The CLIMSAVE Project

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

Guidance report describing the final version of the CLIMSAVE Integrated Assessment Platform

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SEVENTH FRAMEWORK PROGRAMME

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Preface

This Deliverable describes the final version of the Scottish and European CLIMSAVE Integrated Assessment (IA) Platforms. It describes each of the CLIMSAVE IA Platform's four screens (Impact, Vulnerability, Adaptation and Cost-effectiveness) providing the purpose of each screen; definitions of key terms; steps to set-up and use each screen; outputs and health warnings.

1. Introduction

The CLIMSAVE Integrated Assessment (IA) Platform is a unique interactive exploratory tool that contains a series of linked models and databases (Figure 1.1) to allow users to explore the complex issues surrounding impacts, adaptation and vulnerability to climate change at regional and European scales. Two versions of the tool have been developed: a European version and a Scottish version (to test the application of the methodology at the regional scale).

The tool provides sectoral and cross-sectoral insights within a facilitating, rather than predictive or prescriptive, software environment. The power of the tool lies in its holistic framework (multi- and cross-sectoral, climate and socio-economic change; Figure 1.1), and is intended to complement, rather than replace, the use of more detailed sectoral tools used by sectoral professionals and academics.

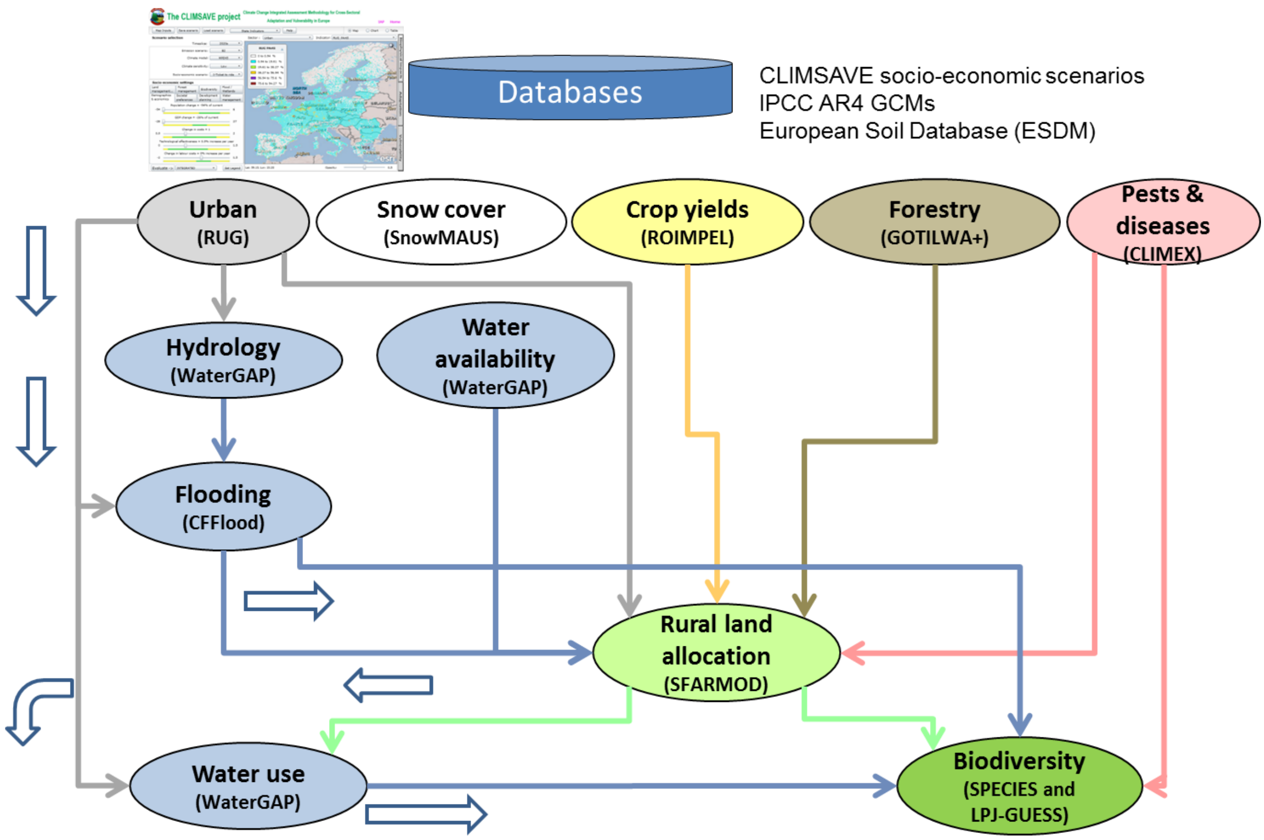


Figure 1.1a: Simplified schematic showing the structure of the linked models within the European CLIMSAVE IA Platform.

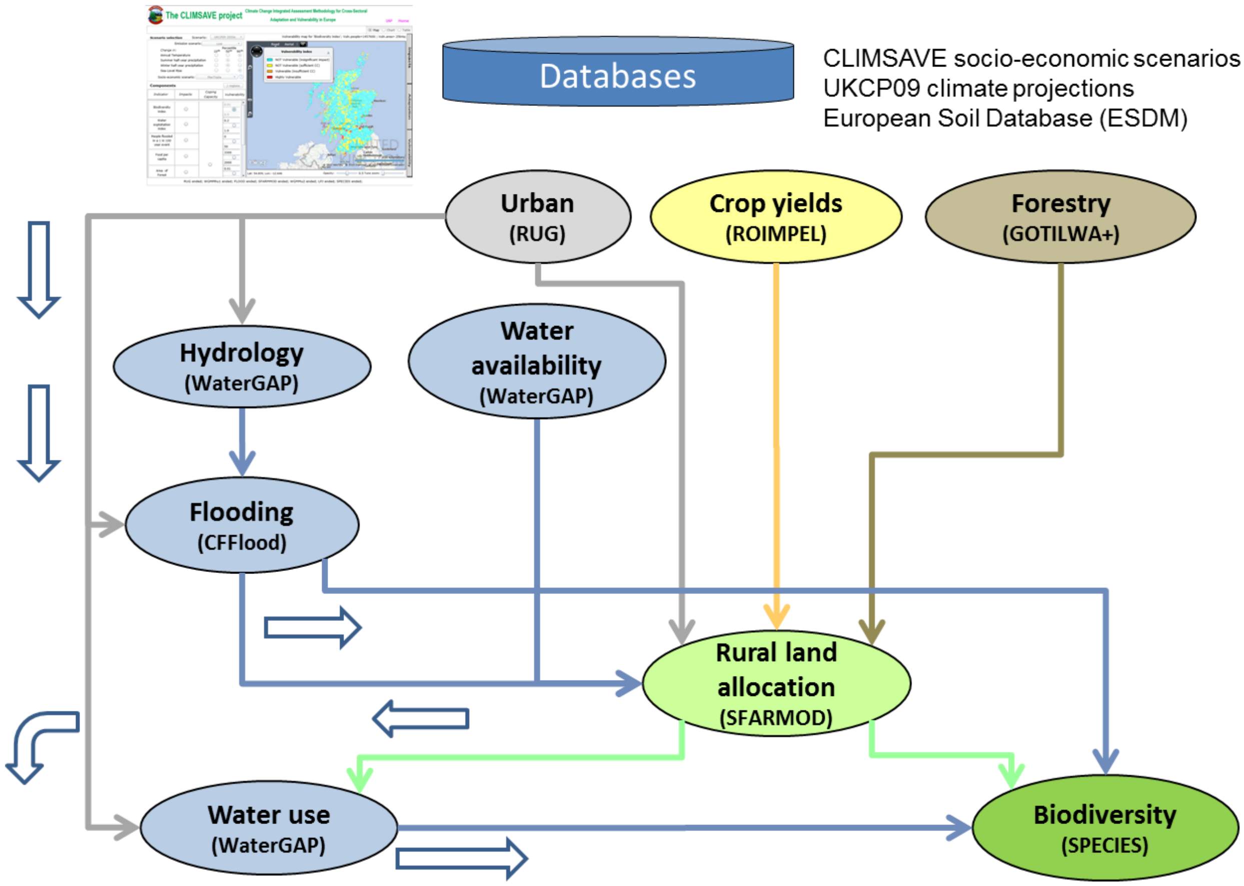


Figure 1.1b: Simplified schematic showing the structure of the linked models within the Scottish CLIMSAVE IA Platform.

As such the CLIMSAVE 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 is also expected to be a valuable teaching tool which contributes to a better adapted Europe through assisting the intellectual development of future decision-makers.

2. Overview of the CLIMSAVE IA Platform

The CLIMSAVE IA Platform contains 4 screens:

- ***Impacts*** - investigate how different amounts of future climate and socio-economic change may affect urban, rural and coastal areas, agriculture, forestry, water and biodiversity;
- ***Adaptation*** - take your scenario from the Impacts analysis and investigate how adaptation can reduce the impacts of climate change;
- ***Vulnerability*** - investigate which areas or 'hot spots' in Europe may be vulnerable to climate change in your scenario, before and after adaptation; and
- ***Costs*** - identify the relative cost of adaptation measures to reduce the impacts of climate change.

You can move through the CLIMSAVE IA Platform screens in a number of ways (Figure 2.1), by looking at, for example:

- Impacts only;
- Impacts and Adaptation;
- Vulnerability before and after adaptation (Impacts → Vulnerability → Adaptation → Vulnerability);
- Adaptation costs (Impacts → Adaptation → Costs).

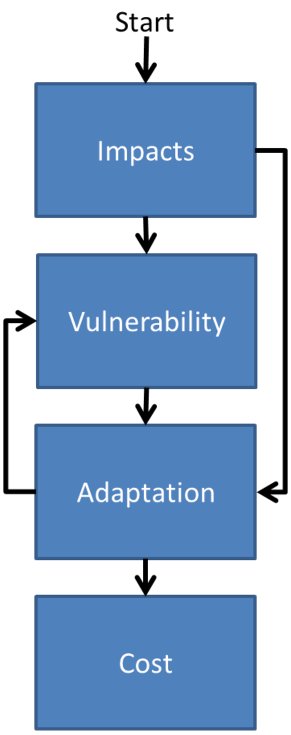


Figure 2.1: Pathways through the CLIMSAVE IA Platform.

Note: In common with all software, the CLIMSAVE IA Platform may very occasionally crash. If this happens, close your browser (and all tabs), and then re-start it.

3. Impacts screen

Purpose: To investigate how different amounts of future climate and socio-economic change may affect urban, rural and coastal areas, agriculture, forestry, water and biodiversity.

Use this screen to:

1) Carry out a sensitivity analysis – under the baseline / current climate, investigate the response of the indicators to changes in the scenario settings;

2) Explore the effects of climate change uncertainty – the CLIMSAVE IA Platform contains multiple climate change scenarios. You can explore the effects of uncertainty by selecting different scenarios in conjunction with the baseline socio-economic scenario;

3) 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.

4) Explore the effects of uncertainty within a socio-economic scenario - You can explore the effects of uncertainty within each socio-economic scenario by moving the sliders within the green range. These values are consistent with the assumptions within each scenario;

5) Model impacts in relation to your own "user-defined" socio-economic scenario - You can explore a wider range of values associated with each socio-economic scenario 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, you will also need to set the values under the Capitals tab.

Key definitions:

- ***Baseline***: The baseline is the present-day reference against which future changes are measured.
- ***Emissions scenario***: A plausible representation of the future development of emissions of greenhouse gases, that are used as a basis for the climate change scenarios.
- ***Scenario***: A plausible description of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technology change, prices) and relationships. Scenarios are neither predictions nor forecasts.
- ***Impacts***: the consequences of climate and socio-economic change on natural and human systems.
- ***Capitals***: The total wealth of an economy can be measured as the sum of all the capital stocks (manufactured, human, social, natural and financial). Capital stocks are used to generate income for consumption and for investment in enhancing capital. Investing in capital stocks now will increase future opportunities for consumption and investment; running down capital stocks will reduce future opportunities
- ***Ecosystem services***: the outputs of ecosystems from which people derive benefits including goods and services (e.g. food and water purification, which can be valued economically) and other values (e.g. spiritual experiences, which have a non-economic value).

Steps to use / set-up

A consistent design has been followed throughout the CLIMSAVE IA Platform to help increase familiarity. Figure 3.1 shows the key areas within the Impacts screen for setting up your model run.

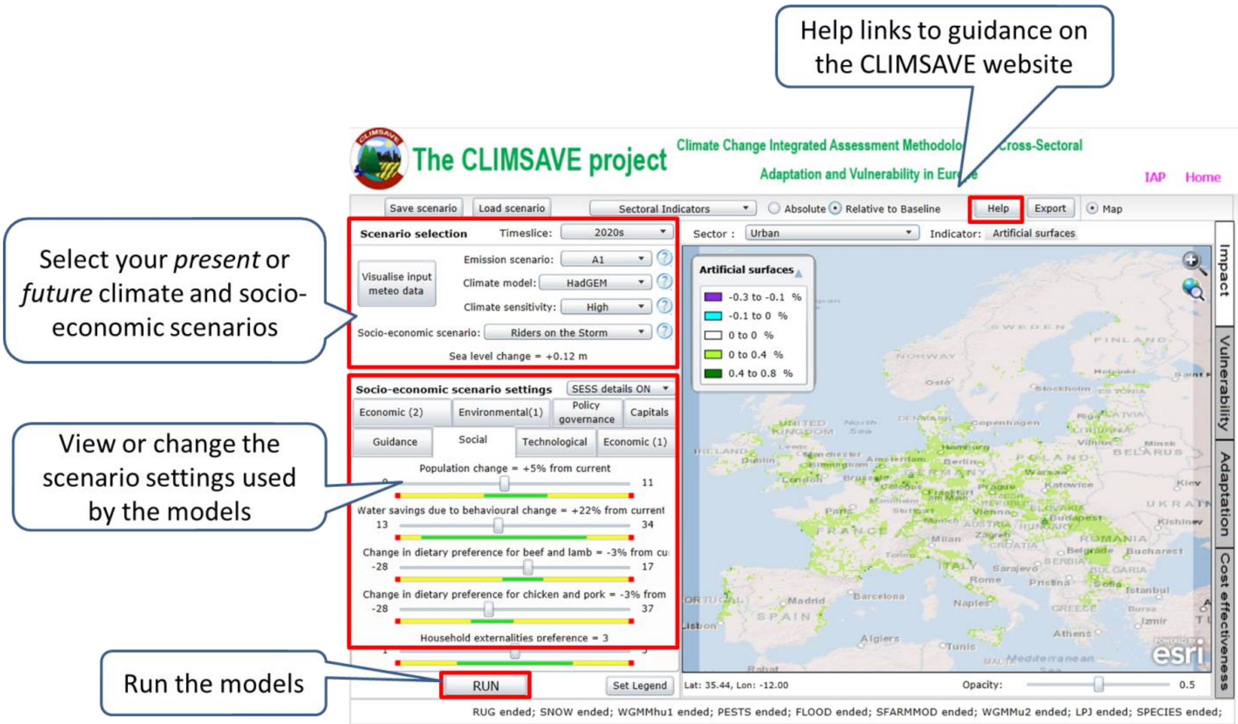


Figure 3.1a: Setting the scenario inputs in the Impacts screen of the European IA Platform.

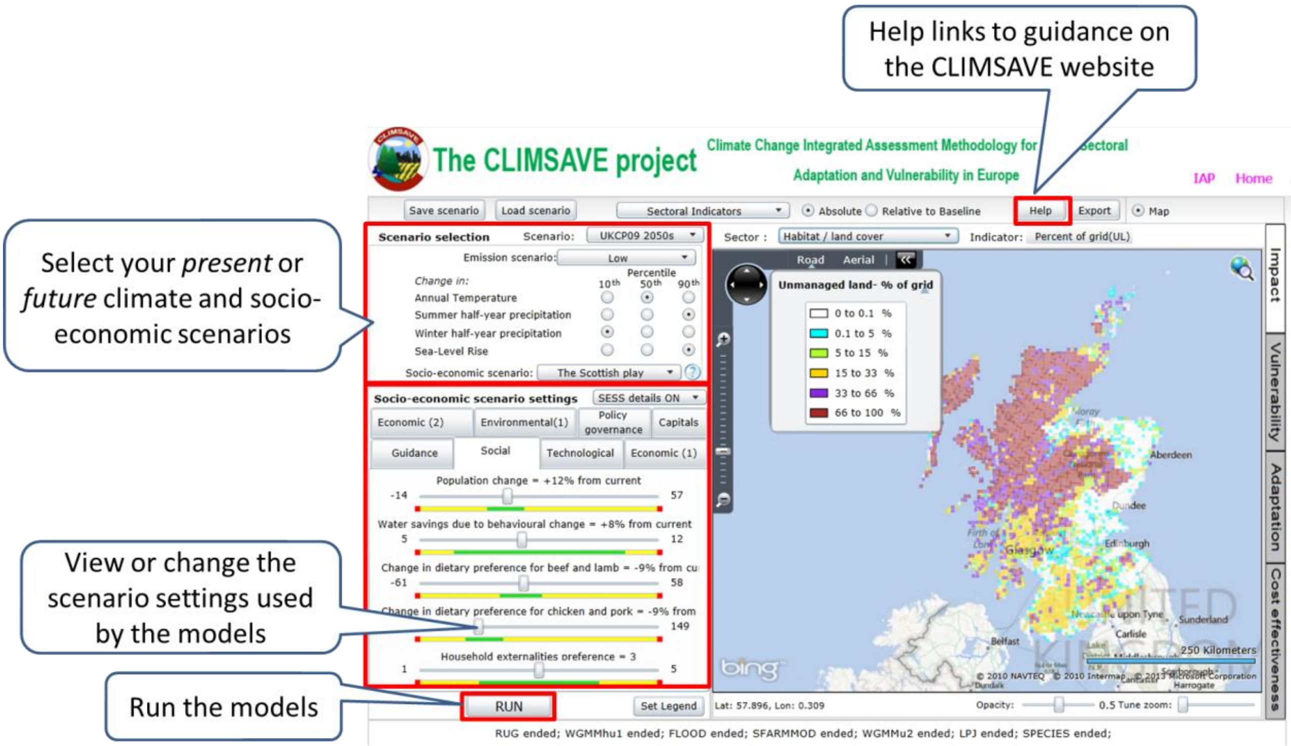


Figure 3.1b: Setting the scenario inputs in the Impacts screen of the Scottish IA Platform.

To run the IAP in the Impacts screen:

1. Select a timeslice from the dropdown menu – Baseline, 2020s or 2050s (*Default: Baseline*).

2. If you select Baseline:
    a. Move the climate sliders to represent a change in temperature, precipitation, carbon dioxide concentration or sea level;
    b. Or keep the climate sliders as they are (representing no change) and modify the socio-economic sliders.

3. If you select 2020s or 2050s, then:

    For Europe (Figure 3.1a):
    a. Choose an emissions scenario – A1, A2, B1 or B2 (*Default: A1*).
    b. Choose a climate model – outputs from five climate models are included: HadGEM, GFCM21, IPCM4, CSMK3 and MPEH5 (*Default: CSMK3*) – see Appendix 1.
    c. Choose the climate sensitivity – Low, Middle, High (*Default: Middle*). Higher sensitivity gives greater temperature increases.
    d. Choose a socio-economic scenario – Baseline, and a choice of four stakeholder-produced CLIMSAVE socio-economic scenarios (*Default: We are the World*).

    For Scotland (Figure 3.1b):
    a. Choose an emissions scenario – Low, Medium or High (*Default*: Low).
    b. Choose the change in annual temperature – 10th (lowest increase), 50th or 90th (highest increase) percentile – see Appendix 1.
    c. Choose the change in summer and winter half-year precipitation – 10th, 50th or 90th percentile (*Default: 50th percentile*).
    d. Choose the sea level rise – 10th (lowest increase), 50th or 90th (highest increase) percentile (*Default: 50th percentile*).
    e. Choose a socio-economic scenario – Baseline, and a choice of four stakeholder-produced CLIMSAVE socio-economic scenarios (*Default: Tartan Spring*).

4. *Optional*: Change any of the socio-economic scenario slider settings or buttons (see section below for further information on the sliders).

5. Press Run.

6. A green "Select species" box will open (Figure 3.2). Select one category in each of the two lists (*Default: "Mixed representative species group" and "Boreal needleleaved evergreen trees"*) [This determines which species models are run for the biodiversity sector].

7. Click on "OK".

8. View results, and consider whether any of the changes are undesirable/unacceptable (and, hence, require adaptation).

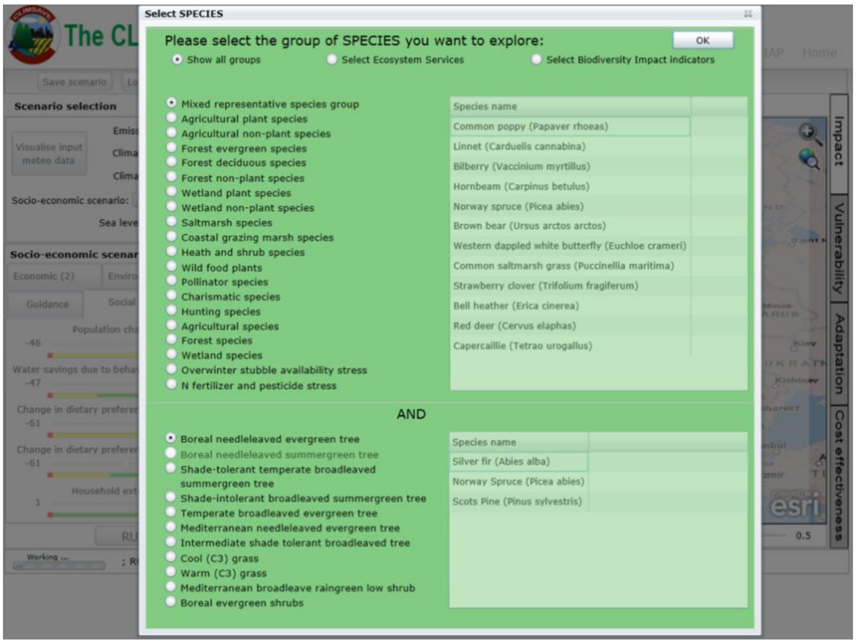


Figure 3.2: The "Select species" screen which appears after pressing Run.

Understanding the sliders and green/yellow/red ranges

Sliders are implemented in the CLIMSAVE IA Platform to help make the socio-economic model inputs transparent (Figure 3.3). They contain 2 key elements:

- The value used by the model – given by the slider position and the stated value above (e.g. -2% for change in bioenergy production in Figure 3.3);
- A traffic light-based system of colour coding of the slider bars which is used to communicate the uncertainty within the CLIMSAVE socio-economic scenarios:
    - **Green** denotes uncertainty that is "credible" within the context of the socio-economic scenario storyline (green for 'Go');
    - **Yellow** denotes wider uncertainty that may be possible, but which is outside of the considered wisdom for the scenario (yellow for 'Caution'). If you move a slider into this area, the socio-economic scenario name changes to "User-defined".
    - **Red**, denotes the 'No-go' zone which, for obvious reasons, a user is not permitted to enter.

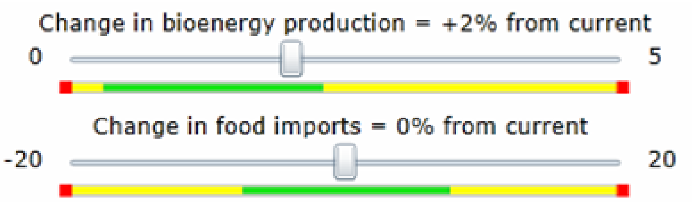


Figure 3.3: Example of the slider structure.

How to find and select outputs (drop-down Indicator structure)

Results from the series of linked models are made available as soon as each model finishes (see Figure 1.1 for the order in which the models run), so that you don't have to wait for the last model before you start viewing results. Figure 3.4 shows the key areas within the Impacts screen for viewing the outputs. You can view model outputs as absolute values or as relative changes from the baseline to see where changes have occurred.

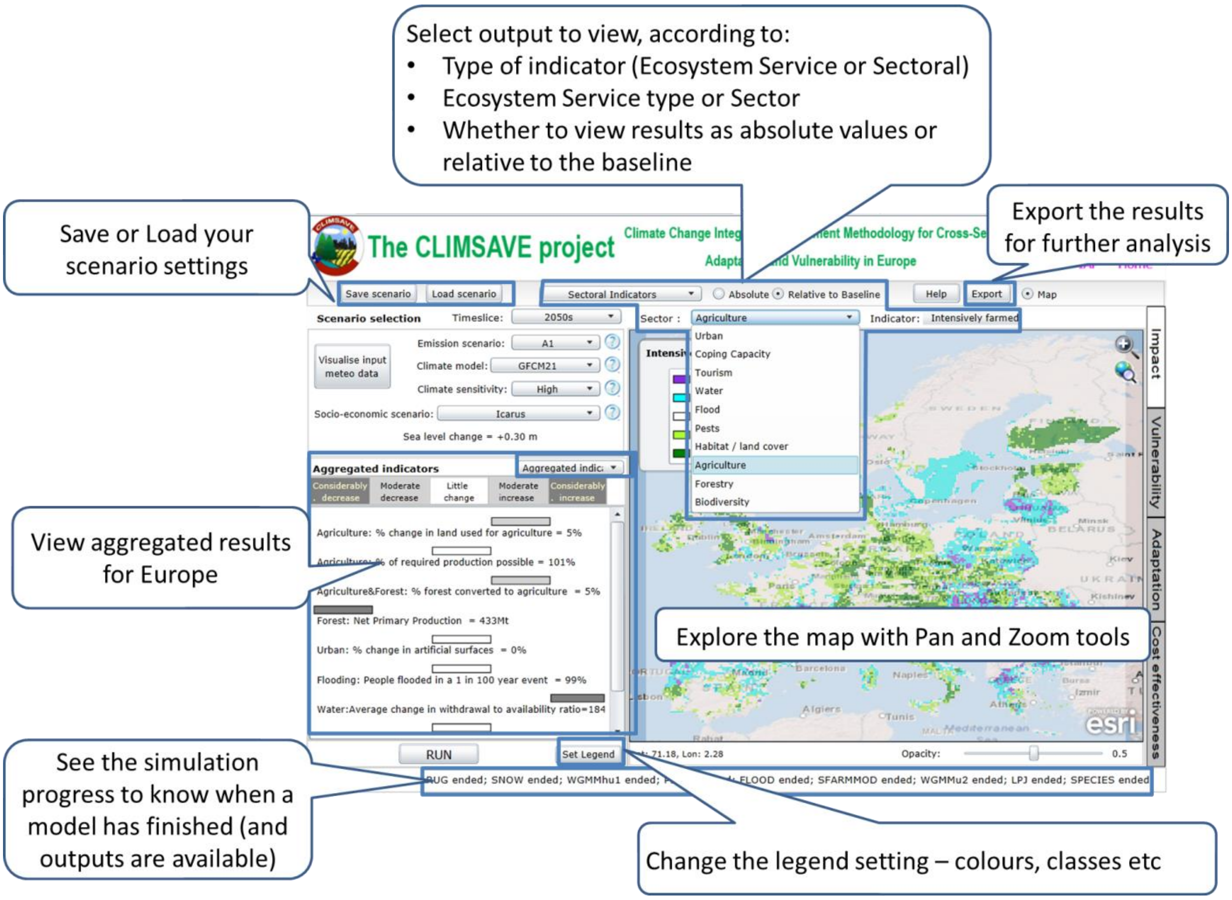


Figure 3.4: Viewing the outputs from the Impacts screen.

Outputs are found by ecosystem service (provisioning, regulating and cultural services), if the "Ecosystem services indictors" is selected (Table 3.1), or by sector (Urban, Tourism, Water, Pests, Flood, Habitat / land cover, Agriculture, Forestry, Biodiversity, Coping capacity), if the "Sectoral indicators" are selected (Table 3.2). They can also be exported as a Comma Separated Value (.csv) file for further analysis.

To provide a European level overview of the multi-sectoral impacts of your scenario, the aggregated indicators (Figure 3.4) provide a qualitative indication of the significance of the changes in each sector.

You can keep a record of your IA Platform settings (scenarios, slider and button settings) for a particular run if you "Save scenario" (which can be re-loaded) or if you "Export" results.

Table 3.1: Menu structure for the outputs if the Ecosystem Services Indicators are selected.

Type of Ecosystem Service	Service	Indicator
Provisioning services	Food	Food production
		Wild plants
	Water	Drinking water
		Irrigation water used
		Cooling water
	Raw materials	Fibre production
		Timber production
Regulating services	Climate regulation	Potential forest carbon balance
	Flood regulation	Flood protection
	Water flow regulation	Water storage in river basin
		Water flow regulation
		Potential Forest Water storage in soil
	Pollination	Pollinator species suitability
Cultural services	Aesthetic / sense of place/ heritage	Natura 2000 sites/Protected areas
		Naturalness
	Recreation & tourism	Charismatic or iconic wildlife
		Species for hunting
		Skiing days

Health warning

The CLIMSAVE IA Platform is not intended for detailed, local scale assessments. Do not zoom in to look at individual or small groups of grid squares.

Description of sliders – what they represent and what they do?

The effect of changing slider values on the impacts is not always intuitive, because of indirect interactions and also due to the effect that a change might have on other objectives. For example, you might increase the area of set-aside (i.e. agricultural land that is not used to produce food) to represent greater biodiversity concern in your scenario, but, whilst this might have local biodiversity gains within the set-aside area itself, the same amount of food still needs to be produced to feed the population within the scenario, so the overall agricultural area will increase to compensate, at the expense of non-agricultural areas. Table 3.3 describes how changing a slider acts upon the models.

Table 3.2: 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		✓	✓

Table 3.3: Explanation of the sliders and their behaviour.

Tab and Slider	Meaning	What it does if you <u>increase</u> the setting
Social:		
1. Population change	1. Change in Population, in % of current.	1. More people, leading to increased urbanisation, demand for water and food; spatial distribution may influence flood impacts.
2. Water savings due to behavioural change	2. Water savings due to behavioural change to use less water (negative values imply increasing water use due to more water-intensive behaviour).	2. Reduce domestic water demand; make water available for other uses (if needed)
3. Change in dietary preference – beef/lamb	3. Reflects the change in preference and demand for largely grass-fed meat.	3. Likely to increase grassland area.
4. Change in dietary preferences - chicken/pork	4. Reflects the change in preference and demand for largely grain-fed meat	4. Likely to increase arable area.
5. Household externalities preference	5. Reflects people's relative desire to live in rural areas with access to green space (1), or urban areas with access to social facilities (5).	5. Expansion of existing urban areas (rather than urbanisation of the countryside).
Technological:		
1. Change in agricultural mechanisation	1. Change in the amount of labour-saving mechanisation.	1. Reduces cost of production leading to changes in relative profitability of different arable crops and changes in crop selection.
2. Water savings due to technological change	2. Water savings in domestic and industrial water demand due to technological improvements.	2. Reduce domestic/industrial water demand; make water available for agriculture (if needed).
3. Change in agricultural yields	3. Changes in crop yields due to crop breeding and agronomy (leading to increases) or environmental priorities (leading to decreases).	3. Increases the amount of food produced per unit of land, so less agricultural area is needed to meet the same level of food demand.
4. Change in irrigation efficiency	4. Changing the amount of water used to produce a fixed amount of food.	4. Increases the amount of food produced per unit of water, making irrigation more profitable and increasing irrigation water use (if water is available).
Economic		
1. GDP change (% from current)	1. Change in Gross Domestic Product, relative to 2010.	1. Society is wealthier, consuming more water; labour costs are higher so making food production more expensive; increased flood damages.

2. Change in oil price (% from current) 3. Change in bioenergy production (% from current) 4. Change in food imports (% from current)	2. Change in oil price, relative to 2010. 3. Represents more land allocated to agricultural bioenergy and biomass crops (and so less for food and nature) or vice versa. 4. Change in food imports, relative to 2010.	2. Increases agricultural input costs of, for example, fertiliser and sprays, leading to changes in relative profitability of different arable crops and changes in crop selection. 3. More agricultural produce is used for non-food uses, so potentially more land is needed to feed people. 4. More imports means less home production required and potentially reduced agricultural land.
Environmental: 1. Set-aside 2. Reducing diffuse source pollution from agriculture 3. Coastal flood event 4. Fluvial flood event 5. Forest management	1. Proportion of arable land set-aside for biodiversity. 2. Reducing crop inputs, such as fertiliser N and pesticides. 3. The coastal flood event return period for which flooding impacts are calculated. 4. The fluvial flood event return period for which flooding impacts are calculated. 5. Dominant management approach for each tree species - optimum, even-age (clearfelling and re-planting to give uniform age distribution) or uneven-aged (patch cutting and planting to produce age distribution).	1. Takes land out of food production, so more agricultural land is needed to maintain food production 2. Leads to reduced crop yields, so more agricultural land is needed to maintain the level of food production. 3. Changes the coastal flood event for which flood impacts are calculated; affects the land available for agriculture. 4. Changes the fluvial flood event for which flood impacts are calculated. 5. Changes the economic viability of managed forest.
Policy governance: 1. Compact vs. sprawled development (BUTTON) 2. Attractiveness of coast (BUTTON) 3. Water demand prioritization (DROP-DOWN)	1. Planning policy to control urban expansion, and so protect land availability for food and biodiversity through, for example, planning restrictions and requirements, tax measures. 2. Preference for living at the coast. 3. How water should be prioritised when demand is greater than availability (giving priority to food production, environmental needs or domestic/industrial needs).	1. High = new urban areas required to house increased or wealthier population are increasingly dispersed around the countryside Low = *vice versa.* 2. High = new urban areas required to house increased or wealthier population are increasingly focussed in coastal areas. Low = *vice versa* 3. N/A

4. Level of Flood Protection (BUTTON)	4. No flood protection – exploratory option that assumes there are no flood defences in place, Minimum represents indicative estimates of flood protection based on land use/land cover and available flood protection data (lower range = default option); and Maximum represents indicative estimate of flood protection based on land use/land cover and available flood protection data (upper range).	4. Maximum = higher flood protection will be applied and it reduces the socio-economic impacts, and may influence the environmental impacts.
Capitals: 1. Human capital 2. Social capital 3. Financial capital 4. Manufactured capital	1. Human capital includes the health, knowledge, skills and motivation of individuals, as well as their individual emotional and spiritual capacities. It broadly covers areas of education, job experience, skills and health. Human capital can be used for adaptation by, for example, using skills to provide early warning or providing training. 2. Social capital consists of the structures, institutions, networks and relationships that enable individuals to maintain and develop their human capital in partnership with others, and to be more productive when working together than in isolation. It includes families, communities, businesses, trade unions, voluntary organisations, legal/political systems and educational and health institutions. Social capital can be used for adaptation by, for example, setting up voluntary organisations for emergency help. 3. Financial capital reflects the productive power of the other forms of capital and enables them to be owned and traded. However, unlike other types, it has no or only little intrinsic value, and reflects the ability of a nation to claim resources by calling in debts from overseas. 4. Manufactured capital consists of material goods, tools, machines, buildings and other forms of infrastructure that contribute to the production process but do not become embodied in its output. Manufactured capital can be created for adaptation by building dams, water pipelines, sea-walls, hospitals, roads, etc.	1-5. Increasing capital has no effect on the Impacts (but it does affect adaptive capacity (used in the Adaptation screen) and coping capacity (used in the Vulnerability screen).

4. Adaptation screen

Purpose: To investigate how adaptation can reduce the impacts of climate change in your scenario.

Key definitions:

- ***Adaptive capacity***: The ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
- ***Adaptation***: Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Steps to use / set-up

The adaptation screen maintains most of the design features of the Impacts screen (Figure 4.1).

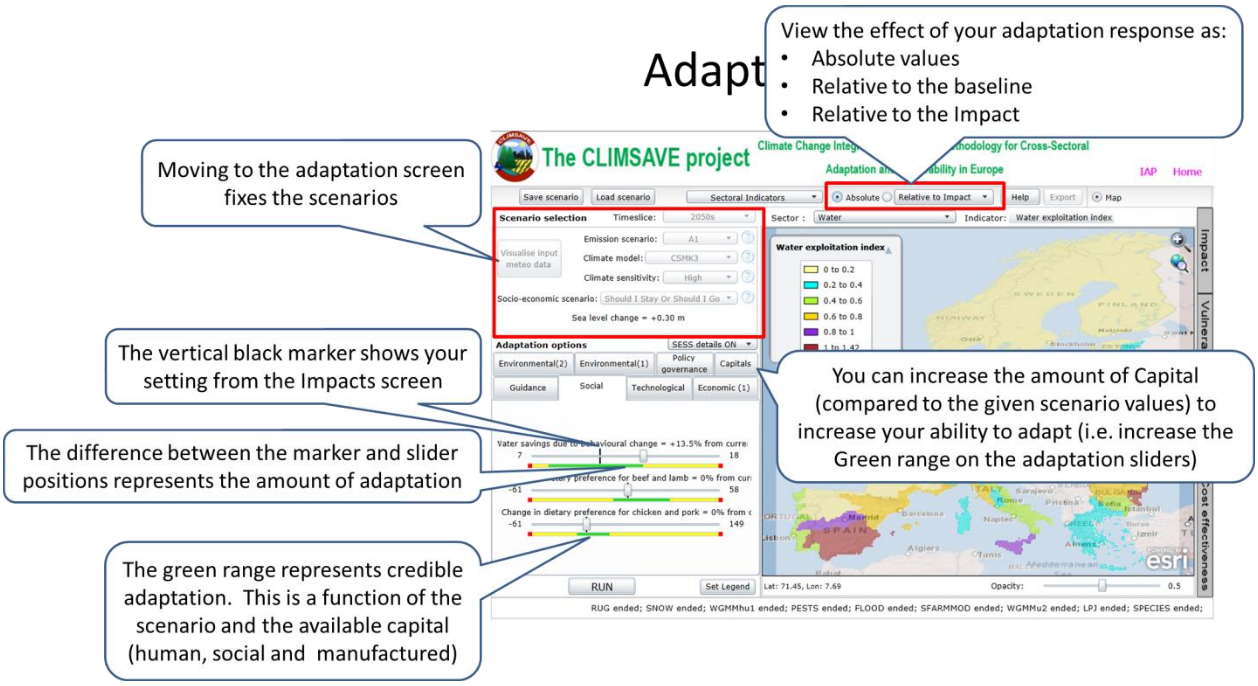


Figure 4.1: Overview of the Adaptation screen.

To run the IAP in the Adaptation screen (based on any unacceptable changes in the indicators due to climate and/or socio-economic change identified in the Impacts screen):

1. Identify sliders / buttons that are likely to act upon that impact (using the guidance in Tables 3.3 and 4.2):
    a. Note: some sliders which cannot be adaptation measures, such as GDP change or population change are omitted in the Adaptation screen.
2. Change the slider or button settings, keeping within the Green zone.
3. Run the model.

4. View the effects of your adaptation response, by comparing your indicator to either the:
    a. Baseline ("Relative to Baseline") to see if adaptation has improved the indicator compared to the current situation; or
    b. Scenario ("Relative to Impact") to see if adaptation has improved the indicator compared to the scenario situation without adaptation.
5. If the changes to the indicator are still unacceptable, you could:
    a. Further increase the amount of adaptation, keeping within the Green range;
    b. Increase Capital availability, which can increase the Green range enabling greater adaptation (Figure 4.2); but you need to think about how would this be achieved;
    c. Further increase the amount of adaptation into the Yellow range; but you need to think whether that feasible in your scenario.

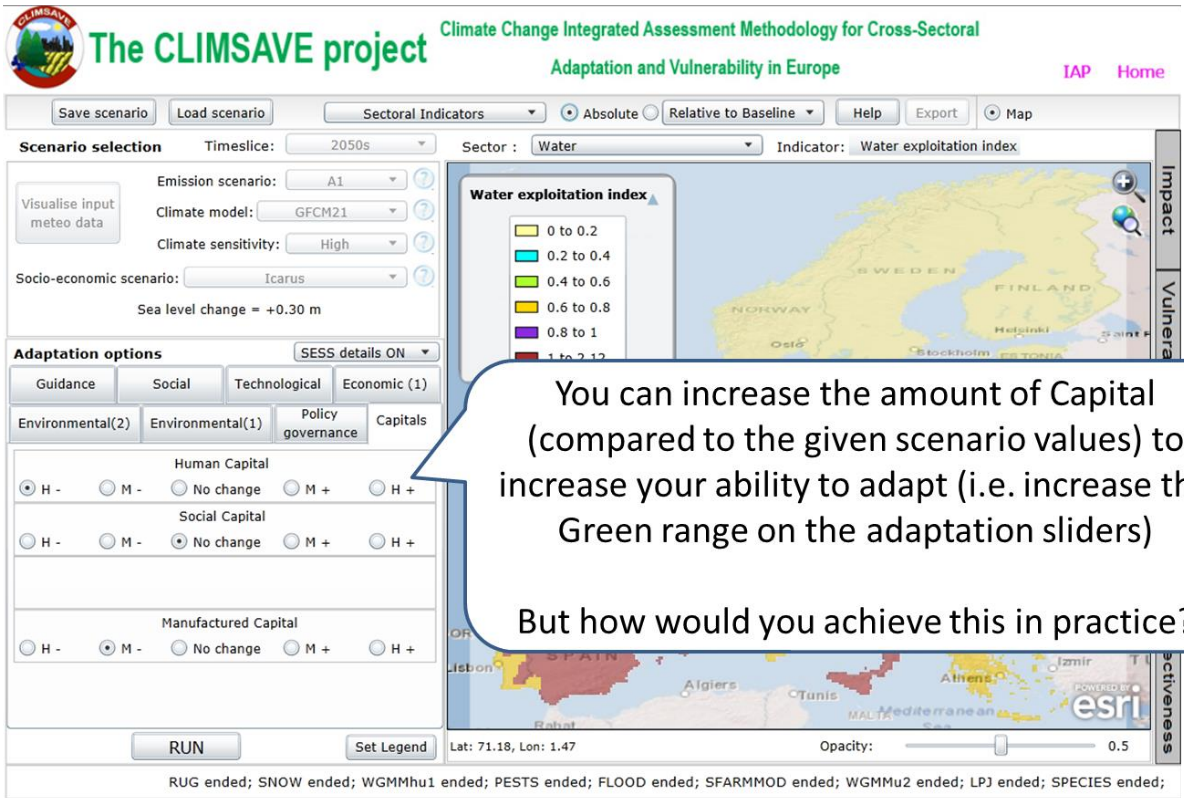


Figure 4.2: Increasing the availability of capitals increases your adaptive capacity.

Understanding the sliders and green/yellow/red ranges

The sliders on the Adaptation screen appear similar to those on the Impacts screen, although some Impacts sliders are missing as they do not represent adaptation responses, e.g. population change. However, the size of the green zone (in this case, the adaptation range) will be less than in the Impacts screen (Table 4.1) according to:

- The adaptive capacity of the scenario, based on the amount of the particular capital which is likely to be limiting for a given adaptation response (Table 4.2);
- The likely importance of the given adaptation response within the socio-economic scenario.

Table 4.1: Matrix to assess the percentage of the green Impacts range that can be realised by adaptation.

Importance of adaptation option:	Adaptive capacity (based on class of limiting capital)				
	Very low	Low	Medium	High	Very High
Low	5	10	25	50	75
Medium	10	25	50	75	90
High	25	50	75	90	95

Table 4.2a: The limiting capital and importance of each adaptation option within the European CLIMSAVE scenarios.

	Limiting capital	We Are The World	Icarus	Should I Stay or Should I Go	Riders on the Storm
Social:					
Water savings due to behavioural change	Human	High	Low	Low	High
Change in dietary preference – beef/lamb	Human	Medium	High	High	High
Change in dietary preferences - chicken/pork	Human	Medium	High	High	High
Technological:					
Improvement in agricultural mechanisation	Manufactured	Medium	Low	Medium	Medium
Water savings due to technological change	Human	High	High	High	High
Change in agricultural yields	Human	High	Low	High	Medium
Improvement in irrigation efficiency	Financial	High	Low	High	High
Economic:					
Change in bioenergy production	Natural	Medium	Low	High	Low
Change in food imports (% from current)	Human	High	Low	High	High
Environmental(1):					
Set-aside	Human	High	Low	Low	Medium
Reducing diffuse source pollution from agriculture	Human	Medium	Low	Low	High
Plant climate-resilient tree species*	Social	Low	Low	High	High
Forest management*	Social	Low	Low	High	High
Environmental(2):					
Protected area (PA) change	Natural	High	Low	Low	Medium
Change in protected area forest	-	-	-	-	-
Change in protected area agriculture	-	-	-	-	-
Method for allocating protected area	Social	-	-	-	-
Policy governance:					
Spatial planning for urban sprawl*	Social	High	High	High	Medium
Spatial planning for coastal development*	Social	High	High	Medium	Low
Water demand prioritization*	Social	High	Medium	High	Low
Flood risk management adaptation approach*					
• Flood protection upgrade	Financial	High	Low	High	High
• Retreat of flood defences	Social	High	High	High	Medium
• Implement flood resilience measures	Financial	High	Low	High	High
• Implement a mixed response of flood measures	-	-	-	-	-

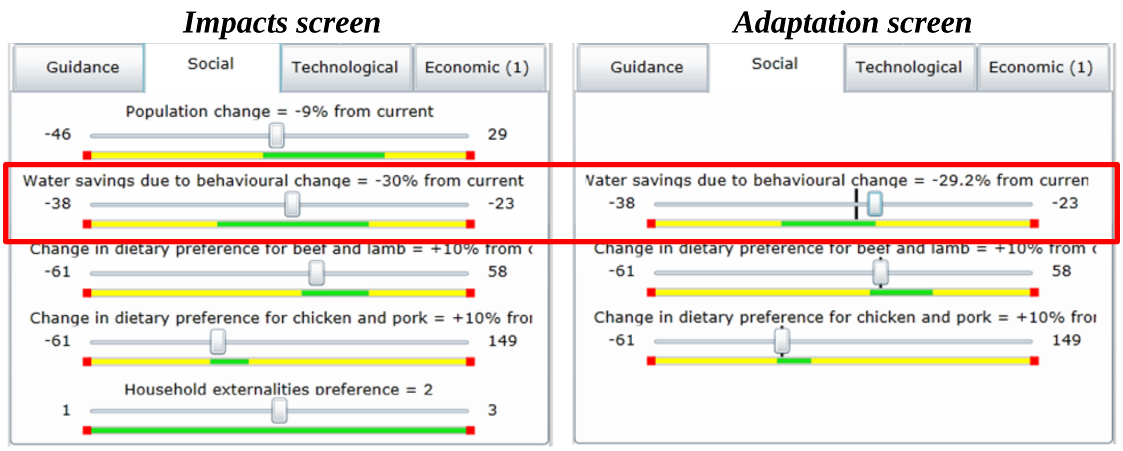
* Adaptation range is not limited in the IA Platform for these options

Table 4.2b: The limiting capital and importance of each adaptation option within the Scottish CLIMSAVE scenarios.

	Limiting capital	Tartan Spring	Mad Max	The Scottish Play	MacTopia
Social:					
Water savings due to behavioural change	Human	High	Low	Medium	Low
Change in dietary preference – beef/lamb	Human	Low	Low	Low	Medium
Change in dietary preferences - chicken/pork	Human	Low	Low	Low	Medium
Technological:					
Improvement in agricultural mechanisation	Manufactured	High	High	Medium	Medium
Water savings due to technological change	Human	Medium to Low	Low	High	Medium
Change in agricultural yields	Human	High	High	High	High
Improvement in irrigation efficiency	Financial	Low	High	High	Medium
Economic:					
Change in bioenergy production	Natural	Low	Low	Low	Low
Change in food imports (% from current)	Human	Low	Low	High	Low
Environmental(1):					
Set-aside	Human	Low	Low	Low	High
Reducing diffuse source pollution from agriculture	Human	Low	Low	Medium	High
Plant climate-resilient tree species*	Social	High	Low	Medium	Medium
Forest management*	Social	High	Low	Medium	Medium
Environmental(2):					
Protected area (PA) change	Natural	Low	Low	Low	High
Change in protected area forest	-	-	-	-	-
Change in protected area agriculture	-	-	-	-	-
Method for allocating protected area	Social	-	-	-	-
Policy governance:					
Spatial planning for urban sprawl*	Social	Low	High	High	High
Spatial planning for coastal development*	Social	Low	Low	High	High
Water demand prioritization*	Social	Industry	Food & industry	Medium	Low
Flood risk management adaptation approach*					
• Flood protection upgrade	Financial	Medium	Medium	Low	Medium
• Retreat of flood defences	Social	Low	Low	Low	High
• Implement flood resilience measures	Financial	Medium	Low	High	High
• Implement a mixed response of flood measures	-	-	-	-	-

* Adaptation range or options are not limited in the IA Platform

Figure 4.3: Example of the effect of limiting the adaptation range for a low importance option in a greatly reduced human capital scenario – water savings due to behavioural change can only change from -30% to ~-29% (a 1 % saving).



Health warning
The sliders on the adaptation screen represent the combined effects of multiple possible adaptation measures. You should consider whether it is achievable to implement the modelled adaptation?

Description of sliders – what they represent and what they do?

The effect of changing slider values to represent adaptation on the impacts is not always intuitive, because of cross-sectoral interactions and also due to the effect that a change might have on other objectives. For example, you might increase irrigation efficiency to reduce water scarcity in your scenario, but, whilst this will decrease the amount of water needed to irrigate a fixed area of land, this action makes irrigated agriculture more profitable (because water is not free). As a result, a greater area of land may become irrigated if water is available leading to an overall increase in agricultural water use. Table 4.3 describes how changing a slider acts upon the models.

Table 4.3: Impacts on the models of changes in the IA Platform's adaptation sliders.

Adaptation option	Examples of adaptation measures	Direction of slider change	What it does if you change the setting
Social:			
1. Water savings due to behavioural change	1. Promoting behavioural change to reduce domestic water demand through, for example, education, training, water pricing.	→	1. Reduces domestic water demand; makes water available for other uses (if needed).
2. Change in dietary preference – beef/lamb	2. Reducing consumption of grass-fed meat in response to food shortages through, for example, education, pricing policy, rationing.	←	2. Likely to decrease grassland area.
3. Change in dietary preferences - chicken/pork	3. Reducing consumption of grain-fed meat in response to food shortages through, for example, education, pricing policy, rationing.	←	3. Likely to decrease arable area.
Technological:			
1. Improvement in agricultural mechanisation	1. Improving agricultural mechanisation to reduce production costs.	→	1. Makes agriculture more efficient so that costs are lower and better able to compete in high cost futures.
2. Water savings due to technological change	2. Using technology to reduce industrial and domestic water demand through, for example, better water efficiency, leakage reduction, etc.	→	2. Reduces domestic/ industrial water demand; makes water available for agriculture (if needed).
3. Change in agricultural yields	3. Increasing yields by plant breeding and agronomy.	→	3. Increases the amount of food produced per unit of land, so either allows food demand to be met or reduces the agricultural area needed to meet food demand.
4. Improvement in irrigation efficiency	4. Changing the amount of water used to produce a fixed amount of food through, for example, more efficient irrigation methods, crop breeding.	→	4. Increases the amount of food produced per unit of water, making irrigation more profitable and increasing irrigation water use (if water is available).

Economic: 1. Change in bioenergy production 2. Change in food imports (% from current)	1. Increasing the demand for crops to be used for bioenergy and biomass (and so less for food and nature). 2. Change how much of Europe's food demand is met by imports	→ ←→	1. Allocates more land to agricultural bioenergy and biomass crops (and so less for food and nature) or vice versa. 2. Decrease – encourage food self-sufficiency, but reduce European land availability for biodiversity, or; Increase imports, but make Europe more vulnerable to external crop failures.
Environmental(1): 1. Set-aside 2. Reducing diffuse source pollution from agriculture 3. Plant climate-resilient tree species 4. Forest management	1. Changing the percentage of arable land removed from production for environmental benefits or to regulate production through, for example, agri-environment options. 2. Changing agricultural practices to reduce water pollution through, for example, fertiliser restrictions, pesticide taxes. 3. Planting tree species which are better suited to the changing climate. 4. Changing forest management practices - to intensive management for timber production with lower nature and recreation values (even-age), or to lower intensity management with good nature and recreation values and reasonable timber production (uneven-aged or selective felling)	←→ ← Drop-down Drop-down	1. Increase: takes on-farm agricultural land out of food production, so expansion of agricultural area is needed to maintain food production. Decrease: takes on-farm biodiversity areas back into food production, so reduced overall agricultural area is needed to maintain food production (if demand can be met). 2. Leads to reduced crop yields, so more agricultural land is needed to maintain food production. 3. Increases the productive forest yield, making forestry more profitable. 4. Changes the profitability of forestry.
Environmental(2): 1. Protected area (PA) change 2. Change in protected area forest	1. Change the total amount of protected area within the case study. This prevents socio-economic pressures from contributing to land-use change in these areas. Protected area cannot however prevent changes resulting from climatic factors taking place. 2. There are three land uses that are targeted for expanding protected areas, these are forests, extensive agriculture (grasslands) and unmanaged land. The forest and agriculture sliders determine the extent to which protected areas deliberately target these land uses. The remainder is targeted at unmanaged land.	←→ →	1. Increase the area of land that retains its current land use in the face of socio-economic pressures. 2. Less decline in forest area.

3. Change in protected area agriculture 4. Method for allocating protected area	3. As 2 4. Choice as to whether the new protected area targets areas with no current protected area (enhancing connectivity) OR whether the new protected areas build on existing protected areas (buffering) OR a combination of the two.	➔ Button	3. Less decline in areas of extensive agriculture. 4. Connectivity -> modify land use change in areas with existing protected area. Buffering -> modify land use change in areas without existing protected area.
Policy governance: 1. Spatial planning for urban sprawl (BUTTON) 2. Spatial planning for coastal development (BUTTON) 3. Water demand prioritization (DROP-DOWN) 4. Flood risk management adaptation approach: • Flood protection upgrade • Retreat of flood defences • Implement flood resilience measures • Implement a mixed response of flood measures	1. Planning policy to control urban expansion, and so protect land availability for food and biodiversity. 2. Discouraging coastal development to reduce exposure to coastal flooding through, for example, planning controls and insurance availability for new properties. 3. Prioritising how water should be allocated when demand is greater than availability (for food, environment, domestic or industrial). 4. Adapt by: • Improving the standard of flood defences to reduce flooding, by building/ maintaining flood defences, improving defence heights. • Allow managed re-alignment where flood defences are moved inland to allow creation of coastal wetlands. • Implement structural flood resilience measures to reduce damages from flooding, such as raising new houses. • Implement both re-alignment of defences (for habitat creation) and upgrade of flood defences to reduce flood risk.	Low Low 3a. Baseline; or Prioritising: ... 3b. Food production 3c. Environmental needs 3d. Domestic/ industrial needs 3e. Sector with highest demand 3f. Provision of drinking water 3g. Provision of cooling water 3h. Food production and environmental needs 3i. Test demand Drop-down	New urban areas required to house increased or wealthier population are increasingly concentrated in/around existing urban centres. New urban areas required to house increased or wealthier population are focussed away from coastal areas. 3a. Relative share of sector as today. 3b. Agriculture is allowed to use up to 80% of water available. 3c. Same as "Baseline" but environmental flows are maintained. 3d. Domestic/industry is allowed to use up to 80% of available water. 3e. Today's biggest water consumer is allowed to use up to 80% of available water. 3f. Domestic is allowed to use up to 80% of available water. 3g. Cooling in electricity production is allowed to use up to 80% of available water. 3h. Agriculture is allowed to use up to 80% of available water, while environmental flows are maintained. 3i. Ignore limits of renewable water resources (e.g. unsustainable use of groundwater). Reduces flood impacts. Creates wetland habitat, usually at expense of agriculture. Reduces flood impacts, by reducing flood damages. Reduces flood impacts and creates habitats.

5. Vulnerability screen

Purpose: To investigate which areas or 'hot spots' in Europe or Scotland may be vulnerable to climate change in your scenario, before and/or after adaptation.

Key definitions:

- ***Impact***: Consequences of climate change on natural and human systems, but depending on whether this is before or after adaptation, one can distinguish between potential impacts and residual impacts.
- ***Potential impacts***: The impacts of climate change that would occur without considering adaptation.
- ***Residual impacts***: The impacts of climate change that would occur after adaptation.
- ***Vulnerability***: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change.
- ***Coping capacity***: The ability of a system to absorb the effects of climate change without producing significant impacts.

Overview of screen design / functionality

The CLIMSAVE project defines vulnerability as being a function of Impacts and Coping Capacity (Figure 5.1). The Vulnerability screen (Figure 5.2), therefore, combines Impacts before (*Potential Impact*) or after adaptation (*Residual Impact*), which are taken from the outputs from the Impacts and Adaptation screens, respectively, with Coping Capacity to derive Vulnerability.

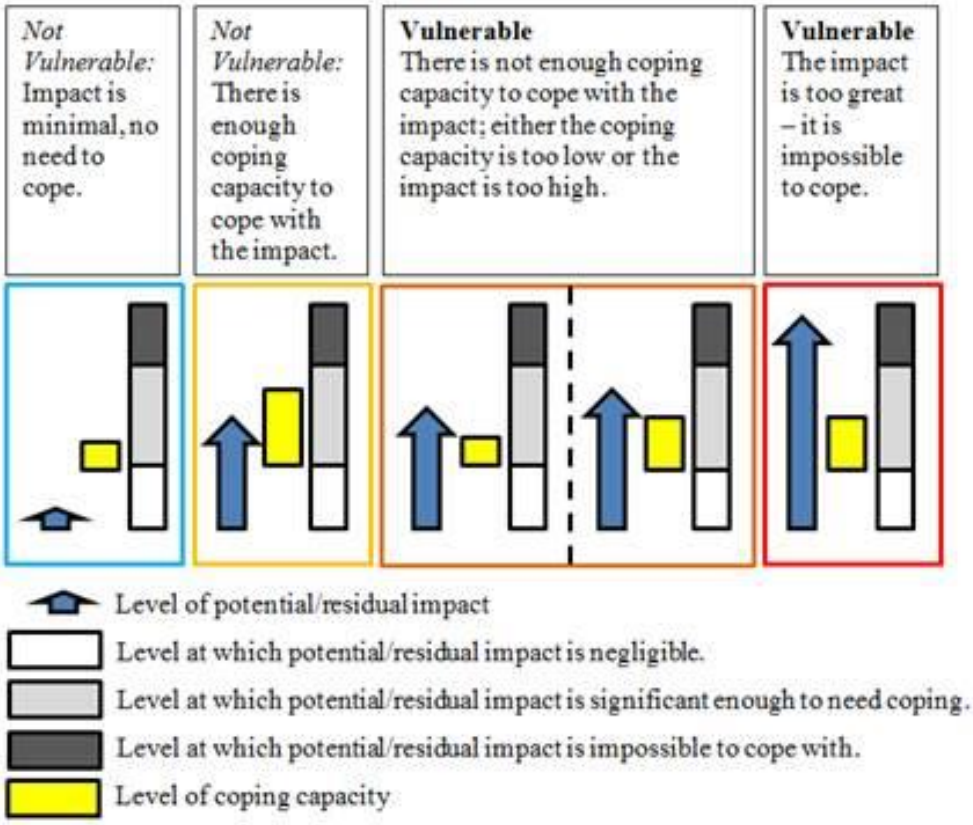


Figure 5.1: Schematic of the vulnerability method.

In essence vulnerability exists where coping capacity is insufficient to cope with the Impacts.

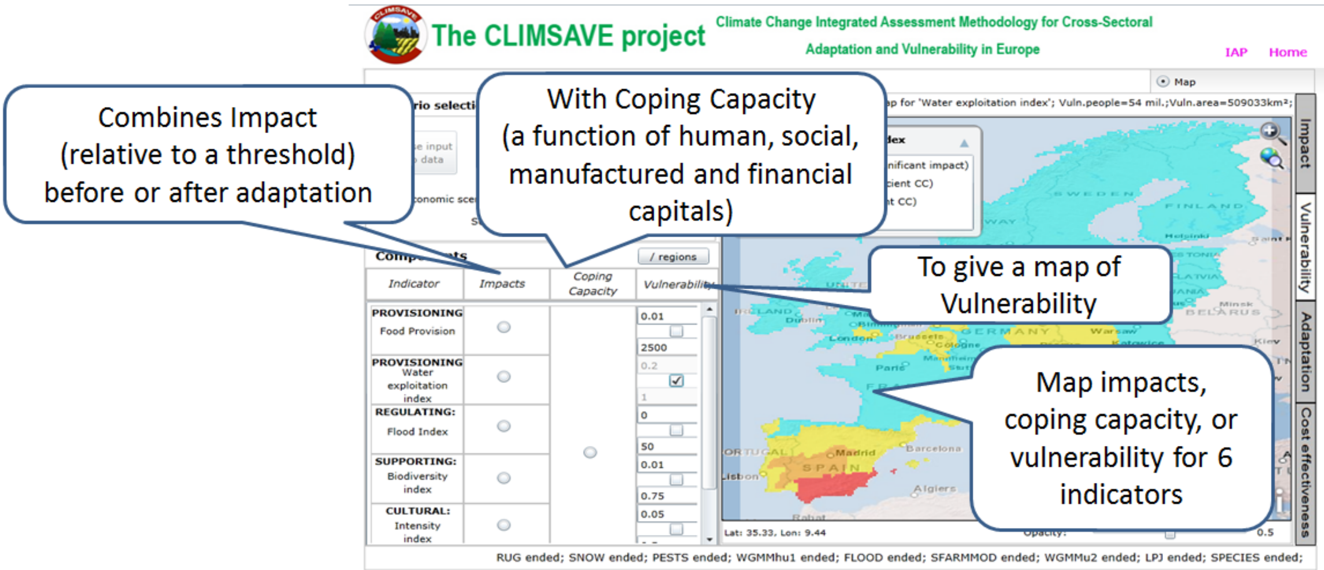


Figure 5.2: Overview of the Vulnerability screen.

Steps to use / set-up

- The scenario settings (timeslice, climate and socio-economic scenario) are fixed from the Impacts or Adaptation screen.
- You can select either to view:
    - Impact – a range of ecosystem service impact indicators covering CLIMSAVE's key sectors can be individually viewed;
    - Coping capacity, based on the aggregation of the four individual capitals (human, social, manufactured and financial capital, which can be viewed on the Impacts screen);
    - Vulnerability of human well-being for a single indicator (Table 5.1) – based on whether the available coping capacity is sufficient to cope with the Impacts;
    - Count of the number of selected indicators (2 to 6) which are either Vulnerable or Highly Vulnerable in each grid cell (Figure 5.3); see Outputs sub-section on page 26 for a definition of these classes.

Table 5.1: Vulnerability indicators.

Indicator	What it represents	How it is calculated
Provisioning services: **Food provision** Scale: Grid cell	The vulnerability of a grid cell in terms of its ability to produce enough calories of food to support its population. Note that it is an index of self-sufficiency at the grid cell level. Transport/import of food would require manufactured or financial capital, and so is reflected by coping capacity.	The total daily calories of all foodstuffs modelled are calculated for the grid cell and divided by the population. The potential for vulnerability begins when there are less than 2500 calories per person per day available. (2500 calories is the male recommended daily allowance).
Provisioning services: **Water exploitation index** Scale: River basin	The vulnerability of a river basin in terms of the proportion of available water resources within that basin that are abstracted for agricultural, domestic or energy production.	The water exploitation index calculated within the IA Platform is compared with expert-derived thresholds. The potential for vulnerability begins when over 20% of the water in a catchment is used.
Regulating services: **Flood index** Scale: River basin	The vulnerability of a grid cell in terms of the number of people modelled to be flooded by a 1 in 100 year (1%) event.	The number of people flooded by both coastal and fluvial flooded is calculated within the IA Platform. The potential for flood vulnerability begins when more than one person is flooded.
Supporting services: **Biodiversity index** Scale: Grid cell	The vulnerability of biodiversity, in general, to changes in both climate and shifting patterns of available habitat.	The biodiversity index uses a selected representative species group of 11 species for Scotland and 12 for Europe. For each grid cell the total number of species with both suitable climate and habitat space is compared with the number of species with suitable conditions at baseline. The potential for vulnerability begins when a single species is lost.
Cultural/ Aesthetic: **Intensity index** Scale: Grid cell	The vulnerability of the provision of natural cultural/aesthetic services as a result of the intensification of land use. More “natural” land uses, such forests, unmanaged land and extensive farmland are considered to provide greater cultural/aesthetic services than urban/intensive land use.	Land uses are scored in the following order of intensity: Urban > Intensive > Extensive > Forest > Unmanaged land. The total score for a grid cell is compared with the value at baseline to determine whether or not the land use has intensified. The potential for vulnerability begins when intensity increases.
Multiple ecosystem services: **Land use diversity index** Scale: Grid cell	Index of the diversity of land use. Areas with a mix of land uses are less vulnerable and score lower than those with few. This reflects the fact that multi-functional landscapes are expected to be more robust to the loss of the ecosystem services associated with any one land use.	One minus the Shannon Index of diversity is calculated using six land use classes (Arable, Intensive grassland, Extensive grassland, Unmanaged, Forest and Urban). Areas with equal proportions score 0 and those which are 100% a specific land use score 1. The potential for vulnerability begins when diversity exceeds 0.6 (equivalent to three approximately equally distributed land uses).

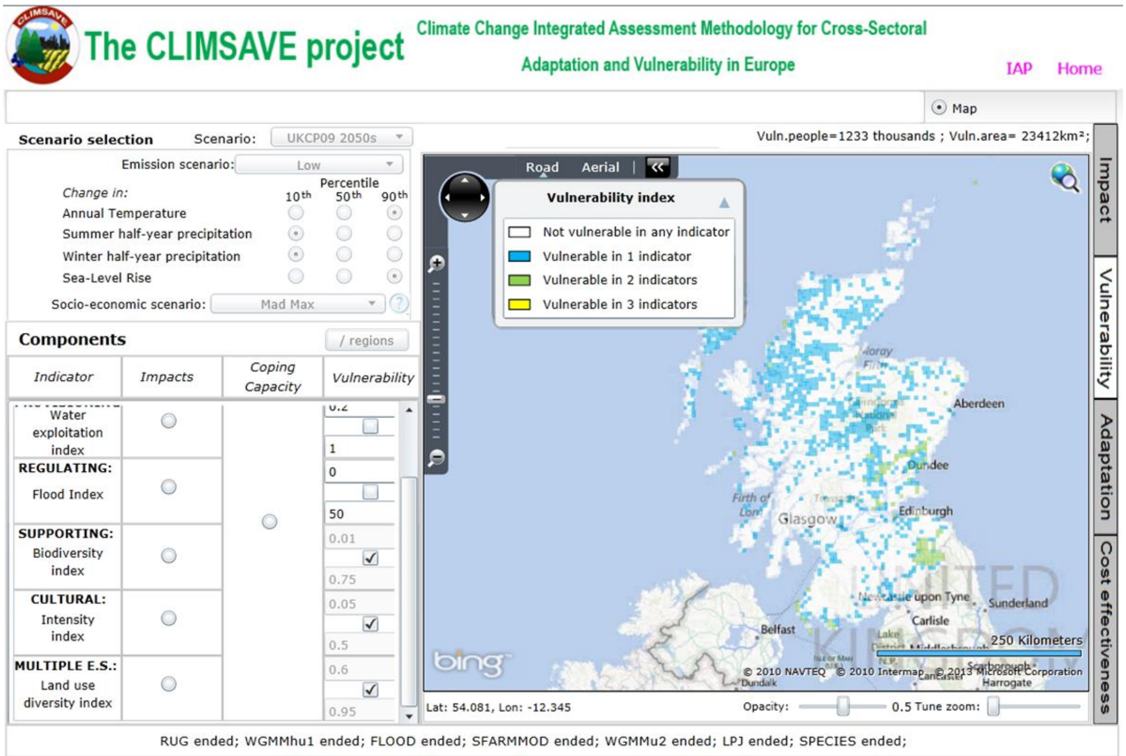


Figure 5.3: Selecting multiple vulnerability indicators to identify vulnerability hotspots.

Outputs

The vulnerability assessment for each of the indictors has four classes:

- Not vulnerable (Insignificant impact) – impacts are sufficiently low that they do not cause any vulnerability (for the selected indicator);
- Not vulnerable (sufficient CC) - impacts are sufficient to potentially cause harm, but society has sufficient Coping Capacity such that the impacts do not lead to vulnerability;
- Vulnerable (insufficient CC) – society has insufficient Coping Capacity to cope with the impacts leading to vulnerability; and
- Highly vulnerable – impacts are so high that society is vulnerable irrespective of the level of Coping Capacity.

<u>Health warning</u>
Whilst the CLIMSAVE project has developed a unique, objective method to assessing vulnerability, it must be recognised that the outputs are only indicative.

6. Cost screen

Purpose: To identify the relative cost of adaptation measures to reduce the impacts of climate change.

Key definitions:

- Cost – a qualitative assessment of the cost of implementation of a measure across a sector, where it is appropriate.
- Potential – a qualitative assessment of the potential contribution an adaptation measure could make to overall effective adaptation in a sector (assuming sufficient Capital availability).
- Limiting Capital – that which will limit the implementation and efficacy of a measure. The colour indicates the level of Capital availability (dark green = very high; yellow = medium; red = very low).
- Cross-sectoral effects – a qualitative assessment of the extent to which an adaptation measure has positive (+) or negative (-) impacts on the state of other sectors and the human benefits derived from them (irrespective of whether these impacts are deliberate or unintended).
- Hard options: technological and engineering solutions.
- Soft options: people-focused solutions (management, behavioural change, policy, etc.).

Steps to use / set-up

The Cost-effectiveness screen (Figure 6.1) maintains the clear link to the scenario settings, and provides a range of qualitative assessments of the cost, potential, limits and cross-sectoral effects for a range of hard (e.g. engineered and technical) and soft (e.g. management, behavioural) options.

To use the screen:

1. Select the adaptation response that you wish to investigate, based upon the adaptation sliders that you have modified in the Adaptation screen;
2. The screen will show qualitative assessments of the cost-effectiveness of a relevant range of 'hard' and 'soft' adaptation measures.

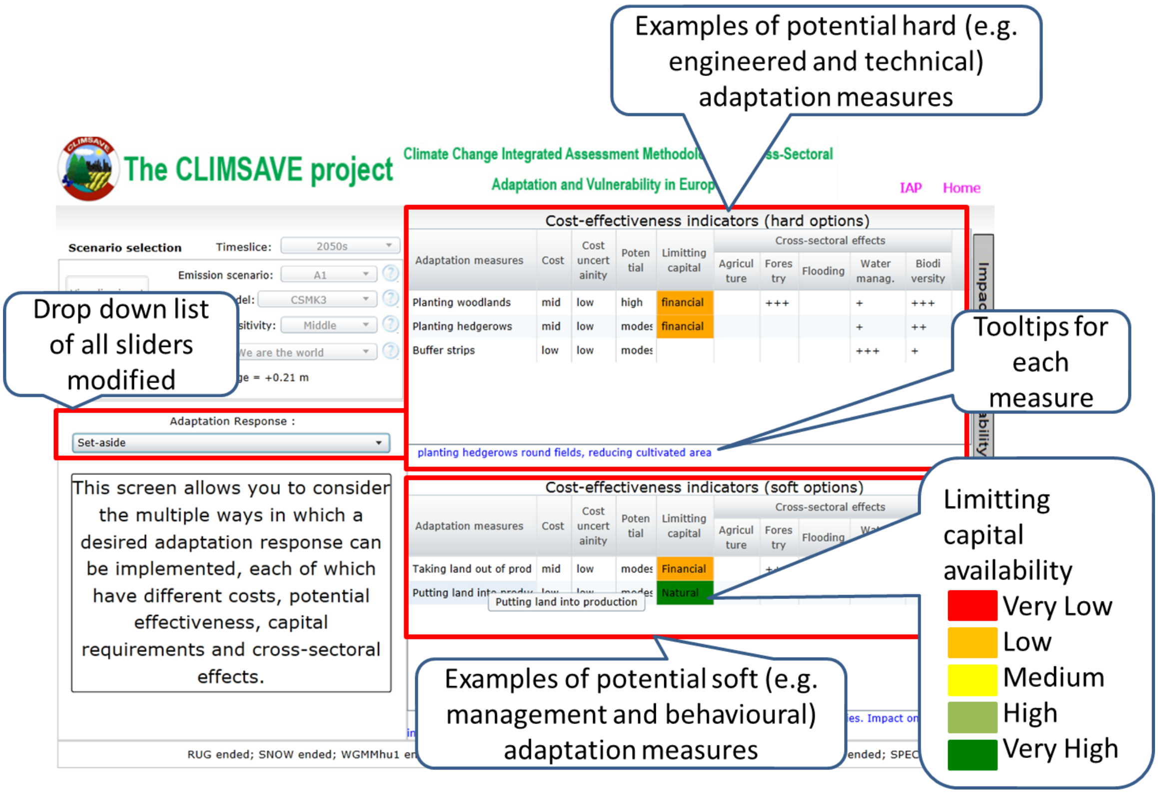


Figure 6.1: Overview of Cost-effectiveness screen design.

Health warning

There is great uncertainty in the costs of adaptation, as there are many local and regional factors that affect the cost of implementing adaptation measures. The underlying cost estimates in the CLIMSAVE IA Platform come from a review of the international literature. As such, the cost estimates should only be considered to be indicative.

7. Concluding remarks

This deliverable describes how stakeholders can use and interpret the outputs from the final Scottish and European versions of the CLIMSAVE IA Platform, in order to interact with the integrated meta-models, IPCC AR4 and UK Climate Projections climate scenarios and the CLIMSAVE socio-economic scenarios. It is anticipated that the use of the CLIMSAVE IA Platforms will help to increase the understanding of the complex issues around climate change adaptation and vulnerability and ultimately contribute towards a better adapted Europe.

Appendices

Appendix 1: GCMs within the European CLIMSAVE IA Platform

In order to capture the uncertainty in future climate change, the CLIMSAVE IA Platform contains outputs from five climate models (HadGEM, GFCM21, IPCM4, CSMK3 and MPEH5). Based on the GCMs used in the CMIP3 project and applied in the IPCC's Fourth Assessment Report, a subset was selected to include:

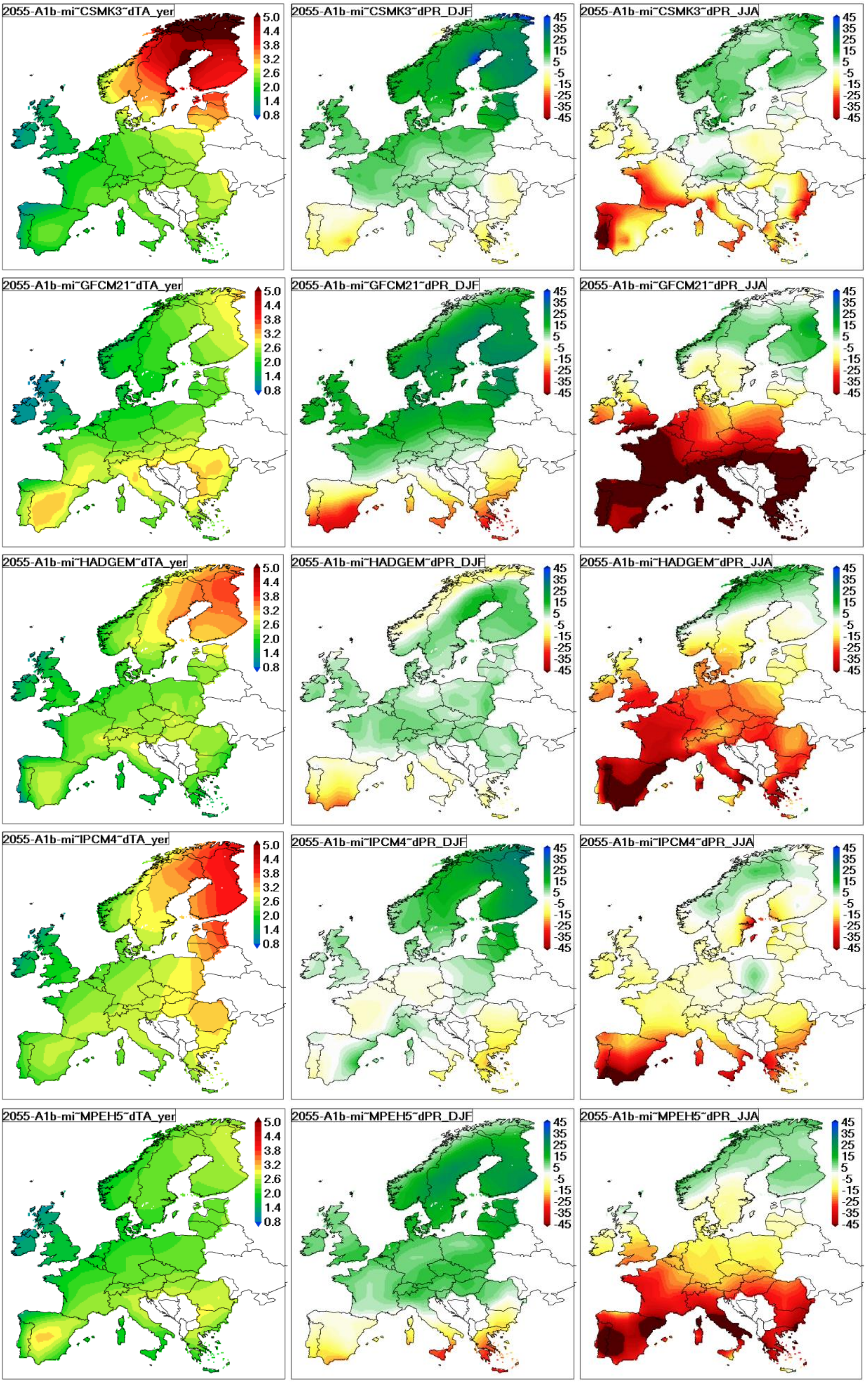
- The GCM with the best ability to reproduce the seasonal cycles of temperature and precipitation in the observed (1961-90) climate [*MPEH5*];
- The GCM which is closest to the multi-GCM mean climate change scenario [*CSMK3*]; and
- The three most diverse GCM is simulating future seasonal temperature and precipitation, representing inter-GCM variability [*HadGEM*, *GFCM21*, *IPCM4*].

Table A1: 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

Figure A1 (on next page): Spatial patterns in projected climate change from (top to bottom) CSMK3, GFCM21, HADGEM, IPCM4, MPEH5 for the 2050s under A1b emissions and medium climate sensitivity.

Change in annual temperature **Change in winter (DJF) precipitation** **Change in summer (JJA) precipitation**



Appendix 2: UK Climate Projections within the Scottish CLIMSAVE IA Platform

In order to capture the uncertainty in future climate change, the Scottish CLIMSAVE IA Platform incorporates a range of climate change scenarios based on the UK Climate Projections 2009 (UKCP09). The UKCP09 scenarios 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, 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 – September) and winter half year (October- March) precipitation change.

Table A2.1: 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 scenario.

Emissions	Annual temperature change percentile	Annual temperature change (°C)	Summer half-year precipitation change (%)			Winter half-year precipitation change (%)			Sea level rise (cm)		
			10th	50th	90th	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	8	16	23
	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	10	19	29
	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	12	24	36
	90th	3.3	-12.0	-4.3	3.6	7.0	15.4	24.3			

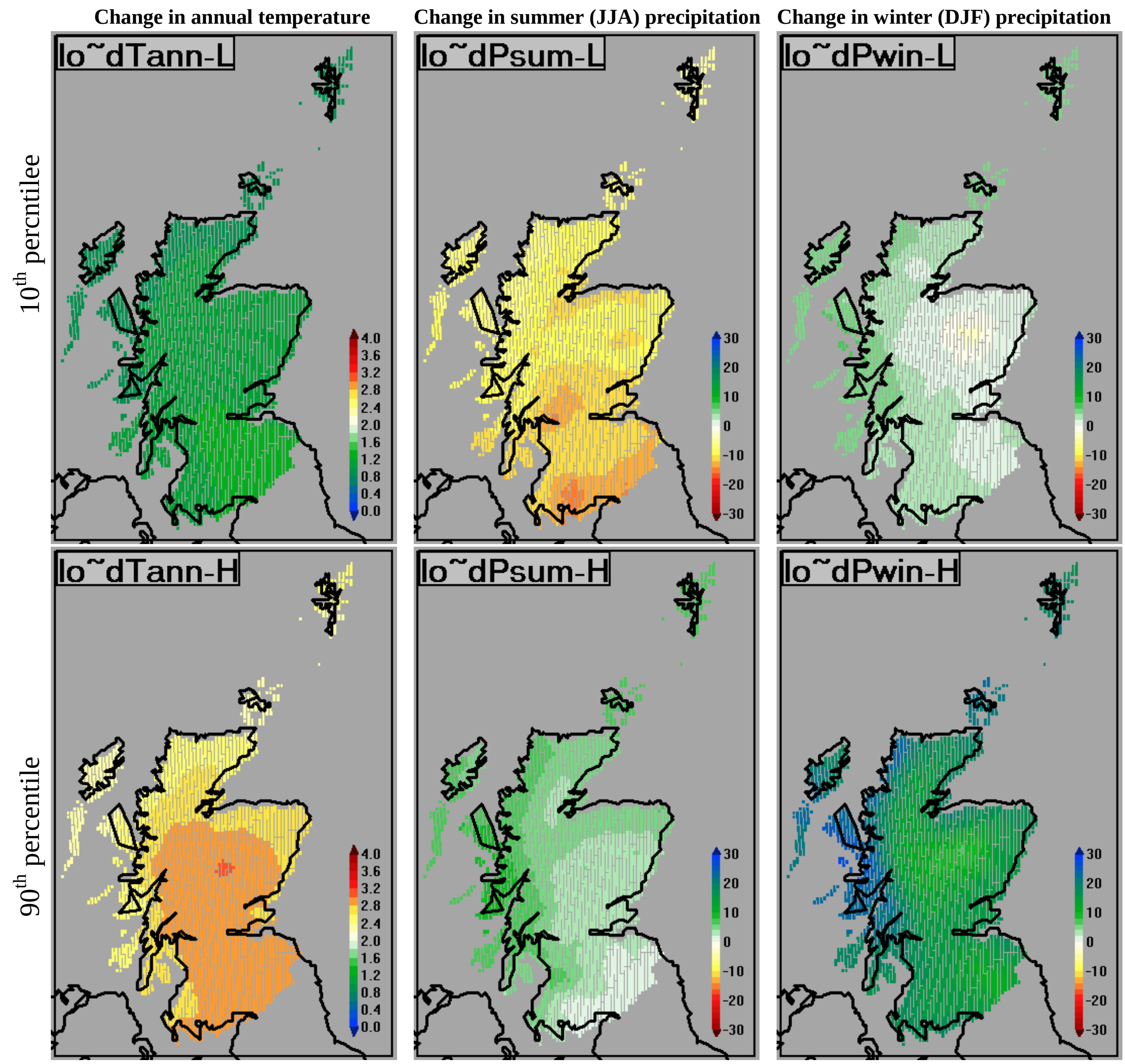


Figure A2.1: Spatial patterns in projected climate change for the 2050s under Low emissions (from UK Climate Projections).

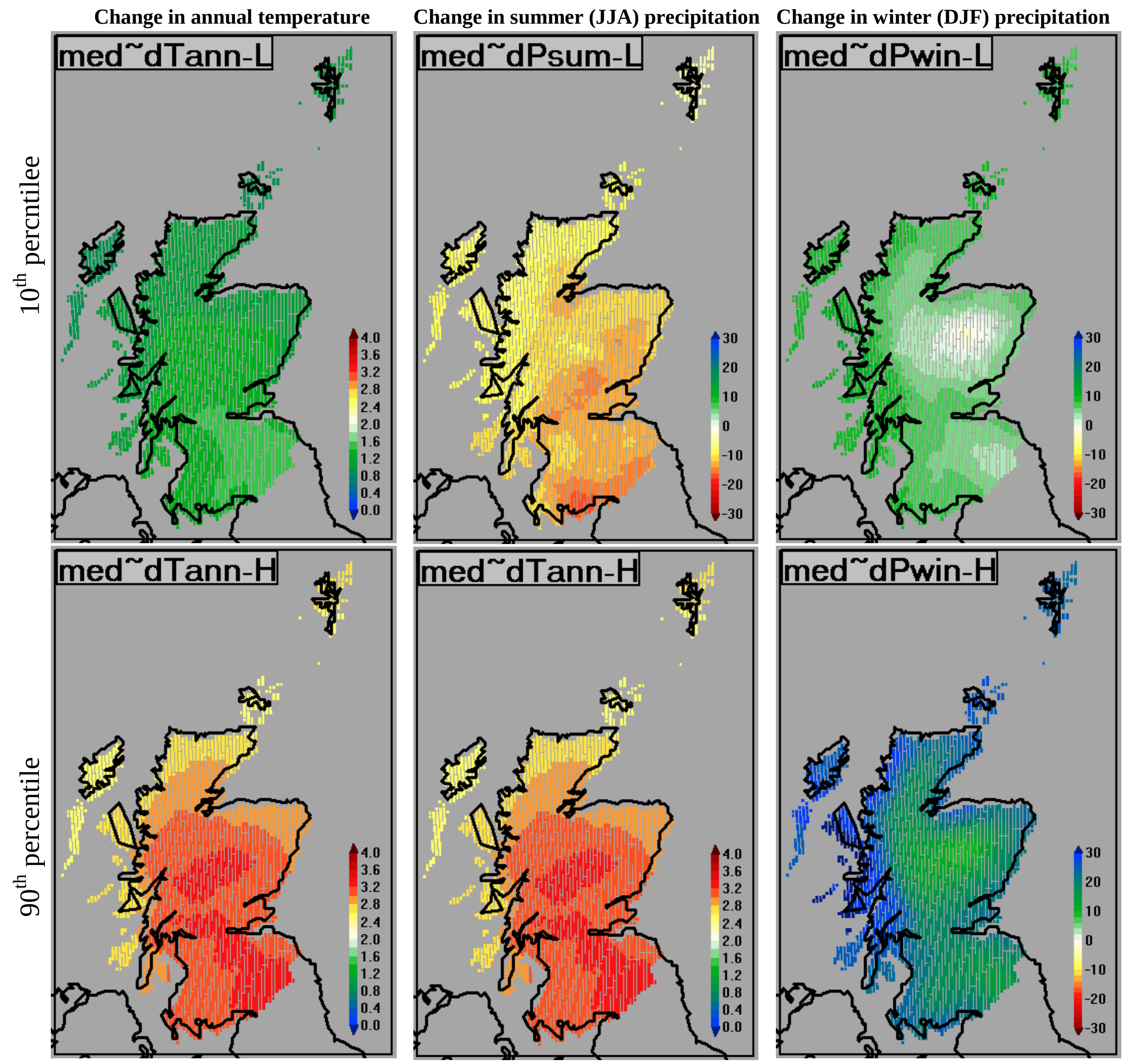


Figure A2.2: Spatial patterns in projected climate change for the 2050s under Medium emissions (from UK Climate Projections).

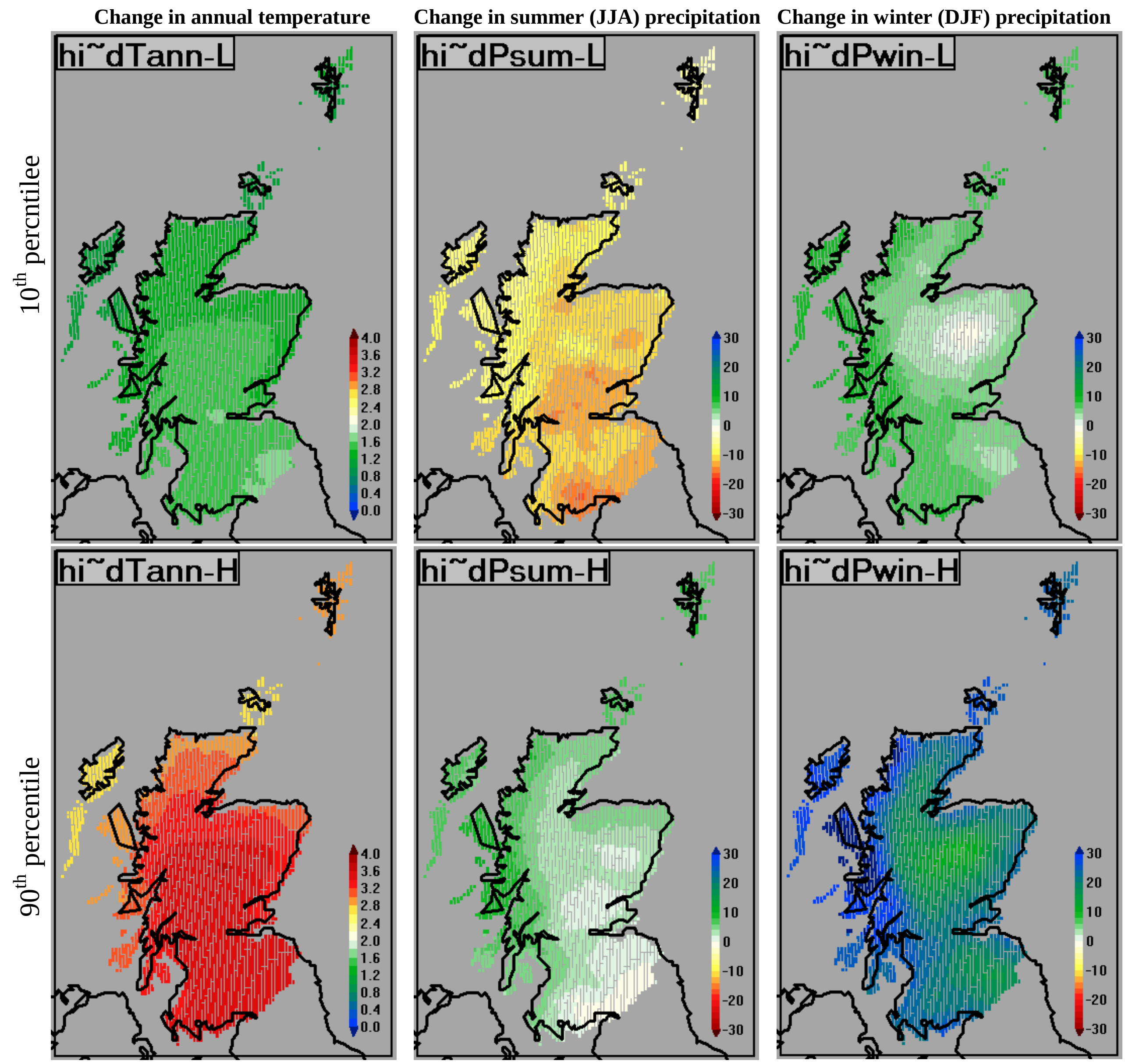


Figure A2.3: Spatial patterns in projected climate change for the 2050s under High emissions (from UK Climate Projections).