The **CLIMSAVE** Project

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

Final Publishable Summary
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SEVENTH FRAMEWORK PROGRAMME

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1. Executive summary

There is widespread acceptance that the climate is changing and, thus, it is vital that decision-makers have access to reliable science-based information to help them respond to climate change impacts and assess opportunities for adaptation. CLIMSAVE is a pan-European project that has developed an integrated assessment approach that enables stakeholders to explore and understand the cross-sectoral benefits and conflicts of different adaptation options to better inform the development of robust policy responses. The main outputs and findings were:

- The CLIMSAVE Integrated Assessment (IA) Platform is a unique user-friendly, interactive web-based tool that enables stakeholders to explore the complex multi-sectoral issues surrounding impacts, adaptation and vulnerability to climate and socio-economic change within the agriculture, forest, biodiversity, coast, water and urban sectors. Two versions of the Platform have been developed: a continental version for Europe and a regional version for Scotland.
- A range of climate change scenarios are incorporated into the IA Platform to allow users to explore the effects of climate change uncertainties on impacts and vulnerabilities. Projections of Europe-wide average temperature change range from 1 to 5^{o}C in the 2050s, whilst precipitation changes range from increases of between 1 and 13% in winter and decreases of between 2 and 30% in summer.
- Four contrasting socio-economic storylines were developed in a series of participatory workshops by European and Scottish stakeholders and quantified for inclusion in the IA Platform. This led to strong feelings of ownership of the scenarios which illustrate that a broad range of futures are envisioned to be plausible, ranging from the very positive (We are the World in Europe or MacTopia in Scotland) to the very negative (Should I Stay or Should I Go in Europe or Mad Max in Scotland).
- Europe and Scotland will be significantly influenced by both climate and socio-economic change. Urban development increases in most scenarios. The number of people affected by a 1 in 100 year flood increases in western and northern Europe. Biodiversity vulnerability and water exploitation both increase in southern and eastern Europe. Changes in land use (intensive farming, extensive farming, forests and unmanaged land) vary depending on the scenario, but food production generally increases across Europe at the expense of forest area to satisfy the demand from an increasing population.
- The broad range of adaptation options to address the impacts of climate change in Europe and Scotland in the IA Platform allows the user to consider their costs, capital requirements, applicability, effectiveness and secondary (synergistic and cross-sectoral) impacts, but detailed assessment is needed to take account of local conditions and constraints.
- However, effective adaptation emerging out of decisions made by local community actors needs to be strongly supported by an empowering national and EU institutional setting which facilitates coordination and knowledge sharing among Member States.
- Mapping of vulnerability hotspots suggests that human well-being is most at risk from water stress and biodiversity loss in southern Europe, and from the lack of food provision and land use diversity in northern Europe. Results for Scotland show that human well-being may benefit from climate change with vulnerability reducing for warmer climate scenarios across a range of socio-economic scenarios.
- The most robust policy strategy (defined in terms of beneficially reducing vulnerability to climate and socio-economic change across sectors, scenarios and spatial scales) is one that increases coping capacity through an increase in social and human capital.
- A review of adaptation and mitigation measures showed that almost all had impacts beyond the original intended one, often in a different sector(s) and many of these were cross-sectoral interactions. Those between adaptation and mitigation measures often were positive, representing potentially cost-effective synergies for addressing climate change.

2. Context and objectives

There is widespread acceptance that climate is changing due to human emissions of greenhouse gases. Such changes in climate will affect all sectors of society and the environment at all scales, ranging from the continental to the national and local. Thus, it is vital that decision-makers and other interested citizens have access to reliable science-based information to help them respond to the risks of climate change impacts and assess opportunities for adaptation to reduce their vulnerability. However, these impacts will be in addition to, or concurrent with, those associated with continuing socio-economic and political changes. Our vulnerability to, and the potential impacts of, climate change therefore needs to be evaluated in a holistic or integrated assessment of the effects of our changing future. Integrated assessment (IA), which is an interdisciplinary process that combines, interprets, and communicates knowledge from diverse scientific disciplines from the natural, engineering and social sciences to investigate and understand causal relationships within and between complicated systems, provides a tool to develop the information resources required.

However, providing results or interpretations to stakeholders based on the outputs of particular simulations of an IA model is not sufficient to test the sensitivity of the system, to engender organisational or behavioural change or to enable knowledge creation as a learning process. It represents a one-way flow of information from researchers to stakeholders, rather than a two-way iterative process of dialogue and exploration of "*what if's*". More interactive IA processes are needed that allow stakeholders to develop their understanding and test ideas, based upon their own hypotheses. Of the more than 65 climate change IA models, most have unacceptably long runtimes for allowing rapid simulation and interactive engagement with the IA. Alternatively, participatory IA platforms involving clear user interfaces, explicit recognition of uncertainty, and transparency in model performance and operation can take account of the value and importance of stakeholder 'lay insight' and promote dialogue between the research and stakeholder communities within a process of mutual learning and guidance.

Improving the adaptive capacity of individuals, groups or organisations requires communicating climate change information and building awareness of potential impacts and the cost-effectiveness of robust adaptation measures at an appropriate level. Participatory IA platforms are a vehicle for communication, training, forecasting and experimentation, whose usefulness is enhanced by the integrated assessment approach which enables stakeholders to explore / understand the interactions between different sectors, rather than viewing their own area in isolation. This contributes to the development of a well-adapted Europe by building the capacity of decision-makers to understand the spatial vulnerability to climate and socio-economic impacts and how these might be reduced by various adaptation options.

The CLIMSAVE project puts science in the service of stakeholders and policy-makers by providing a common platform for an improved IA of climate change impacts, adaptation and vulnerability covering key sectors in Europe. There are six specific objectives:

1. To develop an Integrated Assessment (IA) Platform which includes linkages and feedbacks between key landscape sectors;
2. To integrate stakeholder input into climate change impacts and adaptation research through the development of participatory socio-economic scenarios which are integrated into the IA Platform along with a range of climate scenarios;
3. To apply the IA Platform to assess climate change impacts on, and adaptation options for, different sectors and ecosystem services;
4. To identify vulnerability hotspots through metrics of impacts and adaptive capacity across sectors within the IA Platform;

5. To provide information on the cost-effectiveness of adaptation measures within the IA Platform;
6. To analyse the policy and governance context for adaptation and investigate sources of uncertainty to inform appropriate policy options.

To achieve these objectives, CLIMSAVE has developed a user-friendly, interactive web-based IA platform which allows stakeholders to examine climate change impacts and vulnerabilities for a range of sectors, including agriculture, forests, biodiversity, coasts, water resources and urban development, and their associated ecosystem services. The linked sectoral models within the IA Platform can be used to investigate whether different climate and socio-economic scenarios have a negative or positive effect on each sector's outputs or ecosystem services. The platform also allows stakeholders to explore adaptation options for reducing climate change impacts and vulnerability, discovering where, when and under what circumstances such actions may help. It highlights the cost-effectiveness and cross-sectoral benefits and conflicts of different adaptation options and enables uncertainties to be investigated to better inform the development of robust policy responses. The tool has been developed for Europe and for a regional case study based on Scotland to test the regional application of the approach.

3. Main S&T results

3.1 The CLIMSAVE IA Platform

CLIMSAVE has developed a web-based tool which enables decision-makers and other interested European citizens to access reliable science-based information on the risks of climate change impacts and opportunities for adaptation (Holman et al., 2013). The CLIMSAVE IA Platform is a unique, interactive, exploratory web-based tool to allow European stakeholders to assess for themselves climate change impacts and vulnerabilities for a range of sectors. It provides rapid user-friendly interactivity through www.climsave.eu and the European Climate Adaptation Platform (CLIMATE-ADAPT - http://climate-adapt.eea.europa.eu/), helping to broaden accessibility and participation and increase impact in research communities.

The IA platform has five screens, which have been designed to have a consistent visual identity, in order to increase user familiarity:

- **Start screen** (Figure 1) – provides a brief overview of the other screens in the platform and an 'appropriate use' warning.
- **Impacts screen** (Figure 2) – allows the user to assess the *potential impacts* (i.e. without any adaptation) of future change on the CLIMSAVE sectors, providing spatial and aggregated outputs. This screen can be used to:
  - Carry out a sensitivity analysis – under the baseline / current climate, investigate the response of the indicators to changes in the scenario settings;
  - Explore the effects of climate change uncertainty – the CLIMSAVE IA Platform contains multiple climate change scenarios to explore the effects of different sources of climate change-related uncertainty in conjunction with the baseline socio-economic scenario;
  - Explore the effects of combined climate and socio-economic uncertainty – the IA Platform contains four socio-economic scenarios created in participatory workshops with stakeholders. The CLIMSAVE socio-economic scenarios represent contrasting alternative futures within which to explore the potential impacts of future change. They are not predictions of the future.
  - Explore the effects of uncertainty within a socio-economic scenario - the effects of uncertainty within each socio-economic scenario can be explored by moving the sliders within the green range. These values are consistent with the assumptions within each scenario;

- o Model impacts in relation to a <u>"user-defined" socio-economic scenario</u> - a wider range of values associated with each socio-economic scenario can be explored by moving the sliders into the yellow range. The scenario name will change to "User-defined" as these values may not be consistent with the CLIMSAVE scenario. In this case, the user will also need to set the values under the Capitals tab.

- **Adaptation screen** (Figure 3) – allows the user to assess how adaptation might reduce the impacts of future change. If adaptation is sufficient, the potential impacts are reduced to zero and climate change has no actual impact. If, however, adaptation is insufficient to fully counter the potential impacts, this screen will show the *residual impacts*.
  - o When the user enters this screen, the scenario settings/selection from the Impacts screen are fixed. Each adaptation slider represents a broad range of response measures, rather than an individual measure. In considering how to adapt, adaptation is constrained by the adaptive capacity of the scenario.

- **Vulnerability screen** (Figure 4) – allows the user to identify hotspots of vulnerability where coping capacity is insufficient to cope with either the potential impacts (before adaptation) or residual impacts (after adaptation).
  - o Vulnerability as conceived by CLIMSAVE is a combination of impacts (potential or residual) and coping capacity. The user is able to separately view the impacts and coping capacity in order to understand how vulnerability has been derived. The user can also visualise vulnerability hotspots for a particular sector/ecosystem service or sectorally-integrated vulnerability hotspots.

- **Cost-effectiveness screen** (Figure 5) – allows the user to evaluate the relative cost-effectiveness of different adaptation measures.
  - o This screen allows the user to assess the relative costs, potential (applicability), capital requirements and effectiveness of a range of hard and soft adaptation options, as well as their cross-sectoral impacts. The information, although partly based on quantitative data from the scientific literature, is presented qualitatively to avoid spurious accuracy and to highlight the need to develop detailed assessment of specific adaptation plans that will be dependent on local conditions and constraints.

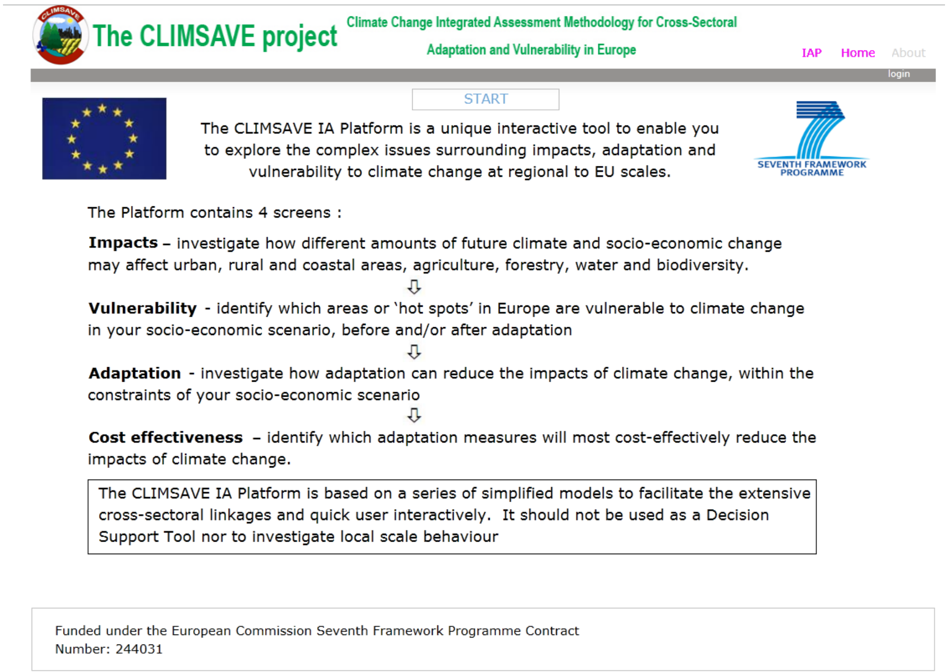


Figure 1: Screenshot of the Start screen to the European and Scottish versions of the CLIMSAVE IA Platform.

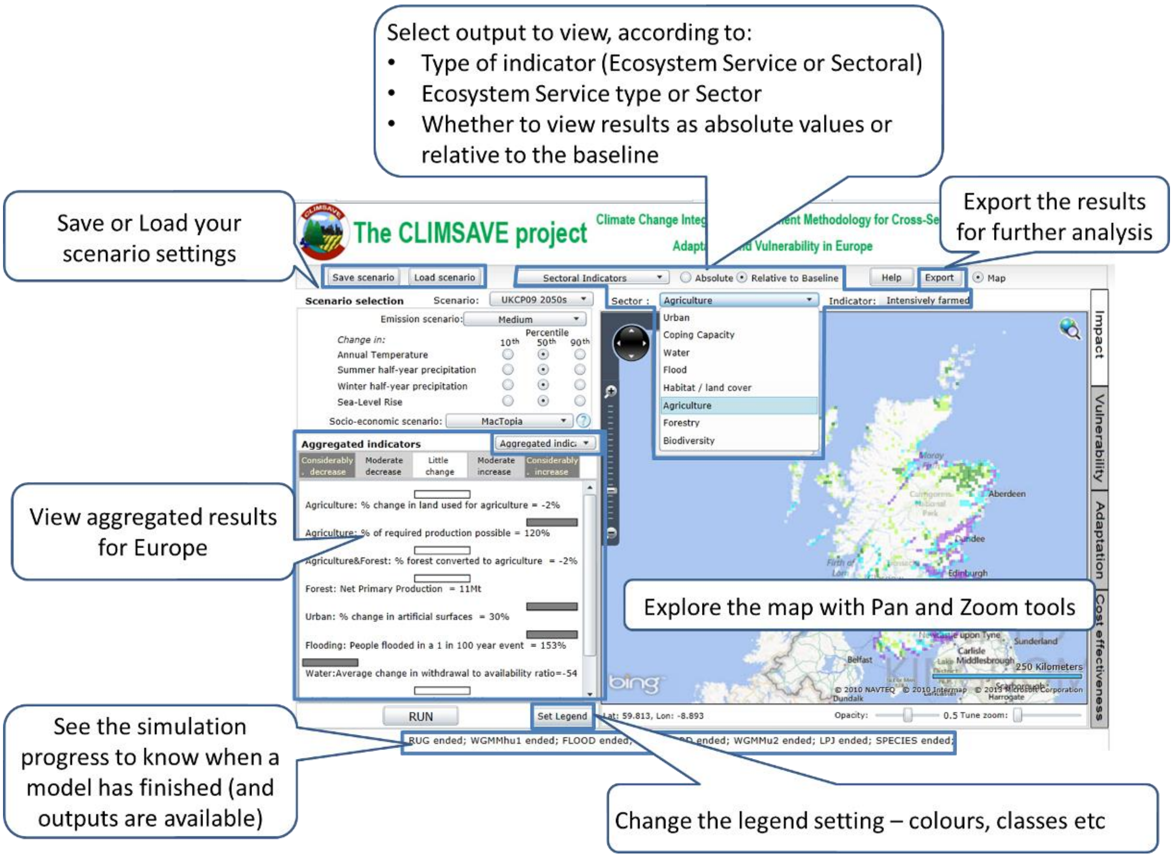


Figure 2: Screenshot of the Impact screen for the Scottish version of the CLIMSAVE IA Platform.

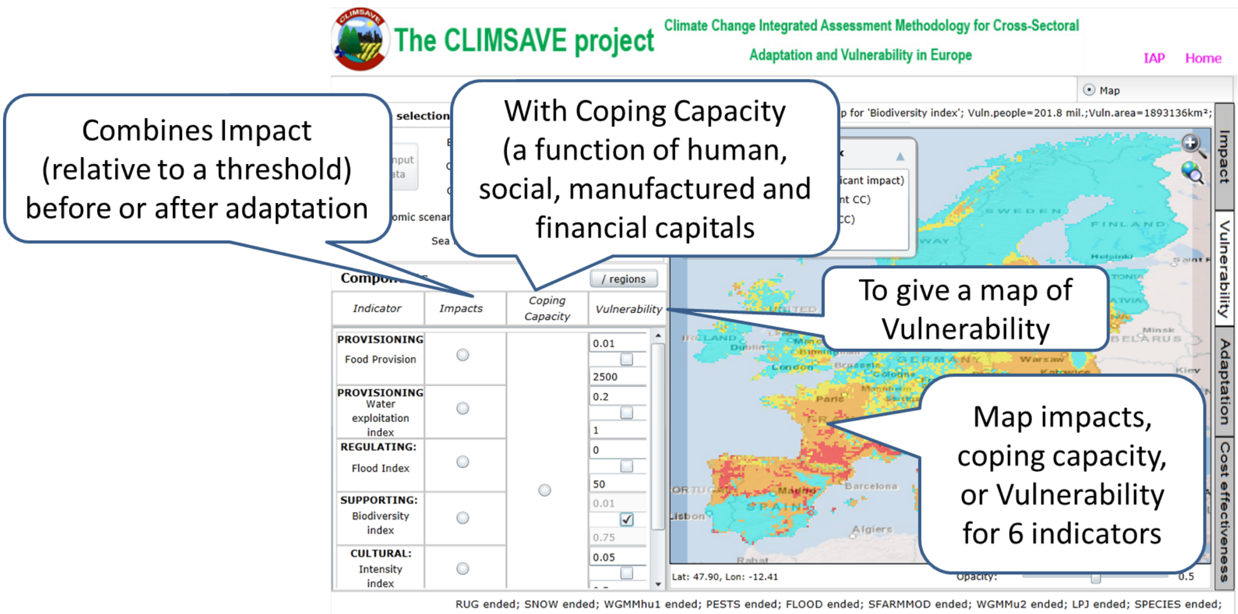


Figure 3: Screenshot of the Vulnerability screen for the European version of the CLIMSAVE IA Platform.

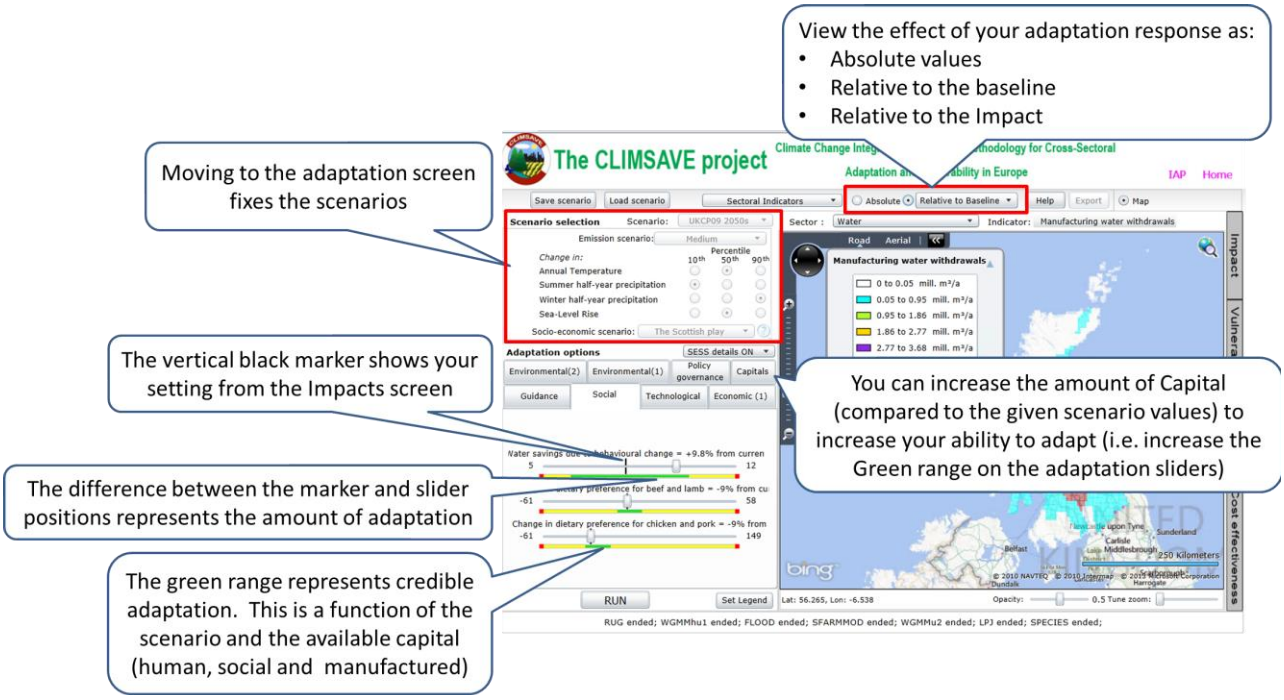


Figure 4: Screenshot of the Adaptation screen for the Scottish version of the CLIMSAVE IA Platform.

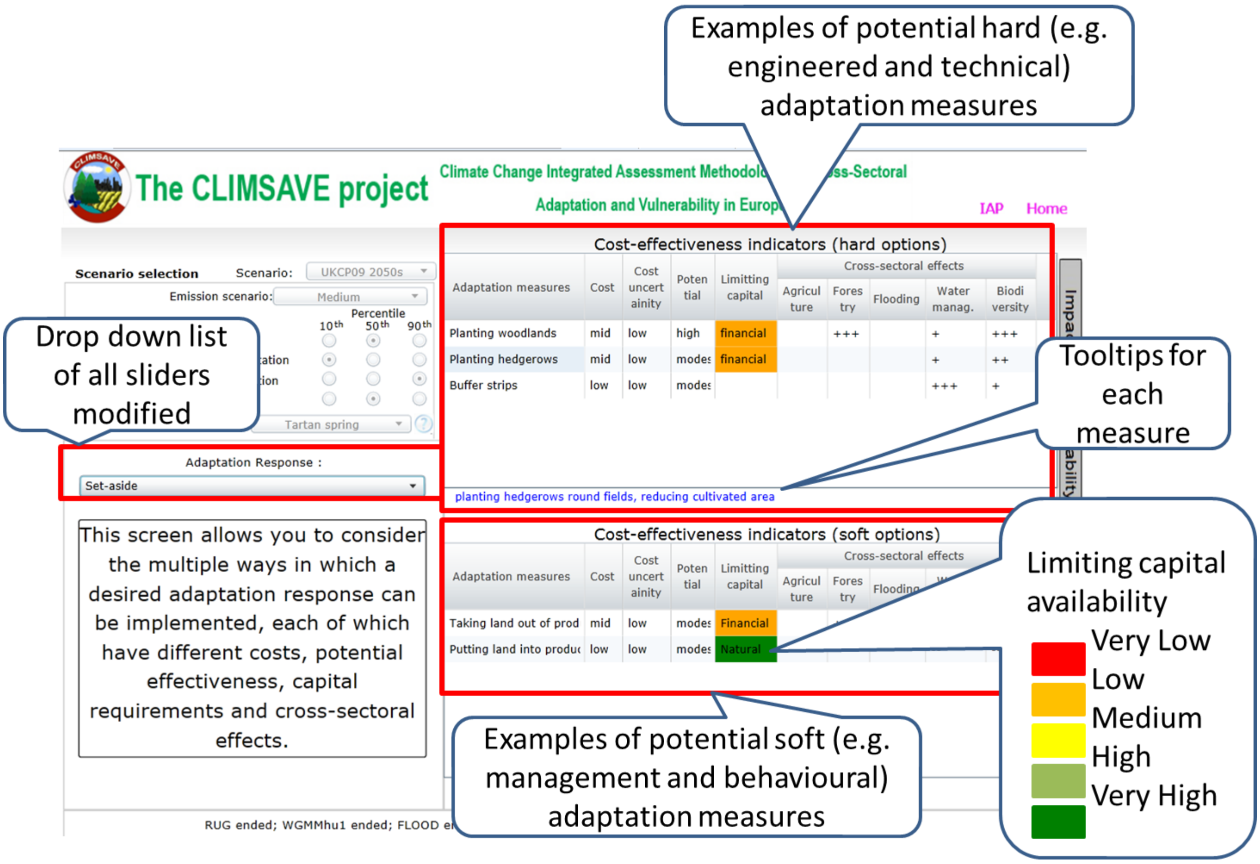


Figure 5: Screenshot of the Cost-effectiveness screen for the European version of the CLIMSAVE IA Platform.

The CLIMSAVE IA Platform is based on a series of linked sectoral models. Figure 6 shows a simplified flow diagram which highlights the linkages between the different sectoral models. For example, projections from the urban model on the location, area and type of urban development affects river basin hydrological responses, the population exposed to flood risk, the land available for agriculture and forestry and consequently habitat availability for biodiversity. In order to provide rapid interactively for the user, the run times of the models should be as short as possible. Hence, a meta-modelling approach was used to deliver these fast run times whereby computationally-efficient or reduced-form models that emulate the performance of more complex models have been developed. Ten different meta-models have been developed using a variety of approaches to abstract the leanest representation for inclusion within the IA Platform that is consistent with delivering both functionality and speed (Table 1; Holman and Harrison, 2012). The meta-models produce outputs on both sector-based impact indicators (covering agriculture, forests, biodiversity, coasts, water resources and urban development; Table 2) and ecosystem services in order to link climate change impacts directly to human well-being.

The Platform is based on a web Client / Server architecture that uses both server-based (i.e. remote) and client-based (i.e. the user's PC) computing solutions on the web. The models and the underlying physical (soils, land-use, etc) and scenario (climate and socio-economic) datasets use server-based web technologies, as this avoids the need for input data to be transferred to the user's PC (and hence the requirement for the user to sign data licenses) and maximises access speed. The web-based interface for stakeholders has been developed using a client-based computing solution based on Microsoft Silverlight technology (a Rich Internet Application framework) as this allows: (i) fast reply to the user actions; (ii) the output data from (server-based) models to be sent synchronously and asynchronously to the client based Interface, as output data from faster meta-models can be displayed by the user whilst other models finish their run to give the impression of a real-time response; and (iii) the opportunity to use map services (e.g. Google Earth, Bing Maps) to display spatial data.

Table 1: Details of the ten meta-models included within the IA Platform. Adapted from Harrison et al. (2013).

Sector	Meta-model	Original model	Meta-modelling approach
Artificial surfaces	Meta-RUG	Regional Urban Growth (RUG) (Reginster and Rounsevell 2006)	Look-up tables
Agriculture (crop yields)	Meta-Crop yield (winter wheat and spring wheat, winter barley and spring barley, winter oil seed rape, potatoes, grain maize, sunflower, soybean, cotton, grass, olives)	ROIMPEL (Audsley et al. 2008)	Soil/climate clustering combined with artificial neural networks
Forestry	Meta-GOTILWA+	GOTILWA+ (Morales et al. 2005)	Artificial neural networks
Rural land allocation	Meta-SFARMOD	SFARMOD (Annetts and Audsley 2002)	Soil/climate clustering combined with artificial neural networks
Water resources and demand	WaterGAP meta-model (WGMM)	Water - Global Assessment and Prognosis (WaterGAP3) (Döll et al. 2003)	3-dimensional surface response diagrams
Flooding	Coastal Fluvial Flood meta-model (CFFlood)	RegIS2 (Mokrech et al. 2008) and DIVA (Vafeidis et al. 2008)	Simplified process-based model
Biodiversity	SPECIES	SPECIES (Harrison et al. 2006)	Artificial neural networks

Table 2: Menu structure for the outputs if the sectoral indicators are selected.

Sector	Indictor (1st level)	Indicator (2nd level)	Europe	Scotland
Urban	Artificial surfaces		✓	✓
	Residential area		✓	✓
	non-residential area		✓	✓
Tourism	Days with 3cm snow cover		✓	
	Days with 10cm snow cover		✓	
Water	Water availability		✓	✓
	Falkenmark index		✓	✓
	Median annual flood discharge		✓	✓
	Water price increase		✓	✓
	Average discharge		✓	✓
	Low flow discharge		✓	✓
	High flow discharge		✓	✓
	Water Exploitation Index		✓	✓
	Manufacturing water withdrawls		✓	✓
	Total water use		✓	✓
Pests	Ecoclimatic Index	List of individual species	✓	
	Number of generations	List of individual species	✓	
Flood	Median annual flood discharge		✓	✓
	Area at risk of flooding		✓	✓
	Threatened people		✓	✓
	People flooded (user-selected event)		✓	✓
	Damages due to flooding		✓	✓
	People flooded in a 1 in 100 year event		✓	✓
Habitat / land cover				
	Area of Saltmarsh		✓	✓
	Area of Intertidal flats		✓	✓
	Area of inland marsh		✓	✓
	Area of Coastal grazing marsh		✓	✓
	Urban		✓	✓
	Intensively farmed	Percent of grid	✓	✓
		Yearly Productivity	✓	✓
		Leaf Coverage	✓	✓
		Biomass	✓	✓
	Extensively farmed	Percent of grid	✓	✓
		Yearly Productivity	✓	✓
		Leaf Coverage	✓	✓
		Biomass	✓	✓
	Unmanaged land	Percent of grid	✓	✓
		Yearly Productivity	✓	✓
		Leaf Coverage	✓	✓
		Biomass	✓	✓
	Forest	Percent of grid	✓	✓
		Yearly Productivity	✓	✓
		Leaf Coverage	✓	✓
		Biomass	✓	✓
Agriculture	Land cover types	Intensively farmed	✓	✓
		Arable crops	✓	✓
		Stubble area	✓	✓
		Extensively farmed	✓	✓
		Unmanaged land	✓	✓
		Managed forest	✓	✓
		Unmanaged forest	✓	✓
		Flood zone	✓	✓
	Indicators	Food production	✓	✓
		Food per capita	✓	✓
		Fibre production	✓	✓
		Timber production	✓	✓
		Land use diversity	✓	✓
		Intensity Index	✓	✓
	Crop inputs / outputs	Irrigation usage	✓	✓
		Fertiliser usage	✓	✓
		Pesticide usage	✓	✓
		Nitrate losses	✓	✓
	Yields	List of crops	✓	✓
	Area	Total crops area	✓	✓
		List of crops	✓	✓
Forestry	Potential Wood Yield		✓	✓
	Leaf Area Index		✓	✓
	Total cross-sectional trunk area		✓	✓
	Potential Gross Primary Production		✓	✓
	Potential Net Primary Production		✓	✓
	Potential Net Ecosystem Exchange		✓	✓
	Potential Above ground biomass		✓	✓
	Potential Below ground biomass		✓	✓
	Potential Carbon stock		✓	✓
	Potential Water stored in the soil		✓	✓
	Potential Soil Organic matter		✓	✓
	Forest productivity	Managed forest yield	✓	✓
		Unmanaged forest yield	✓	✓
		Forest area	✓	✓
		Managed forest area	✓	✓
		Unmanaged forest area	✓	✓
Biodiversity	Shannon Biodiversity Index		✓	✓
	List of plant and animal species	Potential climatic suitability	✓	✓
		Potential climatic and habitat suitability	✓	✓
		Change in potential suitability from baseline	✓	✓
		Stress indicators (as appropriate)	✓	✓
	List of tree groupings and species	Potential Net Primary Production	✓	✓
		Leaf Area Index	✓	✓
		Potential biomass	✓	✓
	Protected areas		✓	
	Number of species present		✓	✓
	Biodiversity Vulnerability Index		✓	✓

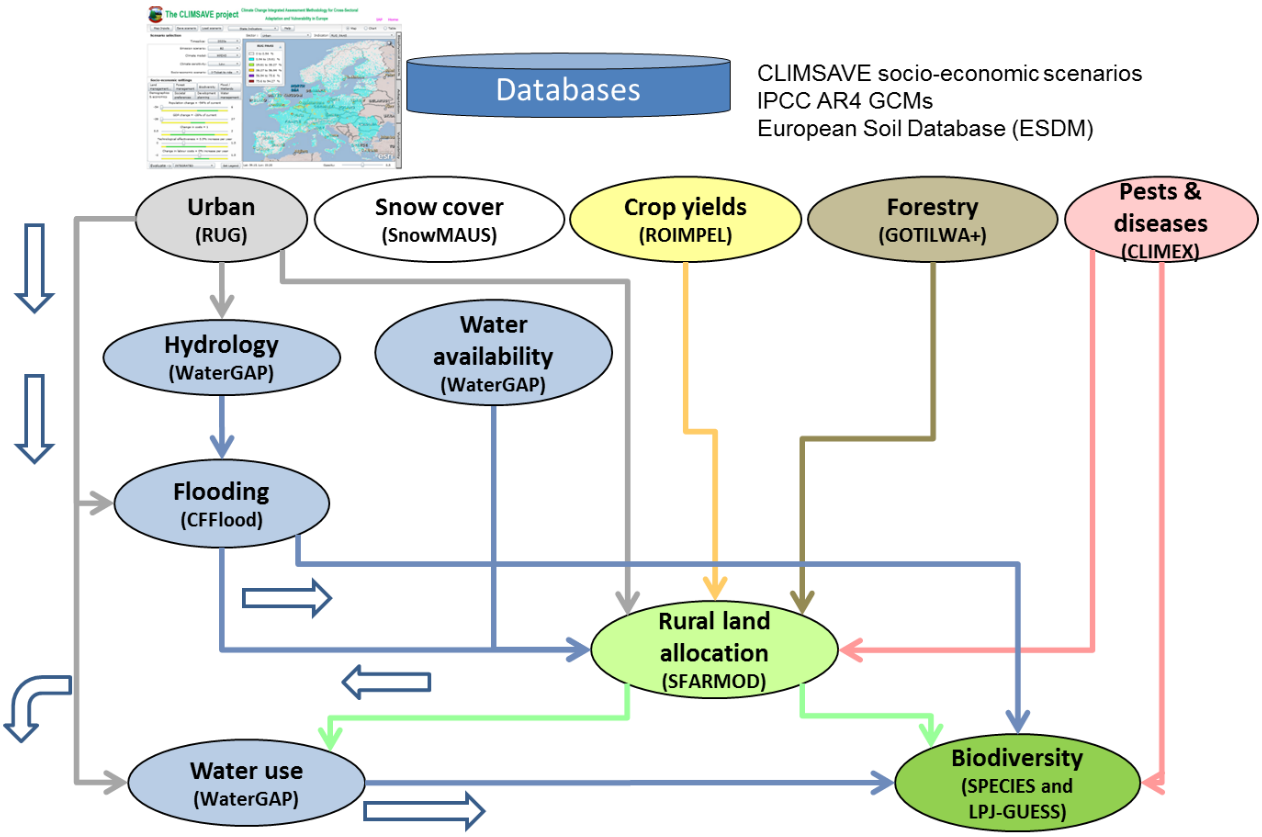


Figure 6: Simplified schematic showing the structure of the linked models within the European CLIMSAVE IA Platform. Adapted from Harrison et al. (2013).

3.2 Climate change scenarios incorporated in the IA Platform

A range of climate change scenarios were prepared and incorporated within the IA Platform (Dubrovsky et al. 2011). The user interface to the European IA Platform allows the user to select a greenhouse gas emissions scenario (SRES A1b, A2, B1 or B2), the climate sensitivity (low, medium or high, with medium being the default) and the global climate model (GCM) in order to explore the effects of climate change uncertainties on impacts and vulnerabilities. In order to make the number of combinations manageable for the user, it was decided to include a maximum of five GCMs within the IA Platform. Thus, a methodology was developed to objectively select a representative subset of GCMs incorporating the "best" GCM (through an assessment of GCM quality, based on the fit between model and observed annual cycles of precipitation and temperature), the most "central" GCM (the GCM whose climate change scenario is the closest to the mean scenario over 16 available GCMs), and three other GCMs that preserve as much uncertainty as possible due to between-GCM differences. The final set of GCMs selected to include in the IA Platform were: MPEH5 ("best"), CSMK3 ("central"), and HADGEM, GFCM21 and IPCM4 (the triplet of most diverse GCMs for Europe).

Projections of Europe-wide area-average temperature change range from 1.1 to 4.9°C in winter and 1.0 to 3.6°C in summer in the 2050s (Table 3). Projections of Europe-wide area-average precipitation changes range from increases of between 1.1 and 12.5% in winter and decreases of between 2.0 and 29.5% in summer. There are large differences in the magnitude and pattern of precipitation changes between the GCMs with GFCM21 and HadGEM showing the strongest reductions in summer precipitation (Figure 7).

Figure 7: Changes in annual temperature (AnnT, ^{o}C), winter (DJF) precipitation (WinP, %) and summer (JJA) precipitation (SumP, %) for the CSMK3 and GFCM21 GCMs for the 2050s assuming a A1b emissions scenario and a medium climate sensitivity.

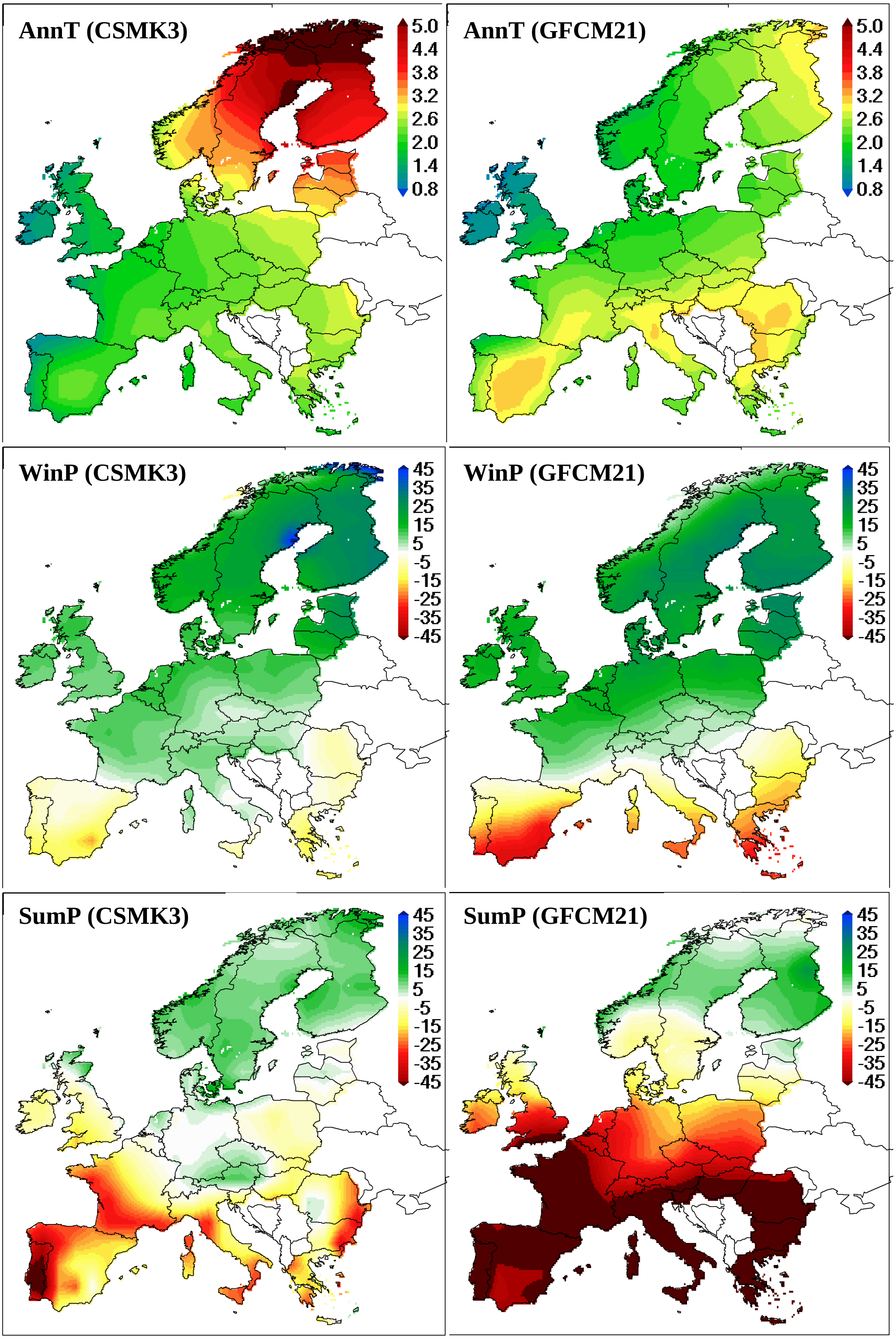


Table 3: European area-average changes in winter (DJF) and summer (JJA) mean temperature and precipitation for the 2050s, the five GCMs and three combinations of emissions scenario and climate sensitivity.

Emissions	Climate sensitivity	CSMK3		IPCM4		HadGEM		GFCM21		MPEH5	
		DJF	JJA	DJF	JJA	DJF	JJA	DJF	JJA	DJF	JJA
2050s Area average temperature change (°C)											
B1	1.5	1.7	1.1	1.3	1.3	1.1	1.3	1.2	1.1	1.2	1.0
B2	3.0	3.3	2.1	2.4	2.5	2.0	2.4	2.3	2.0	2.2	1.9
A1b	4.5	4.9	3.1	3.6	3.6	3.0	3.5	3.4	3.0	3.3	2.8
2050s Area average precipitation change (%)											
B1	1.5	4.2	-2.0	2.5	-4.2	1.1	-9.6	3.6	-13.6	3.6	-7.8
B2	3.0	8.3	-3.4	4.9	-7.4	2.1	-16.8	7.2	-22.6	7.0	-13.6
A1b	4.5	12.5	-4.6	7.4	-10.3	3.3	-23.0	11.1	-29.5	10.6	-18.6

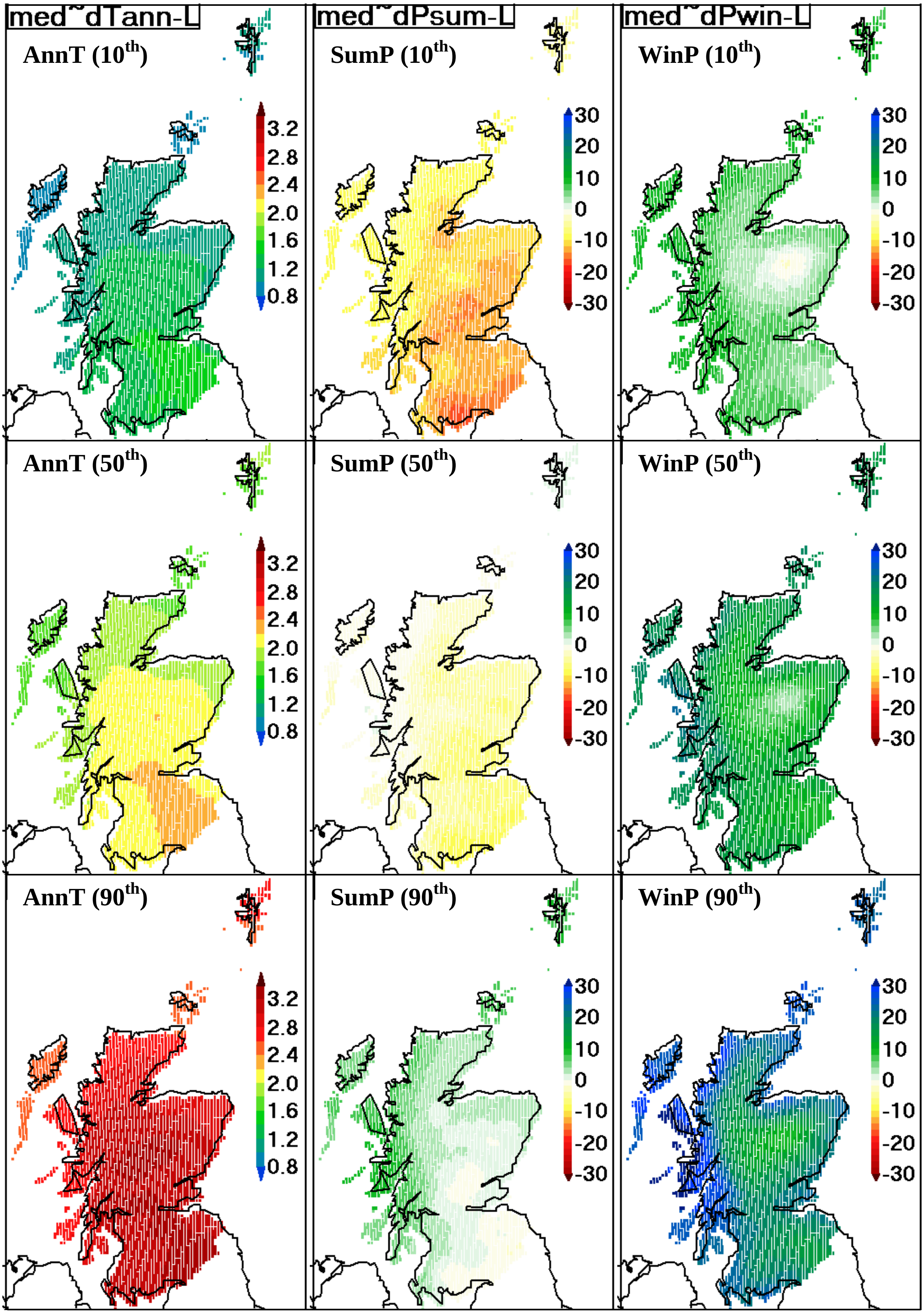
The climate change scenarios incorporated within the Scottish IA Platform are different to those used in the European IA Platform as they are based on the UK Climate Projections 2009 (UKCP09) which assign probabilities (or likelihoods) to the projections of temperature and precipitation change, based on the results of 10,000 climate model simulations per emissions scenario. In order to make the number of combinations manageable for the user, it was decided to identify different degrees of climate change from within these many model simulations. Thus, a methodology was developed to objectively calculate low, medium and high degrees of future warming within a given emissions scenario (based on the 10th, 50th and 90th percentiles of the future average annual temperature) and their associated 10th, 50th and 90th percentiles (representing dry, typical and wet) of the average summer half year (April to September) and winter half year (October to March) precipitation change.

Projections of Scotland-wide area-average temperature and precipitation change are shown in Table 4. Patterns of temperature and precipitation change for the medium emissions scenario and the three percentiles are shown in Figure 8.

Table 4: Scotland area-average changes in annual temperature and summer- and winter-half year precipitation for the 2050s, for the three percentiles of temperature change and associated precipitation change percentiles for the UKCP09 emissions scenarios.

Emissions	Annual temperature change percentile	Annual temperature change (°C)	Summer half-year precipitation change (%)			Winter half-year precipitation change (%)		
			10th	50th	90th	10th	50th	90th
Low	**10th**	1.1	-8.6	-1.7	5.4	1.6	8.0	15.0
	50th	1.8	-9.8	-2.7	4.7	2.5	9.2	16.3
	90th	2.7	-11.4	-3.9	3.9	3.8	10.9	18.6
Medium	**10th**	1.2	-10.2	-3.5	3.3	5.0	11.9	19.1
	50th	2.0	-11.0	-4.0	3.0	6.1	13.2	20.6
	90th	3.0	-12.0	-4.8	2.9	7.8	15.5	23.6
High	**10th**	1.4	-9.2	-2.3	4.8	4.9	12.3	20.3
	50th	2.2	-10.5	-3.4	4.1	5.7	13.4	21.7
	90th	3.3	-12.0	-4.3	3.6	7.0	15.4	24.3

Figure 8: Annual temperature change (AnnT, °C), summer half-year precipitation change (SumP, %) and winter half-year precipitation change (WinP, %) for the 10th, 50th and 90th percentile projections for all variables under the UKCP09 medium emissions scenario.



3.3 Socio-economic scenarios incorporated in the IA Platform

Climate change impacts will be in addition to, or concurrent with, those associated with continuing socio-economic and political changes. Our vulnerability to climate change, therefore, needs to be evaluated in a holistic or integrated assessment of the effects of our changing future. A set of plausible socio-economic futures for Europe were developed with stakeholders through a series of workshops. This participatory approach has two main advantages. Firstly, by developing qualitative scenarios in the form of stories it is relatively easy for a broad range of stakeholders from different backgrounds, expertise and professions to participate. Additionally, the stories are a good basis to stimulate discussion and ultimately shared learning. Secondly, stakeholders quantify the resulting stories, which serve as an important input for the CLIMSAVE IA Platform. In this way, the perspectives of stakeholders on future developments in a number of key sectors, such as agriculture, water, forests and biodiversity can be integrated with model outputs, leading to a set of qualitative and quantitative scenarios co-produced by stakeholders and CLIMSAVE experts.

The CLIMSAVE project developed these scenarios through three professionally facilitated, participatory workshops, which were very positively evaluated by stakeholders (Gramberger et al., 2011a,b; 2012a,b; 2013a,b). In addition to the development of long-term scenarios of socio-economic change, adaptation options for reducing climate change vulnerability were appraised.

The scenarios were developed by looking at forces that drive changes within society and the environment we live in, including changes in social, economic and institutional factors. Stakeholders participating in the workshops drafted a list of the main uncertainties facing Europe or Scotland and from this list selected two key uncertainties that formed the basis for four scenarios (Figure 9). The two key uncertainties for Europe were whether solutions by innovation would be effective or ineffective and whether economic development would be gradual or rollercoaster. The two key uncertainties for Scotland were whether well-being and lifestyle would be equitably or disparately distributed throughout society and whether resources would be in surplus or deficit.

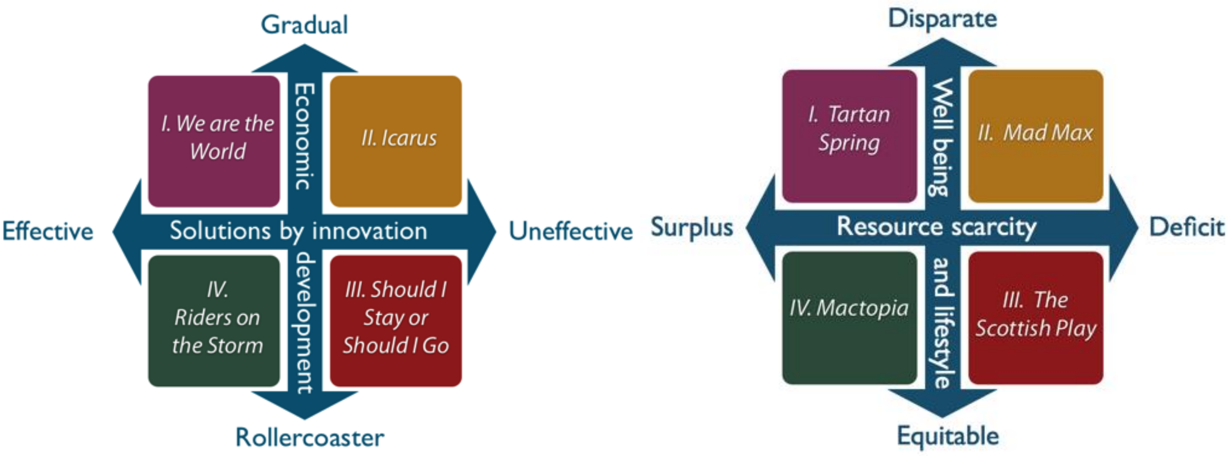


Figure 9: Structure and names of the four socio-economic scenarios for (a) Europe and (b) Scotland.

The CLIMSAVE socio-economic scenarios illustrate that a broad range of futures are envisioned to be plausible for Europe and Scotland, ranging from the very positive (We are the World or MacTopia) to the very negative (Should I Stay or Should I Go or Mad Max).

The four European CLIMSAVE socio-economic scenarios are:

- The most prosperous future scenario, combining high levels of innovation and gradual economic development is We are the World; where effective governments change the focus from GDP to well-being, which leads to a redistribution of wealth, and thus to less inequality and more (global) cooperation.

- In comparison, governments in the Icarus scenario focus on short-term policy planning, which together with a gradually stagnating economy, leads to the disintegration of the social fabric and to a shortage of goods and services.
- The Should I Stay or Should I Go scenario is characterised by actors failing to address a rollercoaster of economic crises, which leads to an increased gap between rich and poor, to political instability and to conflicts. In this scenario most citizens live in an insecure and unstable world.
- The Riders on the Storm scenario is equally hit hard by continual economic crises. However, actors successfully counter the situation through investment in renewable energies and green technologies. In this scenario Europe is an important player in a turbulent world.

The four Scottish CLIMSAVE socio-economic scenarios are:

- Within the Tartan Spring scenario a far-reaching, poorly regulated privatisation, changes Scotland from a prosperous country with abundant resources to one with an eroded social fabric and a low standard of living, culminating in an uprising.
- Equally driven by crises a new self-centred paradigm emerges in the Mad Max scenario, which leads to a growing disparity in society. Survival from day-to-day prevails, while new ‘clans’ are ruling Scotland again.
- Although resources within The Scottish Play scenario are equally scarce, the scenario can rely on traditional Scottish values to deal with the lack of resources. Consequently, lifestyles change towards reducing, re-using, and recycling, leading to a poorer, but greener and, in a way, happier population.
- In the most fortunate scenario, Mactopia, a resource surplus helps Scotland to make a transition towards an equitable and sustainable society to eventually become an IT, life sciences, green technology and finance frontrunner led by a powerful middle class.

The Story-And-Simulation approach was successfully implemented, adapted, and executed at both scales to link the socio-economic stories and to the models within the IA Platform (Kok et al. 2013). Through the participatory workshops stakeholders interacted with, and informed the development of the IA Platform in a number of different ways. Firstly, prototypes of the Platform were presented at workshops to get progressive feedback on the design and functionality. Additionally, the scenario narratives that stakeholders produced were also mined by the project team for additional information to assist the model input quantification. Most importantly, however, stakeholders provided scenario-specific quantitative values for a number of key model input parameters, such as future GDP or oil price. These various methods (stories, fuzzy sets, qualitative tables) together provided a comprehensive insight into the perceptions of stakeholders on key quantifiable parameters of the IA Platform. The main conclusions from implementing the Story-And-Simulation approach were:

- Having stakeholders develop scenarios leads to strong feelings of ownership.
- Directly translating these scenarios into elements of the IA Platform 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.

3.4 Application of the IA Platform to investigate key impacts of climate change

Numerous studies have explored the impacts of climate change at a variety of spatial scales in Europe. However, most of these treat each sector independently thereby ignoring important feedbacks and cross-sectoral interactions. Cross-sectoral interactions are important since changes in one sector can affect another sector either directly, e.g. changes in land use affect regional hydrology or biodiversity, or indirectly through policy, e.g. measures designed for coastal flood defence also impact on coastal habitat. Ignoring cross-sectoral interactions can lead to either over- or under-estimation of climate change impacts and the need for adaptation. Furthermore, many previous studies report the impacts of climate change under current socio-economic conditions, but in fact impacts will interact with those associated with continuing socio-economic and political changes, in potentially complex, non-additive ways.

The European IA Platform was run for 50 climate change and socio-economic change scenarios for the 2050s timeslice to explore the effects of climate change uncertainties on cross-sectoral impacts (Kebede et al., 2013). The scenario combinations can be categorised into three groups:

- Climate scenarios for the five GCMs incorporated within the IA Platform combined with a low emissions scenario (B1) and low climate sensitivity (5 runs);
- Climate scenarios for the same five GCMs combined with a high emissions scenario (A1) and high climate sensitivity (5 runs); and
- Climate scenarios (the 10 runs above) combined with the four CLIMSAVE socio-economic scenarios (40 runs).

The Scottish IA Platform was run for 30 climate change and socio-economic change scenarios for the 2050s timeslice to explore the effects of climate change uncertainties on cross-sectoral impacts. The scenario combinations can be categorised into two groups:

- Climate scenarios across the range of UK Climate Projections incorporated within the IA Platform from the 10^{th} percentile annual temperature increase associated with low emissions (and the associated range of changes in precipitation) to the 90^{th} percentile annual temperature increase associated with high emissions (6 runs);
- Climate scenarios (the 6 runs above) combined with the four CLIMSAVE socio-economic scenarios (24 runs).

Each scenario run was analysed for thirteen indicators representing the six sectors considered within CLIMSAVE (agriculture, forestry, biodiversity, water, coasts and urban). The European indicators were analysed for the whole of Europe and four catchment-based regions for northern, western, eastern and southern Europe. The Scottish indicators were analysed for the whole of Scotland and four catchment-based regions for southern, central and north eastern Scotland, and the Highlands and Islands.

Uncertainty in future impacts due to climate scenarios

The effects of uncertainty due to the climate change scenarios (assuming baseline socio-economics) are shown in Table 5a for Europe and Table 6a for Scotland. This shows the minimum and maximum area-average values across the climate change scenarios for each indicator and region. Most indicators are expressed as percentage change from the baseline, except for the biodiversity vulnerability index and Intensity Index (where the indices are already calculated relative to the baseline) and irrigation usage and forest area which are given as absolute changes. The results show that there is reasonable confidence in the direction of change for most indicators and regions in Europe with only water availability at the European scale, intensively farmed area and water availability for western Europe and extensively farmed area for southern Europe showing uncertainty in the direction of change. For Scotland, there is a good degree of confidence in the direction of change for most indicators at the national scale, with only water availability, water exploitation index and unmanaged land showing uncertainty in the direction of change nationally. There is, however, considerable uncertainty in the direction of change for many of the indicators at the regional scale.

Table 5a: Europe - Minimum and maximum values of the mean change from baseline for the 2050s for the climate change scenarios combined with baseline socio-economics. Coloured cells show indicators where the minimum and maximum trends are in different directions; where this is not the case the direction of the trend may be seen as robust in the context of the scenarios.

Indicator	**Europe**		**West**		**South**		**East**		**North**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Artificial surfaces (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
People flooded (%)	0.5	0.9	1.7	2.6	0.5	1.1	-1.0	-0.4	0.1	0.2
Biodiversity VI (-)	0.0	0.1	0.0	0.2	0.2	0.4	0.0	0.3	-0.4	-0.1
Intensively farmed (%)	-3.6	-0.6	-5.7	1.9	-19.0	-9.1	-10.2	-6.0	5.4	10.0
Extensively farmed (%)	-7.1	-2.0	0.8	7.7	-8.3	4.2	1.6	8.3	-20.3	-17.9
Food production (%)	228	280	327	431	275	337	153	236	113	209
Forest area (km^2)	-1995	-1389	-2999	-1799	-1768	-904	-1799	-1072	-1817	-1059
Unmanaged land (%)	10.7	20.5	3.5	14.2	9.3	33.9	4.9	15.0	19.0	22.3
Intensity index (-)	-0.1	0.0	-0.1	0.0	-0.2	-0.1	-0.1	0.0	-0.1	-0.1
Land use diversity (%)	-0.1	0.0	0.0	0.0	-0.3	0.0	0.0	0.0	-0.2	-0.1
Water availability (%)	-5090	287	-10397	68	-11080	-2419	-7377	-764	227	5608
Water Exploitation Index (%)	0.0	0.2	0.0	0.1	0.1	0.6	0.1	0.3	0.0	0.0
Irrigation usage (10^3 m^3/yr)	0.5	0.9	0.0	0.3	1.7	2.7	0.7	1.5	0.0	0.0

Table 5b: Europe - Minimum and maximum values of the mean change from baseline for the 2050s for the climate change scenarios combined with the CLIMSAVE socio-economic scenarios. Coloured cells show indicators where the minimum and maximum trends are in different directions; where this is not the case the direction of the trend may be seen as robust in the context of the scenarios.

Indicator	**Europe**		**West**		**South**		**East**		**North**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Artificial surfaces (%)	0.0	1.2	0.0	2.5	0.0	1.0	0.0	0.4	0.0	0.6
People flooded (%)	-0.2	2.7	0.5	5.3	-0.2	2.5	-1.9	7.8	0.0	0.6
Biodiversity VI (-)	0.0	0.1	0.0	0.3	0.1	0.5	0.0	0.4	-0.4	0.0
Intensively farmed (%)	-5.5	26.7	-9.0	23.7	-20.7	21.4	-20.5	28.1	3.6	31.7
Extensively farmed (%)	-7.8	5.3	-3.8	7.2	-9.6	7.2	-3.5	12.4	-20.5	4.6
Food production (%)	199	353	302	502	197	397	156	349	101	286
Forest area (km^2)	-4159	-1451	-4340	-1822	-2977	-959	-4875	-653	-4279	-945
Unmanaged land (%)	-1.5	22.5	-0.1	16.4	-0.2	33.4	-0.2	25.7	-4.4	26.2
Intensity index (-)	-0.1	0.1	-0.1	0.1	-0.2	0.1	-0.2	0.1	-0.1	0.2
Land use diversity (%)	-0.1	0.0	-0.2	0.1	-0.3	0.1	-0.3	0.0	-0.2	0.2
Water availability (%)	-5090	287	-10397	68	-11080	-2419	-7377	-764	227	5608
Water Exploitation Index (%)	0.0	0.3	-0.1	0.2	0.1	0.7	0.0	0.4	0.0	0.0
Irrigation usage (10^3 m^3/yr)	0.2	2.4	0.0	3.1	0.4	5.3	0.3	4.0	0.0	0.0

Table 6a: Scotland - Minimum and maximum values of the mean change from baseline for the 2050s for the climate change scenarios combined with baseline socio-economics. Coloured cells show indicators where the minimum and maximum trends are in different directions; where this is not the case the direction of the trend may be seen as robust in the context of the scenarios.

Indicator	**Scotland**		**Highlands and Islands**		**Southern**		**Central**		**North-east**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Artificial surfaces (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
People flooded (%)	10.7	31.6	21.8	47.6	1.2	9.4	7.3	29.9	0.0	13.2
Biodiversity VI (-)	-0.40	-0.20	-0.40	-0.10	-0.30	-0.10	-0.30	0.0	-0.50	-0.30
Intensively farmed (%)	12.2	51.1	38.9	74.9	-60.0	19.1	-35.4	65.5	37.0	85.9
Extensively farmed (%)	6.1	37.1	-4.5	18.0	20.7	89.6	-7.1	87.3	-32.1	30.5
Food production (%)	28.7	130.7	78.5	178.1	-42.4	107.0	-36.8	119.7	36.3	130.2
Forest area (km^2)	-50.5	-37.1	-58.4	-32.7	-38.2	-27.0	-50.3	-24.4	-62.2	-36.8
Unmanaged land (%)	-0.3	0.4	-0.3	0.3	0.0	0.1	-0.2	1.4	-0.2	1.4
Intensity index (-)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Land use diversity (%)	0.0	47.0	0.0	12.0	0.0	78.0	0.0	139.0	0.0	63.0
Water availability (%)	-4.5	15.8	-4.2	19.1	-7.2	9.3	-6.1	13.4	-7.0	9.6
Water Exploitation Index (%)	-8.4	23.4	-12.5	19.5	-7.9	68.0	-7.7	19.7	-7.5	30.6
Irrigation usage (10^3 m^3/yr)	6.1	17.8	5.7	14.1	-6.6	12.9	0.5	15.9	13.9	39.3

Table 6b: Scotland - Minimum and maximum values of the mean change from baseline for the 2050s for the climate change scenarios combined with the CLIMSAVE socio-economic scenarios. Coloured cells show indicators where the minimum and maximum trends are in different directions; where this is not the case the direction of the trend may be seen as robust in the context of the scenarios.

Indicator	**Scotland**		**Highlands and Islands**		**Southern**		**Central**		**North-east**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Artificial surfaces (%)	0.0	31.7	0.0	19.1	0.0	70.2	0.0	27.8	0.0	45.4
People flooded (%)	-2.3	63.3	7.6	72.4	-11.8	71.8	-4.5	55.9	-15.1	67.9
Biodiversity VI (-)	-0.30	0.00	-0.30	-0.10	-0.20	0.00	-0.20	0.10	-0.40	0.00
Intensively farmed (%)	-54.4	46.1	-37.7	93.9	-93.5	-30.8	-81.5	38.3	-64.9	74.4
Extensively farmed (%)	-60.6	62.7	-50.7	32.4	-60.6	108.3	-91.2	127.6	-64.8	99.9
Food production (%)	-9.7	93.2	25.0	252.4	-83.6	21.9	-76.7	42.5	-31.2	141.3
Forest area (km^2)	-55.0	-9.4	-70.5	-15.3	-54.1	-3.6	-71.0	-2.1	-46.4	-1.4
Unmanaged land (%)	-0.4	51.9	-0.4	25.8	-0.3	227.3	-1.5	242.5	-0.4	93.8
Intensity index (-)	-0.1	0.0	-0.1	0.0	-0.2	0.0	-0.1	0.1	-0.2	0.1
Land use diversity (%)	0.0	223.0	0.0	58.0	0.0	395.0	2.0	601.0	0.0	319.0
Water availability (%)	-4.5	15.8	-4.2	19.1	-7.2	9.3	-6.1	13.4	-7.0	9.6
Water Exploitation Index (%)	-57.7	57.5	-61.9	34.5	-57.6	278.5	-57.7	54.6	-52.2	110.6
Irrigation usage (10^3 m^3/yr)	-21.3	10.9	-28.3	9.0	-18.7	8.4	-15.4	14.1	-7.0	27.2

The robust results are that:

- There is no change in **artificial surfaces** as climatic factors do not influence urban development.
- The number of **people affected by a 1 in 100 year flood** increases in northern, southern and western Europe, but declines in eastern Europe. It increases in all Scottish regions, where regional changes are modest, but can be locally significant. The increases reflect the relatively moderate increases in sea-level by the 2050s (18-21 cm in Europe and 8-36 cm in Scotland) under the climate change scenarios on coastal towns and cities. Furthermore, at the resolution of the European and Scottish grid cells, fluvial flooding doesn't significantly increase the number of people flooded in the absence of socio-economic changes.
- **Biodiversity vulnerability** increases in southern, eastern and western Europe, but may improve in northern Europe. This is consistent with the projected decreases in biodiversity vulnerability in all regions of Scotland. The index is based on a group of 12 species selected to represent a cross-section of European/Scottish species from different taxa, regions and habitats. Their vulnerability increases when the climate becomes less suitable. The reduction in vulnerability in northern Europe/Scotland compared to increases in vulnerability elsewhere reflects many of the selected species gaining climate space in the north as it gets warmer and sometimes wetter.
- **Land use indicators**: **Intensive farming** decreases in southern and eastern Europe, and increases in northern Europe. For Scotland, increases are seen in the northeast and Highlands and Islands, leading to an overall national increase. **Extensive farming** decreases in northern Europe, and increases in western and eastern Europe. For Scotland, increases are projected for the southern region. **Food production** increases across all regions of Europe and in the northeast and Highlands and Islands for Scotland. **Forest area** decreases across all regions of Europe and Scotland. **Unmanaged land** increases across all regions of Europe, but shows little change in any region of Scotland. The land use model's primary challenge is to ensure that enough food is supplied to support the European or Scottish population, allowing for food imports. This focus on food provision has the knock-on impact that, even in the absence of socio-economic scenarios, forest area declines often to be replaced by intensive or extensive agriculture.
- The **land use summary indicators** reflect changes in land use with the **intensity index** showing no change or a decrease across all regions of Europe, and no change or an increase across all regions of Scotland. **Land use diversity** decreases in southern and northern Europe, but shows no change in western and eastern Europe. For Scotland, it remains unchanged or increases nationally and in all regions representing an increase in the homogeneity of the landscape. The reduction in the multi-functionality of the landscape is expected to reduce robustness to losses in ecosystem services associated with any one land use.
- **Water-related indicators**: **Water availability** decreases in southern and eastern Europe, and increases in northern Europe. This indicator is entirely climatically driven, reflecting changes in precipitation. The **water exploitation index** shows increases in most European regions, but no change in northern Europe. **Irrigation usage** increases in all European regions, but northern Europe; most notably in southern and eastern Europe. **For Scotland,** it increases in all regions, but southern Scotland; most notably in northeast Scotland.

Uncertainty in future impacts due to climate and socio-economic scenarios

To evaluate the importance of future socio-economic change to the impact range associated with climate change uncertainty, Tables 5b and 6b show the minimum and maximum area-average change for each indicator and region when the climate change scenarios are combined with the CLIMSAVE socio-economic scenarios. The results show that there is increasing uncertainty in the direction of change at both the European and Scottish scales. The results show:

- The socio-economic scenarios generally encourage **artificial surfaces** to increase. The model is heavily driven by population and GDP changes. Therefore, socio-economic scenarios with high population increase and higher GDP, such as Riders on the Storm and MacTopia, see the most growth. Icarus and Mad Max have a population decline and as such show no growth.

- The number of **people affected by a 1 in 100 year flood** increases in western and northern Europe and the Scottish Highlands and Islands, but the range is greater than seen for the climate scenarios alone. There is no clear trend for other regions. This indicator is largely driven by population and changes in the distribution of the urban area.

- The socio-economic scenarios exacerbate the changes in the **biodiversity vulnerability index** driven by climate for Europe or partially offset them for Scotland. This reflects changes in habitat availability driven by a range of socio-economic factors which affect land use change.

- Land use indicators: The socio-economic scenarios make a significant difference to the patterns of **intensive and extensive farming** and **unmanaged land**: there is no longer a clear message for any region of Europe or Scotland with the exception of intensive farming in northern Europe which shows general increases and in southern Scotland which shows general decreases. **Food production** increases across Europe, but for Scotland it only increases in the Highlands and Islands. **Forest area** decreases across Europe and Scotland, with the socio-economic scenarios considerably increasing the range of possible outcomes. For Europe, scenarios such as Should I stay or Should I Go, where pressure is put on the food resource due to increasing population and failed agricultural innovation, show significant increases in food production and intensive farming and a less marked decline in extensive farming, whilst the area of unmanaged land and forestry decline greatly. Conversely, scenarios where the population declines (Icarus) or innovations are successful and dietary preferences change (We are the World and Riders on the Storm) show increases in the area of unmanaged land and more mixed patterns are seen in terms of food production and intensive farming. Similarly for Scotland, scenarios such as The Scottish Play, where an increasing population and a lack of resources puts pressure on the food resource, show significant increases in overall food production and extensive farming, and little change in intensive farming and unmanaged land, whilst the area of forestry significantly declines. Alternatively, scenarios where innovations are successful and high GDP growth allows increased food imports (MacTopia), show increases in the area of unmanaged land at the expense of both intensive and extensive farming.

- Land use summary indicators: The socio-economic scenarios heavily influence the land use **intensity index** and **land use diversity**. For Europe, the intensity index increases in the Should I Stay or Should I Go scenario and decreases in other scenarios. For Scotland, the intensity index decreases in MacTopia in all regions and generally increases under the remaining scenarios in all regions except southern Scotland. The changing patterns in land use also lead to mixed impacts on land use diversity – some regions, such as southern and northern Europe gain new land use classes – and thus increase in diversity as a result of intensification, whilst other areas such as western and eastern Europe decrease in diversity due to loss of forest and unmanaged land and an increase in intensive agriculture. All regions in Scotland decrease in diversity due to loss of forest and changes to unmanaged and agricultural land.

- **Water-related indicators**: There is no socio-economic influence on **water availability**. The socio-economic scenarios exacerbate the increase driven by climate alone in the **water exploitation index** for southern and eastern Europe reflecting changes in both climate and socio-economic factors driving water extraction for agriculture, domestic/industrial use and power generation. In western Europe there is no clear message as some scenarios show a decrease in water exploitation and others an increase. In northern Europe there is no change in water exploitation. **Irrigation usage** increases in all areas (except northern Europe), but most notably in southern and eastern Europe; the socio-economic scenarios significantly modify the extent of this irrigation, both positively and negatively. In the scenarios where water-related innovations are unsuccessful (Icarus and Should I Stay or Should I Go), the water exploitation index is considerably higher (greater stress) and irrigation use is considerably lower. A similar outcome is apparent for Scotland in scenarios where societal breakdown and reducing wealth and resources lead to a loss of human and social capital (Mad Max). Conversely, the scenarios where water-saving innovations are successful (We are the World and Riders on the Storm) or where human capital increases, enabling successful water-saving innovations or 'living with less' (MacTopia and The Scottish Play), use increasing amounts of irrigation, whilst maintaining lower water exploitation values in comparison to the impacts based on climate change alone.

The outputs for each of the thirteen modelled indicators for each of the scenario combinations were tested for significant differences compared to the modelled baseline. Between 82% and 92% of indicator-scenario combinations for Europe and between 65% and 97% for Scotland were found to be statistically significantly different from the baseline. These results clearly show that both Europe and Scotland will be significantly influenced by future change. The results also show that non-climatic pressures, such as future socio-economic change, may be at least as, if not more, important than climate change, but there are many compounding and interacting effects. This highlights the importance of quantifying future impacts for both climate and socio-economic change to more fully capture uncertainties which can better inform the assessment of robust adaptation options.

3.5 Application of the IA Platform to investigate climate change adaptation

Adaptation can be achieved through 'hard' options and 'soft' options. Hard options are engineering and technological solutions; soft options seek to change knowledge or behaviour (and can include changing information and incentives relating to adoption of hard options). Adaptation can be anticipatory or reactive, planned or autonomous. Anticipatory or proactive adaptation takes place before impacts of climate change are observed. Reactive adaptation takes place after the impacts of climate change have been observed. Behavioural changes taken by private actors as a reaction to actual or expected climate change are known as "autonomous" adaptation. Planned adaptation is the result of a deliberate policy decision based on an awareness that conditions have changed and that action is required to return to, maintain, or achieve a desired state. This is partly a matter of perspective: adaptation that is 'planned' by an individual farmer may be viewed as 'autonomous' by the ministry of agriculture (when farmers just get on and do it without any ministry intervention).

Within CLIMSAVE, autonomous adaptation, both anticipatory and reactive, occurs within the meta-models which run inside the IA Platform: for example, the agriculture model automatically selects the best crops for the climate and economic conditions. Planned adaptation is implemented by the Platform user changing the sliders or buttons that control the models – for example, changing the rate at which agricultural technology improves. Each of the sliders represent broad adaptation responses, which could be made up of a range of specific adaptation options, individually or in combination, in most cases including both hard options and soft options. Which options could actually be used is a matter of choice, and depends on the scenario and resources (capitals) available: for example, high wealth scenarios are well suited to expensive solutions; scenarios with strong government are well suited to regulatory and tax solutions; and so on. The cost-effectiveness screen seeks to aid Platform users in thinking about these choices, highlighting the costs, effectiveness, and capital requirements of the different options available for influencing a slider.

CLIMSAVE does not seek to cover all adaptation options, partly because it does not cover all sectors (so there are options in, for example, transport, health and industry that are not included) and partly because the sliders that control the models in the Platform do not reflect every possible aspect of the sectors modelled. Nevertheless, the sliders do cover a very wide range of possible options, and in particular for sectors with a strong influence on land use and land cover. These adaptation options were identified in three main ways. Firstly, research into cost-effectiveness involved a wide-ranging search for estimates of the actual costs of adaptation options, resulting in an extensive database of (primarily hard) adaptation options. Secondly, work on adaptation and mitigation synergies and their cross-sectoral impacts involved a broader search (i.e. without the focus on costed options) for information on adaptation options (Berry et al., 2013). And finally, a range of additional ideas for future adaptation options, including many soft options, were developed in the CLIMSAVE stakeholder workshops, focusing on the sets of adaptation options that might be appropriate under the different future socio-economic scenarios developed by the stakeholders (Gramberger et al., 2012a,b).

To illustrate how the CLIMSAVE IA Platform can be used to investigate impacts and adaptation, we consider the effects of climate and socio-economic change on the Eurasian Bittern or Great Bittern (*Botaurus stellaris*), a wetland bird with a large range across Europe but with a decreasing population. Using a single illustrative climate change scenario within the IA Platform, the bittern will face pressures due to the changing suitability of the climate across important habitat areas in southern and south eastern Europe (Figure 10). This pressure is compounded by water abstraction as these are also areas of increased future water stress due to low water availability and high water demand – the climate change scenario leads to a further 11 river basins experiencing water stress (Figure 10).

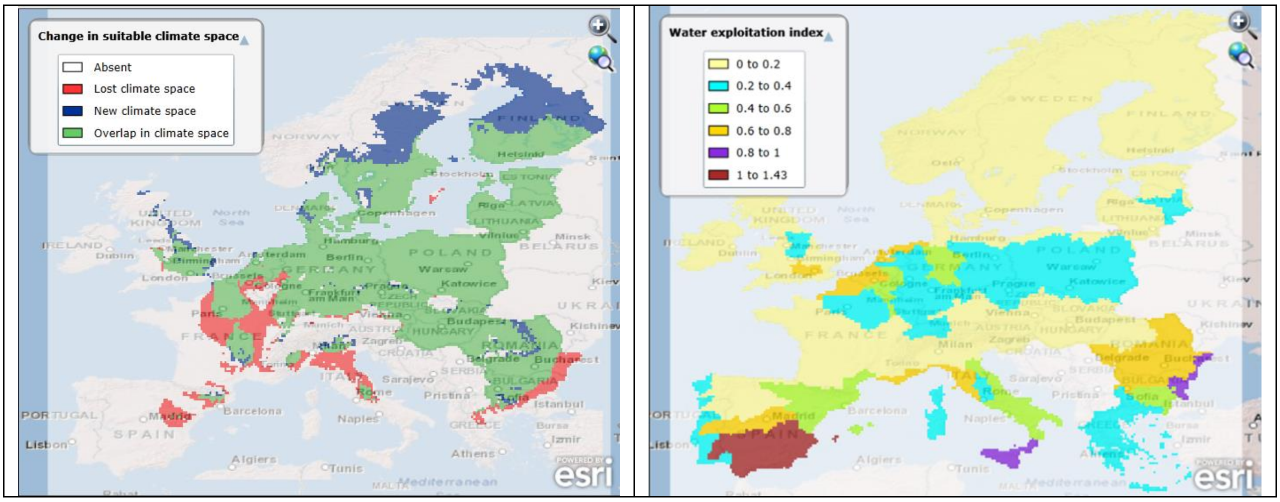


Figure 10: Illustrative example of the pressures from future changing climate suitability (left map) and water stress (right map; indicated by a Water Exploitation Index of >0.4) for the Great Bittern in Europe.

The European IA Platform was used to investigate how two contrasting CLIMSAVE socio-economic futures (We are the World and Icarus) modify the impacts due to climate change, and how these two futures affect the potential of adaptation to reduce the pressures. Without any adaptation, We are the World is shown in Table 7 to reduce the number of water stressed river basins compared to climate change alone (+7 compared to +11), but there are still seven more water stressed river basins than at present (baseline). In contrast, Icarus leads to an increase in both total water use (39% higher than the baseline) and water stressed river basins.

Water saving through behavioural change and technological change are important strategies within the We are the World scenario. However, there is insufficient adaptive capacity to offset the impacts of future change on water stress and total water use, so that maximum water savings only lead to reductions in total water use of -8%. Strategies to increase human capital within the scenario enable further water savings and consequently significant reductions in total water use and the number of water stressed river basins.

Human capital is severely reduced within the Icarus scenario preventing the effective implementation of water saving strategies due to behavioural and technological change, even though the latter is a potentially important adaptation strategy within the storyline. Because of the low starting levels of human capital in the storyline, strategies to increase human capital fail to enable sufficient additional adaptation, resulting in only small reductions in total water use of -7% and the number of water stressed river basins.

Table 7: Illustrative results of applying the IA Platform to investigate the effects of climate and socio-economic change on impacts and the potential for adaptation across Europe.

	Change in number of water stressed river basins (WEI>0.4)		**Change in total water use (%)**	
	We are the World	**Icarus**	**We are the World**	**Icarus**
Impact (relative to baseline) of:				
Climate change only	+11		+13 %	
Climate <u>and</u> socio-economic change	+7	+14	-6 %	+39 %
Effect of adaptation (relative to scenario impact):				
Maximum water savings	-1	-2	-8 %	-5 %
Enhanced water savings due to increased capital availability	-11	-3	-49 %	-7%

The above example illustrates how the CLIMSAVE IA Platform enables users to explore the effects of climate and socio-economic scenarios on sectoral and ecosystem service impact indicators, and to consider the potential for adaptation to offset these impacts. However, models such as the IA Platform cannot represent many of the processes involved in adaptation and it is important for the user to consider how such modelled strategies might be implemented in practice.

The range of adaptation options is wide, with much variety in costs, capital requirements, applicability, effectiveness and secondary (synergistic and cross-sectoral) impacts. Details of the choices are scenario dependent, but also in many cases dependent on local details that cannot be captured in the large-scale modelling of CLIMSAVE. The Platform, therefore, seeks to examine broad trends in possible adaptation, not specific details. The cost-effectiveness screen aims to help Platform users to consider these features at the broad (cross-Europe) scale, offering a general understanding of the relative costs, potential (applicability) and effectiveness of the options, as well as of their cross-sectoral impacts. This is enough to sketch out broad scenarios for adaptation, and to inform the detailed assessment of specific adaptation plans that will be dependent on local conditions and constraints.

3.6 Application of the IA Platform to investigate climate change vulnerability

One of the main goals of adaptation is to reduce the future vulnerability to hazards associated with climate change, taking account of other socio-economic changes. Indicators are needed both to monitor progress in adaptation (process-based or upstream indicators) and to measure the effectiveness of adaptation (outcome-based or downstream indicators). Identification of vulnerability hotspots is an important form of outcome indicator, indicating where important vulnerabilities lie and how they might be tackled. Vulnerability is influenced by a wide range of factors - social, economic, political, cultural and environmental - and vulnerability indicators need to reflect this, while remaining feasible to calculate and implement.

Coping capacity and the vulnerability concept in CLIMSAVE

The CLIMSAVE approach to vulnerability hotspot mapping evaluates the spatially-variable impacts of future scenarios on human well-being (Dunford et al., 2013). To do so it breaks vulnerability down into three key elements: (i) the severity of the impact itself; (ii) the level of adaptation in place to reduce the impact; and (iii) the extent to which humans are able to draw on their available resources (both tangible and societal) to cope with the impacts that remain, i.e. the "coping capacity".

Vulnerability occurs where the level of impact following adaptation is greater than society's ability to cope.

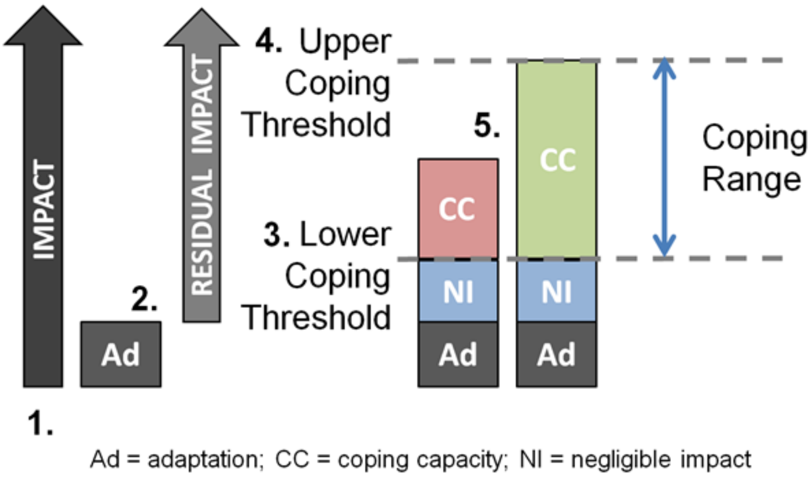


Figure 11: Schematic overview of the CLIMSAVE vulnerability approach.

This concept is shown schematically in Figure 11. Impact is modelled for a wide range of future scenarios (1 in Figure 11). Adaptation acts on the socio-economic scenario variables (for example, increasing the level of flood defence) and adaptive capacity changes with a scenario. The impact following adaptation is termed "residual impact" (2). The extent to which human well-being is affected by the residual impact depends on three further factors: (i) the "lower coping threshold" (the level of residual impact below which the impacts on human well-being can be considered negligible) (3); (ii) the "upper coping threshold" (the level of residual impact above which society is unable to cope, no matter how resource rich it is) (4); and, (iii) the "coping range" (the zone between the two thresholds) (5). Coping capacity reflects the available resources that are available to society and is derived as a function of human, social, financial and manufactured capital. Natural capital is not included in the coping capacity since it is calculated directly by the IA Platform.

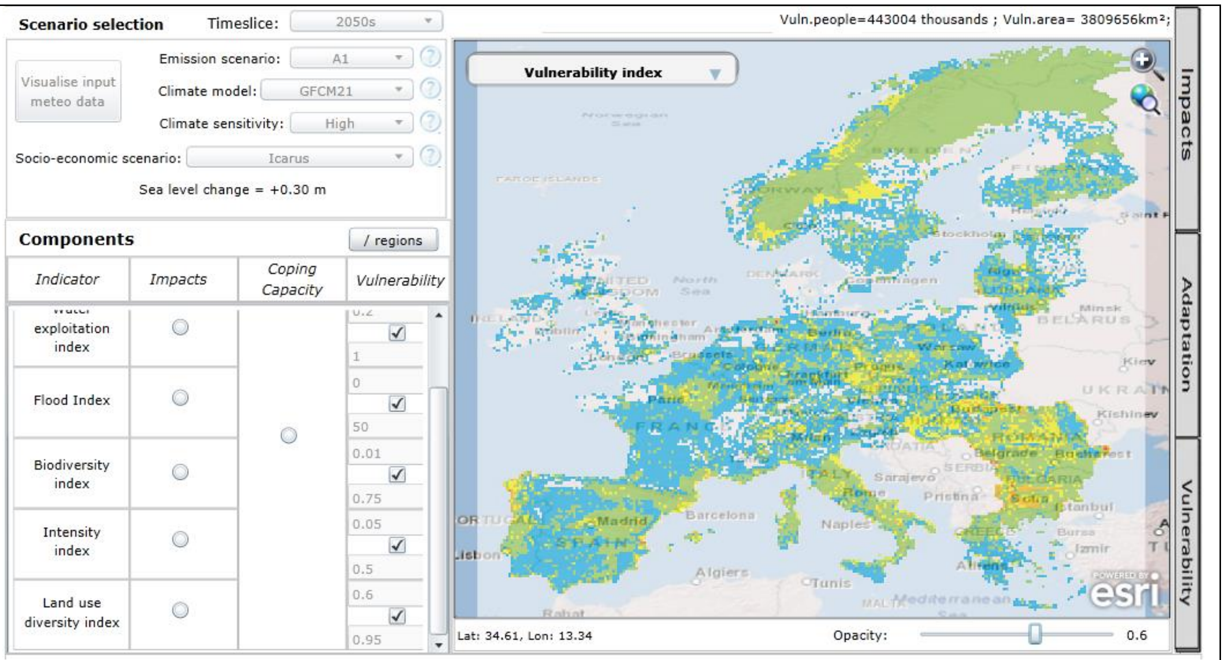
Evaluating vulnerability in the CLIMSAVE IA Platform

Vulnerability is assessed for six ecosystem service indicators and composite indices to represent a cross-section of ecosystem service categories: (i) food supply (provisioning service); (ii) water exploitation index (provisioning service); (iii) people affected by a 1:100 year flood event (regulating service); (iv) a biodiversity index (supporting service); (iv) a land use intensity index (to represent cultural/aesthetic services); and (vi) a land use diversity index (to represent multi-functionality). Upper and lower coping thresholds were selected for each of these indicators/indices. Vulnerability occurs in areas where the significant residual impact is greater than the coping capacity, and a vulnerability index is calculated for each ecosystem service indicator/index at the grid cell level. Grid cells are classified as:

- "Not vulnerable, negligible impact" (residual impact is less than the lower coping threshold);
- "Not vulnerable, coping" (the significant residual impact is less than the coping capacity);
- "Vulnerable, not coping" (the coping capacity is insufficient to deal with the significant residual impact); and
- "Vulnerable, impossible to cope" (the residual impact is greater than the upper coping threshold).

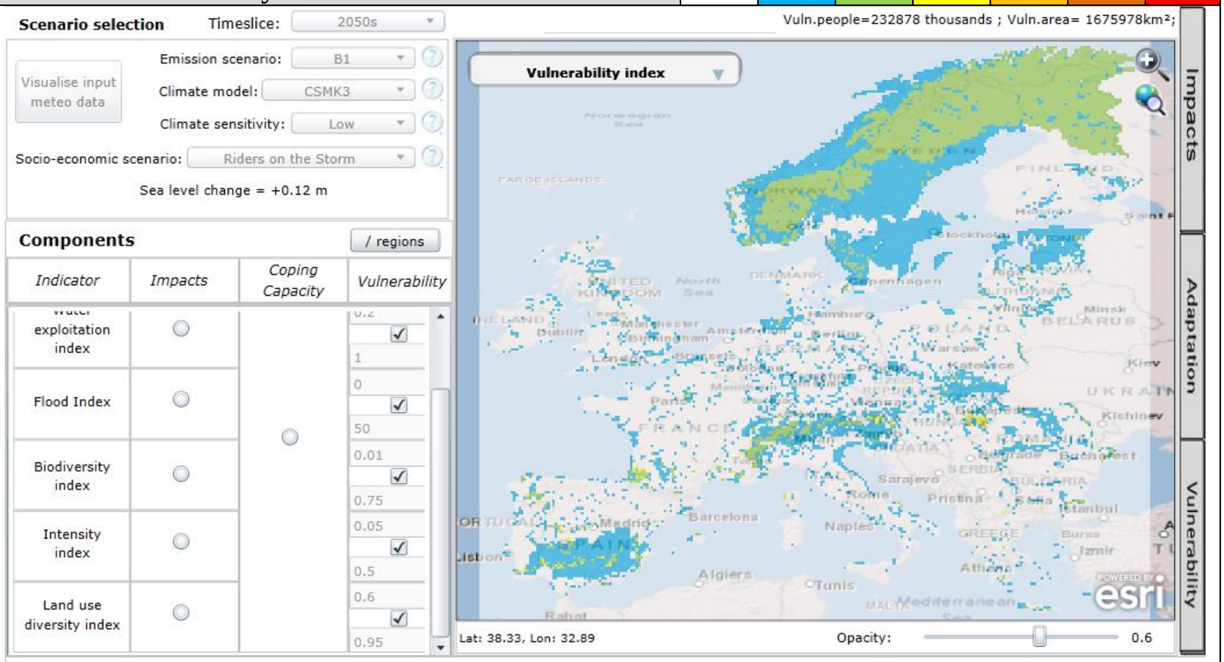
The total vulnerable area and number of vulnerable people are calculated at the European or Scottish scale using the two vulnerable classes and summing the area and population of cells identified as vulnerable. Cross-sectoral aggregate vulnerability is calculated by counting the number of vulnerable sectors in each grid cell.

To illustrate how the CLIMSAVE IA Platform can be used to identify vulnerability hotpots, we present an assessment of multi-sectoral hotspots (aggregate vulnerability) under a low and high vulnerability scenario for Europe (Figure 12).



Scenario: GFCM21, High emissions, Icarus, 2050s
Vulnerable people: 443,004,000; Vulnerable area: 3,809,656 km^2

Colour varies by number of sectors vulnerable:	0	1	2	3	4	5	6



Scenario: CSMK3, Low emissions, We are the World, 2050s
Vulnerable people: 232,878,000; Vulnerable area: 1,675,978 km^2

Figure 12: European aggregate vulnerability for two combined climate and socio-economic scenarios.

In the low vulnerability scenario (CSMK3 climate model combined with low emissions and the We are the World socio-economic scenario for the 2050s), there are a few key areas of vulnerability linked mostly to single indicators, e.g. southern Spain (water exploitation), Estonia (food) and some coastal areas, particularly in northeast Italy (flood). There are very few areas with vulnerability to multiple indicators, the most notable being Scandinavia and the Alps (food and diversity) and pockets of France, Austria and Hungary (food, biodiversity and land use diversity). This reflects the small proportion of Europe that is vulnerable to at least one indicator for both people (46%) and area (36%). In the high vulnerability scenario (GFCM21 climate model combined with high emissions and the Icarus socio-economic scenario for the 2050s), the proportion of Europe that is vulnerable is much larger with 81% of the area and 88% of the baseline population (443,004,000 people) vulnerable to at least one sector. Furthermore, significant areas of Scandinavia, France, Spain, Italy, Lithuania, Romania, Bulgaria and Greece are vulnerable to more than one indicator. Vulnerability differs between geographic areas. In Scandinavia, vulnerability is to food and land use diversity, whilst in southern and eastern Europe, and the areas around Prague and Paris, vulnerability is to biodiversity and water exploitation. Some areas are vulnerable to three indicators, especially along the coast which are vulnerable to floods, but also in parts of Germany, the Czech Republic and Romania where vulnerability is to land use intensity.

3.7 Other CLIMSAVE results

Policy analysis

Adaptation policy in Europe and Scotland was analysed through documents and interviews with policy stakeholders (Pataki et al., 2012). It is argued throughout official EU and Scottish documents that adaptation to the changing climate can be characterised as a positive gain for all sectors and social groups both with regard to environmental as well as economic gains. The toolbox for adaptation contains a wealth of market-based instruments (economic incentives and disincentives) serving the need for material adaptation, and so-called soft policy tools, such as changing the attitudes, values, and norms of economic actors (including producers and consumers) aiming at institutional modification. Climate change cannot be treated as a stand-alone policy issue as it affects many other policy sectors, including health, energy, mobility, water, biodiversity and food. An effective climate change adaptation policy needs to evaluate policies against adaptation requirements as routine practice. Therefore, the EU and Scotland has placed special emphasis on integrating or mainstreaming climate issues into other policy sectors supported by guidelines for so-called 'climate-proofing'.

Adaptation policy-making is a multi-level issue, ranging from international cooperation through the EU, regional, and national level to the very local context. Adaptation activities and decisions are inherently local and based on contextual knowledge. Therefore, adaptation to climate change, and consequently the limits of adaptation, cannot be understood and supported without reference to their local contexts. Local and regional levels of governance should, therefore, be better equipped and enabled for carrying out specific planning and operational activities. The national level has a significant role to play in establishing a favourable and enabling legal and political context. The EU aims to provide added value in coordinating Member States' actions, building up a knowledge base to share experience and best practices (e.g. http://climate-adapt.eea.europa.eu/), and developing financial mechanisms for motivating effective actions (proposing 20% of the European budget to be climate-related expenditure) and ensuring solidarity among European regions differentially affected by climate change.

Policy robustness

CLIMSAVE examined policy robustness in the area of climate change adaptation, focusing on possibilities for effective, long-term policy responses in the face of uncertainties about future climate change and socio-economic development (Jäger et al., 2013). To assess the robustness of adaptation options, the following steps were required. First, it was necessary to cluster adaptation options into so-called policy archetypes that can be tested using the CLIMSAVE IA Platform (Ecosystem-based Adaptation EbA, Market-based Adaptation MbA, Technology-based Adaptation TbA, and People-based Adaptation PbA). Second, the IA Platform was run assuming "no adaptation" for the 2050s timeslice for the four CLIMSAVE socio-economic scenarios developed for Scotland and Europe and for two 'extreme' climate scenarios. Third, the IA Platform was run for the clusters of adaptation options associated with each of the four policy archetypes for the same scenarios. Finally, for each of the runs, the number of vulnerable people was calculated. There are many "soft" adaptation options that are not included in the IA Platform, so these were incorporated into the assessment of policy robustness using expert judgement.

The results show that the use of policy archetypes enables an analysis of policy robustness across scales, sectors and scenarios using the CLIMSAVE IA Platform and expert judgement. The results suggest that PbA in both Europe and Scotland (and EbA in Europe) are generally the most robust. The effectiveness of PbA is related to the fact that it includes two measures that increase coping capacity (human and social capital). The analysis also showed that the vulnerability to flooding had the lowest level of uncertainty associated with its calculation by the IA Platform. This is consistent with the observation that adaption options were generally positive for this indicator across policy archetypes and across scenarios.

It should be noted that we have not explored the robustness of combinations of policy archetypes, which would indeed be more reflective of the reality of responding to vulnerability to climate and socio-economic changes. The methodology developed in this study would be suited to such an exploration of robustness of combinations of archetypes.

Adaptation and mitigation synergies and trade-offs

Adaptation and mitigation are two complementary ways of addressing climate change. Adaptation seeks to reduce the impacts of climate change, while mitigation decreases greenhouse gas emissions or increases carbon storage. CLIMSAVE reviewed a selection of adaptation and mitigation measures for the agriculture, biodiversity, coastal, forestry, urban and water sectors to identify their impacts, how these interact with other sectors, and measures which could enhance both adaptation and mitigation (Berry et al., 2013).

It found that almost all measures had an impact beyond the original intended one and that these additional impacts could be in the same sector, but often involved one or more other sectors. For example, coastal adaptation measures, such as managed realignment and restoration projects, tend to impact on biodiversity via the creation of valuable intertidal habitat, as well as providing carbon storage for mitigation. Examples were found of neutral, positive and negative impacts on the affected sector(s). Few measures had little or no direct impact, although in the urban sector, building measures, such as natural ventilation, insulation and painting surfaces white, have little or no effect on adaption or mitigation in other sectors, nor do many biodiversity adaptation measures. These are no-low regret options and provide benefits despite climate change uncertainties. The highest number of interactions between sectors was positive, with many benefitting adaptation in the biodiversity and water sectors. For example, stormwater management in urban areas using different types of greenspace, such as green roofs, Sustainable Urban Drainage Systems (SUDS) and urban trees can have numerous benefits for biodiversity. In addition to helping urban areas adapt, they can reduce adaptation needed by the biodiversity sector.

Some measures not only contribute to adaptation in other sectors, but also to mitigation, as in the example of coastal adaptation above. Major synergies between adaptation and mitigation also exist for agriculture through reducing greenhouse gas emissions by improving nitrogen use efficiencies and soil carbon storage. Measures include some forms of conservation agriculture, reducing soil erosion, soil moisture conservation, and land use changes involving abandonment or less intensive agriculture.

Also, the restoration of freshwater wetlands, such as peat bogs, to manage water flows could contribute to biodiversity adaptation and mitigate climate change.

Many negative interactions also related to biodiversity and water. For example, no-tillage systems may negatively affect native species, as may some forestry planting and operations, while coastal hard-engineering could prevent ecosystems migrating inland in response to sea-level rise. Possible conflicts with water include afforestation on new land for carbon storage or crop irrigation which can increase water demand, while increasing water supply is needed to meet demands of urbanisation or economic activities. All these changes can impact biodiversity, especially river and wetland species/habitats, and their ability to adapt. These negative impacts may lead to trade-offs, for example between maintaining water levels for biodiversity and agriculture and domestic or industrial supply. For coasts they may relate to managed realignment, where the trade-off is between maintaining the current primary habitat and sustainable coastal defence. For forestry they may be between afforestation for carbon storage and water supply.

Very often interactions with adaptation and mitigation measures in other sectors were not explicit, thus many opportunities of positive interactions are not taken into account in any assessment of the success of measures. An integrated approach to adaptation and mitigation is needed, therefore, so that measures with beneficial cross-sectoral interactions, which may also be more cost-effective, are implemented as well as avoiding negative cross-sectoral interactions. Since many interactions involved biodiversity and water, these may be good sectors to start with and already ecosystem-based adaptation for climate change is being promoted.

4. Potential impact

CLIMSAVE outputs will inform many policy processes ensuring that decisions on how best to adapt to climate change are based on solid scientific analysis. CLIMSAVE's integrated assessment approach will enable stakeholders to explore and understand the interactions between different sectors, rather than viewing their own area in isolation. This contributes to the development of a well-adapted Europe by building the capacity of decision-makers to understand cross-sectoral vulnerability to climate change and how it might be reduced by various adaptation options.

CLIMSAVE has advanced the state-of-the-art in many areas of climate change research, including scenario development, integrated modelling, vulnerability assessment and cost-effectiveness analysis as described through the projects Deliverables. CLIMSAVE has also developed a diverse range of user-relevant outputs through which to generate impact from the research results. All outputs are available from the CLIMSAVE website (www.climsave.eu).

Policy briefs

CLIMSAVE produced two high quality policy briefs for Scotland and Europe based on the key findings from the project. The findings were focussed to address important questions of relevance to policy-makers, practitioners and civil society. These questions were:

- How can policy promote climate change adaptation?
- How can stakeholders explore climate change impacts and opportunities for adaptation?
- What are plausible futures for Scotland / Europe
- What are the key impacts of climate change?
- How might Scotland / Europe adapt to climate change?
- What are the costs of adaptation?
- Where is Scotland / Europe most vulnerable to climate change?
- Which adaptation policy strategies are robust to uncertain futures?
- Why adaptation and mitigation need to be integrated?

The reports have been printed for circulation at relevant events, but are also available as PDFs to download from the website (http://www.climsave.eu/climsave/doc/Policy_Brief_for_Europe.pdf and http://www.climsave.eu/climsave/doc/Policy_Brief_for_Scotland.pdf).

Scenario futures

A set of four qualitative socio-economic scenarios for Scotland and Europe were developed in CLIMSAVE using participatory methods with a broad set of stakeholders. Combining scientific methods and stakeholder knowledge, the resultant 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. In addition to the stories, a series of complementary products including flow-charts, graphs depicting temporal developments, and quantitative estimates of a number of main drivers (e.g. population and GDP) were produced. Together, these stakeholder-determined products depict a picture of possible European and Scottish futures that can be used or further developed in other studies. The stories will have value to both the scientific community and policy-makers in modelling studies, scenario exercises and adaptation planning.

The CLIMSAVE Integrated Assessment (IA) Platform

The CLIMSAVE IA Platform is a unique interactive exploratory web-based tool to enable a wide range of professional, academic and governmental stakeholders to improve their understanding surrounding impacts, adaptation responses and vulnerability under uncertain futures. The tool provides sectoral and cross-sectoral insights within a facilitating, rather than predictive or prescriptive, software environment to inform understanding of the complex issues surrounding adaptation to climate change. The power of the tool lies in its holistic framework (cross-sectoral, climate *and* socio-economic change), and it is intended to complement, rather than replace, the use of more detailed sectoral tools used by sectoral professionals and academics. As such the IA Platform is not intended to provide detailed local predictions, but to assist stakeholders in developing their capacity to address regional/national/EU scale issues surrounding climate change.

The CLIMSAVE IA Platform has four main screens for users to engage with, depending on their particular interests:

- **Impacts** –this screen allows the user to assess the *potential impacts* (i.e. without any adaptation) of future change (climate change with/without socio-economic change) on the CLIMSAVE sectors, providing spatial and aggregated outputs.
- **Adaptation** – this screen allows the user to assess how adaptation might reduce the impacts of future change. If adaptation is sufficient, the potential impacts are reduced to zero and climate change has no actual impact. If, however, adaptation is insufficient to fully counter the potential impacts, this screen will show the *residual impacts*.
- **Vulnerability** - this screen allows the user to identify hotspots of vulnerability where coping capacity is insufficient to cope with either the potential impacts (before adaptation) or residual impacts (after adaptation). The user can also visualise vulnerability hotspots for a particular sector or sectorally-integrated vulnerability hotspots.
- **Cost-effectiveness** - this screen allows the user to evaluate the relative cost-effectiveness of different adaptation measures. Users can assess the relative costs, potential (applicability), capital requirements and effectiveness of a range of hard and soft adaptation options, as well as of their cross-sectoral impacts.

The multi-scale (Europe to regional) and multi-sector (agriculture, forestry, biodiversity, urban, coasts, water) approach of the IA Platform should ensure that the Platform contributes to the UNFCCC Nairobi Work Programme (NWP) focus of catalysing actions on adaptation, ensuring that products and deliverables target stakeholders at all levels and across all sectors.

The IA Platform is freely available on the web (http://86.120.199.106/IAP/#/Introduction), and is compatible with most of the widely used browsers. The CLIMSAVE IA Platform is also one of the tools highlighted on Climate-Adapt (http://climate-adapt.eea.europa.eu/climsave-tool), which includes a movie explaining the platform's functionality and a link to the tool. The integrated methodology and web-based platform incorporate key European sectors, and their interactions, allowing comparisons to be made between European regions based on a common approach, providing clear benefits in approaching adaptation in an integrated, coordinated manner at the EU level (as originally advocated in the EC Green Paper). It is thus hoped that the tool will gain considerable exposure through Climate-Adapt to the regional and national adaptation experts across Europe, thereby meeting the NWP aim "To disseminate existing and emerging methods and tools" and its overall emphasis on information sharing and transnational co-operation.

The Platform is also expected to be a valuable teaching tool within the Higher Education Sector which contributes to a better adapted Europe through assisting the intellectual development of future decision-makers. A set of Powerpoint presentations has been created and made available on the CLIMSAVE website (http://www.climsave.eu/climsave/outputs.html#Powerpoint) providing an overview of the project and presenting research highlights, including the IA Platform. The IA Platform and its associated presentations provide valuable resources for supporting teaching and learning in universities across the world.

Popular articles

To dissemination information about the products from CLIMSAVE, particularly the IA Platform and scenario futures, articles have been written in the popular and specialist press. These are expected to have significant impact for policy and practice communities, as well as for wider stakeholder groups (such as NGOs, business, researchers and civil society), interested in climate change impacts, adaptation and vulnerability. Articles include:

- The Parliamentary Magazine (Green Week edition, 27 May 2013 and Climate Change edition, 24 June 2013),
- YOURIS European Research Media Centre (http://www.youris.com/Environment/Methodology/Solving_The_Climate_Change_Vulnerabilities_Jigsaw.kl#axzz2gfMXalz5),
- Innovation Seeds (article on CLIMSAVE: http://www.innovationseeds.eu/Virtual_Library/Results/CLIMSAVE.kl#.UnzNWLBFBaR, the CLIMSAVE IA Platform: http://www.innovationseeds.eu/Virtual_Library/Knowledge/CLIMSAVE_-_Integrated_Assessment_Platform.kl#.UnzNPrBFBaQ and the Participatory scenario methodology: http://www.innovationseeds.eu/Virtual_Library/Knowledge/CLIMSAVE_-_Participatory_Scenario_Methodology.kl#.UnzN_bBFBaQ), and
- CORDIS (August 2013: http://cordis.europa.eu/fetch?CALLER=EN_NEWS&ACTION=D&RCN=35942).

Scientific publications and presentations at international conferences

The CLIMSAVE project has produced a significant number of journal papers within the peer-reviewed international scientific literature. This includes a Special Issue on the CLIMSAVE project within the Climatic Change journal published by Springer. The publication of 19 papers together in the Special Issue, in particular, is expected to have significant impact in the scientific community, given the breadth and scope of the project's findings. This will reinforce the international awareness of the research gained from the many CLIMSAVE presentations (more than 60) given in Europe and beyond.

CLIMSAVE was one of four FP7 projects which led the organisation of the 1st European Climate Change Adaptation Conference (ECCA) with the RESPONSES, MEDIATION and ClimateCost projects. This was the first European conference focused on climate change adaptation which follows international conferences in Australia (Gold Coast, Queensland) in 2010 and in the United States (Tucson, Arizona) in 2012. The conference took place in Hamburg on 18-20 March 2013 and involved over 700 participants from research, policy and practice. CLIMSAVE partners played key roles in the organisation of the conference, convening and chairing parallel sessions, and contributing oral and poster presentations. In total, CLIMSAVE contributed nine oral presentations and one poster presentation, organised one practitioner session, facilitated the final plenary session, and was responsible for awarding the prizes for best poster and best presentation by a PhD student. CLIMSAVE also had a stand at the conference where it displayed overview and IA Platform posters, had flyers, newsletters and other dissemination products on display, as well as a movie showing the functionality of the IA Platform.

Links to international programmes and networks

Many CLIMSAVE partners are cooperating with other international, European or national research projects, networks or programmes to promote the dissemination and integration of CLIMSAVE results into other research activities. CLIMSAVE has been endorsed by the Global Land Project (a joint research agenda for the IGBP and IHDP) and is included on its website and in its newsletters which promote products from CLIMSAVE to a large international audience. Many CLIMSAVE partners are involved in the IPCC AR5 Working Group 2 (Impacts, Adaptation and Vulnerability), particularly on the chapters on Foundations for Decision-making, Europe, Asia, and Coastal Systems and Low-lying Areas. Furthermore, CLIMSAVE partners contribute to, or participate in, the Shared Socio-economic Pathways (SSPs) working groups, Climate Change, Agriculture and Food Security (CCAFS) research initiative launched by the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP), the Global Foresight Hub, IGBP-AIMES (Analysis & Integrated Modelling of the Earth System), DG Environment's Mapping and Assessment of Ecosystems and their Services (MAES), the European Sustainability Science Group, and the Integrated Assessment Society (TIAS). The involvement of members of the CLIMSAVE team in these important international programmes allows for an exchange of expertise and results, thus, further enhancing the harmonisation of the European and international research area on climate change impacts, adaptation and vulnerability. Finally, targeted international cooperation has been explored with the TaiCCAT (**Tai**wan integrated research program on **C**limate **C**hange **A**daptation **T**echnology) project which has similar goals and perspectives to CLIMSAVE in producing an integrated assessment of climate change impacts, adaptation and vulnerability for Taiwan.

5. Website, partnership and contact details

The CLIMSAVE project involved 18 partners (Table 8). Further information on the project can be obtained from the project's website (www.climsave.eu) or by contacting the Project Coordinator: Dr. Paula Harrison (Paula.Harrison@ouce.ox.ac.uk).

Table 8: CLIMSAVE partners with contact names.

Institute	Contact	Country
Environmental Change Institute, University of Oxford	Paula Harrison	GB
TIAMASG Foundation	George Cojocaru	RO
Prospex bvba	Marc Gramberger	BE
ESSRG Kft	György Pataki	HU
Department of Natural Resources, Cranfield University	Ian Holman	GB
Centre for Ecological Research and Forestry Applications (CREAF)	Santi Sabaté	ES
Center for Environmental Systems Research , University of Kassel	Karl-Heinz Simon	DE
Institute of Agrosystems and Bioclimatology, Mendel University	Mirek Trnka	CZ
Department of Environmental Studies, University of the Aegean	Michalis Skourtos	GR
Rob Tinch (independent)	Rob Tinch	BE
Sustainable Environment Research Institute (SERI)	Ines Omann	AT
School of Geosciences, University of Edinburgh	Mark Rounsevell	GB
Department of Earth & Ecosystem Sciences, University of Lund	Martin Sykes	SE
Land Dynamics Group, Wageningen University	Kasper Kok	NL
School of Civil Engineering and the Environment, University of Southampton	Robert Nicholls	GB
Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences	Lin Erda	CN
Faculty of Science, Health & Education, University of the Sunshine Coast	Richard Warrick	AU
Centre for Strategic Economic Studies, Victoria University	Roger Jones	AU

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