Electronic supplementary material 2: Parameters included in the uncertainty analysis and details of probability-based value sampling

All parameters of the CLIMSAVE IAP with significant effects on predicted climate impacts (as determined by Kebede *et al.*, this issue) are included in the uncertainty analysis (details of IAP parameters are available through Online Resource 1, in Holman & Cojocaru 2013 and Holman *et al.* 2013). Parameters included in the uncertainty analysis are shown in Table 1, below. The ranges of these parameters are designed to be independent within each scenario, meaning that samples can be taken from each independently without accounting for covariance.

In order to assess uncertainty in model outputs, samples were taken from across the uncertainty range of each relevant input parameter and combinations of these samples used to parameterise the IAP (details of the combination method are given in Online Resource 3). In order to accurately sample from each parameter's uncertainty range, we used the following information provided with the IAP (Harrison *et al.* 2013, this issue, Holman *et al.* 2013; Figure 1):

1. The 'central' or most likely single value for each parameter under each scenario;
2. The 'credible' range of each parameter under each scenario;
3. The 'possible' range of each parameter under each scenario.

These values and ranges are defined, respectively, as:

1. The single value that is most likely under a given scenario;
2. The values that are credible under a given scenario;
3. The values that are possible but unlikely under a given scenario.

In order to sample from parameter uncertainty ranges, we made the following probabilistic assumptions about these values and ranges:

1. The 'central' value represents the mode of a continuous probability density function;
2. The 'credible' range represents approximately 90% of the probability density function;
3. The 'possible' range represents approximately 10% of the probability density function.

These assumptions are consistent with the information provided about each value and range and further guidance from modellers and expert stakeholders (in particular that probabilities followed continuous, rather than discrete, distributions), but are not the only possible interpretations. However, there is no 'correct' probabilistic interpretation given the definitions of the values and ranges, and because these relate to unknown or unquantifiable factors. Uncertainties derived from these distributions are therefore as accurate as possible but remain impossible to verify precisely.

Beta distributions are chosen to represent the probability density function (PDF) for each parameter (Figure 1). Once again, other options are available and several could provide satisfactory fits given the approximate nature of the ranges and probabilistic interpretations. However, beta distributions are regarded as the most suitable choice for three reasons: their ability to describe asymmetrical PDFs of the kind required for several IAP parameters, their limited range, which means that ranges of values can be scaled (to the interval [0,1]) rather than truncated, and their relative ease of fitting given the previous two points. Symmetrical distributions such as the Gaussian are not appropriate in this case.

For each parameter and scenario combination (21 parameters across 4 scenarios, giving 84 combinations), distribution fitting proceeded as follows. The possible range was scaled to the interval [0,1] and the scaled central value (interpreted as the mode of the distribution) and the limits of the credible (90%) range were noted. Depending on whether the mode was above or below 0.5, the upper or lower credible limit and the mode were entered into the online beta distribution fitting tool at http://epitools.ausvet.com.au/content.php?page=BetaParams1 (the ability of this tool to reproduce a number of test distributions was assessed prior to its use). The resulting α and β parameters were recorded and the distribution visually checked against the supplied values and ranges.

Parameter sampling was then carried out, using the *rbeta* function in the base package of the R statistical programming language (http://cran.r-project.org/) and the α and β parameters derived above for each parameter in each scenario. In the *We are the World* scenario (see main text), 250 random samples were taken from each parameter, while 50 were taken from each parameter in the remaining three scenarios. The different numbers of samples were compared in terms of final model output, to find whether the lower number was capable of producing coherent output distributions. This was found to be the case (see Online Resource 3). All samples were then re-scaled back to the original range of their parameter and scenario (using the original possible range, as above).

The final step prior to running parameterisations through the IAP was to combine samples in order to explore joint parameter uncertainty space. This procedure is described in detail in Online Resource 3.

References

Harrison, P. A., Holman, I. P., Cojocaru, G. *et al.* (2013). Combining qualitative and quantitative understanding for exploring cross-sectoral climate change impacts, adaptation and vulnerability in Europe. *Regional Environmental Change*, *13*(4), 761–780.

Harrison, P.A., Holman, I.P., Berry, P.M. (this issue). Editorial: Assessing cross-sectoral climate change impacts, adaptation and vulnerability: An Introduction to the CLIMSAVE project.

Holman, I., Cojocaru, G., Harrison, P. (2013). *Guidance report describing the final version of the CLIMSAVE Integrated Assessment Platform*. Available at: http://www.climsave.eu/climsave/doc/Report_on_the_Final_IA_Platform.pdf

Holman, I., Cojocaru, G. (2013). *Report describing the Integrated Assessment Platform (IAP) specification, meta-model specifications and the multi-scale approach.* Available at: http://www.climsave.eu/climsave/doc/Report_on_the_specification_of_the_IAP.pdf

Figure 1: An example visualisation of a continuous variable used in the IAP, with central value (location of the slider), credible range (green) and possible range (yellow), along with the corresponding beta distribution derived from these values and the assumptions listed in the text above. Parameter samples are subsequently taken from the distribution calculated for each parameter in each scenario.

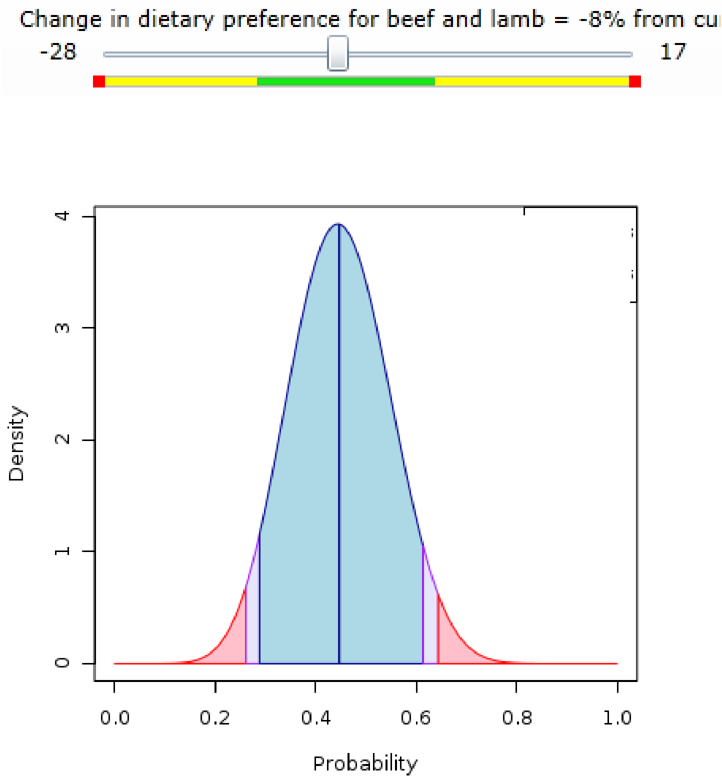

Table 1: The parameters used in the uncertainty analysis and their values, either discrete settings or ranges, central values and, where appropriate, beta distribution parameters, in each scenario. Beta distributions are on the interval [0,1], with all parameter ranges and values scaled to the same interval. Samples were scaled back before use in the IAP. Abbreviations are: LP = lower possible value, LC = lower credible value, CV = central value, UC = upper credible value, UP = upper possible value).

Parameter name (description)	***We are the world***		***Icarus***		***Riders on the Storm***		***Should I Stay or Should I Go***	
	Range (LP, LC, CV, UC, UP)	**PDF**	**Range** (LP, LC, CV, UC, UP)	**PDF**	**Range** (LP, LC, CV, UC, UP)	**PDF**	**Range** (LP, LC, CV, UC, UP)	**PDF**
emissionComboBox (emissions scenario)	Four levels	Equal probs	Four levels	Equal probs	Four levels	Equal probs	Four levels	Equal probs
modelComboBox (climate model)	Five levels	Equal probs	Five levels	Equal probs	Five levels	Equal probs	Five levels	Equal probs
sensitivityComboBox (level of climate sensitivity)	Three levels	Equal probs	Three levels	Equal probs	Three levels	Equal probs	Three levels	Equal probs
ComboBoxSES (socio-economic scenario)	NA	NA – pre-selected	NA	NA – pre-selected	NA	NA – pre-selected	NA	NA – pre-selected
Pop_changeSlider (population change relative to current)	(-26.1, -1.0, 3.0, 15.6, 32.9)	β(10.2, 9.2)	(-45.5, -11.8, -8.6, 12.4, 29.0)	β(37.4, 38.1)	(0.0, 11.1, 16.2, 18.8, 36.9)	β(13.8, 17.4)	(3.0, 16.2, 23.3, 28.6, 49.7)	β(20.6, 26.5)
RuminantLivestk ProductsDemandSlider (change in dietary preference for beef & lamb)	(-61, -37, -21, 0, 58)	β(8.6, 16.1)	(-61, 5, 10, 26, 58)	β(18.0, 12.5)	(-61, -21, -9, 0, 58)	β(26.6, 34.0)	(-61, -11, 0, 26, 58)	β(6.6, 6.3)
NonRuminantLivestck ProductsDemandSlider (change in dietary preference for chicken & pork)	(-61, -37, -21, 0, 149)	β(9.2, 35.6)	(-61, 5, 10, 26, 149)	β(30.8, 59.2)	(-61, -21, -9, 12, 149)	β(31.6, 93.9)	(-61, -11, 0, 26, 149)	β(51.9, 125.2)
StructChangeSlider (water savings due to behavioural change)	(33.9, 40.7, 45.2, 49.7, 56.5)	β(2.2, 2.7)	(-37.5, -33.0, -30.0, -37.0, -22.5)	β(2.6, 2.2)	(38.9, 46.7, 51.8, 57.0, 64.8)	β(1.9, 2.3)	(8.5, 10.2, 11.3, 12.5, 14.2)	β(2.2, 2.8)
techfacSlider (change in agricultural mechanization)	(0, 26, 44, 77, 98)	β(7.8, 9.4)	(0, 5, 10, 26, 98)	β(1.3, 3.9)	(0, 44, 77, 98, 98)	β(2.9, 36.6)	(0, 2, 5, 15, 98)	β(1.3, 1.1)
TechChangeSlider (water savings due to technological change)	(21.8, 26.2, 29.1, 32.0, 36.4)	β(2.2, 2.7)	(-44.1, -38.8, -35.3, -31.8, -26.5)	β(2.6, 2.1)	(33.9, 40.7, 45.2, 49.7, 56.5)	β(2.2, 2.7)	(-75.4, -66.3, -60.3, -54.3, -45.2)	β(2.6, 2.1)
yieldfacSlider (change in agricultural yields)	(-37, -37, -21, 0, 98)	β(9.2, 14.1)	(-37, -21, -9,	β(7.7, 26.5)	(-37, 0, 26, 58,	β(7.6, 8.5)	(-37, -14, -3,	β(14.7, 41.7)

			10, 98)		98)		36, 98)	
IrrigationEfficiency FactorSlider (change in irrigation efficiency)	(-61, 12, 26, 58, 98)	β(7.6, 6.5)	(-61, -37, -9, 0, 98)	β(15.7, 31.3)	(-61, 26, 58, 78, 98)	β(13.3, 5.1)	(-61, -37, -21, 0, 98)	β(8.9, 24.6)
GDP_changeSlider (GDP change)	(0.0, 48.7, 93.9, 113.9, 289.5)	β(5.6, 10.5)	(-60.5, -11.6, 0.0, 25.8, 98.4)	β(7.4, 11.5)	(-27.6, 24.1, 54.0, 77.8, 208.0)	β(10.5, 18.9)	(-84.5, -45.0, -35.8, -10.5, 51.8)	β(16.8, 29.4)
costsfacSlider (change in oil price)	(20, 47, 73, 80, 180)	β(5.3, 9.7)	(80, 173, 210, 222, 400)	β(18.6, 26.8)	(80, 173, 210, 222, 400)	β(18.6, 26.8)	(50, 143, 163, 180, 320)	β(15.5, 21.1)
importfacSlider (change in food imports)	(-20, -17, -13, -11, -5)	β(1.2, 1.2)	(-18, -9, -6, -2, 10)	β(9.5, 12.4)	(-20, -17, -13, -11, -5)	β(1.2, 1.2)	(-20, -17, -13, -11, -5)	β(1.2, 1.2)
BioEnergyCrop DemandSlider (change in bioenergy production)	(0, 0.3, 1.8, 2.4, 5)	β(1.2, 1.3)	(0, 4.3, 6.7, 7.5, 15)	β(10.4, 12.7)	(0, 0.3, 1.8, 2.4, 5)	β(1.2, 1.3)	(0, 0.3, 1.8, 2.4, 5)	β(1.2, 1.3)
CropInputsFactorSlider (reduction in diffuse source pollution from agriculture)	(0.8, 0.95, 1.03, 1.11, 1.27)	β(23.3, 34.4)	(0.8, 0.91, 1.0, 1.09, 1.46)	β(5.1, 11.3)	(0.8, 1.1, 1.2, 1.3, 1.6)	β(21.2, 21.2)	(0.8, 0.97, 1.07, 1.17, 1.56)	β(8.5, 13.5)
coastalSlider (coastal flood events)	(0 ,-, -, -, 500)	U(0, 500	(0 ,-, -, -, 500)	U(0, 500	(0 ,-, -, -, 500)	U(0, 500	(0 ,-, -, -, 500)	U(0, 500
floodProtection RadioButton Low/Medium/High (level of flood protection)	Three levels (params) on/ off	Equal probs	Three levels on/ off	Equal probs	Three levels on/ off	Equal probs	Three levels on/ off	Equal probs