Integrated Modelling of Landscapes to Understand Cross-Sectoral Interactions, Synergies and Trade-offs under Scenarios of Environmental Change

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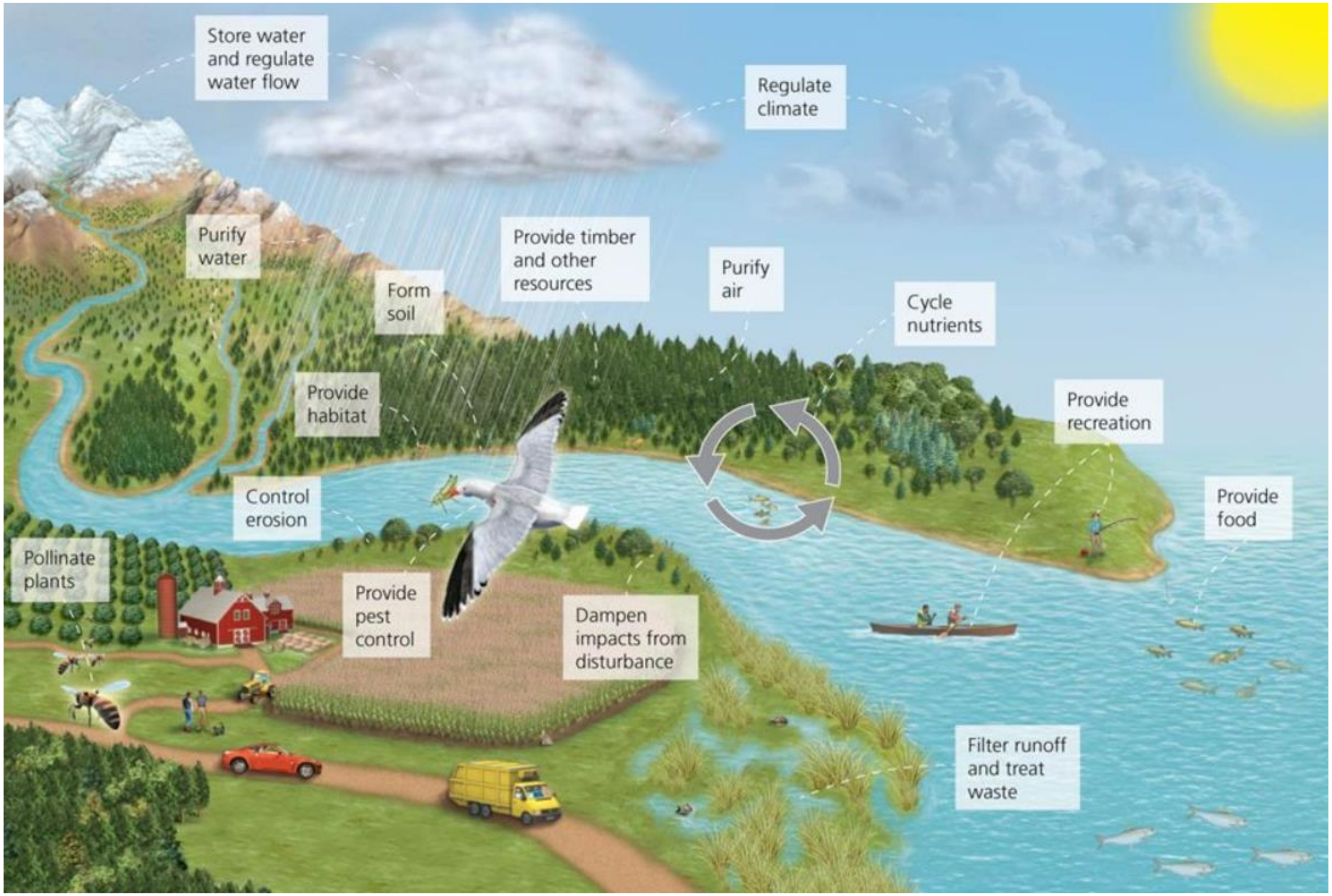
Presentation structure

1. Background
2. Integrated scenario & modelling platforms
3. Single sector vs integrated modelling
4. Uncertainty in integrated modelling systems
5. Exploring policy & management decisions in integrated models
6. Implications for research

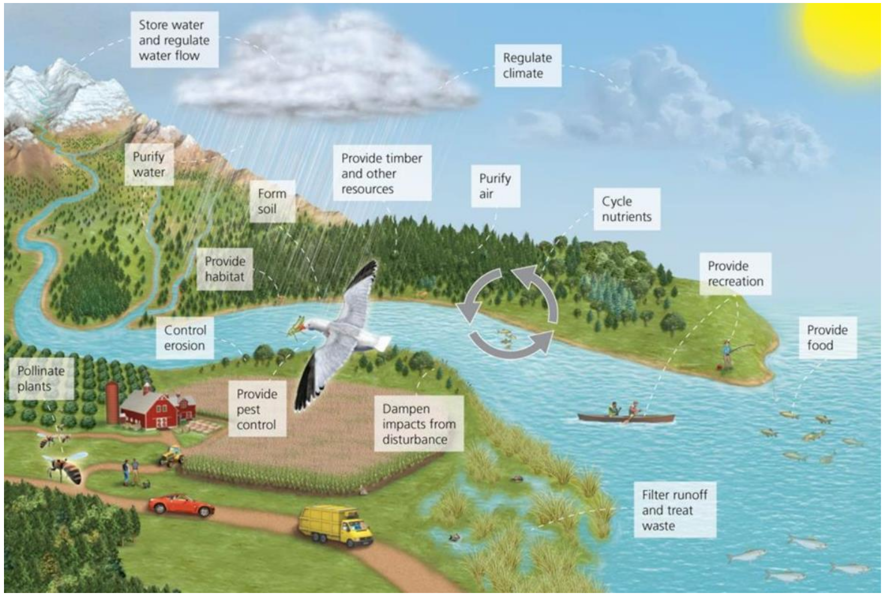
UK landscapes …

… result form complex interactions between natural (e.g. air, soil, land, water, biodiversity) and human systems … and provide multiple, interacting ecosystem services that provide benefits to people …



UK landscapes …

… are affected by multiple, interacting drivers of change (e.g. climate change, pollution, policy, markets, behaviour) …

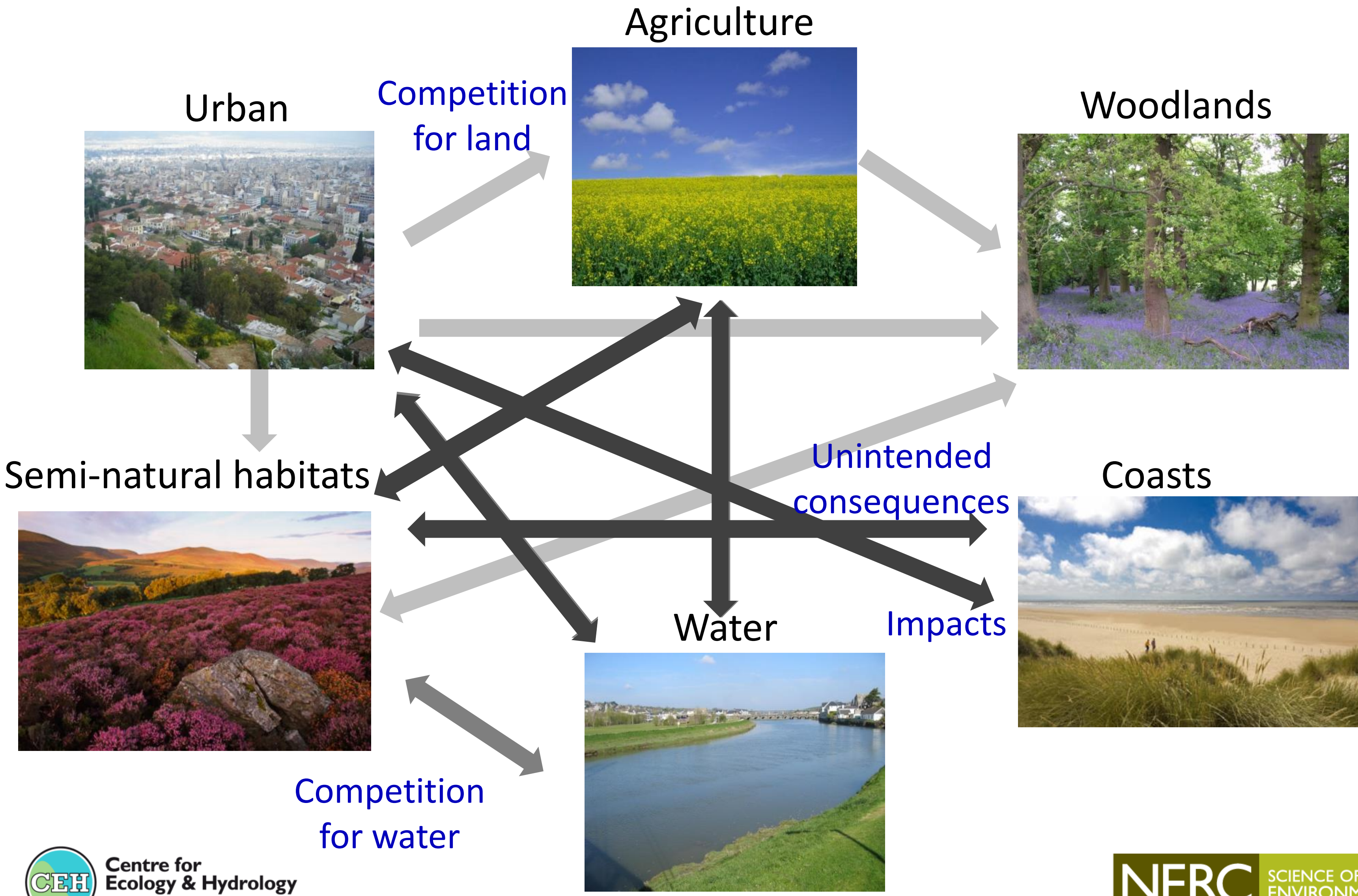


… that are themselves affected by policy or management decisions (as drivers or responses) … and act upon different spatial and temporal scales (incl. spillover effects)

Integrated scenario and modelling platforms

- **Scenarios:** combine consistent changes in multiple drivers to portray a range of plausible futures for a region.
- **Models:** simulate consequences of scenarios and enable exploration of the effectiveness of policy options and management strategies.
- **Integrated models:** Build understanding of interdependencies between sectors and allow exploration of responses that are robust to uncertain futures across sectors, minimising adverse impacts and capitalising on opportunities.
- Important to iterate scenario and model development with stakeholders to ensure a flexible, interactive and responsive approach.
- Need for open and modular integration -> transparent, adaptable.

Cross-sectoral interactions



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CLIMSAVE Integrated Assessment Platform

- Previously:
  - Models ‘belonged’ to the research community
  - Long run-times
  - Lack of flexibility for stakeholders (scenarios, quantification, sensitivity, uncertainty, outputs, etc.)
- The CLIMSAVE IA Platform intends to:
  - Be intuitive and accessible to all
  - Flexible
  - Fast and Interactive
  - Be an exploratory tool, not a DSS

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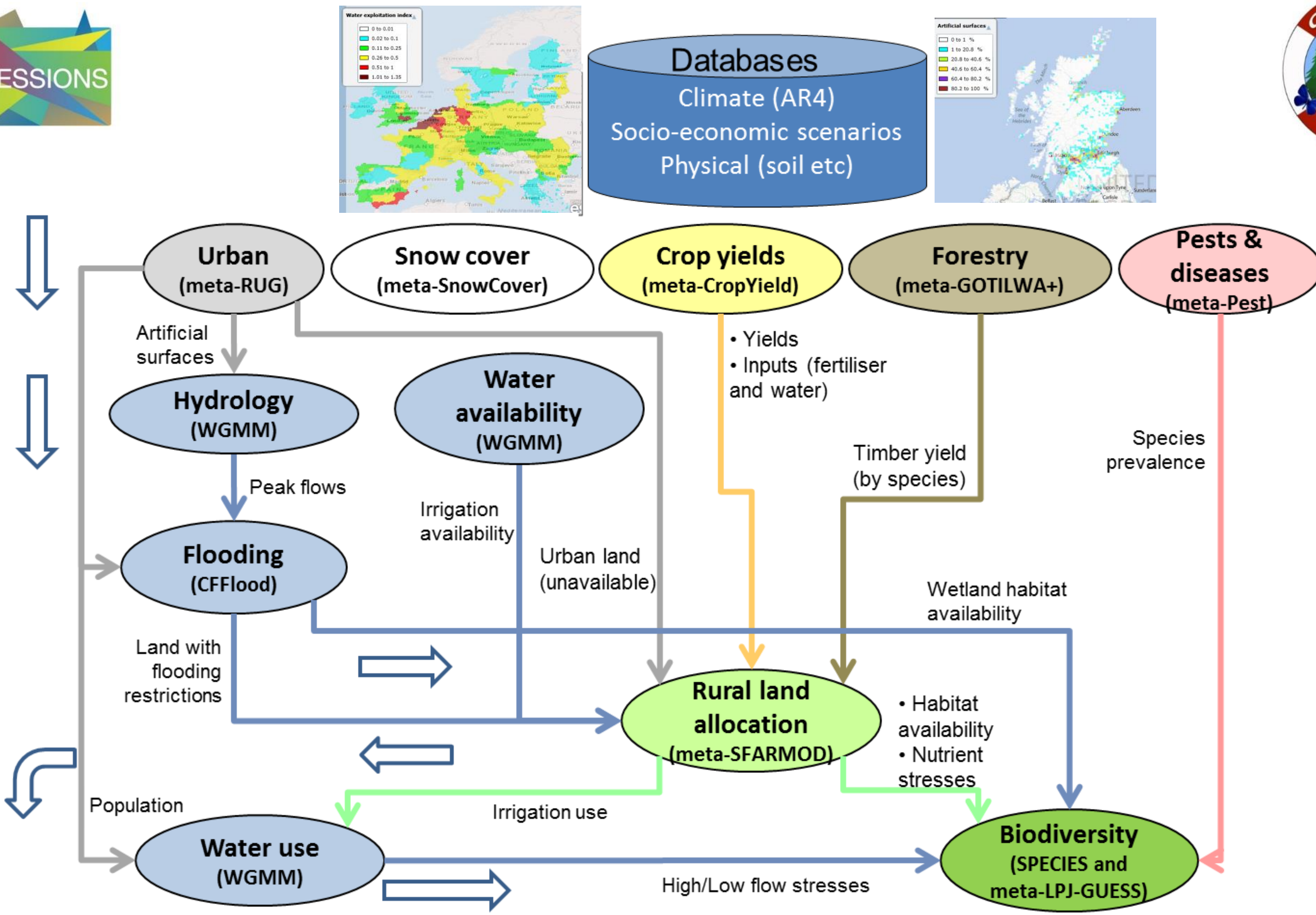
CLIMSAVE Integrated Assessment Platform



Harrison et al. (2015). Cross-sectoral impacts of climate change and socio-economic change for multiple European land- and water-based sectors. *Climatic Change,* 128: 279-292

Participatory stakeholder process

Initial design of IA Platform
Construction of meta-models

Workshop 1:
Draft four socio-economic scenarios
Quantification of scenarios
Feedback on design and functionality

Workshop 2:
Enrich and expand scenarios
Revisit the quantification of scenarios
Define adaptation options

Workshop 3:
Test IA Platform with adaptation options
Explore impacts and adaptation responses

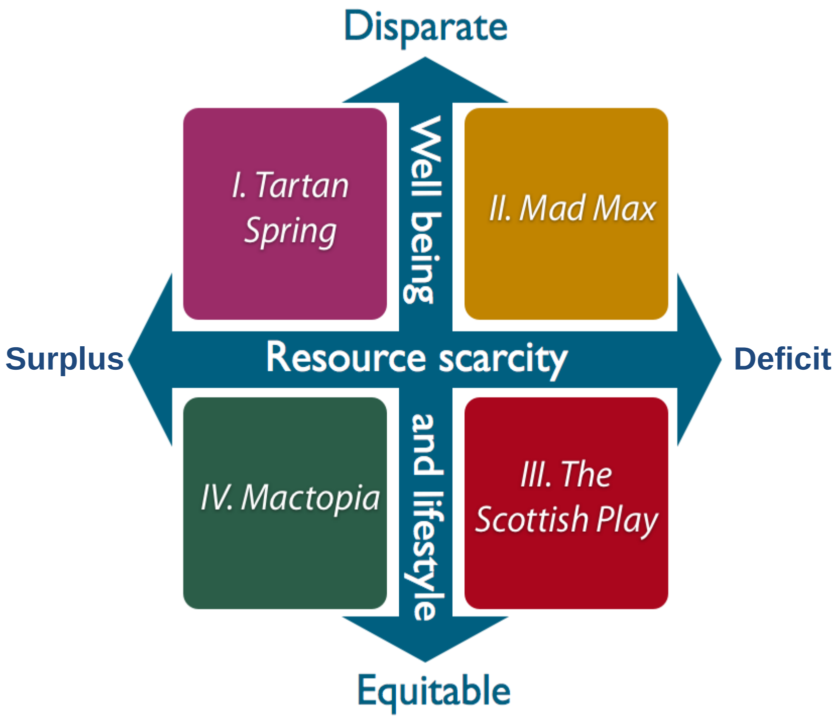
Final CLIMSAVE IA Platform

Harrison et al. (2013). Combining qualitative and quantitative understanding for exploring cross-sectoral climate change impacts, adaptation and vulnerability in Europe. *Regional Environmental Change*, 13: 761-780

Participatory socio-economic scenarios

Europe

Scotland



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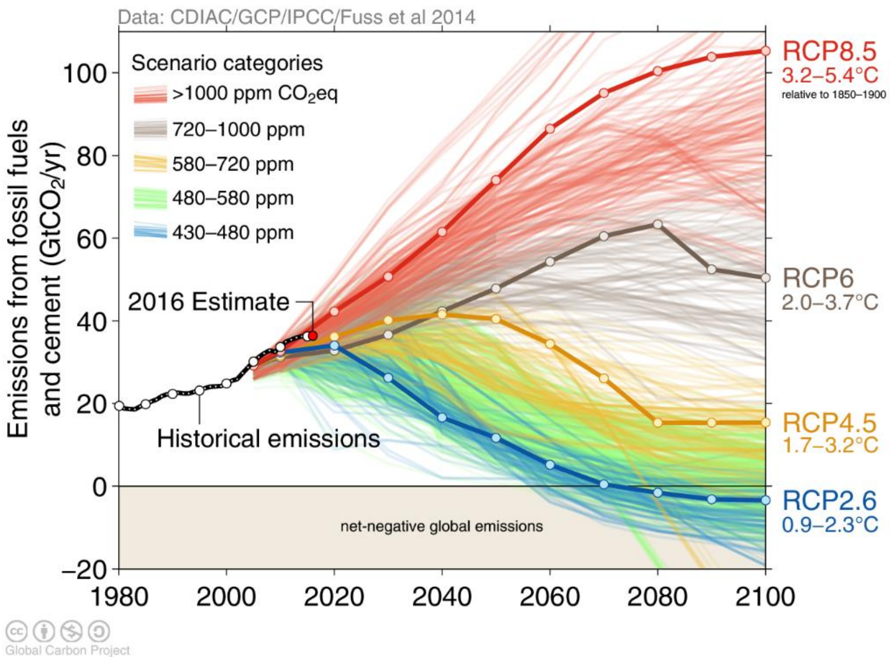
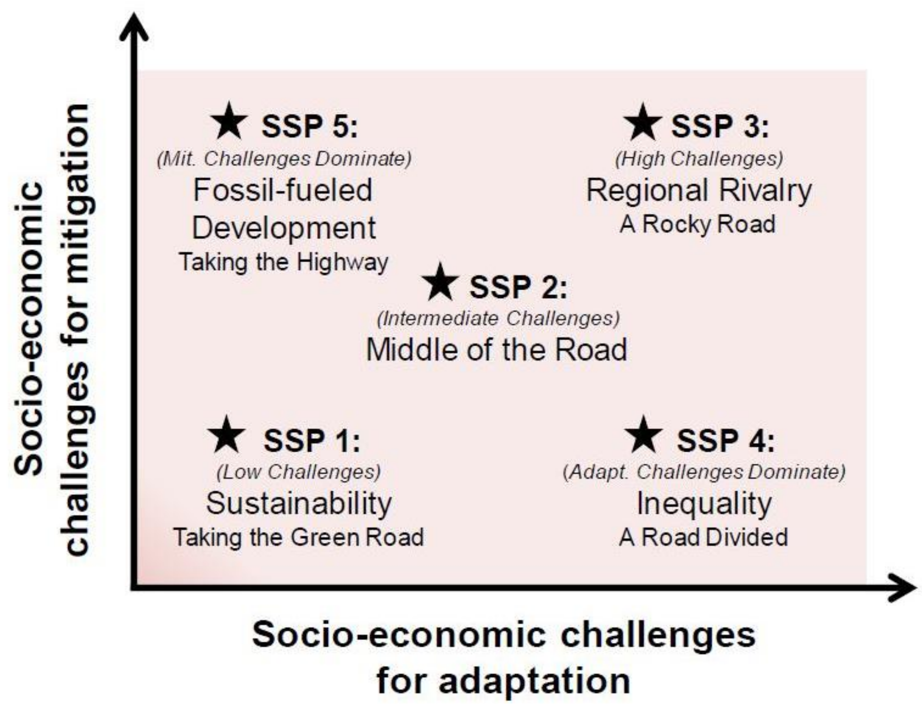
Participatory socio-economic scenarios

Representative Concentration Pathways (RCPs) / UK Climate Projections (UKCP18)



Shared Socio-economic Pathways (SSPs)



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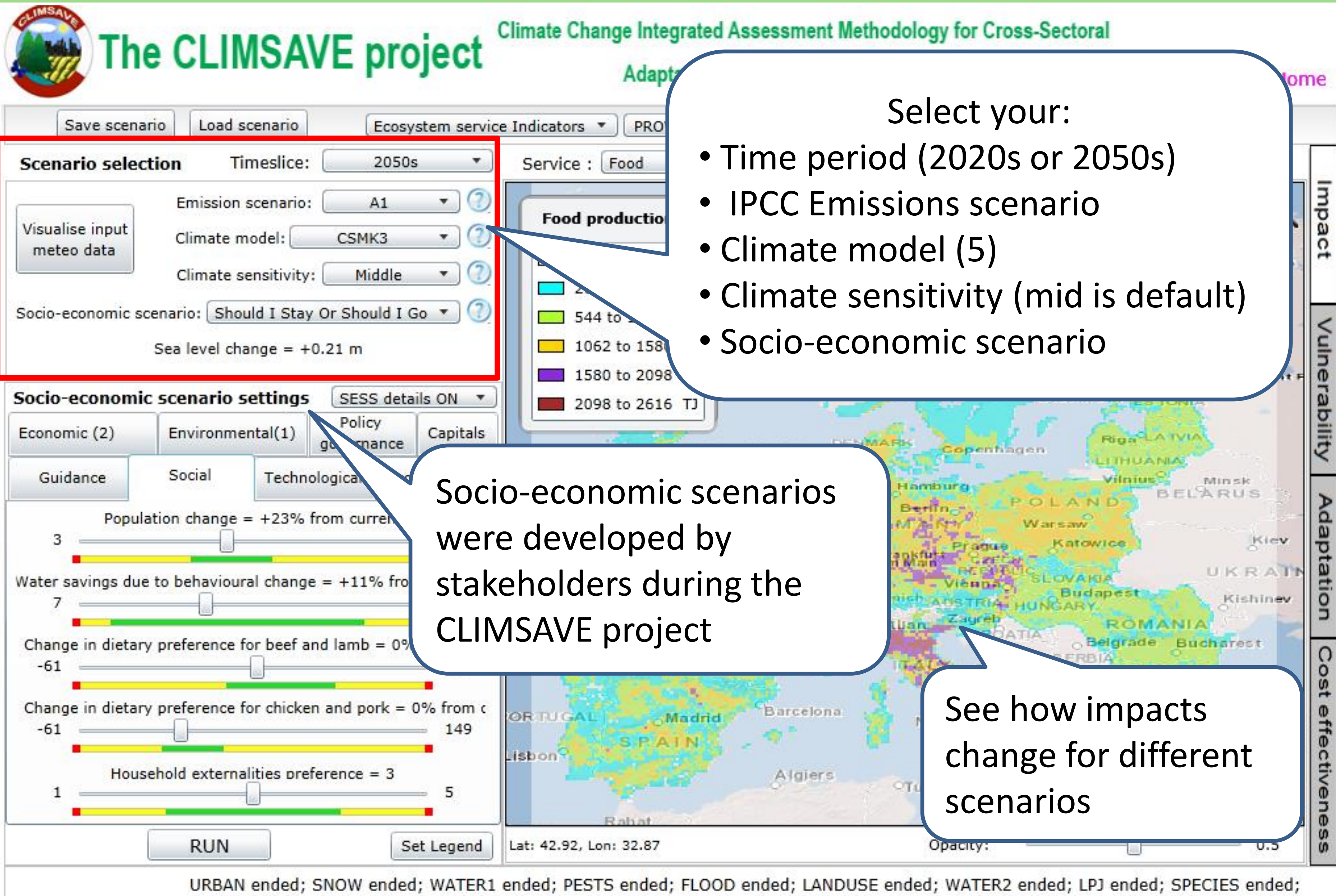
Scenario Analysis



Select your:

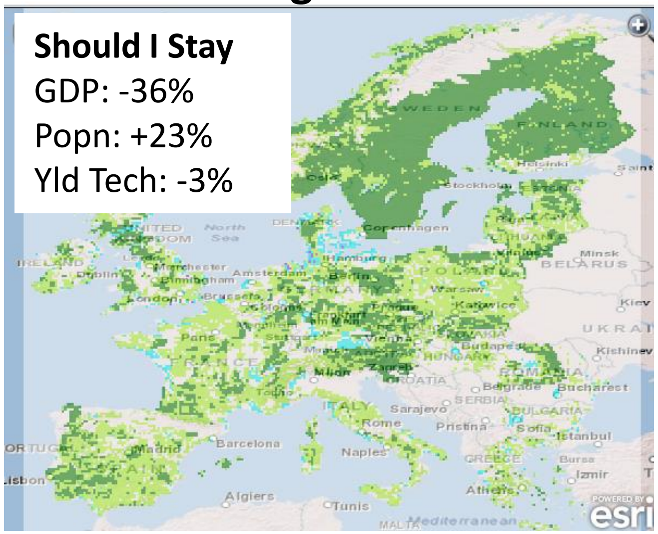
- Time period (2020s or 2050s)
- IPCC Emissions scenario
- Climate model (5)
- Climate sensitivity (mid is default)
- Socio-economic scenario

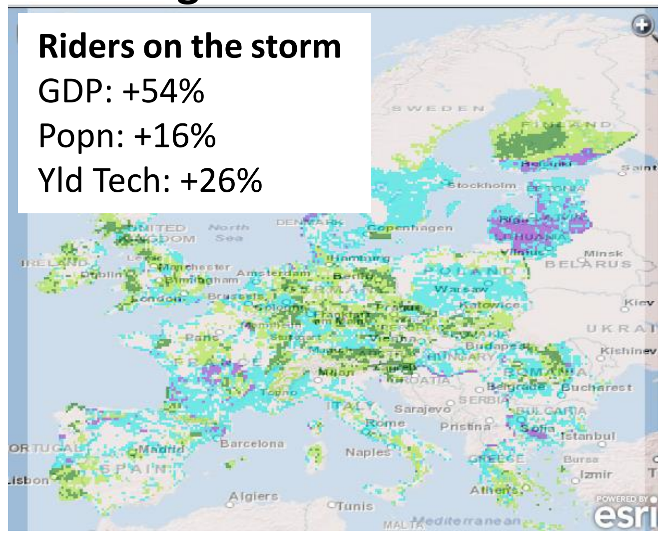
Socio-economic scenarios were developed by stakeholders during the CLIMSAVE project

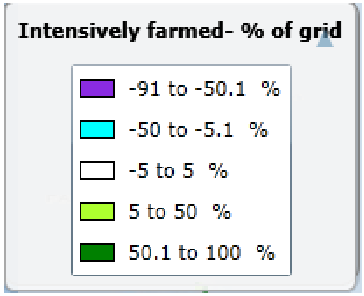
See how impacts change for different scenarios

Illustrative results for the 2050s

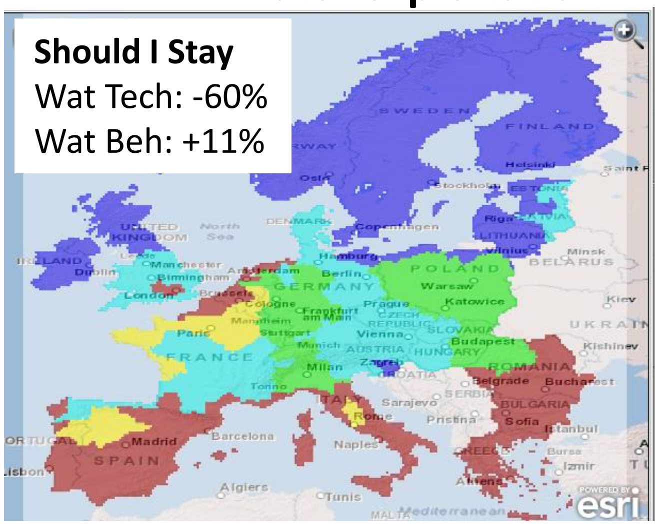
Change in the area of intensive agriculture:

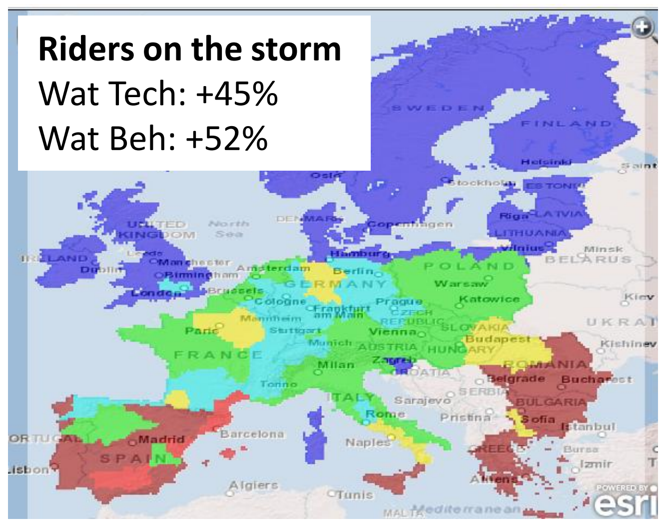


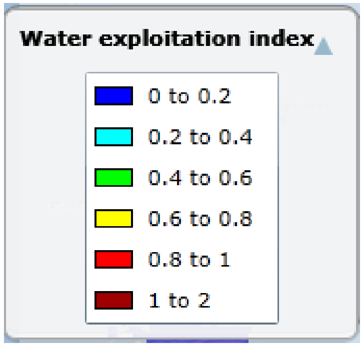




Water exploitation index:

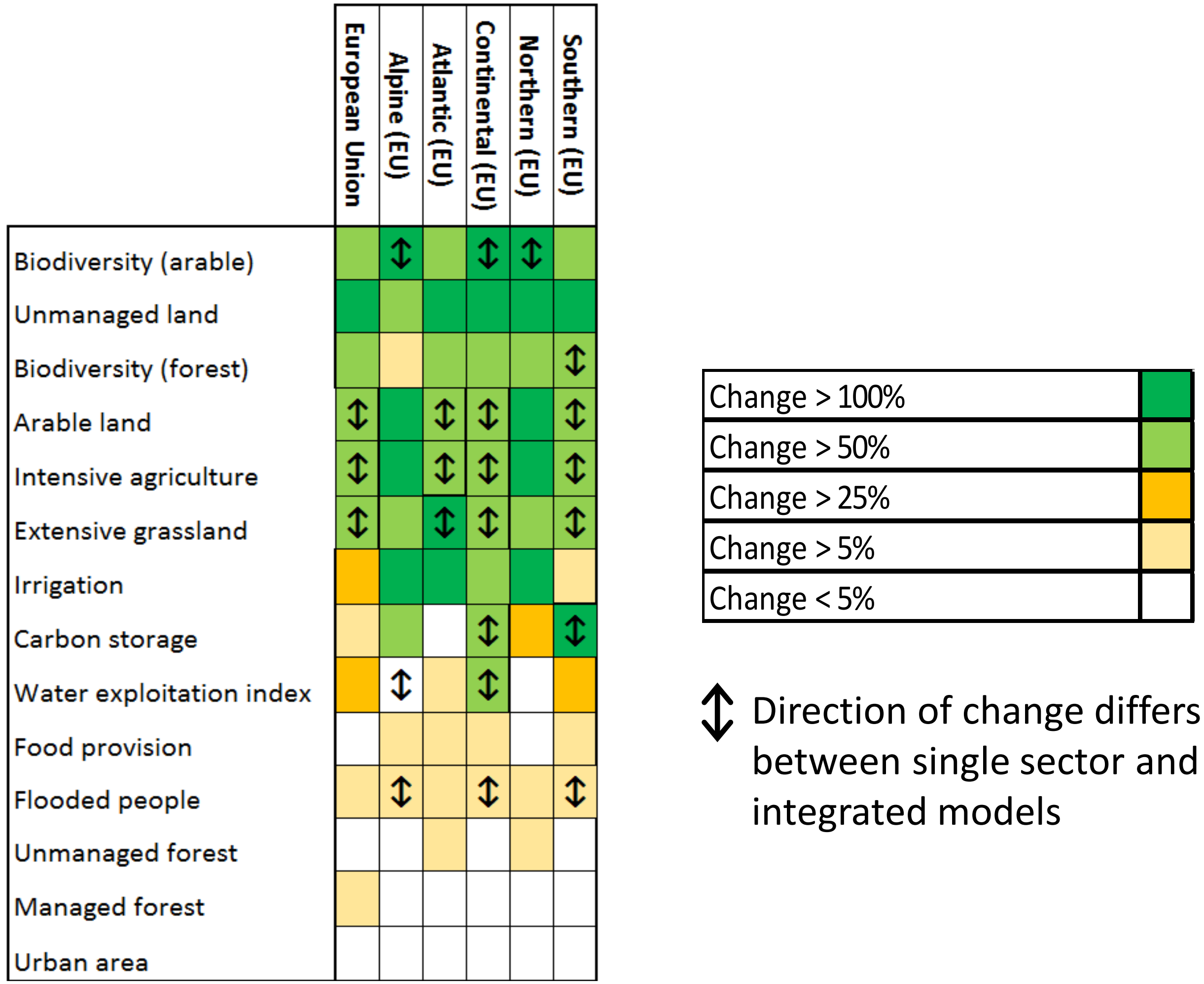






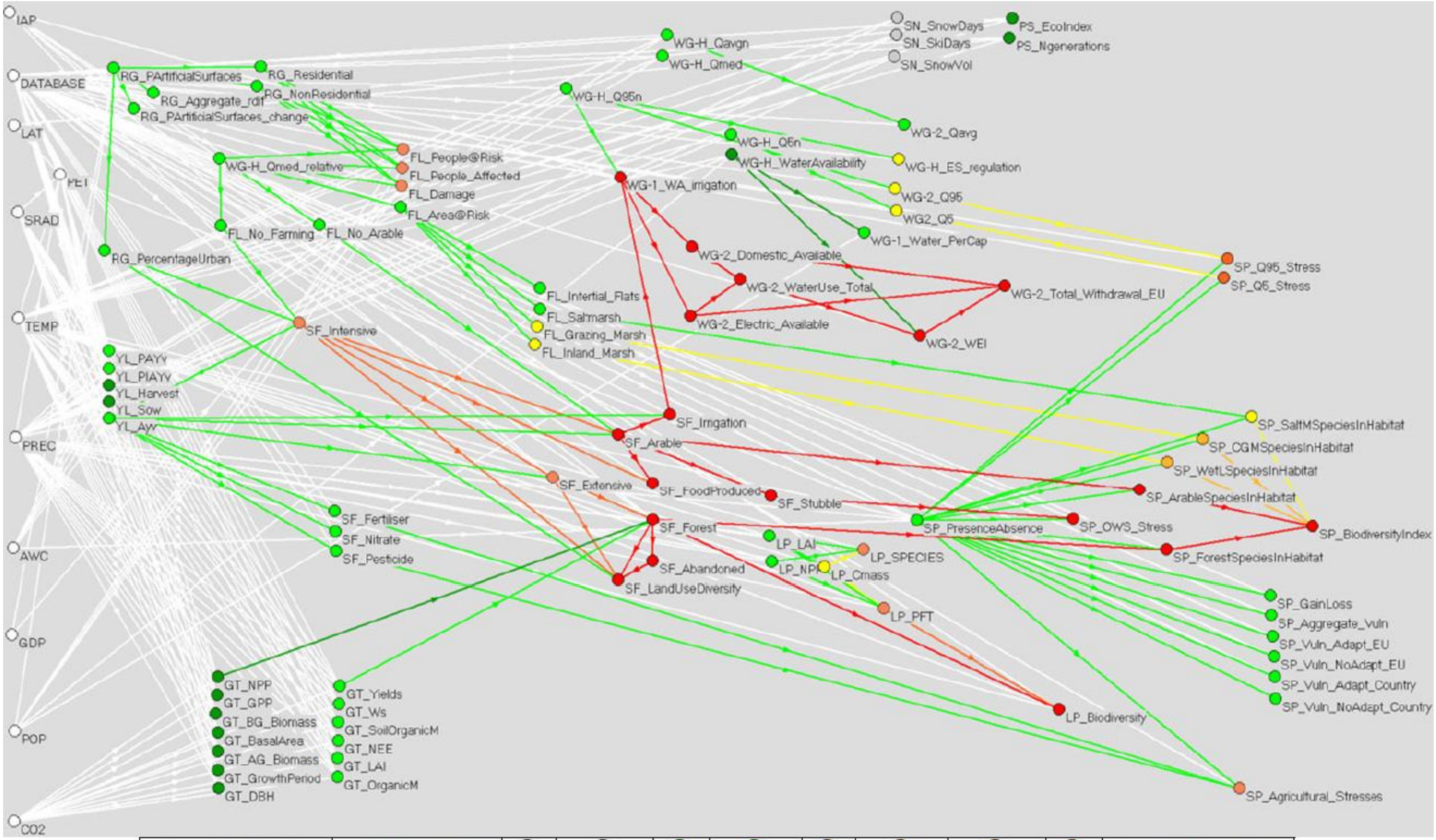
Single sector vs integrated modelling

Differences between single sector and integrated models by regions within the EU:



Harrison et al. (2016). Climate change impact modelling needs to include cross-sectoral interactions. *Nature Climate Change*, 6(9): 885-890.

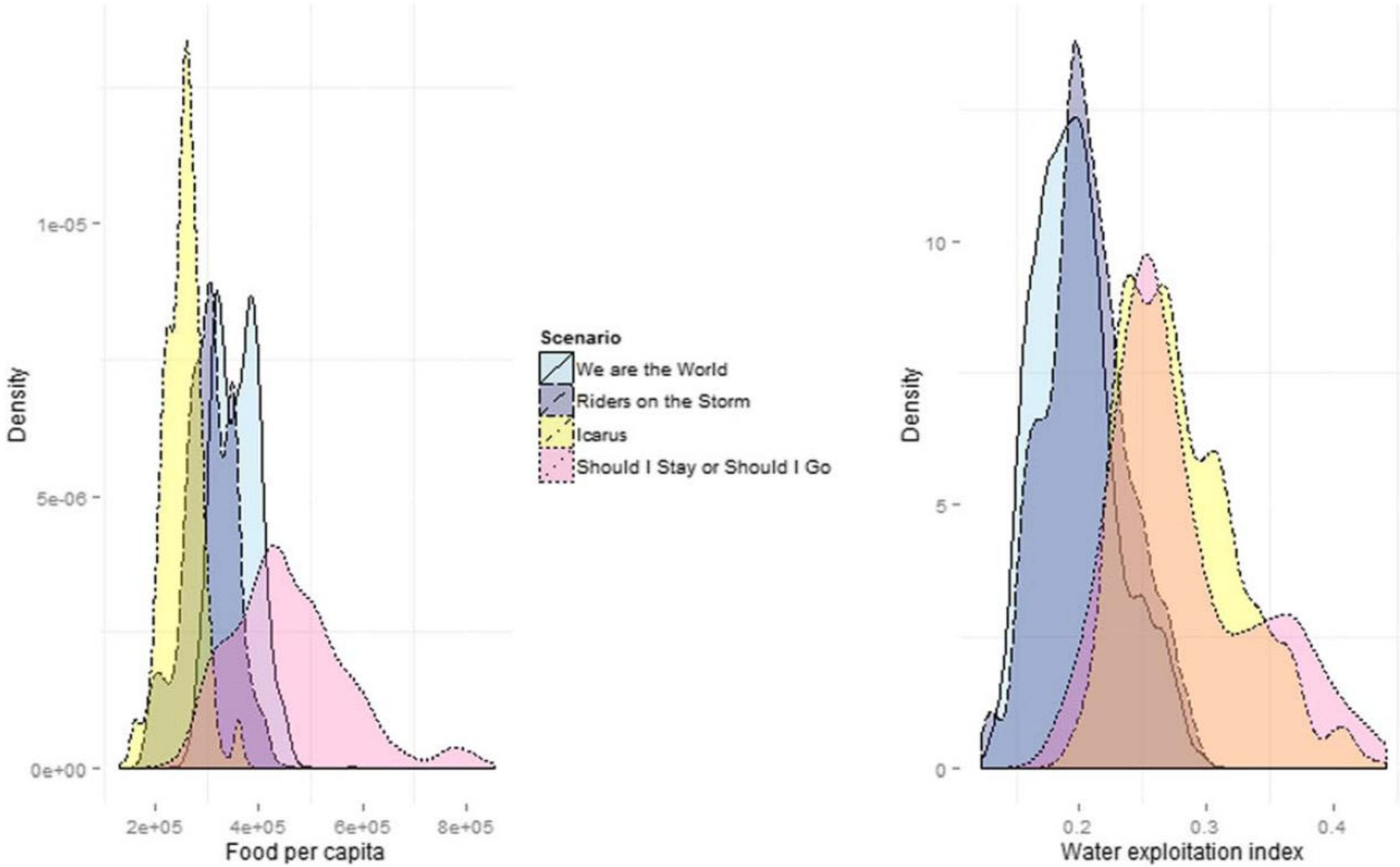
Uncertainty Analysis



Uncertainty Index: Least Uncertainty ○ ● ● ● ● ● ● ● Greatest Uncertainty

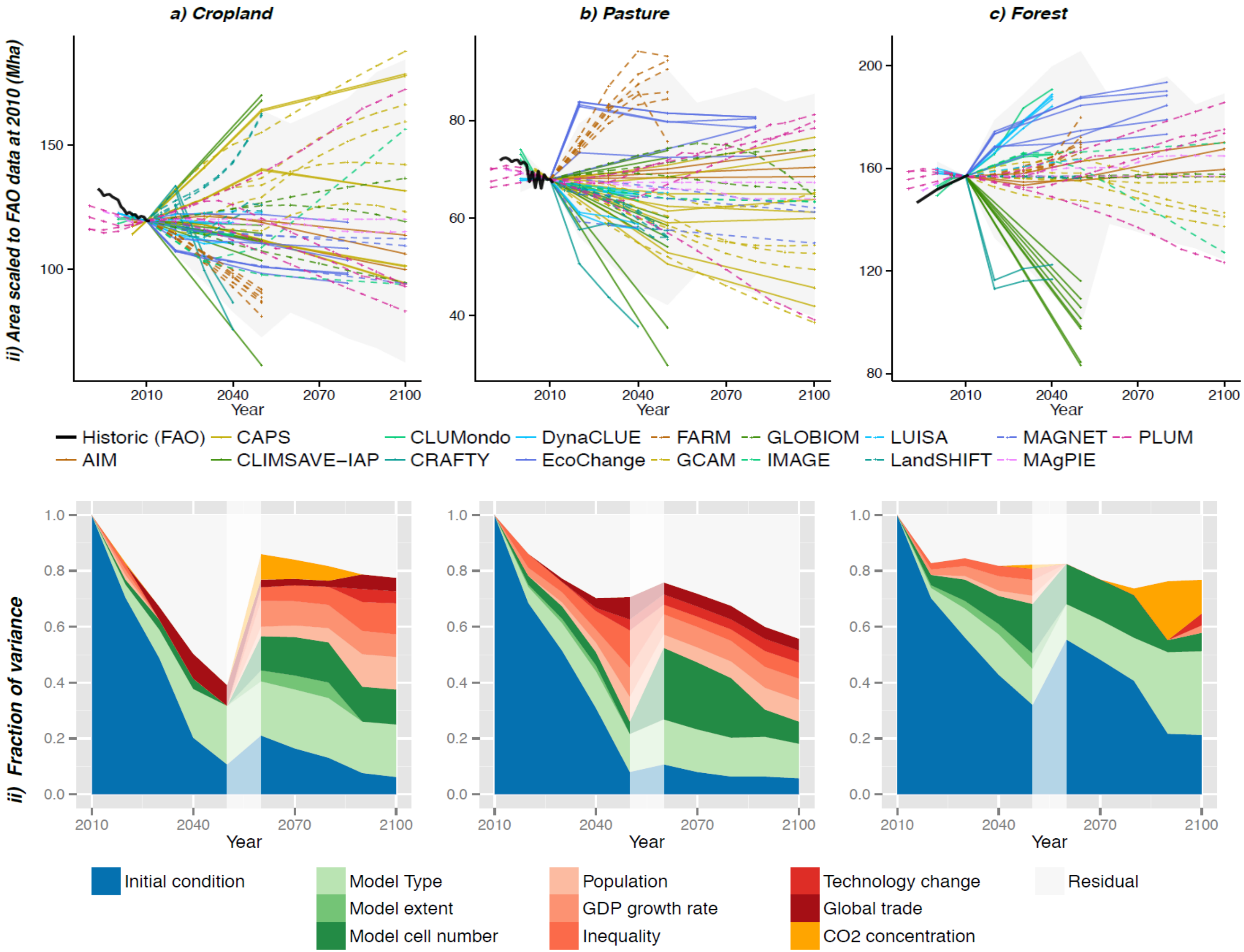
Dunford et al. (2015). Exploring scenario and model uncertainty in cross-sectoral integrated assessment approaches to climate change impacts. *Climatic Change*, 132: 417-432.

Uncertainty Analysis



Brown et al. (2015). Analysing uncertainties in climate change impact assessment across sectors and scenarios. *Climatic Change*, 128: 293-306.

Inter-model Comparison of IA Models: Europe



Alexander et al. (2017). Assessing uncertainties in future land cover projections. *Global Change Biology*, 23: 767-781.

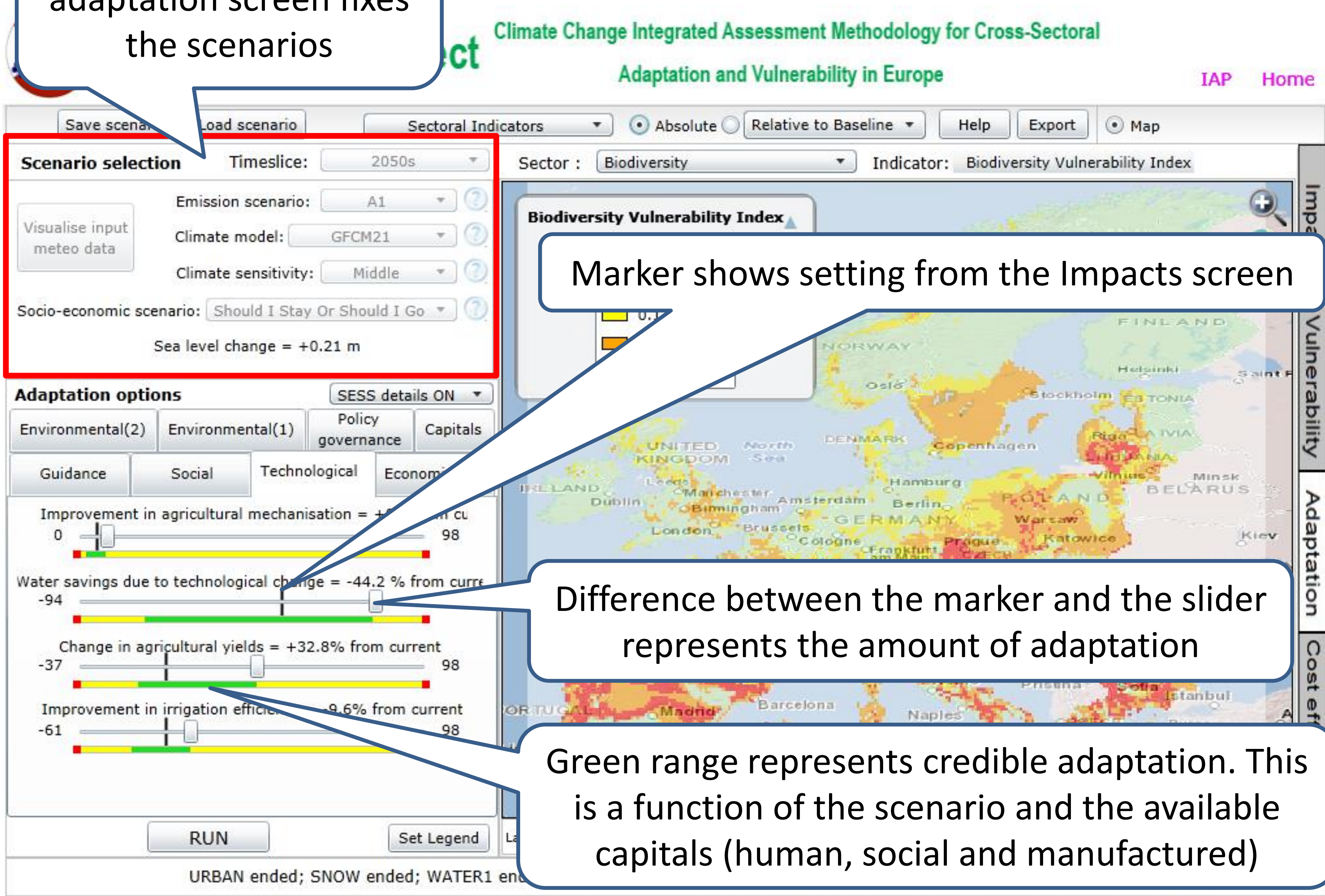
Adaptation analysis

Moving to the adaptation screen fixes the scenarios

Marker shows setting from the Impacts screen

Difference between the marker and the slider represents the amount of adaptation

Green range represents credible adaptation. This is a function of the scenario and the available capitals (human, social and manufactured)



Adaptation strategies

Strategy	Aim
Food self-sufficiency	Food imports are reduced to the minimum to encourage European food self-sufficiency
Maximise water efficiency	Water provision is the top priority. Adaptation approaches include more efficient irrigation and technological and behavioural changes
Irrigation for food	Combination of “food self-sufficiency” and “maximising water efficiency”. Water is prioritised for agricultural use.
Extensify agriculture	Reduce the impact of intensive farming on the environment by farming less intensively and increasing agri-environment scheme uptake
Dietary change	“Extensify agriculture” combined with reduced dietary preferences for land-intensive red and white meat
Maximise timber	Focus on timber production by planting climatically-adapted tree species and reducing agricultural demand by increasing imports
Forests for nature	“Maximise timber” with additional forestry protected to increase the amount of total forest
“Go nature go!”	Expand protected areas (PA) across land uses. Plant competitive tree species; import as much food as possible; increase crop yields and change dietary preferences to minimise agricultural pressures

Dunford et al. (2015). Ecosystem service provision in a changing Europe: adapting to the impacts of combined climate and socio-economic change. *Landscape Ecology*, 30: 443-461.

		Food Self Sufficiency				Irrigation for food				Water Efficiency				Extensify Farming				Dietary Change				Maximise Timber				Forests for nature				Go nature go!			
Climate		✱	✱	✳	✳	✱	✱	✳	✳	✱	✱	✳	✳	✱	✱	✳	✳	✱	✱	✳	✳	✱	✱	✳	✳	✱	✱	✳	✳	✱	✱	✳	✳
Socio-economics		W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W	S
EU	Food		△	△	△		△		△									▽	▽	▽		▽		▽		▽		▽		▽	▽	▽	▽
Northern	Food	△	△		△	▽	△		△	▽				▲			△	▲	▽		△	▽				▼	▽	▼	▽	▼	▼	▽	▼
Alpine	Food	△	△	△	△		△		△	▽		▽		△		△	△		▽		△		▽	▽						▼	▼	▼	▼
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Continental	Food		△	△		△												▽	▽	▽	▽	▽	▽	▽		▽				▼	▼	▼	▽
Southern	Food		△		△		△	△	△					▽		▽		▽	▽	▽								△		△	▲		△
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Southern	Water	▼		▽		▼		▽		▼				▼	△			▼				▼				▼		▽		▼	▽	▽	▽
EU	Timber		▽		▽	▽	▽		▽				△	▼	▼	▽	▼	▽	▽	▽	▼	▽	▲		▲	▽	▲	△	▲	▽	▲	▽	▲
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Southern	Timber													▽	▽		▽				▽	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
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Alpine	Atm. Regulation		▽		▽				▽				△	▽	▽	▽	▼	▽		▽	▼		△		▼	▽	△		▽	▲	▲	▲	▲
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Atlantic	Land. Experience		▽		▽		▽					△	△	▽	▽	▽	▽	▽		▽	▽	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Continental	Land. Experience		▽	▽				△	△	△	△	△	△	▽	▽	▽	△			▽			▼	▲	▽	▽	▼	△	▽	▲	▲	▲	▲
Southern	Land. Experience		▽		▽		▽		▽						▽		▽				▽	▲	▼	△	▽	△	▼		▼	▲	▲	▲	▲
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Southern	Land use diversity	△												△				△				△				△				△			
EU	Biodiversity (F)																							△		△		△		△	△	△	△
Northern	Biodiversity (F)				▽				▽						▽		▽				▽		▽		▽		▽		▽		△		
Alpine	Biodiversity (F)	△	△		▽	△	△		▽	△	△						▽	△	△		▽	△		△		△		△	▽	△	△	△	△
Atlantic	Biodiversity (F)	△	△			△	△			△	△			△			▽	△	△		▽	△			▽	△	△		▽	△	△		
Continental	Biodiversity (F)																▽													△			△
Southern	Biodiversity (F)	△	△	△		△	△	△		△	△	△		△	△	△		△	△	△		△	△	△		△	△	△		△	△	△	△
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▼	Decrease > -20%
▽	Decrease > -5%
△	Increase > +5%
▲	Increase > +20%

✱	Extreme Climate
✳	Moderate Climate
W	"We are the world" socio-economics
S	"Stay or Go" socio-economics

Exploring Adaptation Strategies

CLIMSAVE

IMPRESSIONS

Dunford et al. (2015). Landscape Ecology, 30: 443-461.

Implications for research

- UK landscapes are complex systems that are the product of multiple interdependencies between human and environmental systems.
- Research is needed that considers:
  - multiple drivers and their interactions;
  - multiple sectors/ecosystems and their interactions/trade-offs;
  - multiple spatio-temporal scales and their interactions;
  - multiple interventions/responses and their interactions/trade-offs.
- Integrated modelling recognises the importance of interactions and trade-offs between multiple drivers and ecosystem services and can help inform whole system sustainable solutions.
- But it requires very close working across disciplines and stakeholder engagement.

New mathematical approaches …

- This requires close working between the environmental and mathematical sciences to tackle:
  - The heterogeneity of model types (empirical, process-based, agent-based, IAMs, emulators) and their integration;
  - The complexity of feedbacks and interdependencies between environmental and human processes;
  - The heterogeneity of environmental data (EO, sensors, surveys, crowdsourcing) and its integration/analysis;
  - Downscaling and upscaling of data/models, including dynamic processes and extreme events;
  - Uncertainties, their source, and their propagation through system components.

Thank you