Institute for Climate and
Atmospheric Science

UNIVERSITY OF LEEDS

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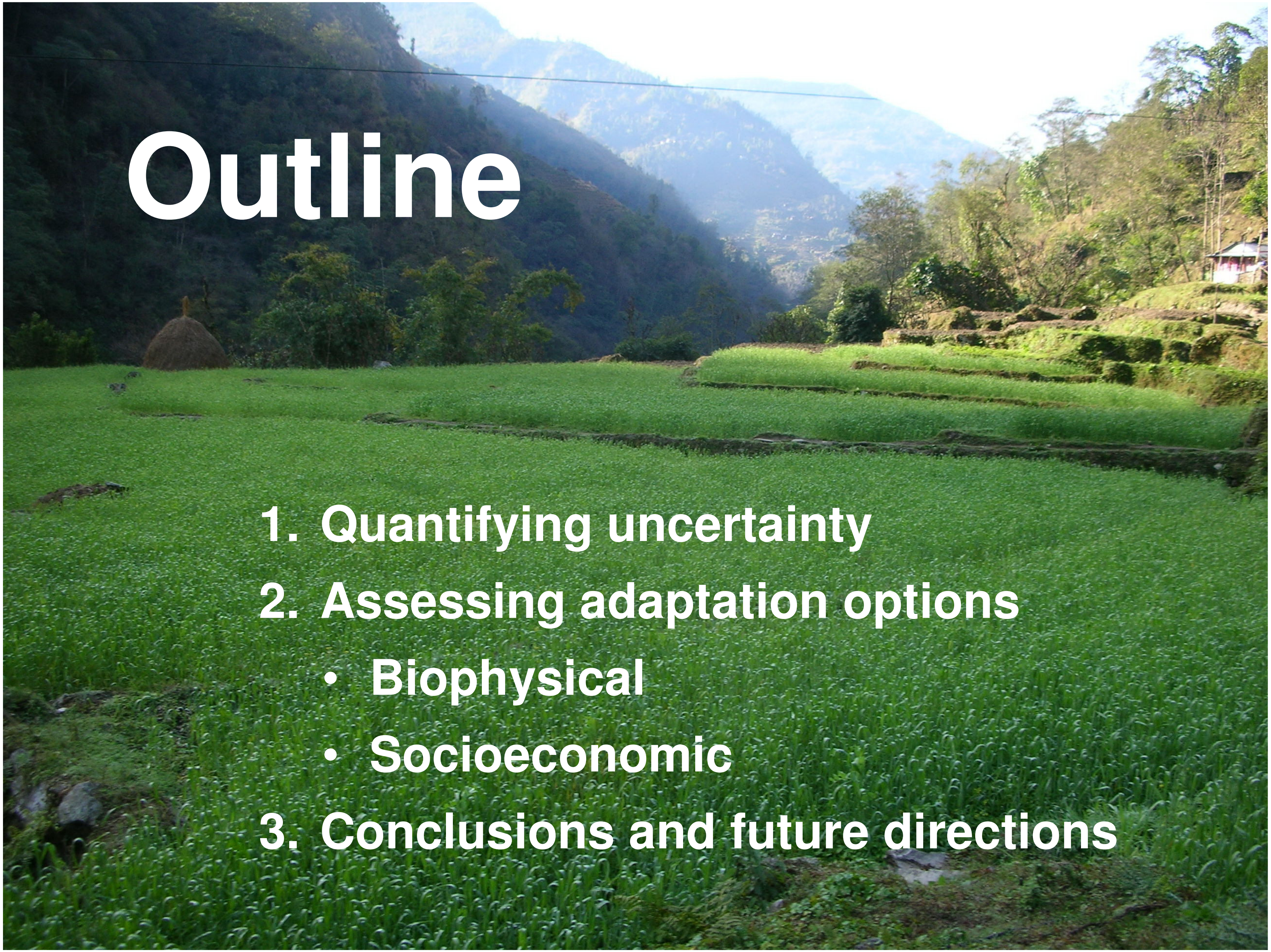
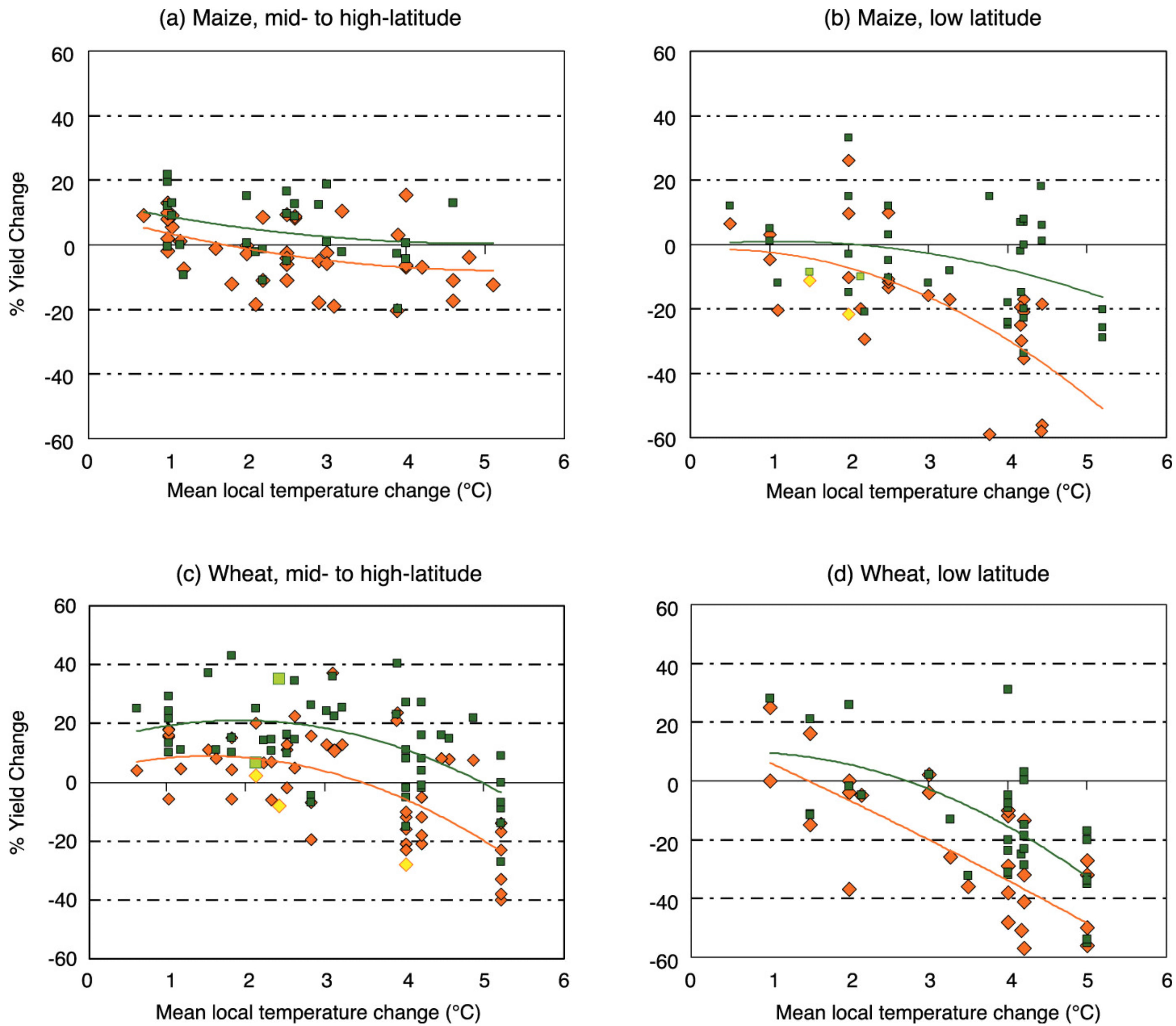
Holistic approaches to modelling crop productivity



Outline

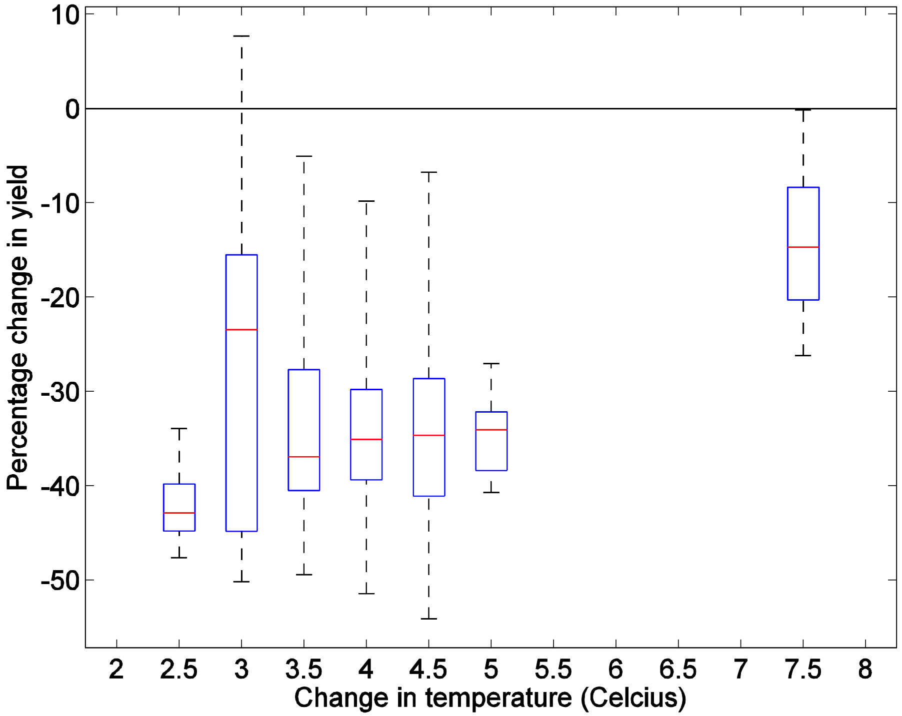
1. Quantifying uncertainty
2. Assessing adaptation options
   - Biophysical
   - Socioeconomic
3. Conclusions and future directions

The need for systematic quantification of uncertainty

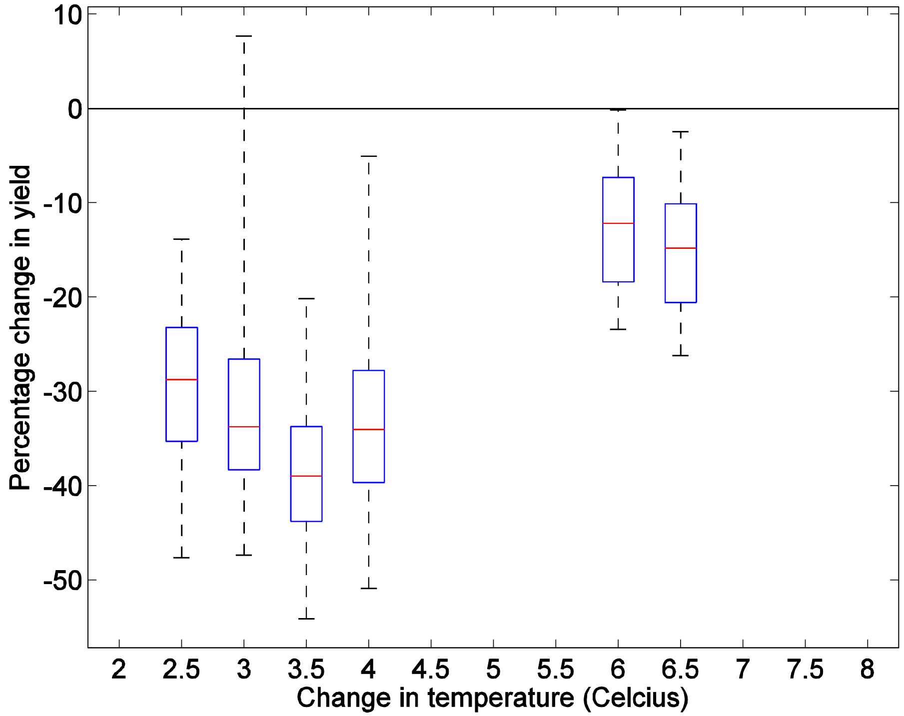


IPCC, 2007

Response of crops to warming from an ensemble of 53 climates and 36 crop responses

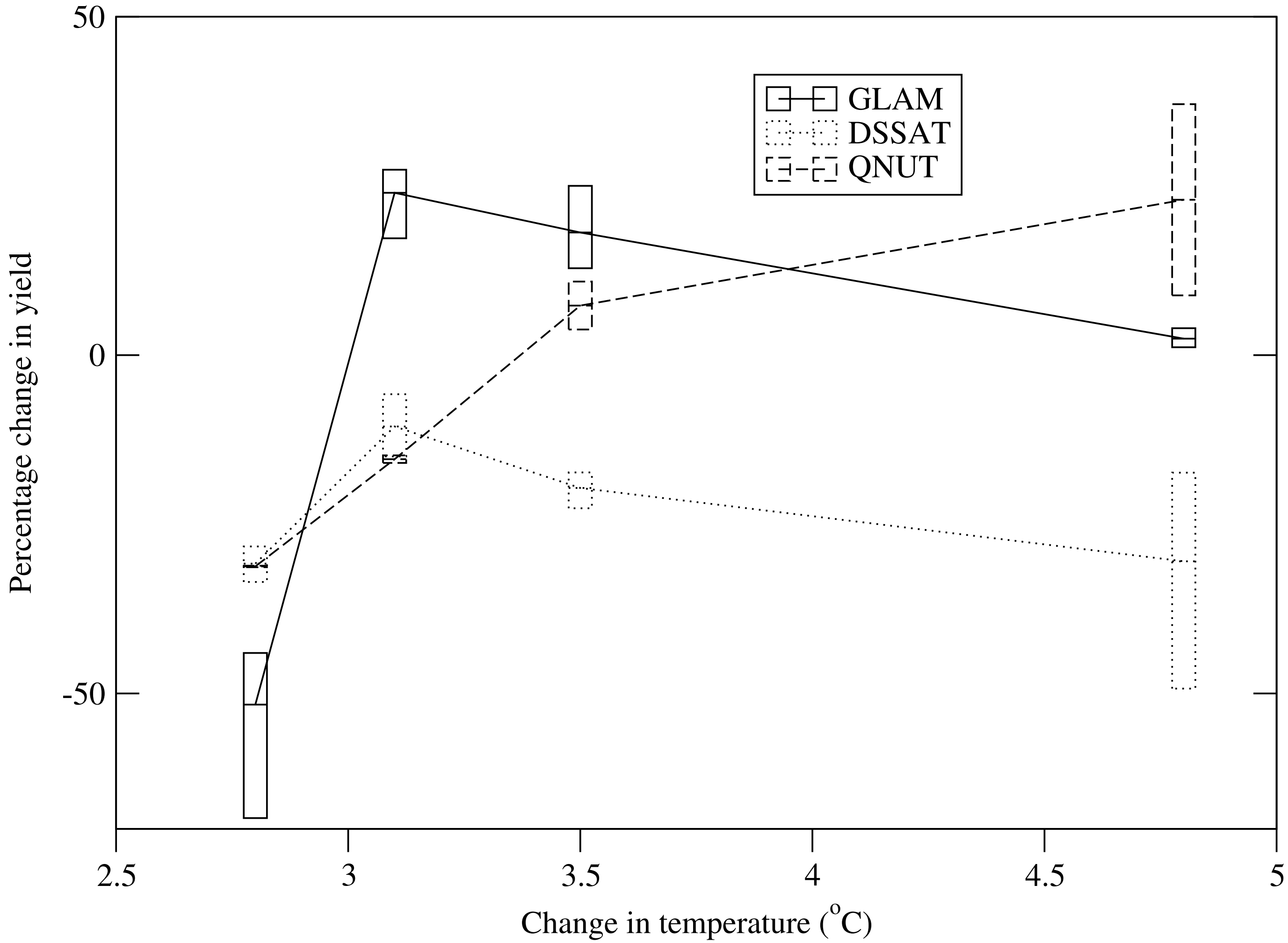


May-Nov mean global temperature



Local temperature during crop growth

Response of crops to warming:
Single-climate multi-crop model ensemble



Challinor et al. (2009a)

Need to improve treatment of uncertainties

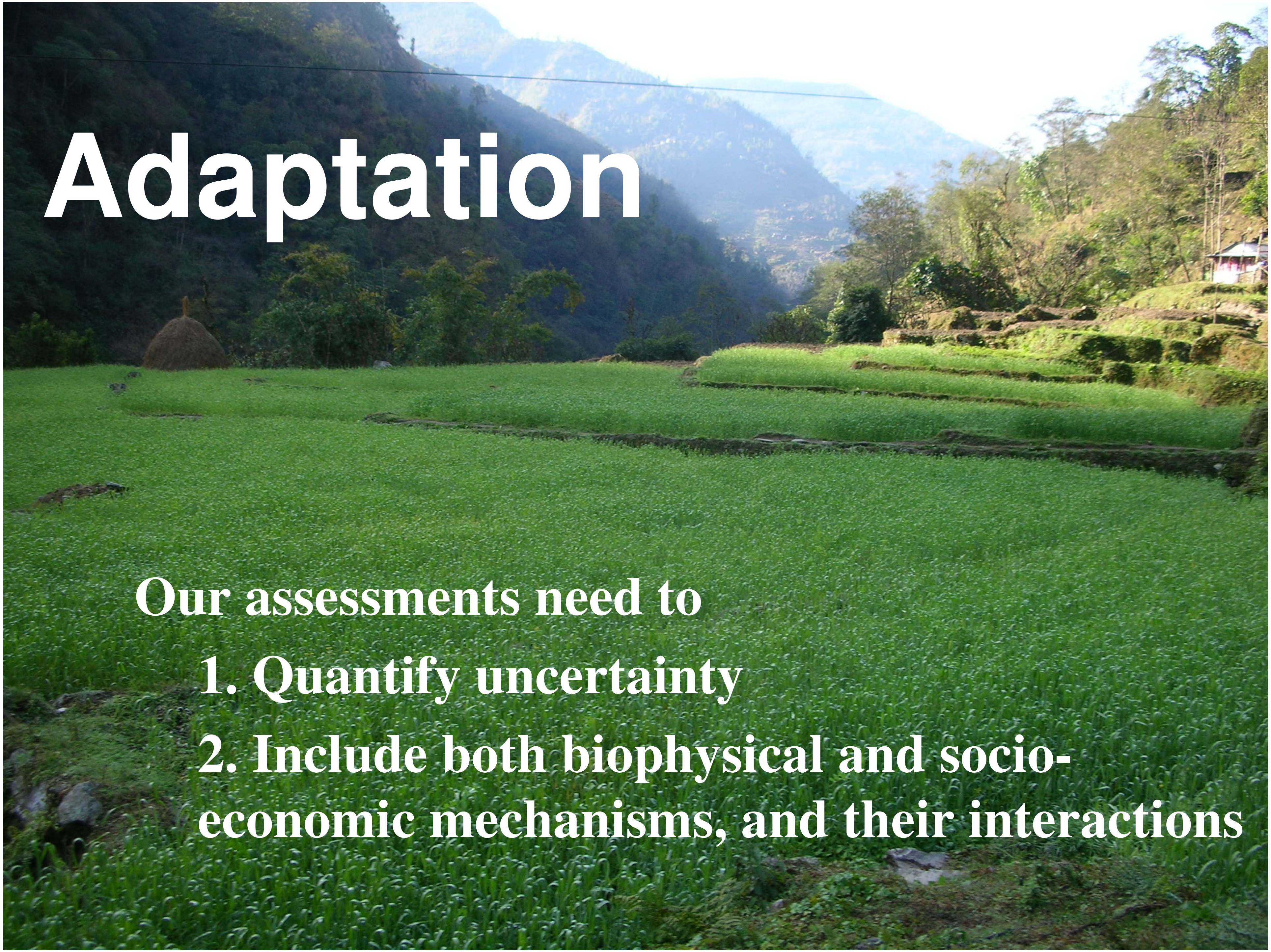
www.equip.leeds.ac.uk

EQUIP

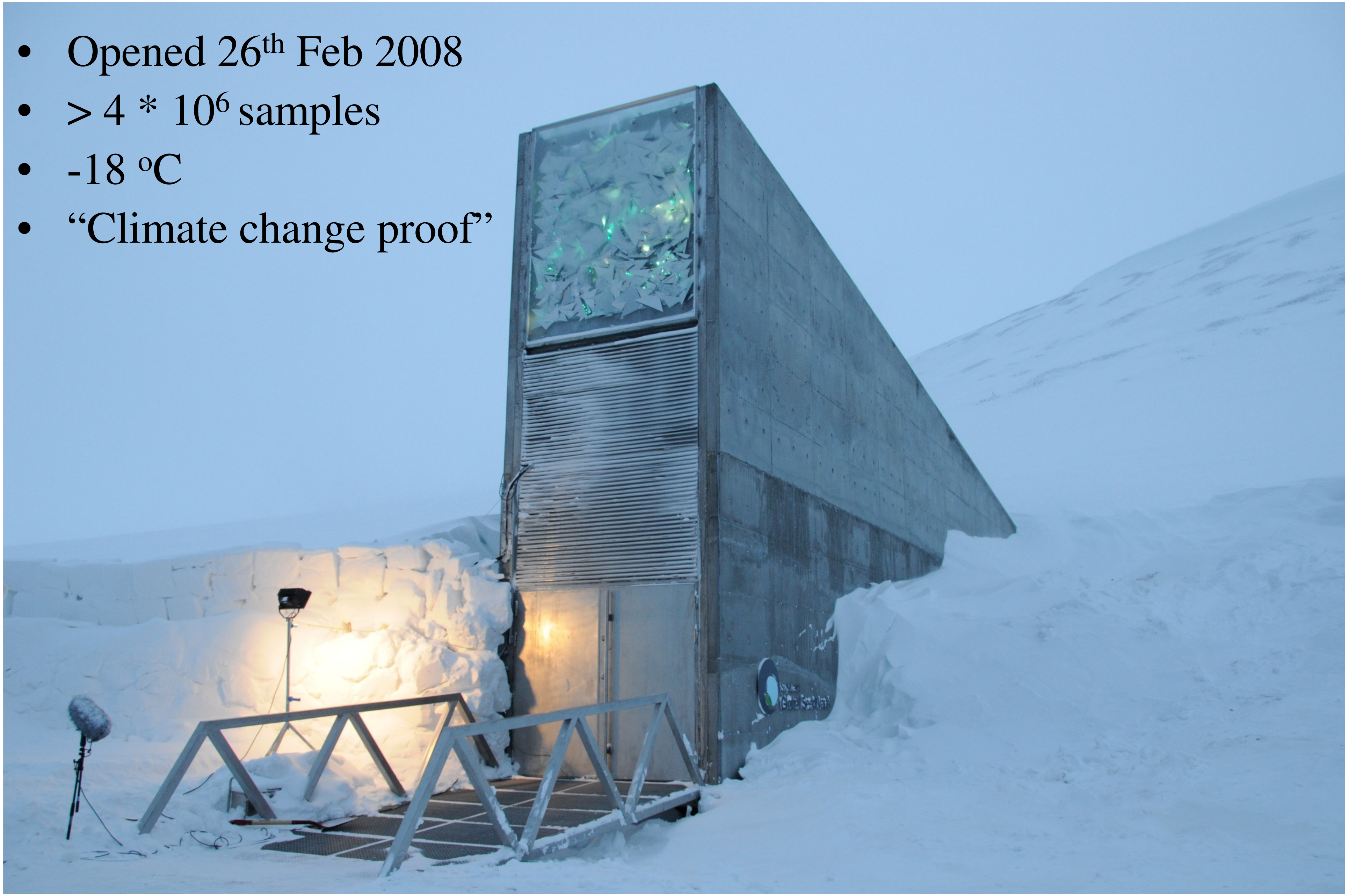
Brings together the UK climate modelling, statistical modelling, and impacts communities to work closely together for the first time to:

- Increate the utility of climate prediction: develop risk-based prediction systems for decision making
- Advance the science of uncertainty: integrated assessments of the cascade of uncertainty from climate to impacts (not just feeding climate ensembles through impact models)
- Develop new methodologies for assessing the information content of climate-model projections

	WP1 Design	WP2 Evaluation	WP3 Engagement
WP4 Implementation			
WP5 Crops			
WP6 Marine Environment			
WP7 Extremes			


Adaptation
Our assessments need to
1. Quantify uncertainty
2. Include both biophysical and socio-economic mechanisms, and their interactions

Svalbard
Global Seed Vault



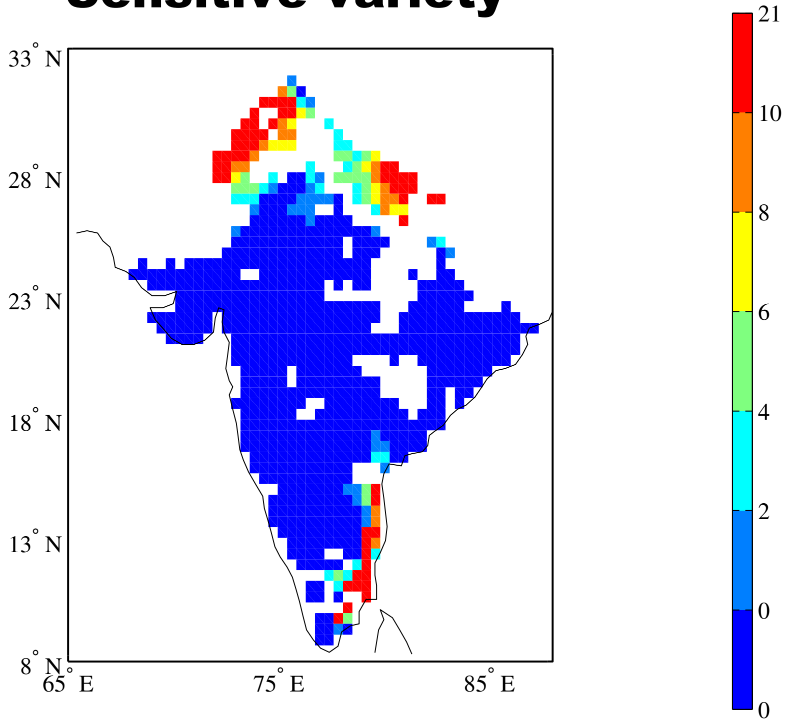
- Opened 26th Feb 2008
- > 4 * 10^6 samples
- -18 ^oC
- “Climate change proof”

Genotypic adaptation to high temperature stress

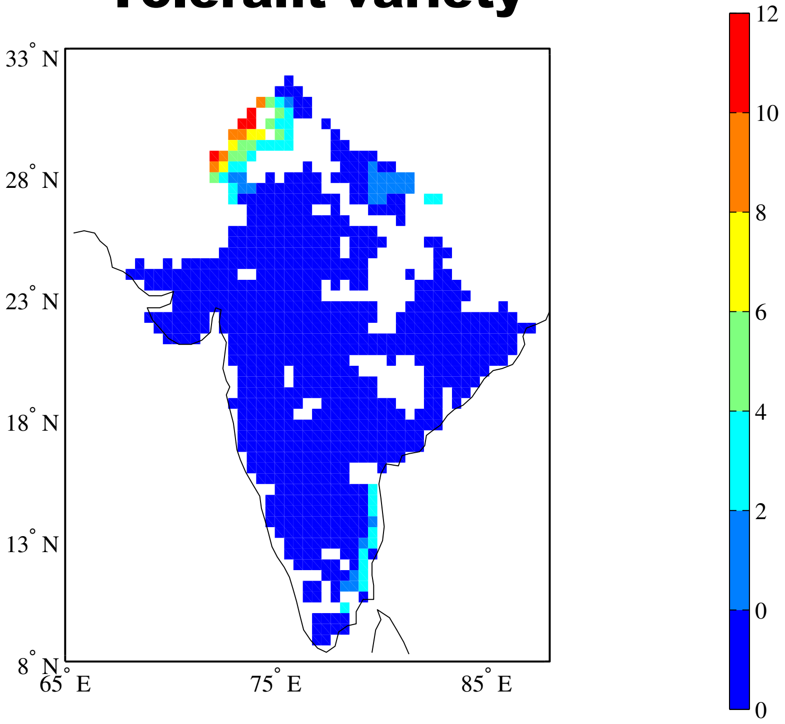
Hadley Centre PRECIS model, A2 (high emission) scenario 2071-2100

Number of years when the total number of pods setting is below 50%.

Sensitive variety

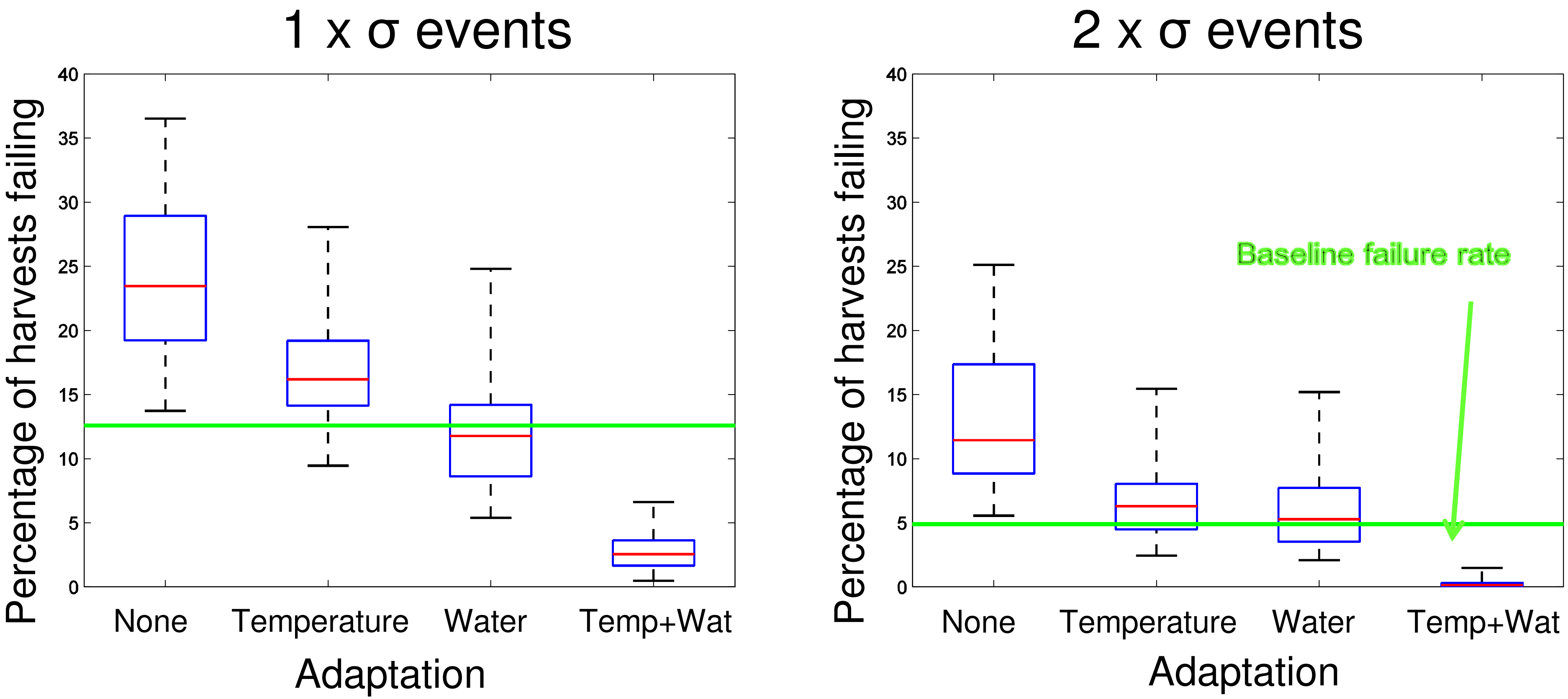


Tolerant variety



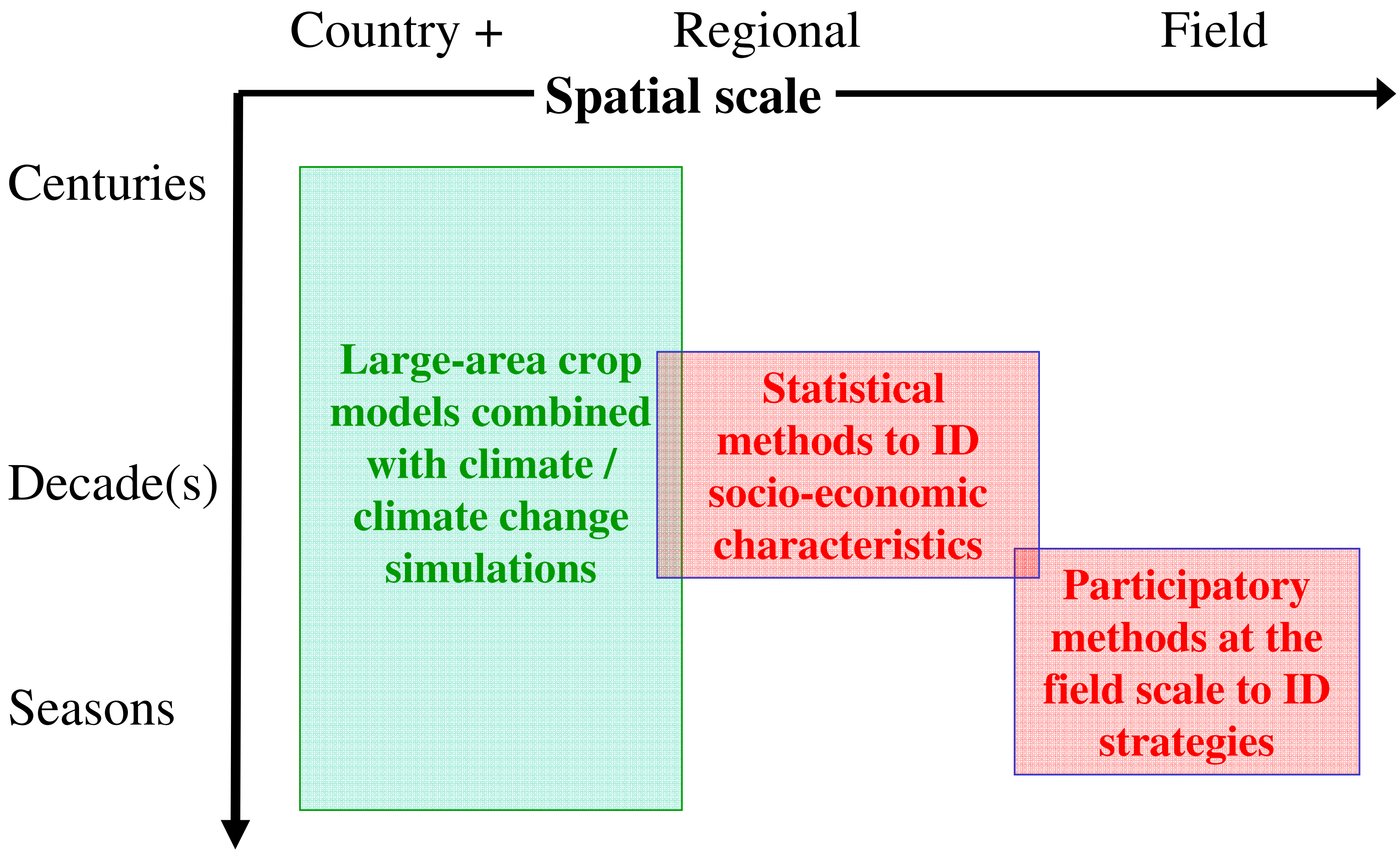
Challinor et al (2007b)

Quantifying uncertainty in genotypic adaptation

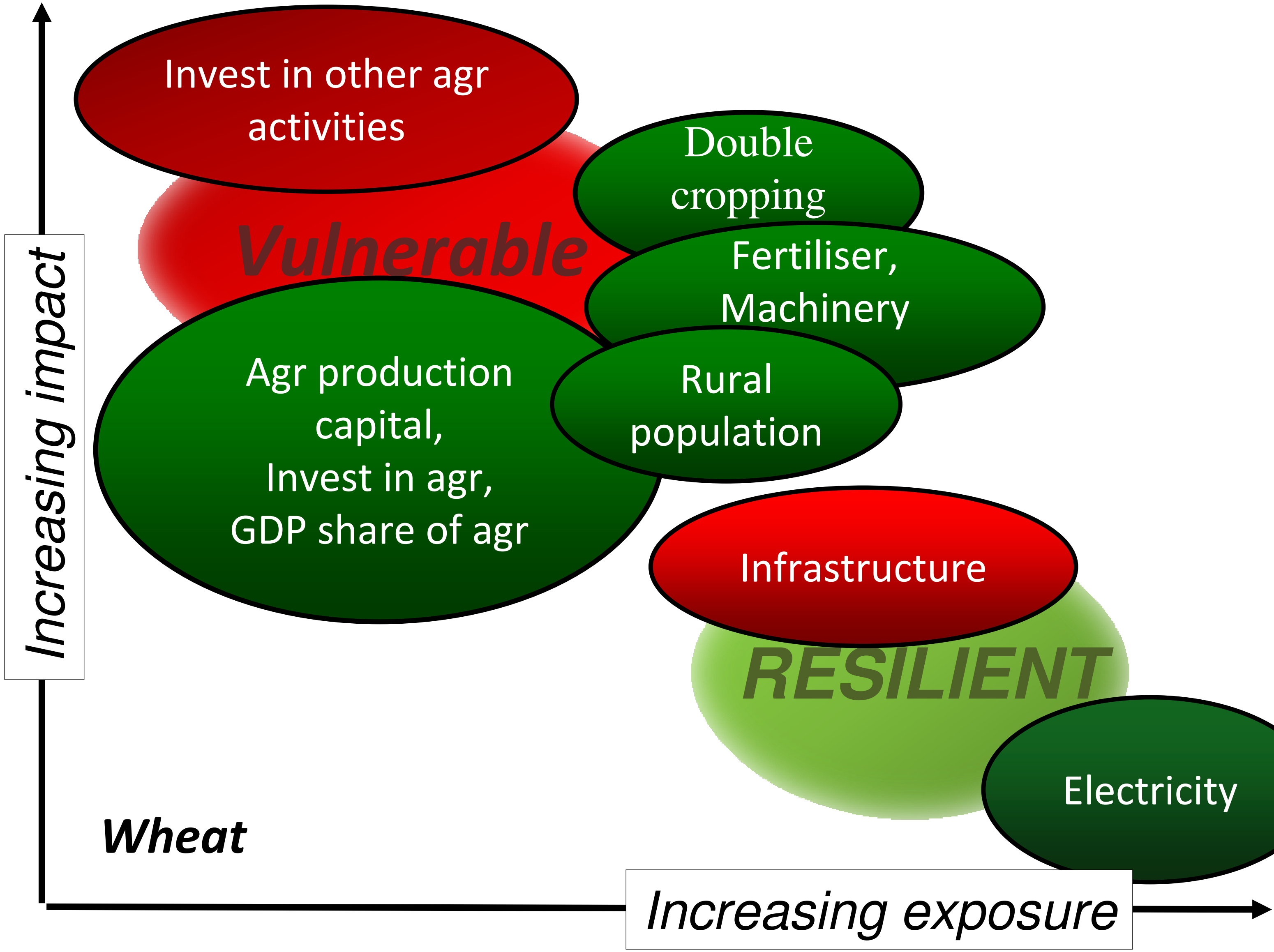


17 climates (QUMP) x 8 crop simulations for transient A1B in NE China

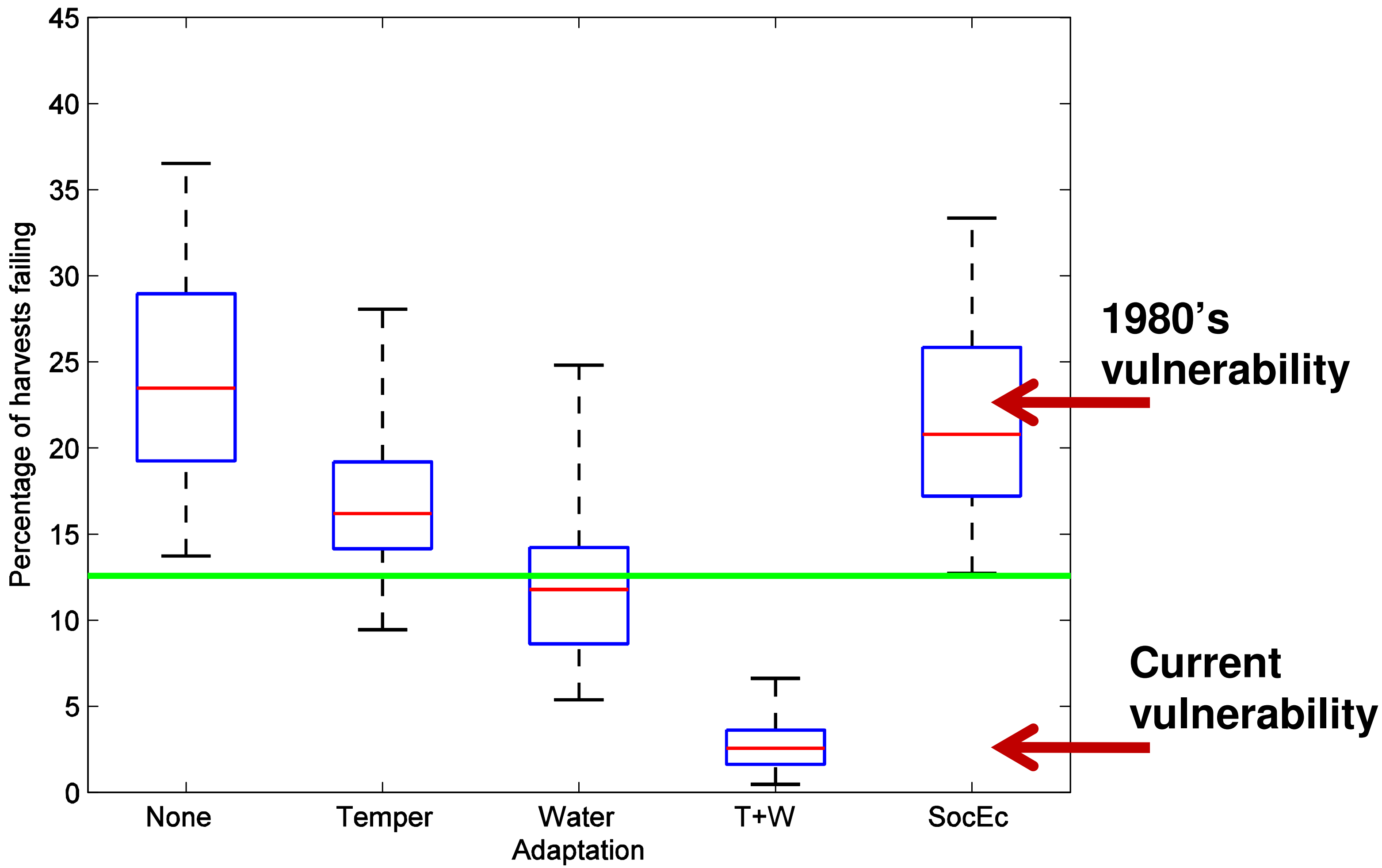
Integrating natural and social science approaches to modelling adaptation



Assessing socio-economic adaptation options



Assessing socio-economic adaptation options




Conclusions

Modelling strategies

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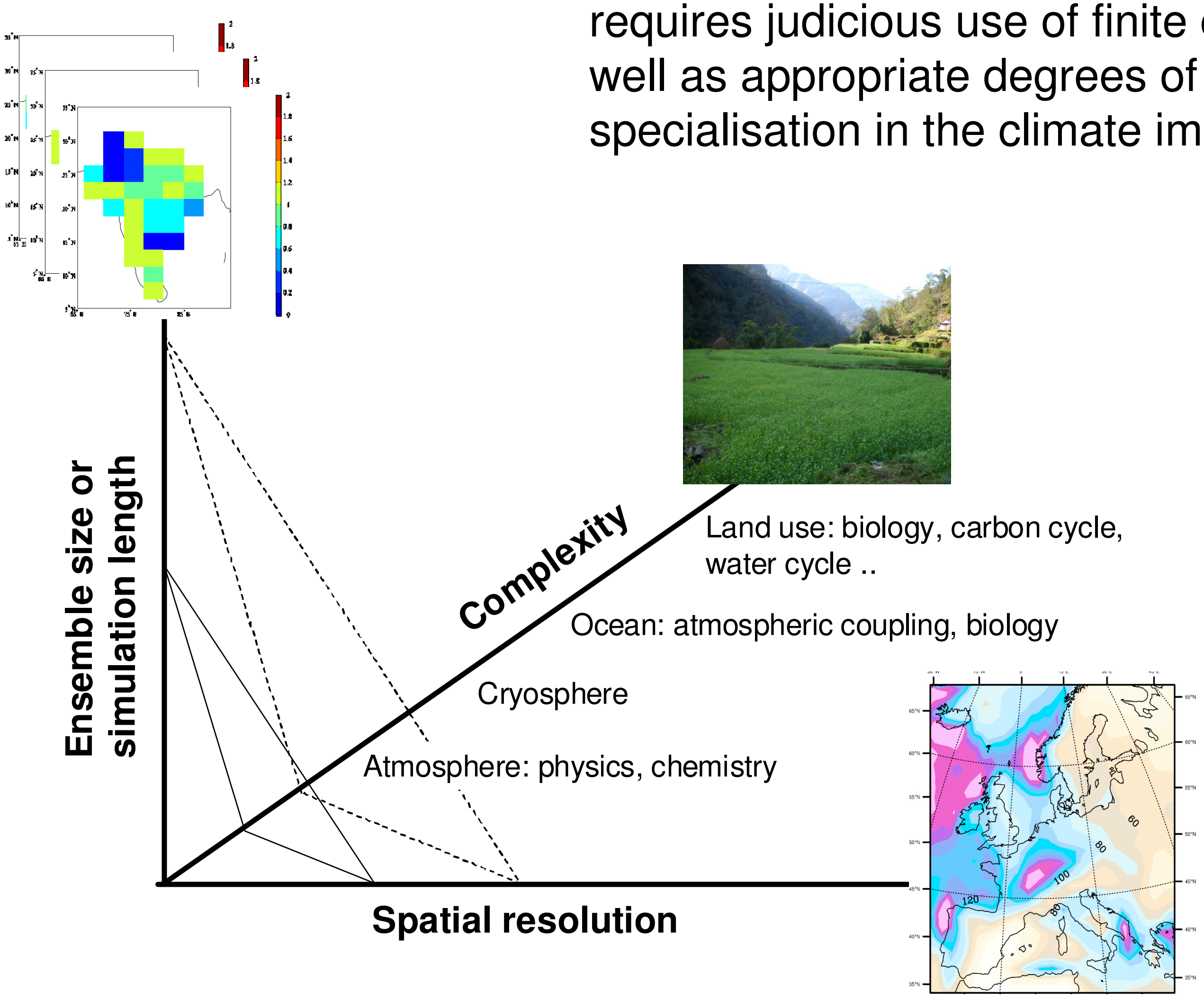
"Assessing climate impacts and adaptation options requires judicious use of finite computational resources as well as appropriate degrees of integration and specialisation in the climate impacts research community"



Challinor et al (2009c)

Modelling strategies

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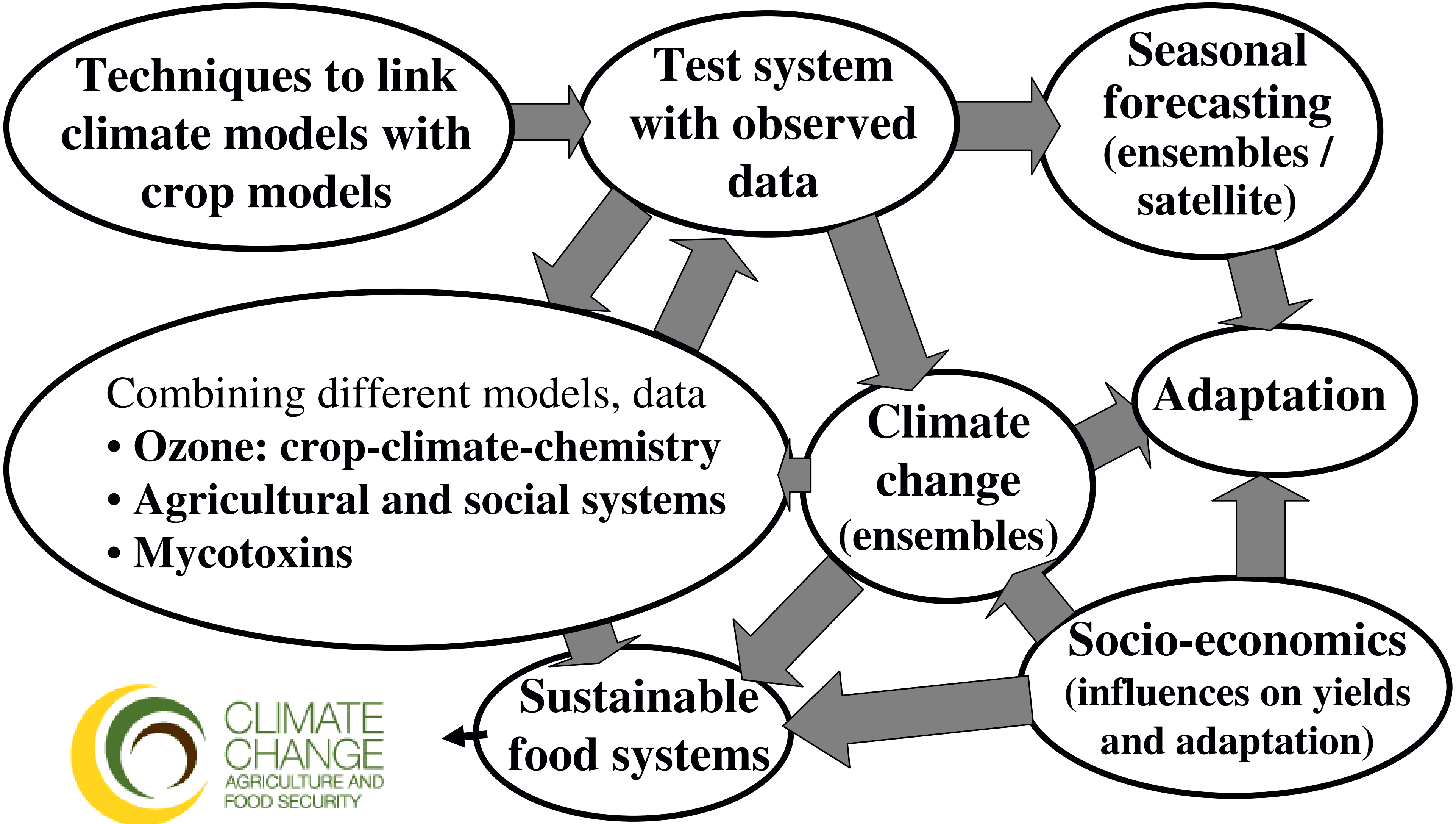

CLIMATE CHANGE
AGRICULTURE AND FOOD SECURITY

Future directions

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- Include both biophysical and socio-economic mechanisms, **and their interactions**
- Local vulnerability depends on land use policies and their effects → extend vulnerability index approach to include other drivers
- Land use perspective: demand for food, energy, carbon storage, biodiversity etc; often in competition
  - Enables study of food production (c.f. yield)

The need for systematic quantification of uncertainty

2 x CO_2 N. America	Wheat	-100 to +234%	Reilly and Schimmelpfennig, 1999
2080s Africa	Cereals	-10 to +3%	Parry et al., 1999
+4^{o}C local ΔT 'low latitude'	Wheat	-60 to +30%	IPCC AR4, chap. 5 (Easterling et al., 2007)
+4^{o}C local ΔT 'mid- to high-latitude'	Wheat	-30 to +40%	IPCC AR4, chap. 5 (Easterling et al., 2007)

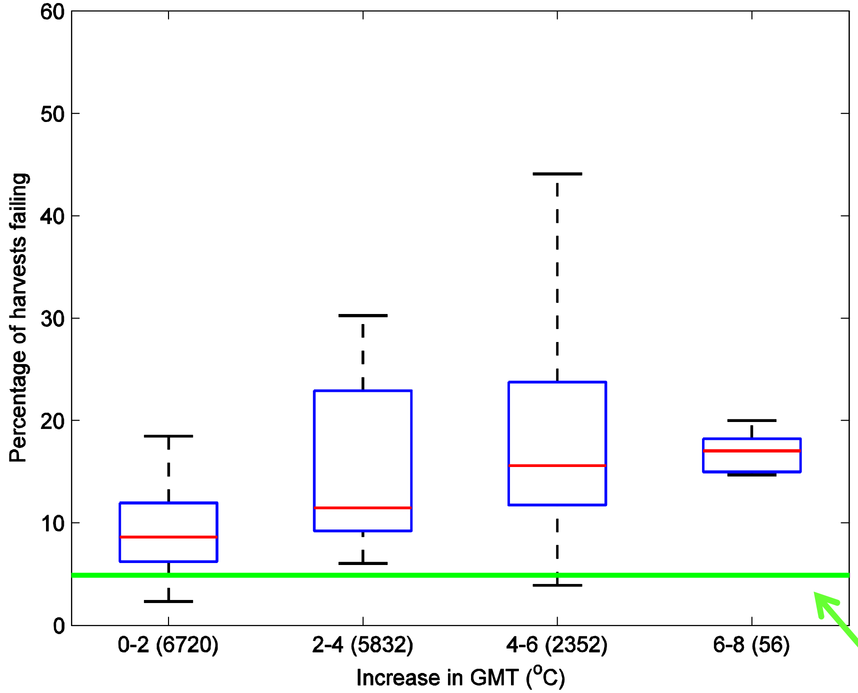
See Challinor et al. (2007a)

Studies

Description	**Climates**	**Crop responses**	**Mean temperture**
All-India A2 scenario with regional climate model (RCM)	1	18	Both > and < Topt
Study of climate and crop modelling uncertainty at one location in India under doubled CO2 (QUMP53)	53	36	<Topt [97%]
A1B scenario in north-east China (QUMP17)	17	8	>Topt
Analysis of adaptation to mean temperature in the USA, using a database of 16,000 wheat trials	-	-	<Topt

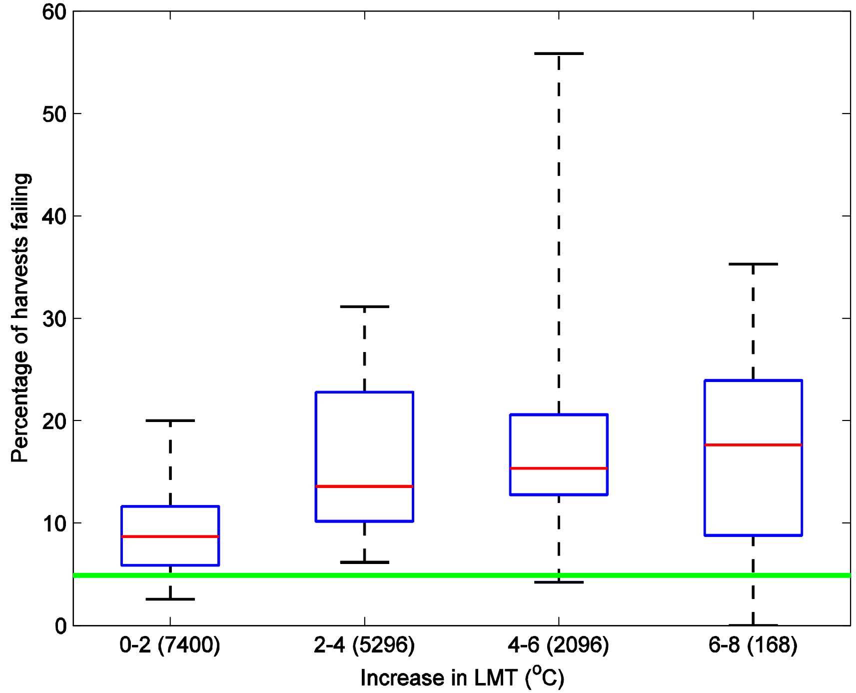
Quantifying uncertainty in crop and climate responses

Global temperature, 2 x σ events



Increase in GMT (°C)

Local temperature, 2 x σ events



Increase in LMT (°C)

Baseline failure rate

17 climates (QUMP) x 8 crop simulations for transient A1B in NE China