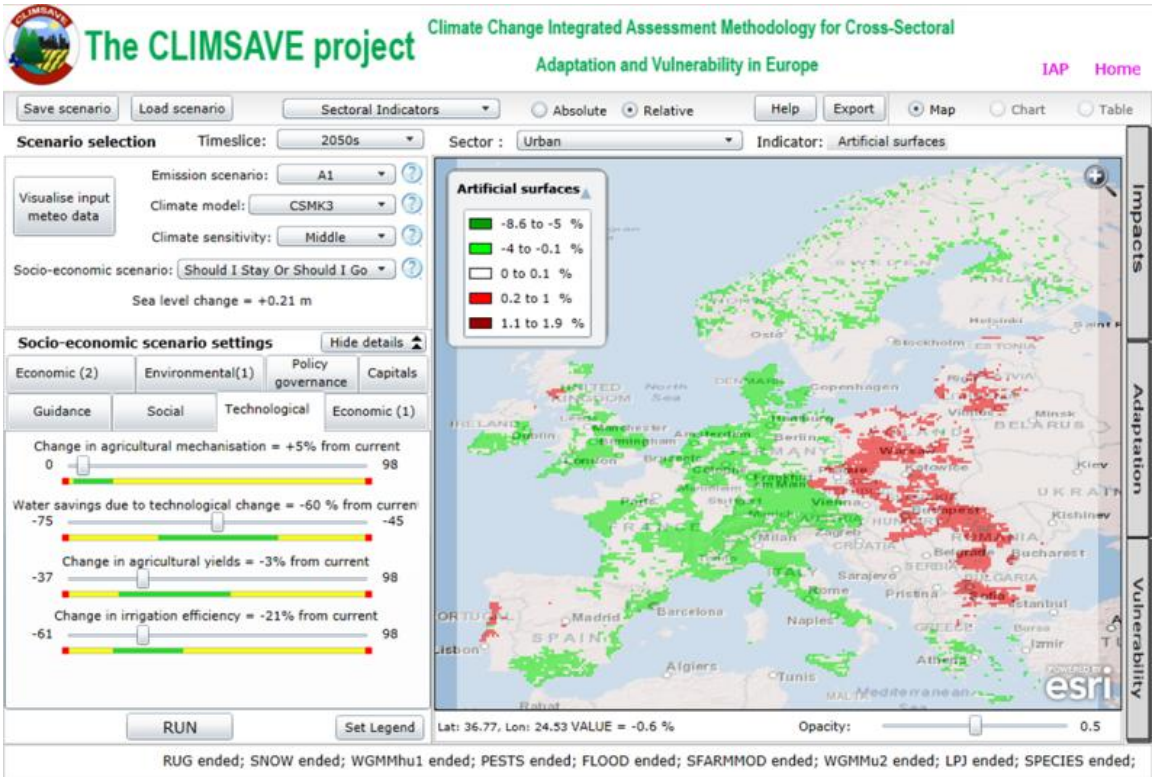


Figure 7: IAP Impact screen. Change in artificial surfaces (red: decrease, green: increase) for the CSMK3 climate scenario with the Should I Stay or Should I Go socio-economic scenarios in the 2050s is shown as an example.

4.1.3 Adaptation screen

Within the "Should I Stay or Should I Go" scenario, the stakeholders prioritised investigation of the effectiveness of water saving adaptation measures, in particular maximising the water savings due to behavioural and technological change within the scenario constraints. This had limited effectiveness in reducing water stress given the challenges of this scenario, partly due to the constrained capital availability. Maximising the time-slice increase in capital (social, human and manufactured) availability in order to increase the credible adaptation range had little additional effect on water stress (see Figure 8). This highlighted that there are undesirable future scenarios in which it is not possible to fully adapt to climate change impacts and, hence, emphasised the importance of mitigation.

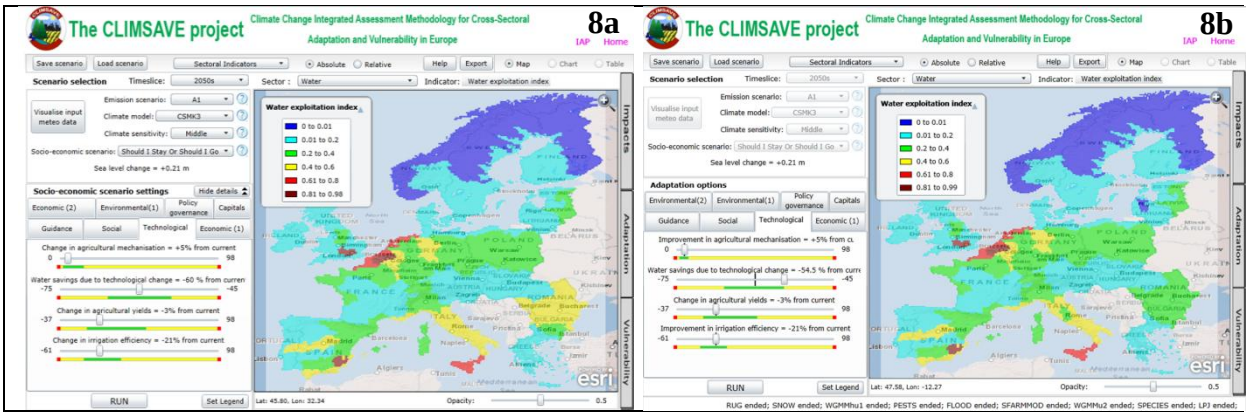


Figure 8: Water Exploitation Index in Should I Stay or Should I Go for the 2050s before (Figure 8a) and after (Figure 8b) consideration of adaptation within the domestic and industrial sectors.

4.2 Interaction of stakeholders with the IAP

Stakeholders interacted with, and informed the development of, the IAP in a number of different ways:

- Firstly, prototypes of the IAP were presented at each of the first and second European and Scottish workshops to get progressive feedback on the design and functionality which informed subsequent IAP versions.
- Perhaps most importantly, they provided quantitative values for a number of key model input parameters, such as future GDP and oil price.
- Additionally, the narratives that stakeholders produced were also mined by the project team for additional information to assist the model input quantification.
- Finally, stakeholders used the IAP during the last workshop in order to help decide on the list of useful and effective adaptation options.

Most of the results obtained are discussed elsewhere in this Deliverable (see Section 3 for fuzzy sets; Section 2 for qualitative parameters; Section 5 for adaptation options). Rather that repeating what is discussed there, this section focuses more on the overall process of working towards, and working with, an online tool.

4.2.1 Input to the IAP

<u>Input through fuzzy sets</u>

Here, a few key observations are given from the overall analysis of using a technique such as fuzzy sets to have stakeholders directly quantify model parameters.

Process:

- Only a very limited set of model parameters could be directly quantified, with a limited degree of spatial explicitness. The final selection included 7 model parameters that would be estimated for 4 geographical regions. In a workshop setting, quantifying a longer list would take too much time.

- The fuzzy sets exercise consists of two separate exercises: (1) an individual exercise during which the actual numbers are estimated by each stakeholder separately; and (2) a group exercise during which the qualitative change is discussed within the scenario groups. Stakeholders understood the importance of the first exercise, but did not particularly value it. A typical remark from the stakeholders on the individual exercise was "Not sure my guesswork provides added value".
- In the second workshop, the group exercise was repeated; the individual exercise was not. Stakeholders remained critical, but a more typical remark was now: "This was an important part of the process and helped towards the consideration of trade-offs and priorities".
- Overall, the process of involving stakeholders directly in the model parameter quantification remains the most challenging aspect of scenario development. Stakeholders are (moderately) critical towards the value of the results; question the way in which the exercise is presented; and do not always consider themselves sufficiently knowledgeable to provide answers.

Results:

- Besides an average value for each parameter estimate, the fuzzy sets approach yields a precise estimate of the fuzziness of these estimates. This information was used in the IAP, by using different 'traffic light' colours accompanying the sliders for socio-economic settings that were based on these estimates. Green (within range), yellow (possible, but outside of range), and red (impossible) colours represent the results from the fuzzy sets exercise. This was an elegant way to represent the fuzziness of the estimates.
- The discussions during the group exercise were documented. This information proved very useful for further enriching the storylines; for understanding the results of the fuzzy sets exercise; and for quantification of additional model parameters.
- The iterative procedure is absolutely essential in using this tool. As explained in Section 3, the numbers of most parameters changed considerably after the second stakeholder consultation.

Conclusions:

- Fuzzy sets is one of the few tools that result in scenario-specific quantitative estimates of model parameters. Future work needs to show its full potential.
- Stakeholders are critical about the process, but value the concepts behind the exercise and support the general idea of using stakeholders in the process of quantification. In part, this criticism might also have been related to the small group sizes. It is possible that with more participants, stakeholders might have been less " uncertain".
- Without iteration, the results are likely to be erroneous, partly depending on the scenario and parameter at hand. Particularly the variables that were expressed in % per year were difficult for stakeholders; periodic changes were more successfully estimated by stakeholders.
- The implementation of the fuzziness of the estimates as slider colours in the IAP was successful.

Input through qualitative parameter estimation

The details are presented in Section 2. Some more general observations are:

- The process is quick, can be done for a large number of parameters, and yields a structured overview of the information present in the storylines.
- The results represent the view of the CLIMSAVE experts, rather than the stakeholders, although "their" storylines have been used as a main source to try and ensure internal consistency in the underlying assumptions.
- The process towards quantification has two stages, where first tabular information is generated, which modellers then use to quantify the model parameters. This longer chain is more susceptible to misinterpretations.

Conclusions:

- This more traditional manner of quantifying model parameters (see Step 4 in the Story-And-Simulation approach in Deliverable 3.1) remains a good way to quickly scan the storylines for relevant information on parameter quantification.
- Because other, more participatory, methods can never be used to quantify all model parameters, this "expert quantification" remains an important aspect of parameter estimation. However, the richness of the stakeholders' storylines is an important determinant of the likelihood of this step producing internally consistent results.
- Past exercises (see Deliverable 2.12 of the SCENES project) have shown that there is a degree of subjectivity in documenting the (often indirect) information from the storylines. This step is crucial, yet perhaps not sufficiently analysed.

4.2.2 Using the IAP – real-time running of the IAP

Below is a list of partly positive and somewhat more critical observations of running the IAP during the workshop. Because the IAP was simultaneously used in eight scenario groups, it is difficult to provide a full overview of all the experiences that stakeholders and CLIMSAVE experts had. A more structured set of conclusions is provided in Section 8:

- We successfully ran the IAP during the workshop with few technical issues and acceptable run times.
- Providing stakeholders with results from the IAP on climate and socio-economic changes stimulated discussions on impacts as well as adaptation needs. This discussion became more specific with IAP support, particularly related to the visualisation of scenario settings and impacts, rather than in the sense of testing scenario sound adaptation options.
- There were adaptation surprises for the stakeholders in using the IAP. As an example, increasing irrigation efficiency was tested by some stakeholder groups as an adaptation to increased river basin water stress, with the expectation that it would reduce agricultural water demand. The actual simulated effect was to increase agricultural water demand, as it increased the relative profitability of irrigated (compared to rain-fed) agriculture and allowed more land to be irrigated – if it is profitable to grow irrigated crops and a farmer has 'saved' water by being more efficient, why wouldn't (s)he use that spare water by increasing the area of irrigated crops? This unintended consequence demonstrated the benefits of the IAP in

developing a more complex understanding of system behaviour, but also demonstrating the need for additional guidance/support to explain such surprise behaviour.

- Using the tool in the workshop context highlighted certain functionality limitations – particularly the desire to view the effect of adaptation relative to the starting impacts of that scenario, rather than to the baseline. Using a prototype of the IAP at WS3 allows time to address such functionality limitations within the final IAP version.
- However, there were issues with the fact that we used a version of the IAP that was not finished, and that did not provide the functionality as presented in earlier workshops. The fact that the vulnerability screen and the adaptation costs screen were not available, limited the usefulness of the IAP, and left some stakeholders disappointed.
- In some scenario groups, expectations regarding the scope of the IAP could have been better managed. As stakeholders were invited to identify and prioritise adaptation options across all possible fields (rather than the natural resource management areas of the CLIMSAVE project), it was inevitable that to some, the IAP would appear to fall short of their needs. This is how it was originally planned, but it could perhaps have been stressed more strongly in some groups. Note that limiting adaptation options to what the IAP could accommodate would have probably been equally or even more frustrating to stakeholders.
- There seemed to have been some degree of disappointment when the IAP 'failed' to adequately adapt to the climate change impacts in some scenarios. This seemed to be perceived as a weakness in the IAP, rather than it producing an appreciation that there are futures to which we cannot adapt (and hence highlights the importance of mitigation).

4.3 Recommendations

- **More time needs to be devoted to fully obtain the benefits of interacting with the IAP**. As it was, time was too short to assess system behaviours (sensitivities), impacts (vulnerabilities) and cross-sectoral adaptation effects.
- **Be careful when raising expectations of stakeholders**. The full functionality of the IAP was explained and discussed with stakeholders during the first two workshops. The fact that the version that was used was incomplete was disappointing for some stakeholders.
- **Any future interaction with the IAP has to be based on a more complete version**. At the very least, the effects on vulnerability need to be part of the platform.
- **Explore the possibility to include "soft" measures in the adaptation screen.** Executing a (documented) sensitivity analysis a priori could enable users to translate "soft" measures to slider settings.

5. Adaptation options

5.1 Adaptation options and clustering

At the second workshop for both the European and Scottish scenarios, the stakeholders spent time identifying the adaptation options appropriate for the individual scenarios. After the workshops the CLIMSAVE team clustered the options. The clusters that were identified are indicated in Table 8, and a full overview of all adaptation measures selected for each scenario and cluster are provided in Deliverable 1.3a/b. The measures include both those that can be explored directly using the CLIMSAVE IAP and a wide range of other measures.

Table 8 shows that the selection of measures differs across the scenarios. For all scenarios, adaptation measures in agriculture, natural resource management, infrastructure/technology, awareness-raising and governance/regulations were selected. Overall, many more measures were suggested for changes in natural and manufactured capital than for changes in social, human and financial capital. An analysis of Table 8 and the full tables in Deliverable 1.3a/b provide three conclusions with regard to the scenario process carried out in the CLIMSAVE project:

- **The adaptation options selected by the stakeholders cover all forms of capital** (natural, financial, manufactured, social and human). This indicates that the brainstorming session during the second workshop worked well, so that for each scenario a broad list of possible measures was generated. This was strongly supported by a session in which each scenario group could visit the other scenarios, hear a short summary of the storyline, look at the adaptation measures that had been proposed and suggest further options that the group could consider. In most cases this expanded the list of measures that each group finally proposed.
- **The clustering process was extremely useful in highlighting the commonalities and differences between the scenarios** at each level and between the levels. This process was carried out by first clustering the measures within scenarios and then naming the clusters. That is, the clusters were not predefined. These clusters were very useful in the third workshop to show the participants what kinds of measures had been proposed and where there might be a need to think more carefully about possible measures (e.g. in most scenarios, there was much more emphasis on measures that used natural and manufactured capital rather than social and human capital).
- **The stronger emphasis on natural and manufactured capital, and the lesser emphasis on human and social capital is not necessarily surprising**, since measures that use social and human capital have not been emphasised in the adaptation discourse in recent years. There is, however, an increasing interest in using skills, traditional knowledge or networks, so future projects might want to include more participants with this kind of focus and stimulate the participants to think more about "people-based" adaptation measures.

Table 8: Categorisation of adaptation options and the number of measures selected for each scenario in Europe and Scotland.

	Icarus	Should I stay or should I go	We are the world	Riders on the storm	Mactopia	Tartan spring	Mad Max	The Scottish play
NATURAL CAPITAL								
1. Agriculture	1	6	9	8	8	5	14	7
2. Biodiversity	-	2	-	2	2	-	-	-
3. Natural resource management	1	4	12	8	8	6	5	16
FINANCIAL CAPITAL								
4. Insurance	2	6	1	-	2	2	1	
5. Financial support / incentives	1	1	2	7	2	6		1
6. Taxes	-	1	2	-	-	1	-	-
MANUFACTURED CAPITAL								
7. Green infrastructure	3	4	4	2	8	3	-	6
8. Energy	-	1	5	-	7	6	2	6
9. Infrastructure / technology	5	9	19	11	18	7	7	9
HUMAN CAPITAL								
10. Expertise	1	2	1	7	4	1		1
11. Awareness	5	3	7	7	3	1	1	6
SOCIAL CAPITAL								
12. Social networks	-	2	-	2	3	2	2	6
13. Socio-technology	1	-	-	3		2	2	1
CROSS-CUTTING								
14. Governance / regulations	4	14	11	7	7	4	3	18
15. Emergency response	-	3	7	5	-	1	3	8
16. International cooperation	-	-	5	-	2	-	-	-

Recommendations:

- Once the storyline is well developed, a moderated session in which the participants propose adaptation measures that fit with the storyline is an effective way of providing a broad list of possible responses. This can be supported by a session in which participants "visit" the other scenarios and see what measures have been proposed elsewhere.
- A clustering process between workshops 2 and 3 provides useful meta-level information for the third workshop.
- More attention should be given to including stakeholders with experience in the use of human and social capital for adaptation, and the identification of such measures should be stimulated (to balance the usual tendency to consider measures that rely on building infrastructure).

5.2 Robust policy measures

As described in CLIMSAVE Deliverables 1.4 a/b, during the third workshop, the participants were asked to identify adaptation options that might work across all four scenarios for Europe and Scotland.

5.2.1 Europe

For the European scenarios, the following measures were listed as potential candidates for robust options:

- **"Active citizens"**. A much-encompassing group of options with a focus on a bottom-up governance approach, inspiring active citizenship, through public-private partnerships.
- **"Reduce consumption"**. Overall reduction of various kinds of resource consumption.
- **"Share best practice"**. In essence rather a specific group of options related to sharing best practice with regards to disaster management.
- **"Building social trust"**. Overall building of social trust – related to active citizenship and bottom-up governance.
- **"Training and education"**. Increase training activities and efforts related to education to have a more informed / aware population related to climate change.
- **"Alternatives for the use of natural resources"**. Reduce exploitation of natural resources by developing alternatives.
- **"Regional solutions"**. Regional solutions to regional problems – different parts of Europe must do what is best for their specific geography and situation.
- **"Spatial planning"**. Increasing efforts for spatial planning, mostly in order to preserve natural resources and the landscape.
- **"Flexible policies"**. Policies need to be flexible so that they can more easily adapt to unexpected developments.
- **"Keep climate change on the policy agenda"**. Important to mainstream the issue of climate change and to keep it on the policy agenda - makes people and governments more aware.

These options were considered by each scenario group, with each group reporting back on which measures work in their scenario. Details of this analysis are reported in Deliverable 1.4a. This led to results as summarised in Table 9.

Table 9: Candidate options for robustness in the four European scenarios, and an indication of their robustness after analysis across all scenarios.

Candidates (plenary)	**We are the World**	**Icarus**	**Should I Stay or Should I Go**	**Riders on the Storm**	**Robust?**
Active citizenship	Yes, a given in this scenario	Partly, problems with self-centrism	Yes	Yes	Not in Icarus
Reduce consumption	Yes, less = more	Partly, only for eco-eco	Yes, more effective use	Yes, sustainable resource use	Robust, but with remarks
Share best practice	Yes, important for direct actions	No, only at regional level	Yes	No, not a priority	Not in Icarus
Build social trust	Yes, a given in this scenario	No, only at family level	Yes, but rather local	Yes, together with training and citizenship	Yes, but only local
Training and education	Yes, but as such it does not help against CC	No, not a focus	Yes	Yes, together with trust and citizenship	Not in Icarus
Alternative use for natural resources	Yes, but this is not enough	Yes, eating less meat is essential	Yes, but only low-tech works	Yes, based on technology	Yes
Regional solutions	Partly, but yes related to adaptation	No. Would be nice, but unlikely	No	Yes, a given in this scenario	No
Spatial planning	Yes, possible and important	Partly, spatial measures are taken	No, very limited	Yes, green transformation	Not in Should I Stay or Should I Go
Flexible policies	Yes, for many different policies	No, attempted but failing because of populism	Partly, local and for a while it would work	No, mistrust of government	No
Keep CC on the agenda	Yes, a given in this scenario	No, problems with populism	Partly, mostly through other policies	Yes, important in this scenario	No

In summary, for the European scenarios, reducing consumption of resources, increasing alternative use of resources and spatial planning can be considered as robust options across the four scenarios. Active citizenship and building social trust are mostly robust, but highly context-dependent.

Based on a final plenary discussion, a list of five robust options was compiled for the overall cross-scale plenary:

1. **Reduce consumption (eco-eco)**
2. **Increase the alternative use of resources**
3. **Active citizens – added after discussion**
4. **Building social trust**
5. **Spatial planning**

5.2.2 Scotland

For the Scottish scenarios, the following measures were listed as potential candidates for robust options:

1. **Innovation**
2. **Flood management**
3. **Social cohesion**
4. **Best use of land**
5. **Dietary preferences**

These options were considered by each scenario group and each group reported back on which measures worked in their scenario. Details of this analysis are reported in Deliverable 1.4b. This led to results as summarised in Table 10.

Table 10: Candidate options for robustness in the four Scottish scenarios, and an indication of their robustness after analysis across all scenarios.

Candidates (plenary)	**Tartan Spring**	**Mad Max**	**The Scottish Play**	**Mactopia**	**Robust?**
Innovation	No, lack of money	Partly, technical aspects increase profit	Yes, many different options are feasible	Yes, prerequisite for the scenario	Partly, lack of money and focus can be problematic
Flood management	Yes, some people still flooded	Yes, flood defences would work	Yes, many options are feasible	Yes, many options are feasible	Yes, although options can be limited
Social cohesion	Partly, emerges later	Partly, might emerge later but no priority	Yes, core to the scenario	Yes, essential in the scenario	No, although it does emerge
Best use of the land	Yes, increasing profitability	Partly, see innovation	Yes, implementation might be problematic	Yes, practical issues regarding multifunctional land use	Yes, but there are practical issues
Dietary preferences	No, not valued in society	No, difficult to change	Yes, many options feasible	Yes, part of the scenario	No

In summary, innovation, flood management and best use of land can be considered robust options across the four Scottish scenarios. However, they are still very context-dependent.

Based on the closing Scottish plenary discussion, a list of three robust options was compiled for Scotland for the overall cross-scale plenary:

1. **Innovation**
2. **Optimise land use**
3. **Flood management**

For both the European and Scottish scenarios, for the "negative" scenarios (Icarus, Should I stay or should I go?, Mad Max) the list of adaptation options was shorter than for the other scenarios. This is not surprising in as much as lack of resources or lack of effective innovation restricted the options that could be selected. For robustness assessment, however, this meant that a number of options were found to not be robust because of the negative scenarios. This has an important policy message: as long as developments in the future are along the lines of the more positive scenarios, more adaptation options will work. However, if a broad selection of adaptation options is adopted, but development is along the lines of a "negative" scenario, quite a few of the selected options will fail.

The testing of robustness relied on an early version of the IAP. The results presented above might well change when the final version of the platform is available.

Recommendations

- Pay attention to the "negative" scenarios given their important role in determining robustness.
- Be aware that the robustness analysis carried out at the third workshop used an early version of the IAP. A more detailed analysis will be carried out by the CLIMSAVE team and reported in Deliverable 5.4.

6. Cross-scale interaction

6.1 Rationale

Towards the end of the second workshops at both the Scottish and European level, the possibility was discussed to organise a joint third and last workshop. The suggestion was fully supported by stakeholders at both levels. By and large, they were enthusiastic about the possibility to interact with stakeholders working at the other scale, and to learn about the scenarios that were developed. At both workshops, stakeholders voiced a preference for a third joint workshop rather than a single-scale workshop. It was decided to look into the possibility of organising a cross-scale workshop.

6.2 Methodological issues related to a cross-scale workshop

The CLIMSAVE methodology as described in Deliverable 3.1 was built around the notion of three single-scale workshops; designing and applying the method at the European scale and testing the method at the Scottish scale. Combining both workshops into one would pose a number of issues:

1. The time available to finalise the scenario development at a single scale would be shortened for two reasons. Firstly, and affecting both scales, time would have to be devoted to the cross-scale interaction, which necessarily would limit time for other activities. Secondly, and affecting the European scale, the cross-scale workshop would have to be a 2-day instead of a 3-day event.
2. The number of aims of the joint workshop would be increased. Besides the goals of a single-scale workshop, cross-scale interactions would be an additional aim. Past experiences clearly indicated that the number of different goals in any given workshop needs to be limited.
3. The number of activities would increase. Adding an additional aim while shortening the overall time available would lead to less time available for each activity and more activities that needed to be addressed.
4. Logistically, it would be a very intensive process that would partly depend on finding a location that would facilitate a workshop with two plenaries and up to eight break-out groups, as well as internet access to allow for the interaction with the IAP.

6.3 Solutions and programme of the cross-scale workshop

A number of discussions took place within the scenario team, in which we tried to balance the preferences of the stakeholders and the possibilities to add these to the overall scenario development process. Despite some initial hesitance, it was decided to follow the wishes of the stakeholders and organise a two-day, cross-scale workshop. Related to the three issues, the following solutions were proposed (see Deliverable 3.1 for details of the programme):

1. The European workshops officially lasted three days, but in practice took little more than two full working days. Additionally, although stakeholders would be together in one space, relatively little time would be spent on cross-scale activities. After careful consideration, it was concluded that the total loss of time could be minimised to save sufficient time to finalise essential single scale aspects first.
2. The number of aims would be high. Apart from having to revisit the qualitative stories and develop sets of adaptation options, a main objective of the third workshop was to interact with the IAP. A cross-scale comparison was added as a goal. A highly structured programme with a large number of skilled facilitators was clearly identified as absolutely essential in this type of setting.
3. A logical consequence of having more aims was an increase in the number of activities. We decided to maintain the number of aims, but to cut back on a number of activities. Importantly, the idea to develop "roadmaps" of adaption options was dropped, in favour of a simpler listing of the most important options. Furthermore, less time was devoted to evaluation of the qualitative storylines and introductory presentations. This created room in the program for a cross-scale section.
4. A location was suggested in the heart of Edinburgh: the Playfair Library. This location was close to perfect for our wishes. It was large enough to host close to 100 persons; long enough to enable two parallel plenaries at the same time; and had a large enough number of small alcoves that could be used for scenario breakout groups. Additionally, it would not require Scottish stakeholders to travel far. Finally, it would be in reach of the University's wireless network.
5. An important contribution to the success of the meeting was a one-day "dry run" held in the Playfair Library six weeks before the workshop. Participants included a core

team of the facilitators, scenario supporters and members of the IAP team. This meeting clarified and adjusted the agenda for the December workshop and tested the IAP.

Summarising, most of the logistical aspects (location, facilitators, length of workshop, etc.) could be changed such that a cross-scale workshop would be possible. This would respond to the suggestion from the stakeholders, yet, it would be a rather shorter workshop with many different aims and activities. It would be the last in the series of workshops, and because of this, failure would be disastrous. Balancing the pros and cons, led us to decide to organise a two-day cross-scale workshop.

6.4 Content

6.4.1 Cross-scale robustness

Based on the discussion during the combined Scottish-European plenary, three cross-scale robust categories of adaptation options emerged:

1. **Spatial planning**. This category combines the 'land use optimisation' options from Scotland and 'spatial planning' options from Europe. At both scales, the efforts to preserve natural resources were emphasised.
2. **Social and technological innovation**. This category includes the 'innovation' options from Scotland, and the 'increase alternative use of resources' and elements of 'reducing consumption' options from Europe. With that, the cross-scale robust elements relate both to technological innovation and social/planning aspects.
3. **Social dimension**. This came through very strongly at the European level, but was initially absent from the final list for Scotland. After some discussion, it was re-introduced as potentially robust at the Scottish scale. The final category includes a broad sweep of social issues from social trust and cohesion, to active citizenship. At both scales, it was specifically noted that local efforts were more feasible.

There are a number of interesting aspects to the list of three overall categories of robust options:

1. All three have elements of social capital. Spatial planning relates to organisational, policy and planning issues; innovation was specifically also seen as social innovation; and the social dimension captures a range of additional social aspects of adaptation.
2. Relatively little emphasis was placed on 'technical fixes' and natural capital. Despite the strong focus on interaction with the IAP, which includes mostly technical adaptation options, the final set of categories does not focus specifically on this type of adaptation option. Natural capital is represented in spatial planning, and technological options in innovation.

It is perhaps equally interesting to note a few of the categories that did not make it on this final list:

- **Flood management**. It was clearly ruled out in the plenary as a category that would need to be considered at the local scale.
- **Dietary preferences**. Present on both scales as a candidate, but considered not an option for the negative scenarios in Scotland.

- **Human capital**. More in general, the final list does not cover aspects of human capital.

In conclusion, the results show that stakeholders identified a (small) number of overall robust categories of adaptation options. This list focuses on social capital, with elements of natural and manufactured capital.

6.4.2 Overall conclusions on content

Here are some overall observations:

+ A great added value was the fact that robustness was discussed across scenarios AND across scales by the stakeholders. The final list of cross-scale candidates for robustness was a product of the workshop, not post-processed conclusions by researchers. As far as we are aware, this is the first time that this was attempted during a cross-scale workshop.

+ Due to a committed and skilled team of facilitators, scenario supporters and modelling experts, the meeting was logistically almost flawless, as also noted by the stakeholders (see Deliverable 1.4a/b).

+ Although concrete indications from the stakeholder questionnaire are lacking, stakeholders in general seemed to have highly valued the interaction with their counterparts and getting a preview of the scenarios that were developed.

- There are drawbacks to omitting the step of roadmapping. Adaptation options remain somewhat general and not always well tied in with the scenario. Some scenarios maintain their utopian feel and have not landed (Mactopia; see stakeholder remark saying "…hadn't realised our scenario was a bit light until reading the report…."), while some other scenarios maintain their dystopian feel and did not fully explore possibilities within (Icarus; see stakeholder remark saying "…most aspects hopefully never happen.").

- The discussion on robustness at both scales separately yielded a high number of occasions of "This is a given in the scenario". This is slightly unsatisfactory, as the intention of discussion options is to be more precise, and not to 'hide behind' the story. This is partly due to a lack of time to further explore what is actually 'given' in the scenario.

- The discussion on robustness at both scales also yielded a high number of "no's". Similarly, more time would have allowed for a deeper discussion on just how impossible certain options are.

- There are some indications that stakeholders were somewhat more critical about the third workshop than the first and second. "Less engaging"; "third workshop not as slick as first and second". The need for such a large amount of highly-trained and highly knowledgeable people was perhaps too high. Eight facilitators, eight scenario supporters, and eight note takers, eight model experts… it is close to impossible to provide the same level of excellence in all groups. Also, the link with the IAP was less complete than originally planned. Comments were the exception rather than the rule, but there were some signs that it was a risky undertaking. As said, the final list of adaptation options did not relate strongly to the list of options possible within the IAP.

7. Stakeholder satisfaction

7.1 Summary of results

Below is a summary of the results from the stakeholder questionnaire as handed out after all workshops. For the exact wording of questions, we refer to the detailed presentation in Deliverables 1.2a/b, 1.3a/b and 1.4a/b.

WS1 Europe	Very good	Good	OK	Bad	Very bad
Introductory presentations	7 (44%)	7 (44%)	2 (12%)	0	0
Facilitation	11 (65%)	3 (17.5%)	3 (17.5%)	0	0
Practical arrangements	13 (76.5%)	4 (23.5%)	0	0	0

WS1 Scotland	Very good	Good	OK	Bad	Very bad
Introductory Presentations	7 (58%)	4 (33%)	1 (8%)	0	0
Facilitation	9 (69%)	4 (31%)	0	0	0
Practical arrangements	9 (69%)	3 (23%)	1 (8%)	0	0

WS2 Europe	Very good	Good	OK	Bad	Very bad
Workshop in general	4 (40%)	6 (60%)	0	0	0
Introductory presentations	2 (20%)	6 (60%)	2 (20%)	0	0
Facilitation	7 (70%)	2 (20%)	1 (10%)	0	0
Practical arrangements	7 (70%)	3 (30%)	0	0	0

WS2 Scotland	Very good	Good	OK	Bad	Very bad
Workshop in general	11 (92%)	1 (8%)	0	0	0
Introductory presentations	8 (73%)	3 (27%)	0	0	0
Facilitation	12 (100%)	0	0	0	0
Practical arrangements	9 (75%)	3 (25%)	0	0	0

WS3 Europe + Scotland	Very good	Good	OK	Bad	Very bad
Workshop in general	13 (72%)	5 (28%)	0	0	0
Content supporters	7 (39%)	8 (44%)	3 (17%)	0	0
Facilitation	14 (78%)	4 (22%)	0	0	0
Practical arrangements	10 (55.5%)	7 (39%)	1 (5.5%)	0	0

7.2 Analysis

Overall, throughout the entire CLIMSAVE process, we received very positive feedback from stakeholders. The majority of participants were generally very satisfied with the facilitation, the content support and the practical arrangements. A few comments might be regarded as indicating that the third workshop was not as well received as the two previous ones ("less engaging than scenario-building workshop" and "Very well organised, but third workshop not as slick as first and second"), although more than 72% of the participants rated the workshop as 'very good'. The fact that it was a highly complex workshop with two parallel processes might have affected its "smoothness". Nevertheless, both the Scottish and European stakeholders were very positive about meeting and exchanging with their counterparts, and exploring the other group's work and outcomes. Participants stated they: "…found the whole process very interesting and it was good to be able to share our experience with the European group", "Interesting", a "Challenging and informative workshop".

When looking closer at the evaluation of the workshop, the quantification exercises (fuzzy sets) seemed to be the most difficult part. A number of participants mentioned they did not always have enough background or expert input to give sound answers. Some participants raised concerns about the scientific character of the exercise and the accurateness of the data produced, as several of them felt they did not have enough information to give an appropriate estimate. However, despite the complexity and challenge associated with this exercise, most participants agreed that it was an important part of the process and helped the consideration of

trade-offs and priority areas. This wide agreement is reflected in some of the individual comments from Workshop 1: "Insufficient information for my answers to be useful", "Personally I had problems with the individual exercise and it seems others had the same issue. Therefore the estimates might be not very useful", "Not sure my guesswork provides added value". Comments on the quantification session during Workshop 2 indicate similar difficulties: "The most difficult sessions. It would have been useful to have more technical information and data to take into account", "Difficult to quantify, but done in a good way", "Difficult to apply quantification to theoretical scenarios, but useful and interesting to attempt". There are a number of additional reasons that might have played a role in stakeholders perceiving the fuzzy sets exercise as difficult:

- As mentioned in Section 4, stakeholders might have had a problem with the relatively small group sizes that made them feel uncomfortable with the importance of their individual estimates. This required stakeholders to become more specific than they had been previously in the workshop. Narratives alone might have made stakeholders feel more comfortable as a non-expert due to the fuzziness of wording.
- Time was too short to do the exercise properly.
- The role of the fuzzy sets exercise in the entire process was not communicated clearly enough. Note that CLIMSAVE experts pointed out that the specificity of the fuzzy set exercises enriched the storyline development process (in particular consistency and cross-sectoral side effects), and was thus essential in the overall scenario development process (see Section 3.3).

The overall feedback on the IAP gathered after Workshop 3 was still positive, but significantly less so than for other evaluated parts of the workshop: 9 participants (50%) rated the IAP as good, 8 participants (44%) as OK, and 1 participant (6%) as bad. To a major extent this can be explained by the fact that the IAP was not finalised and therefore did not allow participants to explore the full range of what was originally promised to them. During the feedback session participants remarked it would be better if the IAP was not used as a stand-alone tool, but rather as a tool that supports discussion. Furthermore several participants said that training on the use of the platform would be needed. At the same time, a majority of the stakeholders saw the IAP as having great potential.

At the end of Workshop 3, the stakeholders were also asked to evaluate the full CLIMSAVE workshop series (see summary below). Comments were again highly positive. It is important to note, though, that 33% of respondents attended the whole series, while 61% attended at least two workshops. Despite the fact that the project did not succeed in keeping the full group of stakeholders engaged throughout all three workshops, there was significant continuity. This is the result of a very careful and deliberative process, as part of which stakeholders were asked to nominate a replacement from their own organisation in case they were not able to attend a follow-up workshop personally. Consequently, the same organisations were present throughout the entire series.

Products developed during the course of the workshops, such as the finalised storylines and the adaptation options, were rated positively by a large majority of participants: the former were rated 'very good' or 'good' by 88% of the respondents, and the latter by 67% (see details in the summary below). Almost all stakeholders (94%) noted that the options and strategies developed are useful for the debate on climate change. The same group also agreed on scenario development as valuable and useful in developing climate change strategies.

Almost all stakeholders felt they gained at least somewhat relevant knowledge for their work by participating in the CLIMSAVE workshop process (44% very much, 22% much, 33% somewhat). Often mentioned by stakeholders was a certain surprise regarding the importance of soft measures and/or social capital in dealing with climate change adaptation. Another surprising outcome as seen by participants is the importance of cross-cutting issues, and of innovation in order to obtain adaptation. These are examples of new linkages the stakeholders discovered between factors affecting climate change adaptation, helping to identify the importance of related policy actions.

8. Overall conclusions and recommendations

This section will first present a set of conclusions and recommendations by topic (Section 2 – Section 7), followed by a set of more generic overall conclusions and recommendations.

8.1 Stakeholders

- **By and large, stakeholders at both scales were satisfied** with individual as well as with the overall series of workshops. Due to a committed and skilled team of facilitators, scenario supporters and modelling experts, the meetings were almost flawless logistically, as was noted by the stakeholders.
- **It is more difficult to engage stakeholders at the European level.** It proved more difficult to attract stakeholders at the European scale than in Scotland (number of participants for workshops 1-3: 19, 11, 12 for Europe versus 27, 19, 15 for Scotland). There are a variety of reasons, most of which were beyond the control of CLIMSAVE project partners, including: (1) longer travel times; (2) difficulties to identify with the region and feel ownership with the process and resulting scenarios; (3) stakeholders included many higher-level officials with busy agendas and other priorities, leading to a relatively high amount of cancellations.
- **The approach to ask a replacement from within the same institution** for each stakeholder who could not attend, was very time consuming yet reasonably successful.

Recommendation:

- **Try to add semi-structured interviews** to involve more stakeholders in the scenario development at the supra-national scale.

8.2 Uncertainties and stories

8.2.1 Uncertainties and constructing skeleton scenarios

- **The use of a set of existing uncertainties worked** in the sense that it triggered a broad range of discussions.
- **Discussions related to the exact wording of uncertainties are lengthy, but essential.** A wealth of information was collected. Despite the fact that the uncertainties were revisited in WS2, there seems to be untapped potential in this list (i.e. information that did not find its way into the storylines).
- **Selecting uncertainties and skeleton scenarios**. This session was smooth and quick, but in hindsight side perhaps a bit too quick, since it fixed the scenarios, which in

Europe turned out to be partly overlapping. In conjunction with the long list of uncertainties, this session might need more attention.

Recommendations:

- **Experiment with other forms of "fast-track" scenarios** (i.e. using existing products) in order to kick-start the scenario development process, in full understanding of the potential consequences for stakeholder motivation and buy-in.
- **Integrate the results of this discussion in the scenario development.**

8.2.2 Developing stories

- **Stories remain an excellent type of qualitative scenario**, capturing the dynamics over time as well as the complexity of the changes. Any scenario development exercise should include stories as one of the main products.
- **The participatory methods employed in CLIMSAVE were by and large successful**, and could serve as a state-of-the-art toolbox for other projects.
- **Sessions related to story development were among the most successful**. There was a strong momentum in both WS1 and WS2 at both scales in the sessions related to story development. This is shown in part by the fact that we yielded eight rather detailed stories after WS1 all of which expanded greatly after WS2, including new titles and supporting graphs.
- **Additional qualitative products were highly complementary**. The qualitative tables on a number of additional model parameters yielded detailed, structured and complementary additional information.

Recommendation:

- **Aim at developing multiple outputs, focusing on stories,** but also on more structured outputs.

8.3 Fuzzy sets

- **Fuzzy sets is a welcome, yet challenging addition to the Story-And-Simulation toolbox.** The tool lived up to its potential to have stakeholders quantify important model parameters, while still presenting difficulties in application and analysis.
- **Fuzzy sets provides a method that is simple and rather straightforward,** particularly when compared to other recently suggested tools to bridge qualitative and quantitative stories.
- **Stakeholders perceived this as the most challenging session**. This has been shown before, and relates mostly to the unease of some stakeholders to provide numbers, regarding themselves as laymen rather than experts.
- **The "individual exercise" that yielded the translation key between words and numbers is perceived as cumbersome and is best minimised.** Iteration during WS2 without discussing numbers was a good methodological advance.

- **Group discussions during the fuzzy sets exercises provided important extra qualitative information.** Documentation of discussions during the exercise was very insightful and added to the depth of stories.
- **Stakeholders need more time for quantification** to get familiar with the aim, process and variable content.
- **A structured and well-prepared facilitating guidance and background material are essential** for the quantification exercise.
- **There are issues with estimating certain parameters**, particularly those that are represented as % per year (e.g. population), or those that change little (e.g. household size).

Recommendation:

- **Continue experimentation with fuzzy sets** and other methods that bridge qualitative and quantitative scenarios. Consider how to develop the approach to deal more substantially with the identified shortcomings. For example, experiment with asking information on less parameters, providing more time for discussion.

8.4 Interaction with the IAP

8.4.1 Using stakeholder information to parameterise the IAP

- **Various methods together provided a comprehensive insight** into the perceptions of stakeholders on key quantifiable parameters. Multiple, largely complementary, methods were used (stories, fuzzy sets, qualitative tables) that all held a piece of the puzzle.
- **Results of the "fuzziness" of fuzzy sets were communicated back to stakeholders** through sliders in different colours. This was a nice way of using the information, while also showing the stakeholders that we took their input seriously.

Recommendation:

- **Experiment with other ways in which the input from stakeholders can be demonstrated**.

8.4.2 Interaction between stakeholders and the IAP

- **The interaction between the stakeholders and the IAP was largely successful**. We had a running version of the IAP running simultaneously on about 10 computers. Stakeholders executed multiple runs with different combinations of adaptation options, and used the results in their evaluation. Stakeholders also expressed interest in being informed about future updates of the IAP.
- **There were a number of relatively significant points of criticism related to the interaction**:
    - There were issues with the fact that the IAP was a draft version. Most importantly, the vulnerability screen and adaptation cost screen were not available. This limited the insights stakeholders could gain. Importantly, we

need to live up to the promises that were made to stakeholders during the first two workshops.
    - The expectations of stakeholders were not always well managed.
    - There was a mismatch between adaptation options in qualitative discussions and possibilities of the IAP. Despite the fact that this was communicated to stakeholders several times, this was seen as frustrating by some groups.
    - The support (from modelling experts) was not always sufficient. Every team had a scenario supporter and modelling expert, but the (integrated) behaviour of the IAP was sometimes difficult to understand.
    - Time allocated to interaction with the IAP was limited. More time would have allowed for a more in-depth exploration of the cross-sectoral implications and robust adaptation options using the IAP.

Recommendation:

- When using a draft version of an online tool, make sure that expectations are well managed to prevent stakeholder disappointment.
- Conduct an early user study, and perhaps be more limited in our scope. Trying to suit everyone risks suiting none.

8.5 Adaptation options

- **An open brainstorm is a quick and efficient way to generate a long list of adaptation options**. The brainstorm session at the end of WS1 to generate lists of adaptation options was very useful and yielded a lot of information.
- **The majority of adaptation options relate to natural and manufactured capital, despite a reasonable balance.** Despite a rather good balance between capitals when grouping options, extra stimulus to include human capital or social capital aspects is needed.
- **There are drawbacks to omitting the step of connecting adaptation options within one story.** By omitting the step of roadmapping, adaptation options remain somewhat general and were not always well tied in with the scenario. Some scenarios maintain their utopian feel and have not landed, while others maintain their dystopian feel and did not fully explore all possibilities.

Recommendation

- **Pay more attention to "soft" adaptation options during the qualitative sessions.** "Hard adaptation" options are covered by the IAP.

8.6 Robustness / multi-scale workshop

8.6.1 Process of organising a cross-scale workshop

- **The CLIMSAVE experience shows that it is possible to successfully organise a cross-scale workshop.** Given that professional facilitators are in charge of the process, a cross-scale workshop can be successfully organised.

- **(Too) many aims for one workshop**. Some elements did not quite succeed to the degree that we hoped for. Particularly dropping the roadmapping (i.e. more discussion on connection between options, in space and time) might have influenced the outcome.
- **Stakeholders were overall very positive, yet slightly more critical about the third workshop**. It is difficult to conclude if this was related to the cross-scale aspect, the expectation of working with the IAP, or for other reasons. Critical comments were the exception rather than the rule.

Recommendation:

- **Try it again!**

8.6.2 Results from the cross-scale workshop

- **"Negative" scenarios are absolutely crucial** in the determination of robust options. They deserve additional attention relative to "positive" scenarios. Dystopian scenarios such as 'Icarus' or 'Mad Max' have limited possibilities to adopt adaptation options. Although rather frustrating for those stakeholders directly involved in constructing this type of scenario due to the lack of options, they are instrumental in evaluating if adaptation options are robust.
- **"Positive" scenarios are absolutely crucial** in drafting the list of candidates for robustness. Utopian scenarios such as 'We Are the World' or 'Mactopia' are essential in the creative brainstorm of what range of options could potentially work in the future.
- **Stakeholder-driven cross-scale adaptation options were identified.** Perhaps contrary to some expectations, a (short) list of cross-scale, cross-scenario robust adaptation options was drafted.
- **Robust options were largely related to social capital,** with elements of natural and manufactured capital.
- **Flood management and other "technical fixes", as well as consumer preferences and other behavioural change options were not considered robust.** Technological solutions were seen as too expensive in some futures, while behavioural change was not realistic in dystopias.

Recommendation:

- When the aim is robustness, **utopian and dystopian scenarios need to be given more attention.**

8.7 Overall conclusions

We listed a large number of conclusions and recommendations in the previous sections, without indicating importance or urgency to follow-up. Here we will present a short number of key conclusions, based on what has been concluded before. The emphasis is on the overall Story-And-Simulation approach and on advancing the state-of-the-art.

8.7.1 The Story-And-Simulation approach

- **Overall, the Story-And-Simulation approach was successfully implemented, adapted, and executed at both scales**. Story-And-Simulation was, is and will continue to be the state-of-the-art framework when the aim is linking stories and models. In particular:
    - Having stakeholders develop scenarios leads to strong feelings of ownership.
    - Directly translating these scenarios into elements of the IAP fosters this feeling.
    - Linking stories and models, particularly in a "live" workshop, is a powerful means to bring together scientists and stakeholders in a process of co-production of knowledge.
    - Iterations increased the consistency between stories and models.

- **There are a number of potential drawbacks and (methodological) pitfalls that need to be carefully considered**:
    - Careful stakeholder selection does not automatically translate into high or continued stakeholder participation.
    - Dependency on models during any of the workshops needs to be accompanied by a detailed back-up plan in case of emergency, as well as realistic assumptions on operational functionality.
    - Methods such as fuzzy sets can be used to bridge qualitative and quantitative scenarios, yet remain challenging and are in need of further testing.
    - There is a risk of overburdening the stakeholders with a large number of different tools and methods, geared towards different but complementary results. The number of knowledge-brokerage tools needs to be adjusted to fit the participants' experience and expectations.

Recommendation:

- **Maintain experimenting with the Story-And-Simulation approach**, particularly with other methods and tools. Special attention should be given to:
    - Stakeholder participation at the supra-national scale.
    - Tools that formalise the link between stories and models. Fuzzy sets remain underexplored, perhaps use these in combination with other methods.
    - The use of fast-track scenarios for either developing the list of uncertainties, the skeleton scenarios, or the full stories.
    - Cohesion and consistency between adaptation options by employing methods such as roadmapping or backcasting.

8.7.2 Advancing the state-of-the-art

A large number of projects exist in which scenarios have been developed. Particularly over the last decade, the number of scenarios in environmental science has boomed. It is beyond the scope of this Deliverable to provide a literature review, although good recent reviews are provided by van Notten *et al.* (2003); Börjeson *et al.* (2006); Varum and Melo (2010); and Amer *et al.* (2013). More than anything, these reviews demonstrate how quickly the scenario toolbox has developed with some describing it as "methodological chaos" (see Amer *et al.*,

2013). Rather than adding to this amalgam, the below will focus on one specific type of scenario development, which has been termed the "intuitive logic school", also referred to as the "Shell approach". It is based on the work of Herman Kahn (RAND) and Pierre Wack (Shell), taken forward in environmental sciences by the Millennium Ecosystem Assessment, and since has become the default among others in climate change research. The Story-And-Simulation approach (see Section 1) as used in CLIMSAVE advocates us to start with these 'intuitive scenarios' (Story) and link them with models (Simulation).

From this background, the scenario development methods as employed in CLIMSAVE have advanced the state-of-the-art in the following ways:

- **Strengthened the link between qualitative and quantitative scenarios**. The iterative use of fuzzy sets; multiple qualitative products (stories, lists of uncertainties, tables with qualitative information, documented discussions during the fuzzy sets exercise); and online modelling platform all contributed to the stronger link.
- **Organising and analysing a cross-scale workshop**. Although often suggested, the organisation of a cross-scale workshop with both parallel and cross-scale scenario development has not been described before. A notable exception was the so-called "Megameeting" within the GEO-4 scenario development process in Bangkok in 2005. Results of that meeting bringing together six world regions have never been officially documented.
- **"Live" interaction between stakeholders and the Integrated Assessment Platform.** There are other examples of stakeholders interacting during a workshop with mathematical models. What is novel is the attempt to develop integrated scenarios while working with an integrated model.
- **Drafting cross-scale robust adaptation options.** Related to the second point, the employed cross-scale method yielded a set of adaptation options that are (potentially) robust across scale and a range of scenarios, while having been tested by an IA model.

9. Guidelines

The aim of this section is to provide a set of guidelines, which address the question of how to practically implement the conclusions and recommendations made in the previous sections. In general terms, it provides insights in answering the question:

9.1 How to develop and analyse scenarios?

This is done by posing a set of sub-questions and statements with some short indications of possible answers and implications. The set of guidelines is not meant to be a detailed manual for scenario practitioners, but rather a more conceptual overview of the main steps and issues that need to be considered when undertaking a scenario exercise. A number of excellent scenario manuals, handbooks and cookbooks exist, also related to large scenario exercises that can help with filling in the details:

- Millennium Ecosystem Assessment (Henrichs *et al.*, 2010). This section is based to a large extent on the logic of the scenarios chapter of the MA Handbook
- World Resources Institute (Zurek *et al.*, 2008)
- Global Environment Outlook (Jäger, *et al.*, 2007)
- ASB – Partnership for Tropical Forest Margins (Evans *et al.*, 2006)

Below, we have structured the guidelines in five steps, basically following the four phases as recognised in the MA Handbook (see Figure 9).

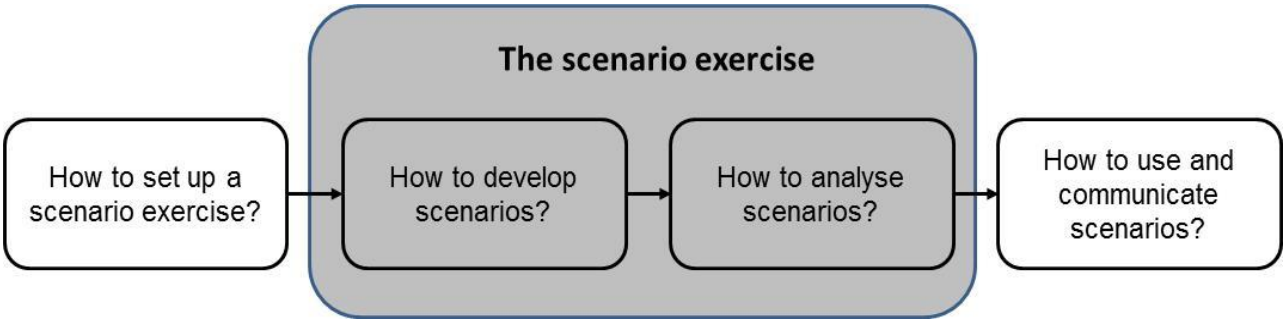


Figure 9: Four phases in the development of scenarios. Based on the Quick Reference Chart (p214 in Henrichs *et al.*, 2010).

9.1.1 How to explore the future with a scenario exercise?

What is the purpose of the scenario exercise?

Scenario exercises can serve a large range of very different purposes, and an essential first step is to define what the purpose of your scenario exercise will be. Possible purposes include: to support scientific exploration, start a collaborative learning process, or to aid strategic planning or decision-making. In CLIMSAVE, a mix of all three goals was pursued.

Why are scenarios primarily developed?

Apart from the main purpose, scenarios can be developed for a variety of additional reasons. These could include to: challenge mental maps; raise awareness; stimulate discussion; or test strategies. In CLIMSAVE, these were all part of the reasons for development, with ultimately a focus on the testing of strategies.

What type of scenario needs to be developed?

Many scenarios have been developed, and consequently, there are many types of scenarios that can be discerned. Several authors have offered classifications (e.g. Van Notten *et al.*, 2003; Börjeson *et al.*, 2006; Wilkinson and Eidinow, 2008). An often used main categorisation is by the inclusion of norms. Scenarios can be either normative (how can a target be reached?), explorative (what can or might happen?), or reference (what is expected to happen?). In CLIMSAVE, explorative scenarios were developed. They describe a set of plausible futures including a description of how events unfold over time.

9.1.2 How to set up a scenario exercise?

What outcomes to expect?

Scenario exercises can have two main types of outcomes: a process (learning by all stakeholders involved) and a product (the actual set of scenarios). In CLIMSAVE the emphasis has been towards the actual set of scenarios, but without neglecting the process outcomes by embarking upon a participatory process.

How to frame the purpose of a scenario exercise?

At the onset of the exercise, those in charge of putting together the scenario exercise will need to discuss and decide on specific goals. Stakeholders and decision-makers might be included in this discussion. Relevant questions include:

- Why is the scenario exercise being initiated?
- What policies will be informed?
- Which stakeholders are most interested?

The answer to these and similar questions depends on the general context. In CLIMSAVE, the specific goals were largely given by the 'Description of Work' of the project and the aims of the project itself: analysing future climate impacts and adaptation options.

How to define the scope of a scenario exercise?

Determining the scope involves making decisions about a number of issues, including: (1) how long will it take? (2) how much does it cost? (3) how to involve stakeholders? and (4) what spatial and temporal scales should the scenarios address?

All of these and other questions need to be answered in detail, before the actual exercise can be undertaken. Issues of resource use and scales are particularly crucial in scoping the exercise. In CLIMSAVE, the use of resources was decided upon in the 'Description of Work'. The temporal scale was related to the need to be able to detect effects of climate change and implemented adaptation options; and the spatial scale was discussed in close collaboration with the developers of the IAP - their spatial boundaries for Europe and Scotland being adopted.

How to establish an authorising environment and project team for a scenario exercise?

The authorising environment refers to the level of support offered by stakeholders and funding bodies. It relates, among others, to crucial quality control aspects of the resulting scenarios, namely credibility, legitimacy, and relevance of the scenario exercise. Additionally, planning, organising, and facilitating a scenario exercise is a lot of work and requires a group effort, which commonly a "Scenario Team" will be tasked with. And finally, scenario exercises that rely heavily on stakeholder input benefit from including a professional facilitator as member of the scenario team. In CLIMSAVE, a scenario team with persons from all the different WPs was established, and stakeholder workshops were professionally facilitated.

How to manage participation in a scenario exercise?

Participation is time consuming and therefore a balance needs to be struck between having effective and useful participation and staying within the budget and time constraints of the exercise. Balancing stakeholder involvement and expert knowledge within a time-bounded exercise is difficult. The more the stakeholders are encouraged to participate, the more complex and lengthy the process becomes, and time constraints must be managed strategically. In CLIMSAVE, we opted for a complex and intensive process in order to safeguard a high level of stakeholder participation.

9.1.3 How to develop scenarios?

A multitude of issues are of importance for the decision on which methods and tools to employ when developing scenarios. Most key points relate to details that are beyond the scope of this Section, and for which we refer to the scenario manuals. At a more conceptual level, the following steps are crucial:

- **Step 0. Deciding which approach to follow**. A host of different approaches can and have been used, very much depending on who built the scenario and for what purpose. Generally speaking there are three different approaches; inductive, deductive and incremental. The deductive approach focuses on exploring the most uncertain and most important driving forces in a systematic manner. The inductive approach requires similar steps, but applies a different and less structured method. The incremental approach builds on expanding a reference or business-as-usual scenario. In CLIMSAVE, we opted for a deductive approach. The following steps are based on the decisions needed when developing deductive scenarios.
- **Step 1. Identifying the focal issue**. It has proved to be helpful to further clarify the questions that a set of scenarios should attempt to address and to establish a so-called focal issue or focal question. Focal questions help identify which specific topics need to be included in the actual scenarios and which might be omitted, thus grounding the scenarios. In CLIMSAVE, we limited scenarios to the socio-economic context to explore robustness of adaptation options and climate change impacts.
- **Step 2. Discuss drivers and construct skeleton scenarios**. Here the focus should be on the main drivers of change expected to play a major role in the future. Based on this, a set of skeleton scenarios can be developed, for example, by using the "axes approach" as employed in CLIMSAVE.
- **Step 3. Describe scenario assumptions**. This stage involves developing a set of stories about how various drivers interact. Apart from a set of stories, the output could be quantified and used to run simulation models to quantify future impacts. The translation of qualitative descriptions into quantitative assumptions, however, is not trivial. This process might involve specific methods and tools. In CLIMSAVE, it was a specific aim to combine stories and models using the Story-And-Simulation approach. Fuzzy sets were used to directly quantify model parameters.

9.1.4 How to analyse scenarios?

Although strictly speaking not part of the scenario development exercise, the analysis of the potential implications of scenario assumptions is often core to environmental scenario exercises: much of the value of the exercise lies in being able to compare different outcomes.

<u>How to analyse across qualitative and quantitative information?</u>

There is a high degree of (potential) complementarity between stories that involved stakeholders and stimulated creative thinking, and models that are quantitative and rigorous (see Table 11). In fact, this is the very reason that the Story-and-Simulation approach has been suggested and successfully adopted, also in CLIMSAVE. However, the large degree of complementarity might sometimes hinder the analysis of the resulting products as they are not necessarily consistent: the story that is being told by qualitative scenarios may differ from the

story told by the model results. When qualitative and quantitative scenarios are being developed, scenario analysis has to carefully consider the differences between both types. The use of qualitative and quantitative scenarios was crucial in the CLIMSAVE scenario development method. For details on the methods and preliminary analysis we refer to Deliverable 3.1.

Table 11: Key characteristics of qualitative and quantitative scenarios.

Qualitative scenarios (stories)	**Quantitative scenarios (mathematical models)**
Credible	Internally consistent
Not implausible	Plausible
Creative, out-of-the-box thinking	Depending on model architecture
Developed by stakeholders	Developed by scientists
Qualitative	Quantitative
Based on stakeholder perception	Based on state-of-the-art scientific thinking
Not limited by data availability	Data-driven
Focus on socio-economic changes	Focus on biophysical data

How to analyse across a set of scenarios?

There are a number of ways to compare outcomes of different scenarios. Important options include to:

- Look for differences in future developments across scenarios.
- Look for similarities in future developments across scenarios.
- Identify trade-offs described in the various scenarios.
- Identify robust policy options (i.e. options that are effective in response to each scenario).

In CLIMSAVE, the focus was on policy options, but as shown, for example, in Section 2.3.2 an analysis of the similarities/differences across scenarios is needed.

9.1.5 How to use and communicate scenarios?

A detailed description of the aspects important in the communication and use of scenarios is beyond the scope of this Deliverable. Yet, we would like to stress that scenario exercises do not end after developing and analysing a set of scenarios; their use and active communication is as important as the scenario development process and needs to be planned well ahead. Effective use and communication of scenarios depends on their respective contexts and, in particular, on whether the scenario process applied was appropriate, the type and format of scenarios were suitable, whether an adequate communication strategy exists, and if the scale of analysis fits the context. In CLIMSAVE the use and communication of the scenarios received ample attention. A main strategy was the quantification of the scenarios and their representation in the Integrated Assessment Platform.

10. References

Amer, M., Daim, T.U., & Jetter, A. (2013). A review of scenario planning. Futures, 46: 23-40.

Börjeson, L., Höjer, M., Dreborg, K.-H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques - towards a user's guide. Futures, 38: 723-739.

Evans, K., Velarde, S.J., Prieto, R., Rao, S.N., Sertzen, S., Dávila, K., Cronkleton P., & de Jong, W. (2006). Field guide to the Future: Four Ways for Communities to Think Ahead. In: Bennett E. and Zurek M. (Eds.), Nairobi: Center for International Forestry Research (CIFOR), ASB, World Agroforestry Centre, pp.87. Available online at: http://www.asb.cgiar.org/ma/scenarios.

Henrichs, T., Zurek, M., Eickhout, B., Kok, K., Raudsepp-Hearne, C., Ribeiro, T., Van Vuuren, D., & Volkery, A. (2010). Scenario Development and Analysis for Forward-looking Ecosystem Assessments. Chapter 5 in: UNEP (Ed.), Ecosystems and Human Well-being: A Manual for Assessment Practitioners, Island Press, Washington.

Jäger, J., Rothman, D., Anastasi, C., Kartha, S., & van Notten, P. (2007). Training Module 6: Scenario development and analysis. In: UNEP, IISD 2007, GEO Resource Book: A training manual on integrated environmental assessment and reporting. UNEP and IISD publication. Available online at: http://www.iisd.org/pdf/2007/geo_resource.pdf.

Van Notten, P.W.F., Rotmans, J., van Asselt, M.B.A. & Rothman, D.S. (2003). An updated scenario typology. Futures, 35: 423-443.

Van ‘t Klooster, S.A., Van Asselt, M.B.A. (2006). Practising the scenario-axes technique. Futures, 38(1): 15-30.

Varum, C. A. & Melo, C. (2010). Directions in scenario planning literature – A review of the past decades. Futures, 42: 355-369.

Wilkinson, A. & Eidinow, E. (2008). Evolving practices in environmental scenarios: a new scenario typology. Environmental Research Letters, 3: 045017 (11pp).

Zurek, M., Biggs, R., Raudsepp-Hearne, C., Bennett, E., Kok, K., & Velarde, S.J. (2008). Exploring future trends in ecosystem services. In: Ranganathan, J., Raudsepp-Hearne, C., Lucas, N., Irwin, F., Zurek, M., Bennett, K., Ash, N., West, P. (Eds.), Ecosystem Services: A guide for decision makers. WRI, Washington, pp.45-53.

11. Annexes

Annex 1: Summary of stakeholder responses

Below is an overview of the responses provided by stakeholders from the questionnaire handed out after WS3, reflecting on the total series of three workshops in Scotland and Europe.

1. In how many CLIMSAVE Stakeholder Workshops have you participated?

Write number: 1 workshop: 7 2 workshops: 5 3 workshops: 6

2a. In how far is the knowledge gained during the CLIMSAVE workshops relevant for your work?

8 Very much 4 Much 6 Somewhat ☐ Little ☐ Very little ☐ No opinion

2b. What were the three most useful things you learned?

Please write:

- 'Understanding complexity + "Soft" items such as social awareness are important in climate change adaptation'
- Good tips for visualisation of complex model results.'
- 'Consideration of social impacts + cross-cutting learning + contacts.'
- 'Scenario work was the most important part of the CLIMSAVE experience + important to go through a creative and structured process to develop ideas about future scenarios + there are common adaptation / resilience issues in Scotland and Europe.'
- 'Consistent opinions on sustainable development + info on Scottish sectors + importance of social cohesion.'
- 'The complexity of the problem.'
- 'Scenario development + interaction between IAP and stakeholders + IAP development.'
- 'A pan-EU model could serve as a platform for planners + cross-relationships between risks + liked the EU-Scotland practical session.'
- 'Scenario development + unexpected interactions within scenario storylines - as decided by IAP + contact with relevant people.'
- 'The importance of social capital + some options such as reduced meat consumption are effective mitigation AND adaptation strategies + natural flood defences alone can be effective.'
- 'Great way / inspiration of organising workshop + understand climate change impacts better + possibilities / limits of CLIMSAVE.'
- 'Importance of social capital + how relevant the robust options are already today + the big aid for reaching impact / connection the agricultural sector has on other sectors and systems.'
- 'The extent of the impact of reduced meat consumption + general acknowledgement of the crucial importance of social capital.'
- 'Importance of social capital in adaptation to climate change + the relative unimportance of (technological) innovation + that it is fun to do this kind of exercise.'
- 'Different ideas, views, different scenarios.'
- 'Better understanding of scenario development + new ideas on facilitation and stakeholder participation.'
- 'Social equity is most important adaptation tool + innovation is key to successful adaptation + providing similar conditions (economic, etc). Scotland's adaptation strategies could be compatible within Europe.'

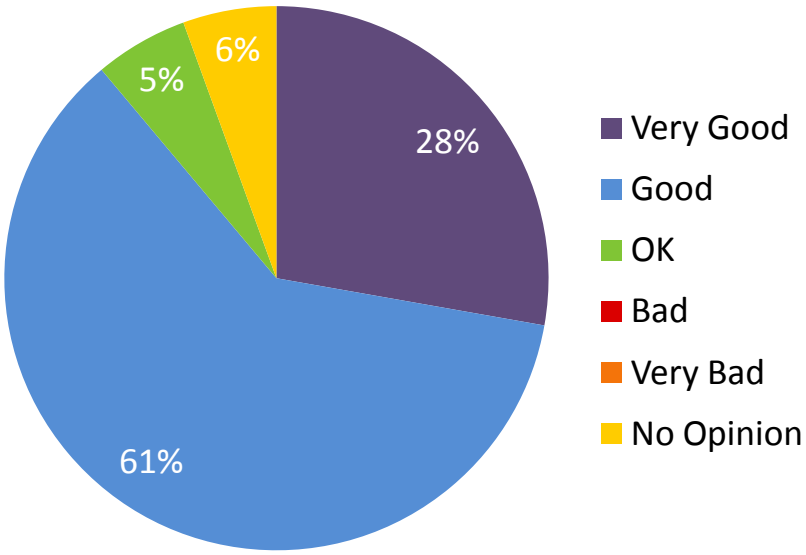
3. Did you make any new contacts during the CLIMSAVE workshops that are useful for your work?

16 Yes 2 No

4. How do you rate the finalised storylines?

Please mark:

5 Very good 11 Good 1 OK ☐ Bad ☐ Very bad 1 No opinion



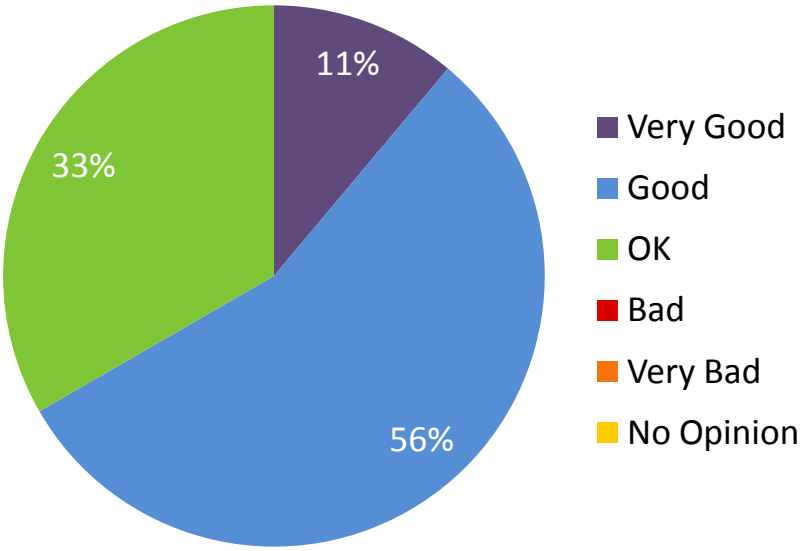
Comments – Please write:

- 'The scenarios sometimes felt a bit .... It would have been useful to interact with the people who had derived them.'
- 'Are they realistic?'
- 'Excellent fictions, practical use in context.'
- 'Useful "extreme" socio-economic pathways to distinguish social changes.'
- 'Lack of ownership as I did not contribute.'
- 'They are consistent, some aspects are plausible, most aspects hopefully never happen.'
- 'They might need some clean-up to get more internally consistent.'
- 'Conclusions are very interesting.'
- 'I think Mactopia had more detail in the post-its that we did not include in the narrative - hadn't realised ours was a bit light until reading the report from the 2nd workshop.'

5. How do you rate the set of adaptation options?

Please mark:

2 Very good 10 Good 6 OK ☐ Bad ☐ Very bad ☐ No opinion



Comments – Please write:

- 'Including additional options and interpreting existing options is desirable to refine the model.'
- 'I imagine they will look better once the project team has analysed them, less generic.'
- 'Not totally comprehensive.'
- 'I would have made social cohesion more explicit.'
- 'It can be difficult to incorporate them into the IAP.'
- 'Partly cannot be integrated in the model + not sure whether there was enough expertise in the small groups to come up with excellent solutions.'
- 'A bit vague and general, yet absolutely relevant.'
- 'Could be more specific - many policy-makers may start asking "what exactly do you mean?"'
- 'In process, some valuable options fell off the cliff, hope this information is not lost.'
- 'Too soon to tell until tool is finished. Needs explanation bubbles as discussed in workshop.'

6. How much do you agree or disagree with the following statements regarding the whole CLIMSAVE scenario process?

	I disagree completely	I disagree to some extent	I cannot say	I agree to some extent	I agree completely
The scenario-building process as a whole is useful for climate change strategies	-	-	1	4	13
Participating in the workshops has helped me to build a more comprehensive understanding of the climate change issues	-	-	1	10	7
Participating in the workshops has helped me to see climate change adaptation in a new way	-	3	1	8	6

	I disagree completely	I disagree to some extent	I cannot say	I agree to some extent	I agree completely
Participating in the workshops has helped me in understanding the policy actions needed	-	-	4	9	5
The workshops have helped to find novel linkages between factors affecting climate change adaptation	-	-	1	12	5
Thinking about the long-term has helped in assessing the problems faced by climate change adaptation in Europe in a meaningful way	-	-	2	11	5
Applying the IAP has helped me to evaluate the usefulness of adaptation options	-	1	5	10	2
Thinking about climate change adaptation using four scenarios has increased the quality of the resulting options and strategies	-	-	-	10	8
The adaptation options and strategies developed are useful for the debate on climate change	-	-	1	3	14

7. Any further comments?

Please write:

- 'I am unsure this will be a tool used by Scottish Water because we probably want answers; but it is valuable for our input to be included in its development and I am sure that, as it is used by those working in research and policy, it will come back to us in terms of research areas we may be interested in seeing develop.'
- 'Good luck in the future.'
- 'Excellent organisation!'
- 'Excellent work and organisation.'
- 'Discussion groups were too small.'
- 'While useful, this process needs to be contrasted / compared with other analyses.

Annex 2: Results from fuzzy sets exercises in Europe.

Table 12: Results from the fuzzy sets exercise for Europe.

From WS1	**IAP Slider Positions - Europe**						**From WS2***	**IAP Slider Positions - Europe**				
We are the World							**We are the World**					
2020s	min absolute	min credible	default	max credible	max absolute		**2020s**	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50		GDP	0.00	0.87	1.45	1.67	3.00
Population	-2.00	-0.53	-0.47	0.20	0.50		Population	-2.00	-0.53	-0.47	0.20	0.50
Food imports	2.00	10.67	14.00	17.67	30.00		Food imports	2.00	10.67	14.00	17.67	30.00
Arable land for biofuels	0.00	4.25	6.67	7.50	15.00		Arable land for biofuels	0.00	4.25	6.67	7.50	15.00
Oil price	80.00	173.33	210.00	221.67	400.00		Oil price	80.00	173.33	210.00	221.67	400.00
Household size	1.00	1.50	1.97	2.13	2.90		Household size	2.00	2.33	3.12	3.27	4.80
2050s							**2050s**					
GDP	-2.00	0.87	1.45	1.67	3.00		GDP	0.00	0.87	1.45	1.67	3.00
Population	-2.00	-0.53	-0.47	0.20	0.50		Population	0.00	0.23	0.33	0.38	0.70
Food imports	2.00	10.67	14.00	17.67	30.00		Food imports	0.00	3.33	6.67	8.67	15.00
Arable land for biofuels	0.00	0.33	1.75	2.42	5.00		Arable land for biofuels	0.00	0.33	1.75	2.42	5.00
Oil price	50.00	143.33	162.50	180.00	320.00		Oil price	0.00	46.67	72.50	80.00	180.00
Household size	1.00	1.50	1.97	2.13	2.90		Household size	2.40	3.40	3.88	4.23	6.20
Should I Stay or Should I Go							**Should I Stay or Should I Go**					
2020s	min absolute	min credible	default	max credible	max absolute		**2020s**	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50		GDP	0.00	0.87	1.45	1.67	3.00
Population	-2.00	-0.53	-0.47	0.20	0.50		Population	0.00	0.23	0.33	0.38	0.70
Food imports	10.00	19.17	26.67	31.67	50.00		Food imports	2.00	10.67	14.00	17.67	30.00
Arable land for biofuels	2.00	7.83	10.67	11.83	20.00		Arable land for biofuels	0.00	4.25	6.67	7.50	15.00
Oil price	50.00	143.33	162.50	180.00	320.00		Oil price	30.00	100.00	138.33	153.33	300.00
Household size	2.00	2.33	3.12	3.27	4.80		Household size	2.00	2.33	3.12	3.27	4.80

From WS1	IAP Slider Positions - Europe				
Should I Stay or Should I Go					
2050s	min absolute	min credible	default	max credible	max absolute
GDP	-5.00	-1.83	-1.47	-0.63	0.60
Population	-5.00	-1.67	-1.53	0.03	0.40
Food imports	2.00	10.67	14.00	17.67	30.00
Arable land for biofuels	0.00	0.33	1.75	2.42	5.00
Oil price	80.00	173.33	210.00	221.67	400.00
Household size	2.40	3.40	3.88	4.23	6.20
Riders on the Storm					
2020s	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50
Population	-5.00	-1.67	-1.53	0.03	0.40
Food imports	15.00	31.67	40.00	45.00	70.00
Arable land for biofuels	5.00	12.50	15.00	17.67	25.00
Oil price	80.00	173.33	210.00	221.67	400.00
Household size	2.00	2.33	3.12	3.27	4.80
2050s					
GDP	0.00	0.87	1.45	1.67	3.00
Population	-2.00	-0.53	-0.47	0.20	0.50
Food imports	2.00	10.67	14.00	17.67	30.00
Arable land for biofuels	0.00	4.25	6.67	7.50	15.00
Oil price	0.00	46.67	72.50	80.00	180.00
Household size	2.00	2.33	3.12	3.27	4.80

From WS2*	IAP Slider Positions - Europe				
Should I Stay or Should I Go					
2050s	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50
Population	0.10	0.38	0.53	0.65	1.00
Food imports	0.00	3.33	6.67	8.67	15.00
Arable land for biofuels	0.00	0.33	1.75	2.42	5.00
Oil price	50.00	143.33	162.50	180.00	320.00
Household size	2.40	3.40	3.88	4.23	6.20
Riders on the Storm					
2020s	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50
Population	0.00	0.23	0.33	0.38	0.70
Food imports	10.00	19.17	26.67	31.67	50.00
Arable land for biofuels	0.00	4.25	6.67	7.50	15.00
Oil price	80.00	173.33	210.00	221.67	400.00
Household size	2.00	2.33	3.12	3.27	4.80
2050s					
GDP	0.00	0.87	1.45	1.67	3.00
Population	0.00	0.23	0.33	0.38	0.70
Food imports	0.00	3.33	6.67	8.67	15.00
Arable land for biofuels	0.00	0.33	1.75	2.42	5.00
Oil price	80.00	173.33	210.00	221.67	400.00
Household size	2.00	2.33	3.12	3.27	4.80

From WS1	IAP Slider Positions - Europe				
Icarus					
2020s	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50
Population	-2.00	-0.53	-0.47	0.20	0.50
Food imports	10.00	19.17	26.67	31.67	50.00
Arable land for biofuels	2.00	7.83	10.67	11.83	20.00
Oil price	50.00	143.33	162.50	180.00	320.00
Household size	2.00	2.33	3.12	3.27	4.80
2050s					
GDP	-5.00	-1.83	-1.47	-0.63	0.60
Population	-2.00	-0.53	-0.47	0.20	0.50
Food imports	2.00	10.67	14.00	17.67	30.00
Arable land for biofuels	2.00	7.83	10.67	11.83	20.00
Oil price	80.00	173.33	210.00	221.67	400.00
Household size	2.40	3.40	3.88	4.23	6.20

From WS2*	IAP Slider Positions - Europe				
Icarus					
2020s	min absolute	min credible	default	max credible	max absolute
GDP	-2.00	-0.27	0.00	0.50	1.50
Population	0.00	0.23	0.33	0.38	0.70
Food imports	15.00	31.67	40.00	45.00	70.00
Arable land for biofuels	2.00	7.83	10.67	11.83	20.00
Oil price	30.00	100.00	138.33	153.33	300.00
Household size	1.00	1.50	1.97	2.13	2.90
2050s					
GDP	-2.00	-0.27	0.00	0.50	1.50
Population	-2.00	-0.53	-0.47	0.20	0.50
Food imports	2.00	10.67	14.00	17.67	30.00
Arable land for biofuels	0.00	4.25	6.67	7.50	15.00
Oil price	80.00	173.33	210.00	221.67	400.00
Household size	2.40	3.40	3.88	4.23	6.20

*WS2 after iteration

Annex 3: Results from fuzzy sets exercises in Scotland.

Table 13: Results from the fuzzy sets exercise for Scotland

From WS1	**IAP Slider Positions - Scotland**						**From WS2***	**IAP Slider Positions - Scotland**				
Tartan Spring							**Tartan Spring**					
2020s	min absolute	min credible	default	max credible	max absolute		**2020s**	min absolute	min credible	default	max credible	max absolute
GDP	0.50	2.67	3.83	4.33	8.00		GDP	0.50	2.67	3.83	4.33	8.00
Population	-0.01	0.11	0.36	0.42	1.00		Population	-0.01	0.11	0.36	0.42	1.00
Food imports	3.00	34.33	39.17	41.67	70.00		Food imports	3.00	34.33	39.17	41.67	70.00
Arable land for biofuels	0.00	4.00	4.83	5.07	10.00		Arable land for biofuels	0.00	0.33	4.83	2.33	5.00
Oil price	80.00	206.67	210.00	233.33	400.00		Oil price	80.00	206.67	210.00	233.33	400.00
Household size	1.75	2.32	2.49	2.63	3.50		Household size	1.75	2.32	2.49	2.63	3.50
2050s							**2050s**					
GDP	2.00	5.50	5.67	6.33	10.00		GDP	-1.00	0.50	1.33	1.92	4.00
Population	-1.00	-0.03	0.00	0.19	1.00		Population	-0.01	0.11	0.36	0.42	1.00
Food imports	3.00	34.33	39.17	41.67	70.00		Food imports	0.00	15.33	20.00	20.67	40.00
Arable land for biofuels	0.00	0.33	1.70	2.33	5.00		Arable land for biofuels	0.00	0.33	1.70	2.33	5.00
Oil price	120.00	256.67	273.33	296.67	500.00		Oil price	120.00	256.67	273.33	296.67	500.00
Household size	2.20	2.90	3.13	3.25	4.50		Household size	2.30	3.60	3.77	3.93	5.50
Mad Max							**Mad Max**					
2020s	min absolute	min credible	default	max credible	max absolute		**2020s**	min absolute	min credible	default	max credible	max absolute
GDP	-5.00	-1.92	-1.08	-0.83	2.00		GDP	-5.00	-1.92	-1.08	-0.83	2.00
Population	-1.00	-0.03	0.00	0.19	1.00		Population	-2.00	-0.82	-0.77	-0.75	0.00
Food imports	1.00	23.33	27.33	31.33	51.00		Food imports	0.00	15.33	20.00	20.67	40.00
Arable land for biofuels	2.00	14.67	15.67	17.33	30.00		Arable land for biofuels	0.00	4.00	4.83	5.07	10.00
Oil price	80.00	206.67	210.00	233.33	400.00		Oil price	80.00	206.67	210.00	233.33	400.00
Household size	2.20	2.90	3.13	3.25	4.50		Household size	2.20	2.90	3.13	3.25	4.50

From WS1	IAP Slider Positions - Scotland						From WS2*	IAP Slider Positions - Scotland				
Mad Max							**Mad Max**					
2050s	min absolute	min credible	default	max credible	max absolute		**2050s**	min absolute	min credible	default	max credible	max absolute
GDP	-5.00	-1.92	-1.08	-0.83	2.00		GDP	-5.00	-1.92	-1.08	-0.83	2.00
Population	-0.01	0.11	0.36	0.42	1.00		Population	-1.00	-0.03	0.00	0.19	1.00
Food imports	1.00	23.33	27.33	31.33	51.00		Food imports	0.00	15.33	20.00	20.67	40.00
Arable land for biofuels	0.00	4.00	4.83	5.07	10.00		Arable land for biofuels	0.00	0.33	1.70	2.33	5.00
Oil price	20.00	93.33	96.67	108.33	200.00		Oil price	55.00	135.00	151.67	163.33	300.00
Household size	2.30	3.60	3.77	3.93	5.50		Household size	2.30	3.60	3.77	3.93	5.50
The Scottish play							**The Scottish play**					
2020s	min absolute	min credible	default	max credible	max absolute		**2020s**	min absolute	min credible	default	max credible	max absolute
GDP	-5.00	-1.92	-1.08	-0.83	2.00		GDP	-5.00	-1.92	-1.08	-0.83	2.00
Population	-1.00	-0.03	0.00	0.19	1.00		Population	-1.00	-0.03	0.00	0.19	1.00
Food imports	3.00	34.33	39.17	41.67	70.00		Food imports	1.00	23.33	27.33	31.33	51.00
Arable land for biofuels	0.00	0.33	1.70	2.33	5.00		Arable land for biofuels	0.00	0.33	1.70	2.33	5.00
Oil price	80.00	206.67	210.00	233.33	400.00		Oil price	80.00	206.67	210.00	233.33	400.00
Household size	1.20	1.80	1.90	2.03	2.50		Household size	1.20	1.80	1.90	2.03	2.50
2050s							**2050s**					
GDP	-10.00	-4.67	-3.92	-3.67	1.00		GDP	-1.00	0.50	1.33	1.92	4.00
Population	-0.01	0.11	0.36	0.42	1.00		Population	-0.01	0.11	0.36	0.42	1.00
Food imports	0.00	15.33	20.00	20.67	40.00		Food imports	0.00	15.33	20.00	20.67	40.00
Arable land for biofuels	0.00	0.33	1.70	2.33	5.00		Arable land for biofuels	0.00	0.33	1.70	2.33	5.00
Oil price	20.00	93.33	96.67	108.33	200.00		Oil price	120.00	256.67	273.33	296.67	500.00
Household size	1.75	2.32	2.49	2.63	3.50		Household size	1.75	2.32	2.49	2.63	3.50

From WS1	IAP Slider Positions - Scotland						From WS2*	IAP Slider Positions - Scotland				
MacTopia							**MacTopia**					
2020s	min absolute	min credible	default	max credible	max absolute		**2020s**	min absolute	min credible	default	max credible	max absolute
GDP	2.00	5.50	5.67	6.33	10.00		GDP	2.00	5.50	5.67	6.33	10.00
Population	0.10	0.47	0.80	0.84	2.00		Population	-0.01	0.11	0.36	0.42	1.00
Food imports	3.00	34.33	39.17	41.67	70.00		Food imports	3.00	34.33	39.17	41.67	70.00
Arable land for biofuels	1.00	8.67	10.33	10.33	20.00		Arable land for biofuels	0.00	4.00	4.83	5.07	10.00
Oil price	120.00	256.67	273.33	296.67	500.00		Oil price	80.00	206.67	210.00	233.33	400.00
Household size	1.75	2.32	2.49	2.63	3.50		Household size	1.75	2.32	2.49	2.63	3.50
2050s							**2050s**					
GDP	0.50	2.67	3.83	4.33	8.00		GDP	-1.00	0.50	1.33	1.92	4.00
Population	-0.01	0.11	0.36	0.42	1.00		Population	0.10	0.47	0.80	0.84	2.00
Food imports	10.00	47.00	49.50	55.00	80.00		Food imports	10.00	47.00	49.50	55.00	80.00
Arable land for biofuels	0.00	0.33	1.70	2.33	5.00		Arable land for biofuels	0.00	0.33	1.70	2.33	5.00
Oil price	80.00	256.67	210.00	233.33	400.00		Oil price	120.00	256.67	273.33	296.67	500.00
Household size	1.75	2.32	2.49	2.63	3.50		Household size	1.75	2.32	2.49	2.63	3.50

* WS2 after iteration