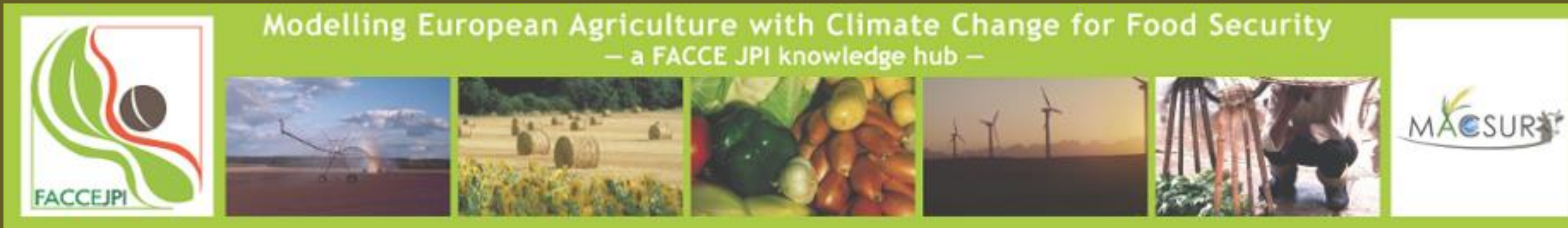

The importance of climate and policy uncertainty in Norwegian agriculture

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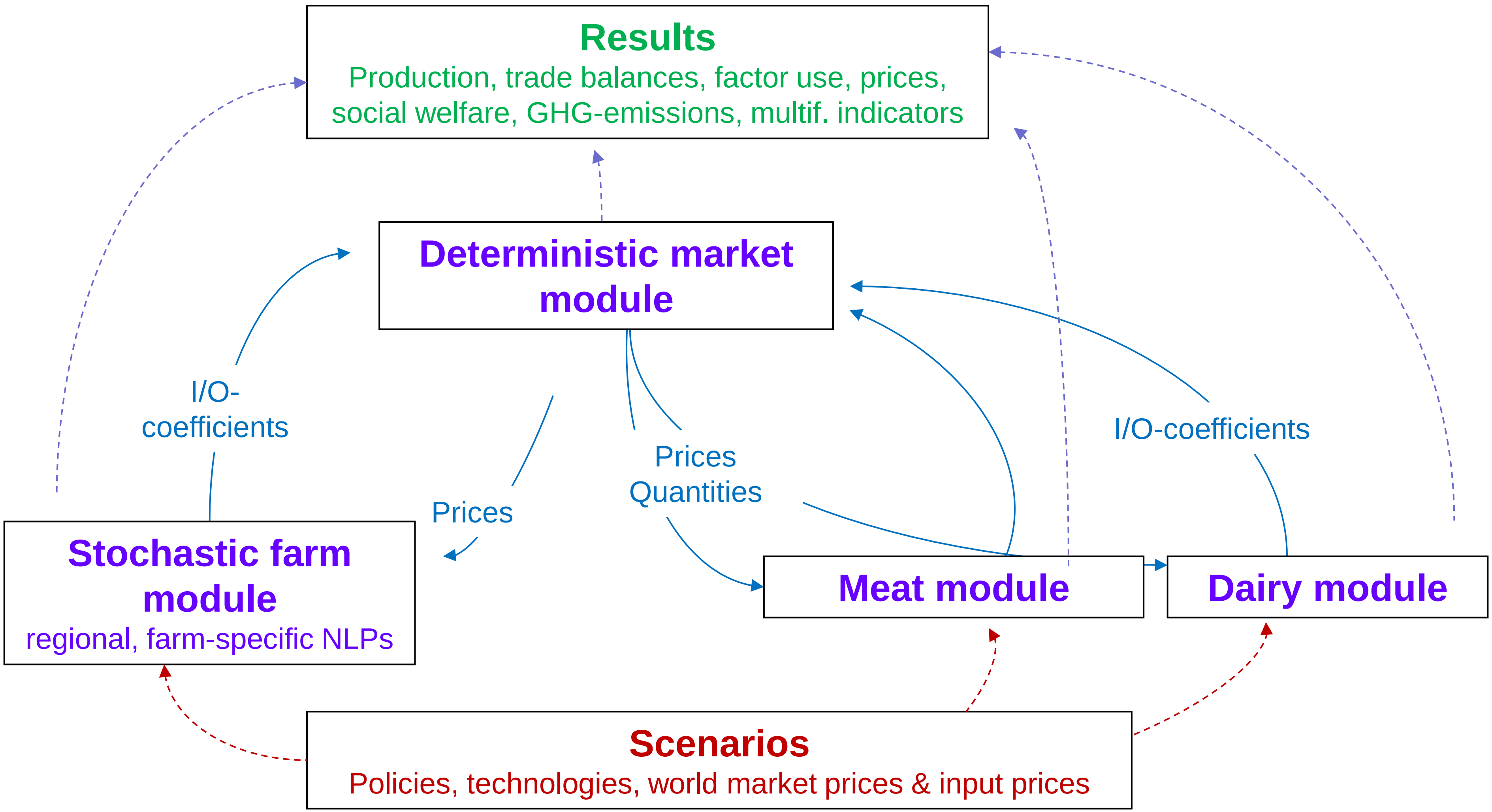
Background and motivation

- Decision-making under uncertainty
  - Unknown weather at time of crop planting
  - Crop planting, farm management, and harvest differ in timing
  - Medium-term agricultural policies not known

- Methodological approach
  - Stochastic regional farm-specific module
    - Standard mean-variance model
  - Stochastic scenario method
    - Run numerous simulations where risk-averse farmers make decisions under uncertainty in an otherwise deterministic environment

Jordmod sector model



Stochastic farm module

- Risk-averse farmers make crop planting decisions (activity level and N-intensity) under uncertainty regarding yields and payment rates:

$$E(U|\theta,\vartheta) \equiv \max_{\boldsymbol{y},\boldsymbol{x}} M\big(PS(\boldsymbol{y},\boldsymbol{x}|\boldsymbol{p},\boldsymbol{w},\theta,\vartheta)\big) - 1/2 \cdot \delta \cdot V\big(PS(\boldsymbol{y},\boldsymbol{x}|\boldsymbol{p},\boldsymbol{w},\theta,\vartheta)\big).$$

- Nature resolves uncertainty. Farmers adjust animal production system given revealed yields and payment rates
- Farmers adjust animal production system given crop levels and N-intensity:

$$E(U|\theta^n,\vartheta^n) \equiv \max_{\boldsymbol{x}} M\big(PS(\boldsymbol{x}|\boldsymbol{y},\boldsymbol{p},\boldsymbol{w},\theta^n,\vartheta^n)\big) - 1/2 \cdot \delta \cdot V\big(PS(\boldsymbol{x}|\boldsymbol{y},\boldsymbol{p},\boldsymbol{w},\theta^n,\vartheta^n)\big)$$

$E(U|\theta,\vartheta)$: *expected utility*

$M(PS)$: *Mean of producer surplus*

$V(PS)$: *Variance of producer surplus*

δ: *E standard error risk aversion coefficient*

$\boldsymbol{p}$: *vector of exogenous output prices*

$\boldsymbol{w}$: *vector of exogenous input prices*

$\boldsymbol{y}$: *vector of crop activity levels and N − intensities*

$\boldsymbol{x}$ *vector of animal activity levels*

θ: *stochastic weather variable with discrete distribution* τ_n *and probabilities* q_n

ϑ: *stochastic policy variable with discrete distribution* σ_n *and probabilities* ρ_n

Scenario set-up

- Run $N \times N$ simulations for $\tau_1, \ldots, \tau_N \times \rho_1, \ldots, \rho_N$
- Receive "pseudo-stochastic" distribution of W: $\mathrm{W}(\boldsymbol{x}|\boldsymbol{y}^{\theta_1 \vartheta_1}, \boldsymbol{p}, \boldsymbol{w}, \boldsymbol{b}), \ldots, \mathrm{W}(\boldsymbol{x}|\boldsymbol{y}^{\theta_N \vartheta_N}, \boldsymbol{p}, \boldsymbol{w}, \boldsymbol{b})$
- *N = 5*

Description	Deviation from mean in terms of std.dev.
MIN3	-3
MIN1	-1
MEAN	0
PLUS1	+1
PLUS3	+3

Three scenarios

Policy uncertainty

		Climate uncertainty				
		Min3	Min1	Mean	Plus1	Plus3
Policy uncertainty	Min3			X		
	Min1			X		
	Mean			X		
	Plus1			X		
	Plus3			X		

Combined climate and policy uncertainty

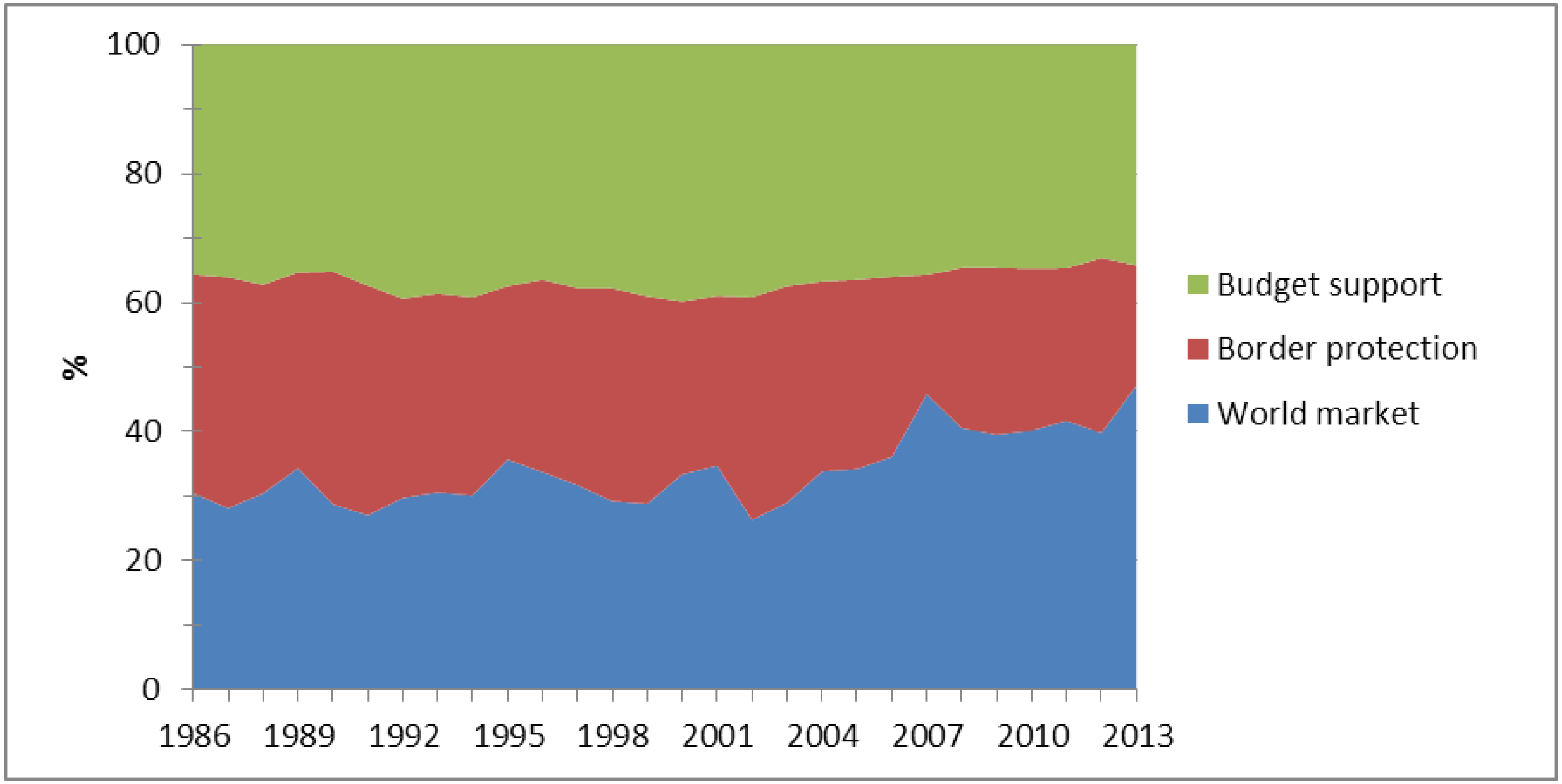
		Climate uncertainty				
		Min3	Min1	Mean	Plus1	Plus3
Policy uncertainty	Min3	X	X	X	X	X
	Min1	X	X	X	X	X
	Mean	X	X	X	X	X
	Plus1	X	X	X	X	X
	Plus3	X	X	X	X	X

Climate uncertainty

		Climate uncertainty				
		Min3	Min1	Mean	Plus1	Plus3
Policy uncertainty	Min3					
	Min1					
	Mean	X	X	X	X	X
	Plus1					
	Plus3					

Uniform probability distribution

Importance of policy risk:
Gross farm revenues in Norway (1986-2013)



Source: OECD (2014)

NILF
Norsk institutt for landbruksøkonomisk forskning

Modelling policy risk

Mean and variance of aggregate budget support, 2000-2013, 2011- prices

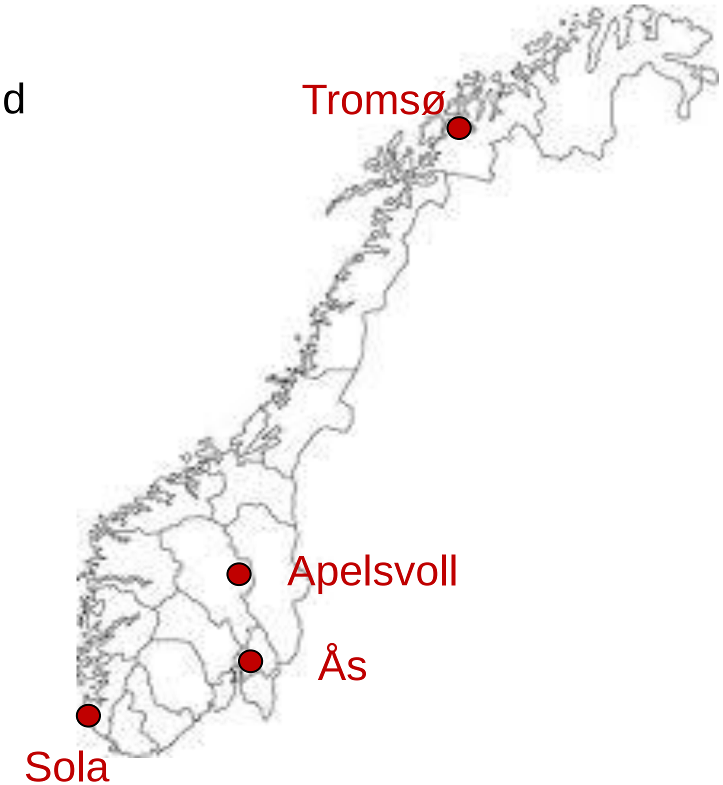
	mill 2011-kr
Highest	13 992
Lowest	11 939
Mean	12 915
Std.dev.	554

Scenario	Application factor
MIN3	.8714
MIN1	.9571
MEAN	1
PLUS1	1.0429
PLUS3	1.1286

Modelling stochastic grass yields

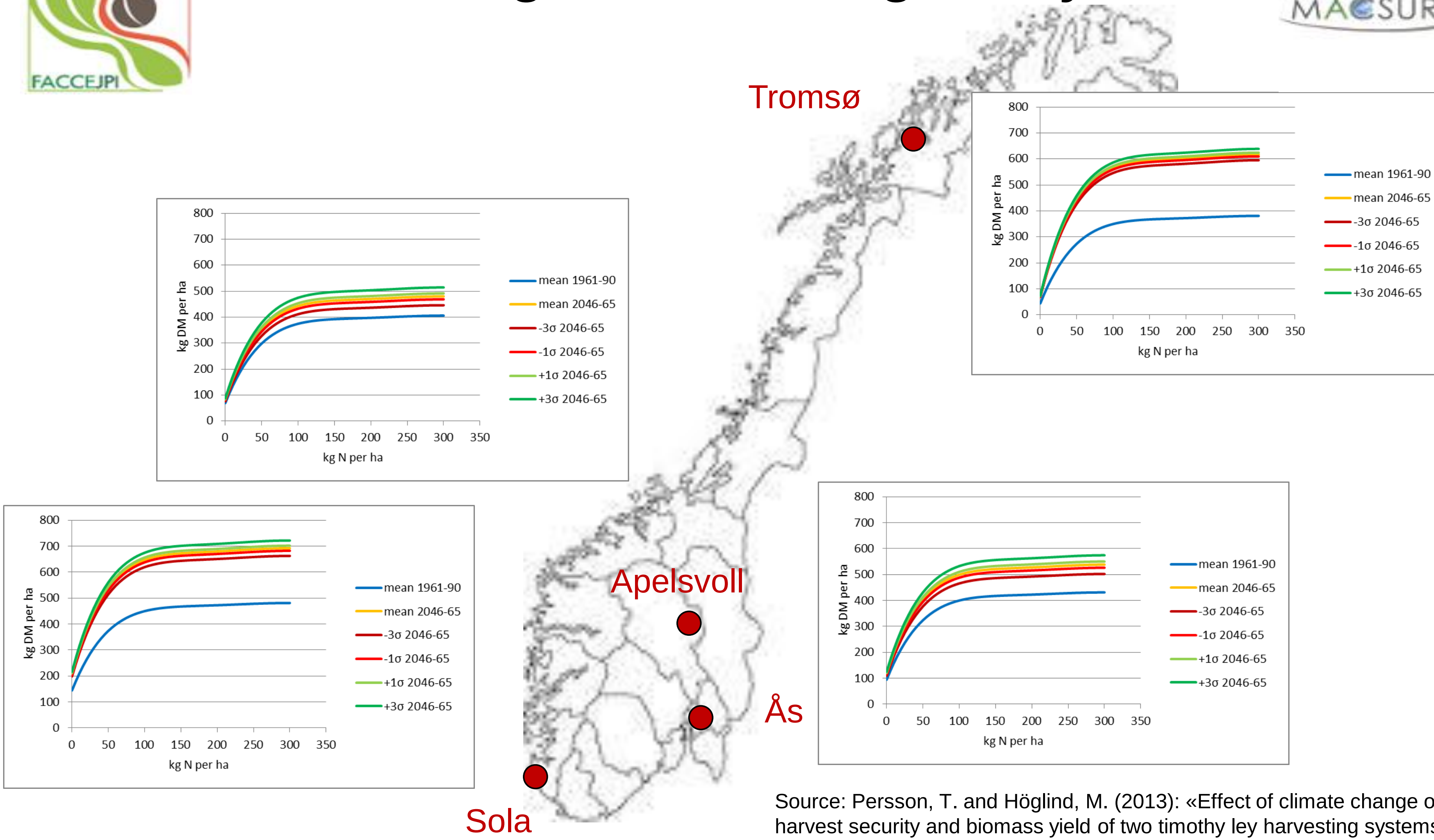
- LINGRA model
- Simulated biomass yields at four locations (g DM ha^{-1} cut & grazing) for base period (1961-90) and simulation period (2046-65)
- 1 N-level
- Yield gap 36-58 % in base period
- Calibration of explicit yield functions depending on N

kg fodder units per ha	Baseline	Simulation	Application factor
Mean	9 299	10 670	
Variance		1 190	
Std.dev.		34.5	
MIN3		10 567	0.9903
MIN1		10 636	0.9968
MEAN		10 670	1.0000
PLUS1		10 704	1.0032
PLUS3		10 773	1.0097



Source: Persson, T. and Höglind, M. (2013): «Effect of climate change on harvest security and biomass yield of two timothy ley harvesting systems in Norway». *The Journal of Agricultural Science* 152(2): 205-216

Modelling stochastic grass yields



Source: Persson, T. and Höglind, M. (2013): «Effect of climate change on harvest security and biomass yield of two timothy ley harvesting systems in Norway». *The Journal of Agricultural Science* 152(2): 205-216

Modelling stochastic cereals yields

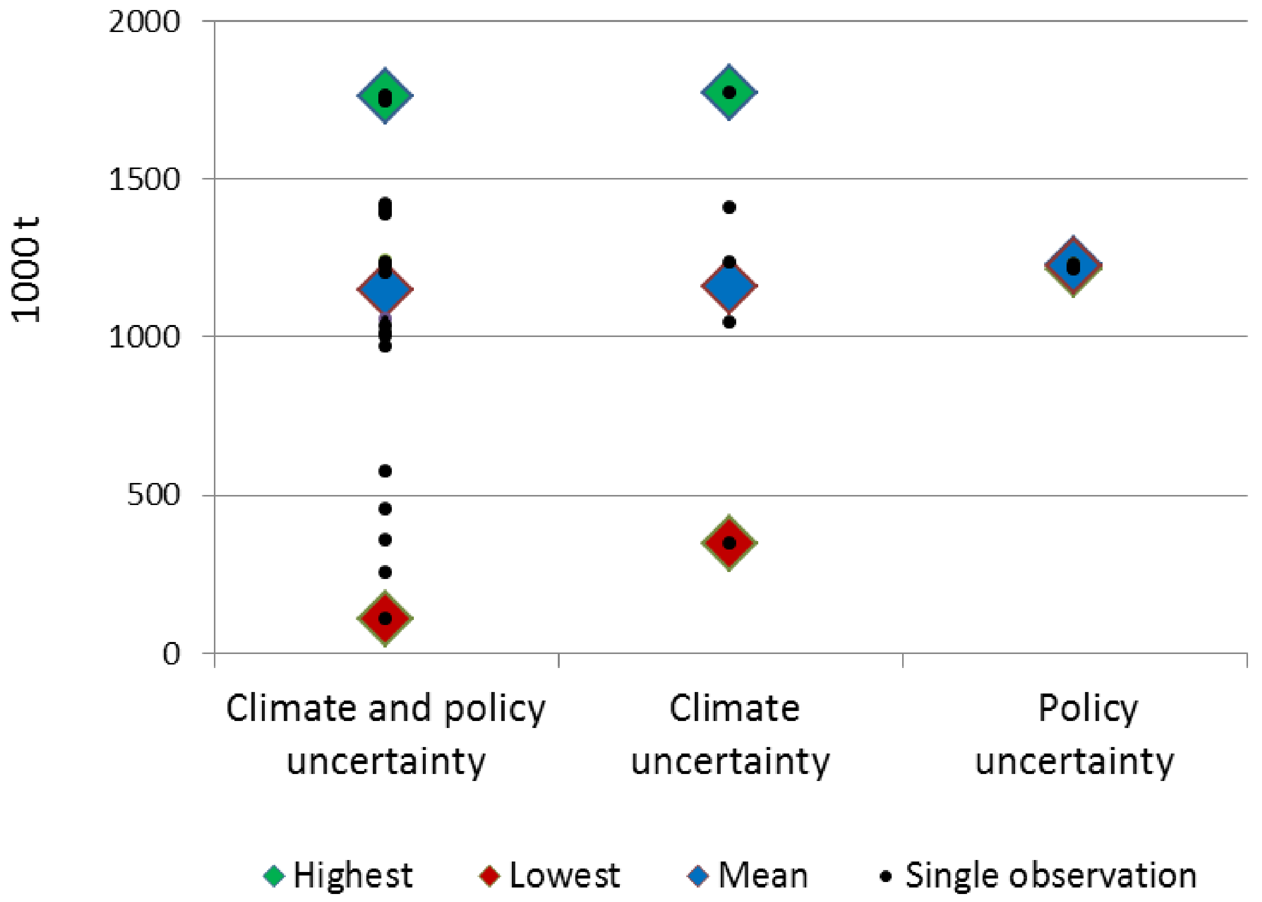
Rawdata

- CSM-CERES-wheat model
- Daily weather data generated by 15 global climate models A1B scenario
- 4 sets of representative soil profiles with various size
- 3 wheat varieties (Bjarne, Demonstrant, Zebra)
- 1 planting date
- 1 N-fertilizer level

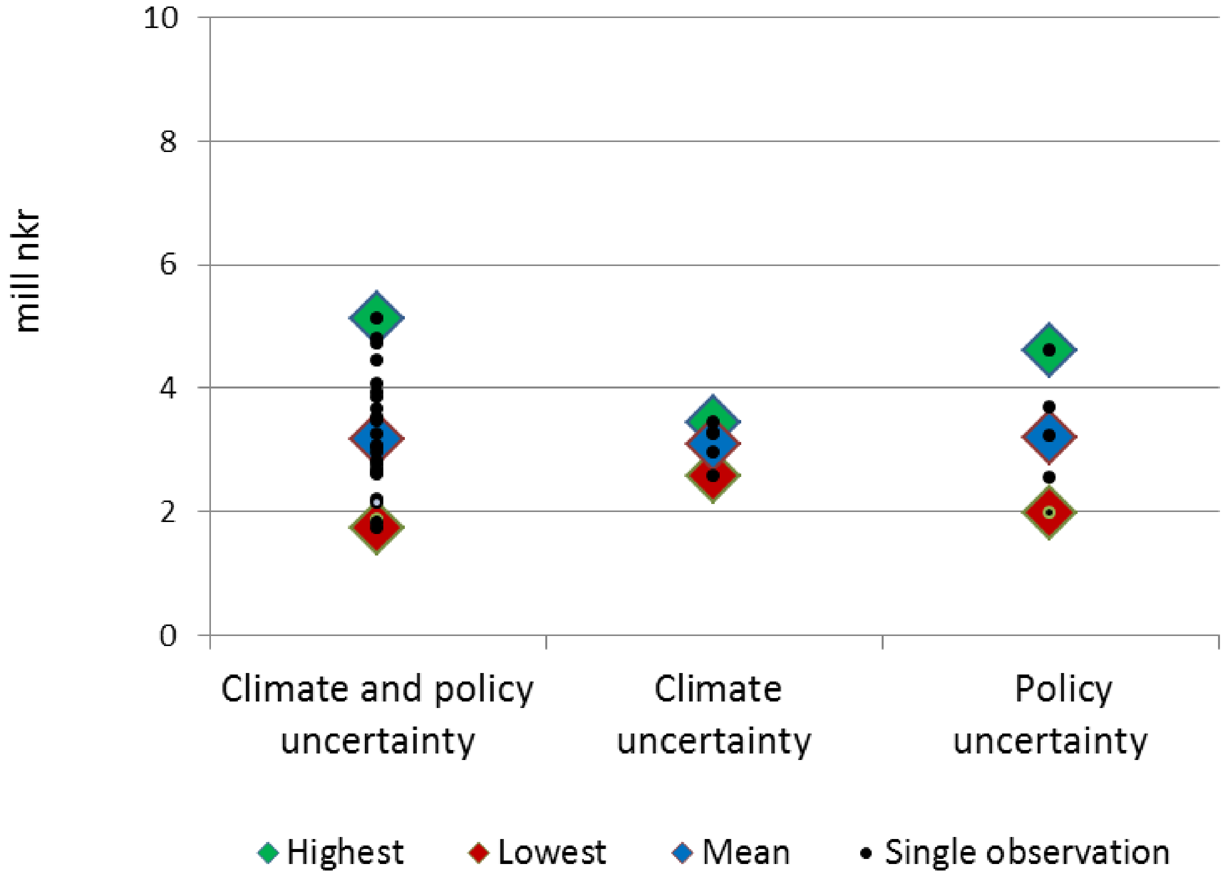
kg/ha	Baseline	Simulation	Application factor
Mean	5 133	5 724	
Variance	437 388	525 883	
Std.dev.	661	725	
MIN3	3 149	3 548	0.6913
MIN1	4 472	4 999	0.9739
MEAN	5 133	5 724	1.1151
PLUS1	5 794	6 449	1.2564
PLUS3	7 117	7 899	1.5390

Source: Persson, T. and Kværnø, M (2014): Impact of soil properties regionalization methods on regional wheat yield in souteastern Norway. MACSUR Mid-term conference, April 1-4, Sassari, Italy

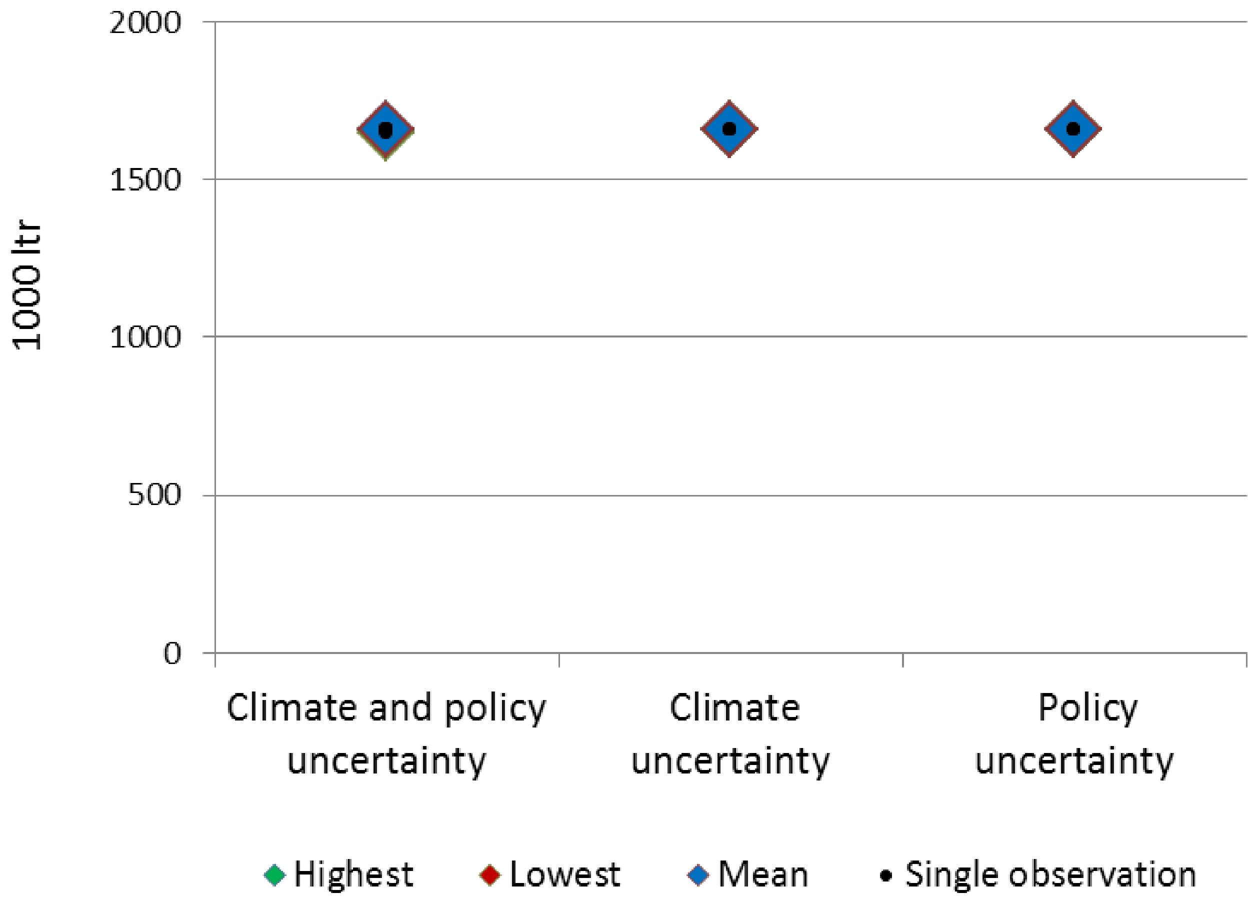
Results: Cereals production



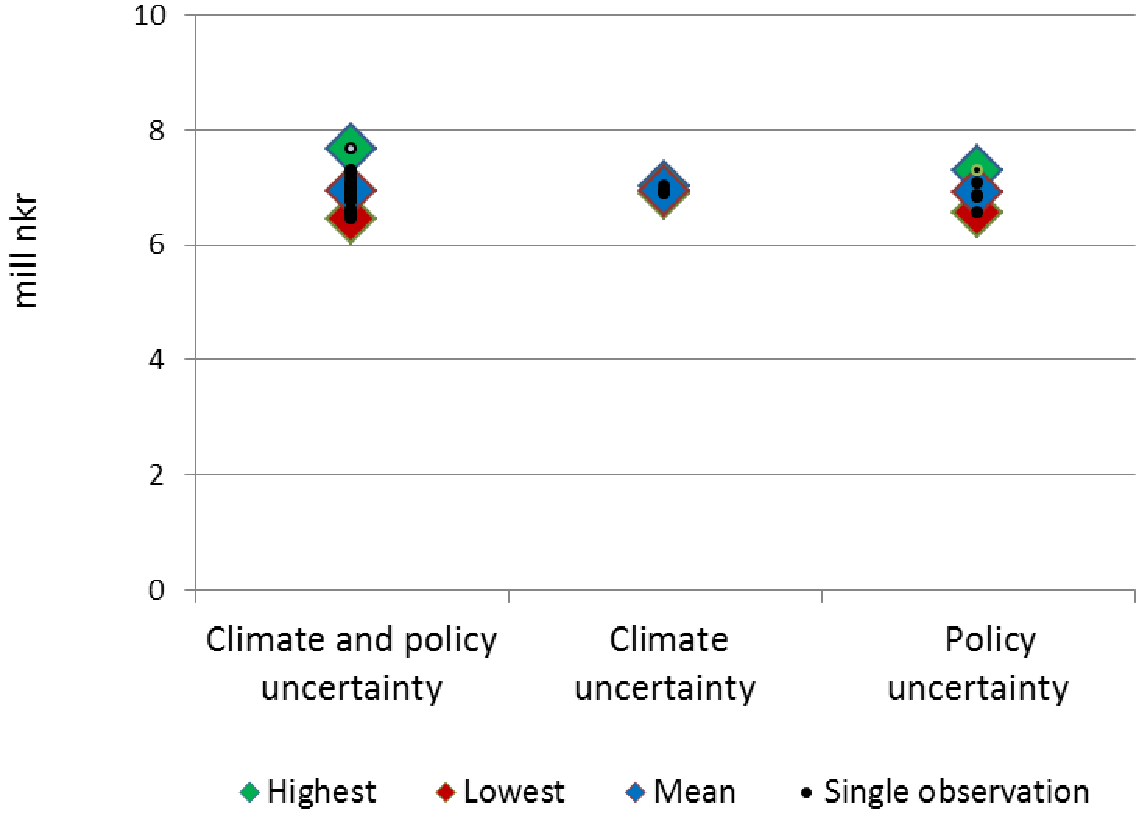
Results: Land rents



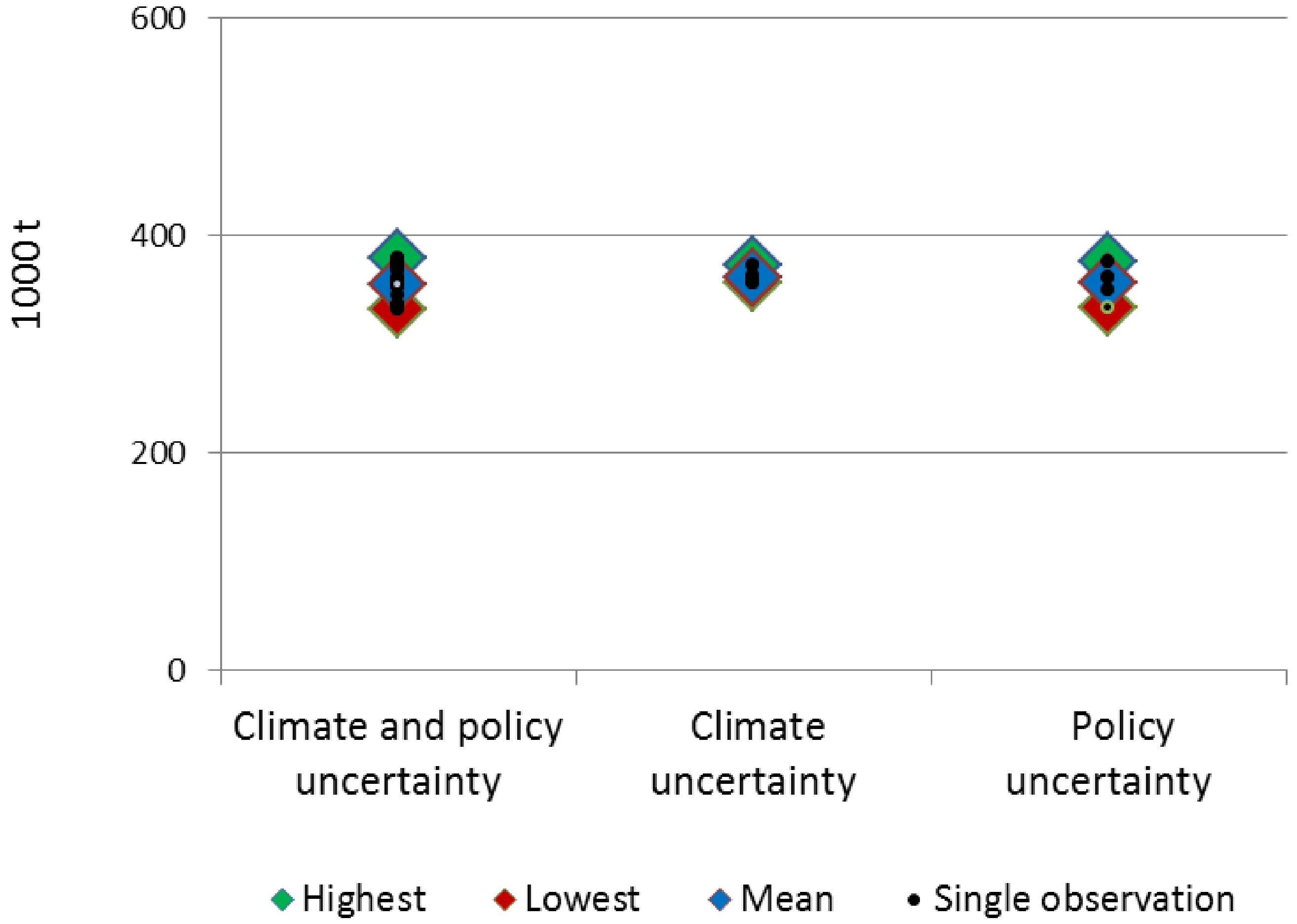
Results: Milk production



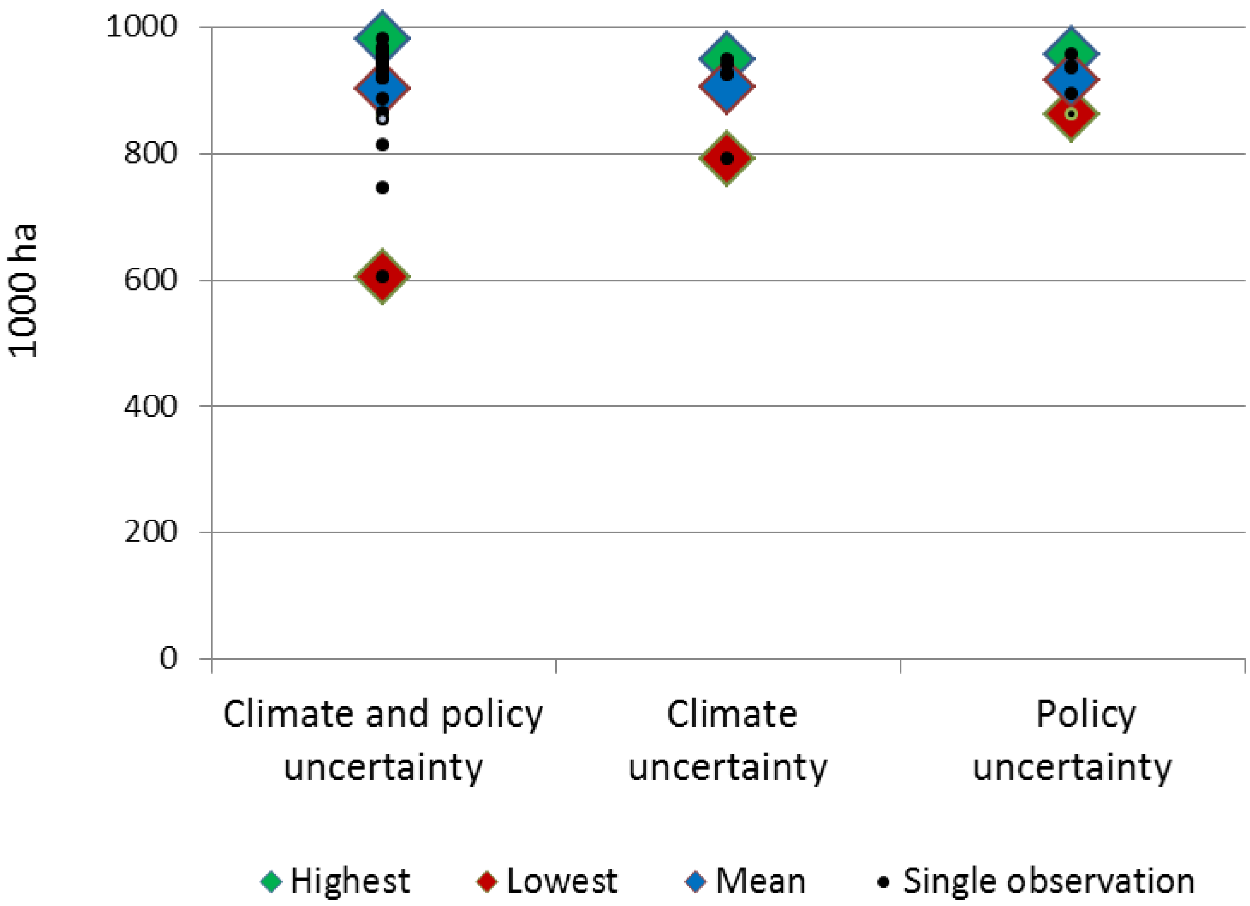
Results: Milk quota rents



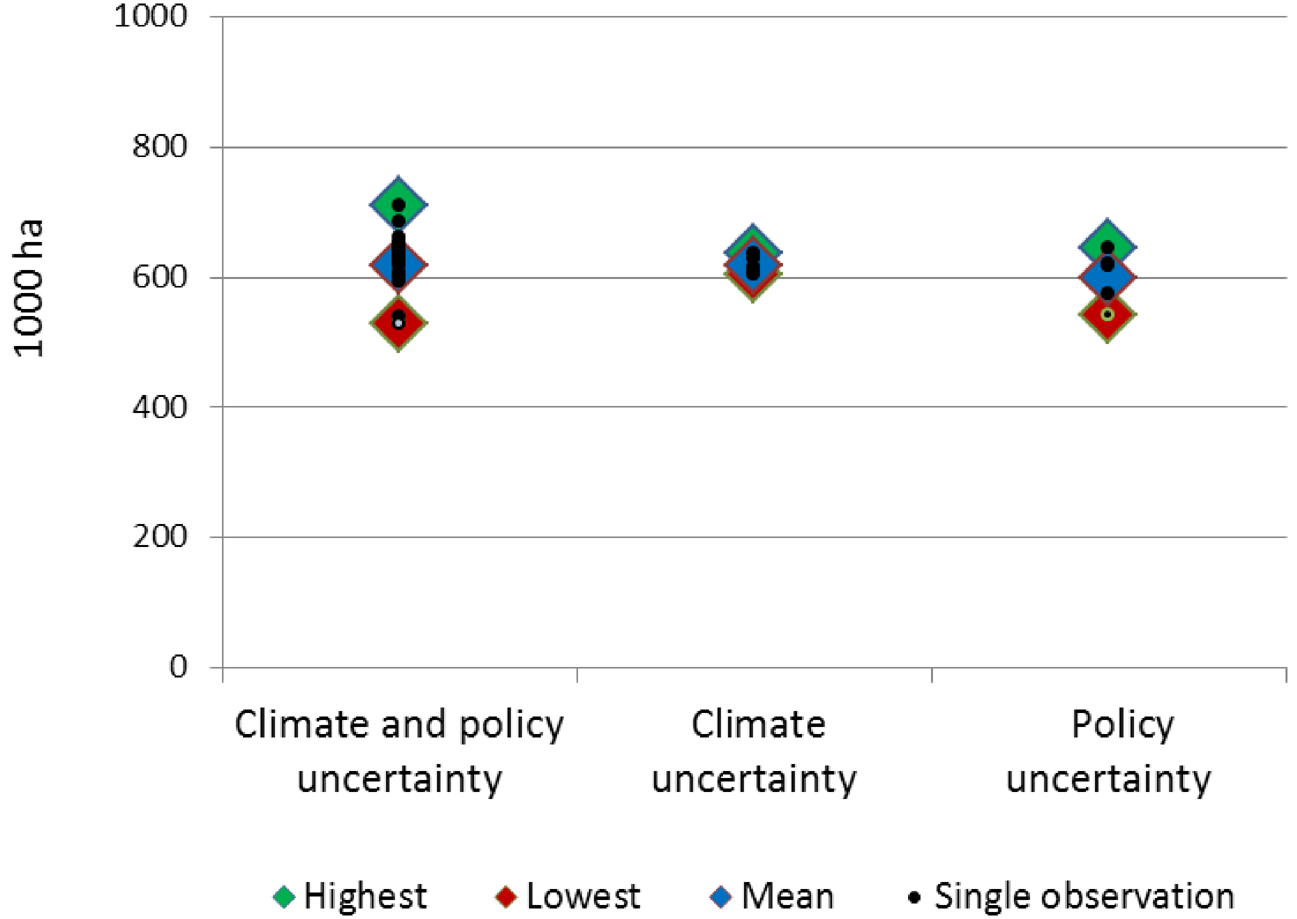
Results: Meat production



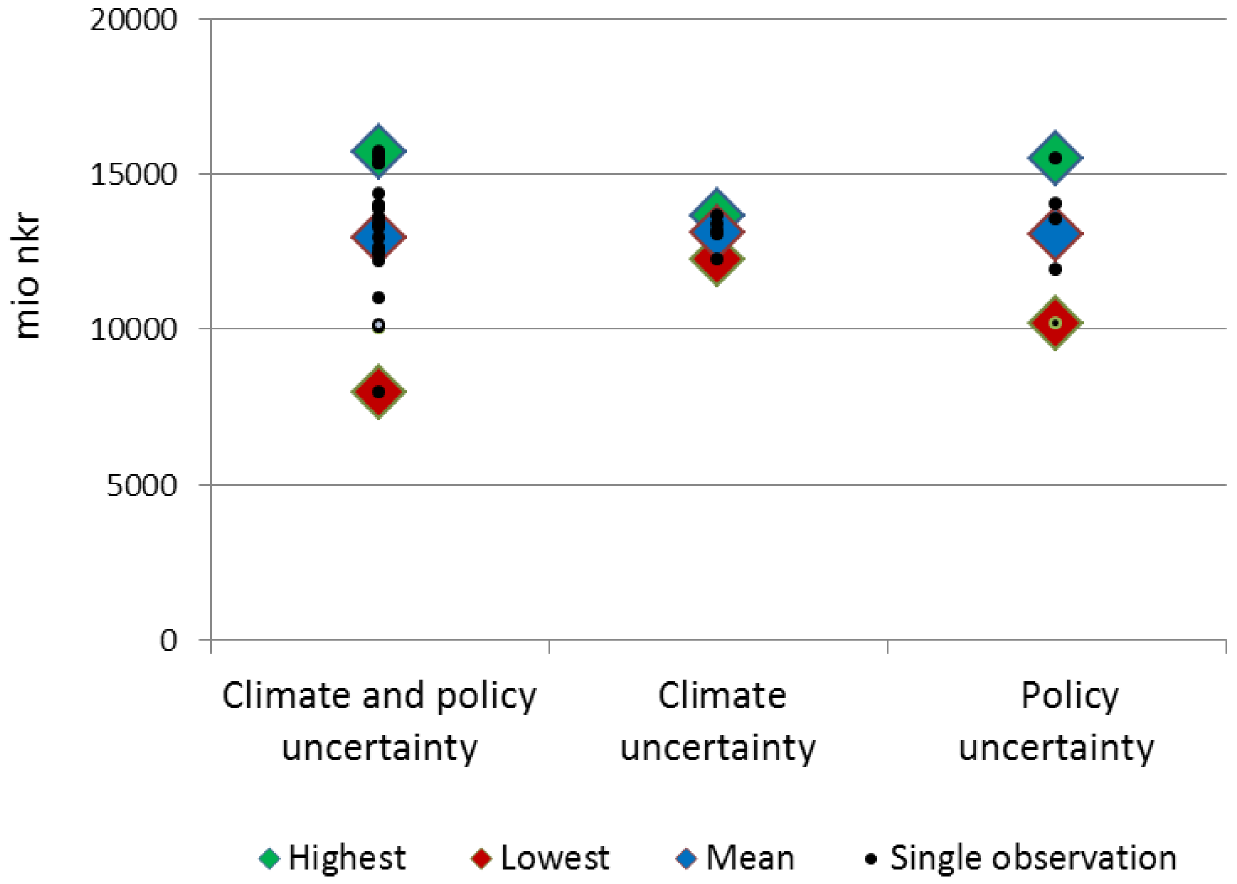
Results: Agricultural area



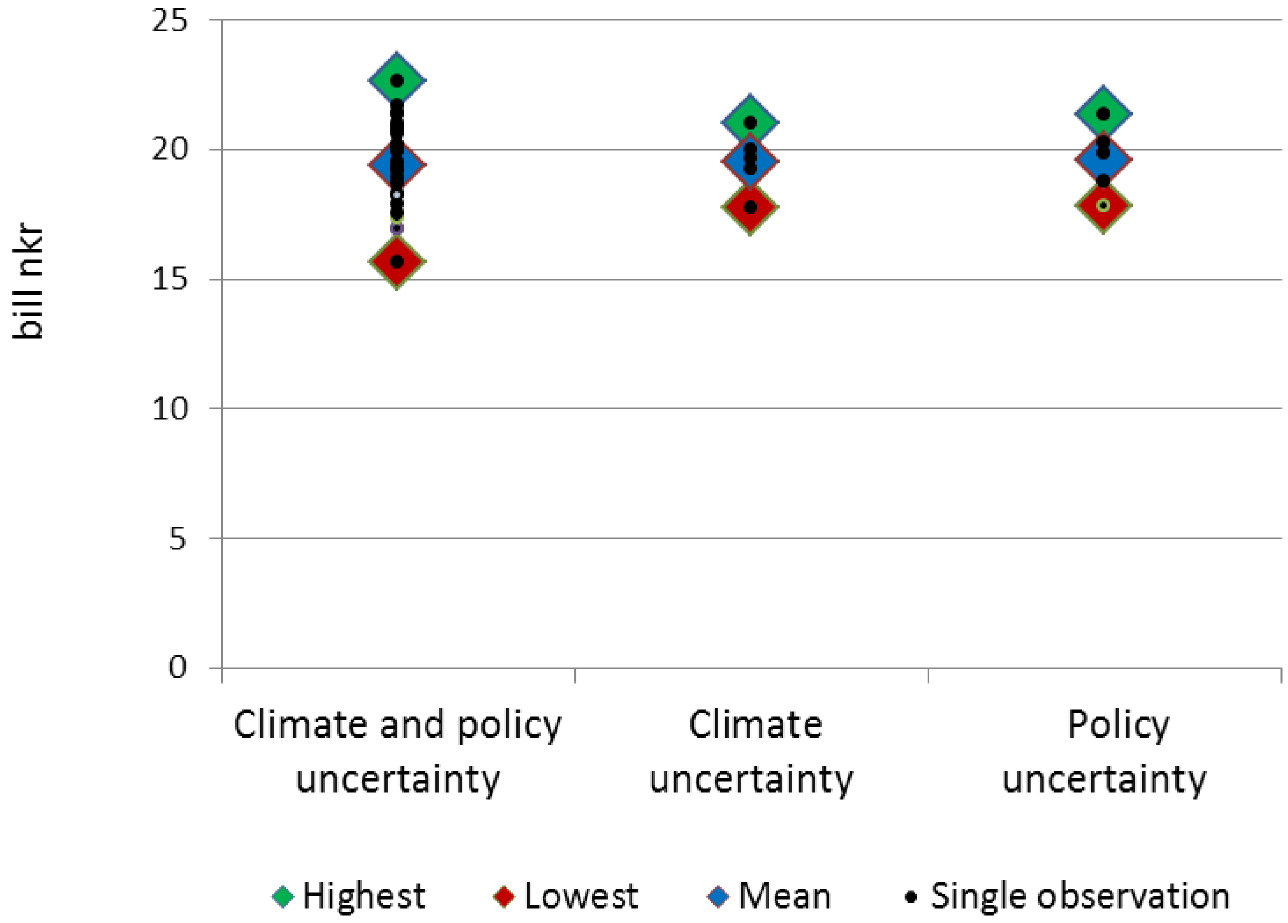
Results: Fodder area



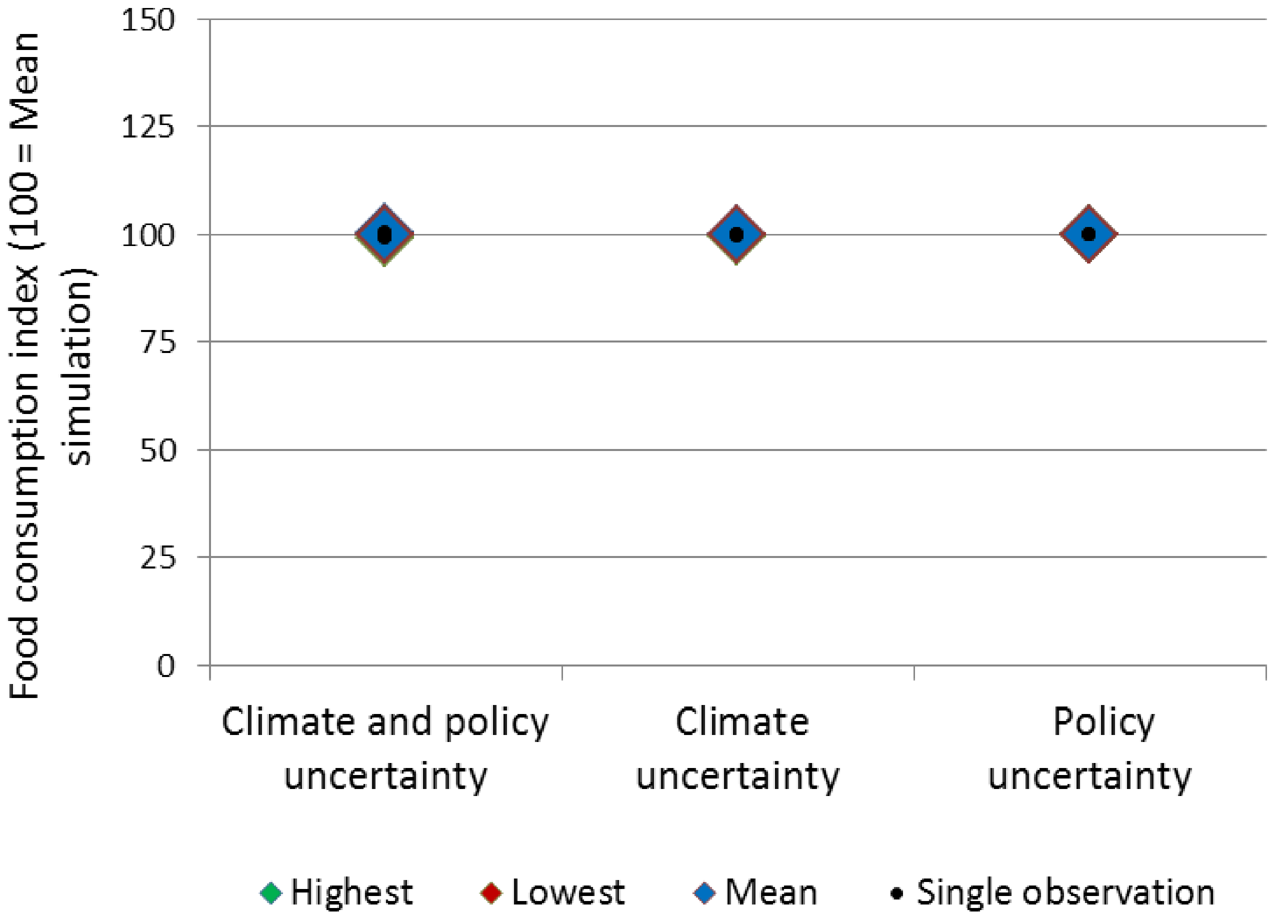
Results: Budget support



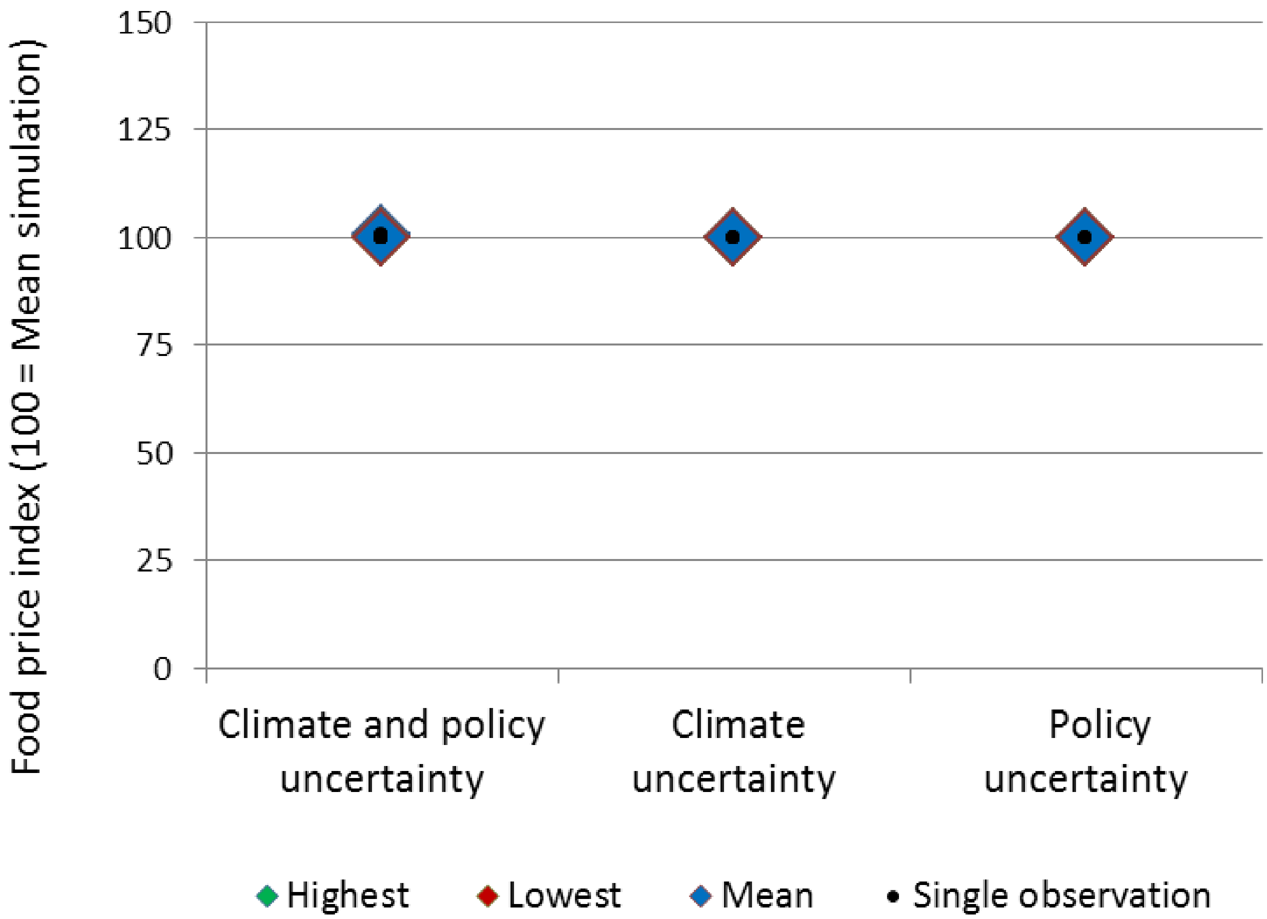
Results: Agricultural income



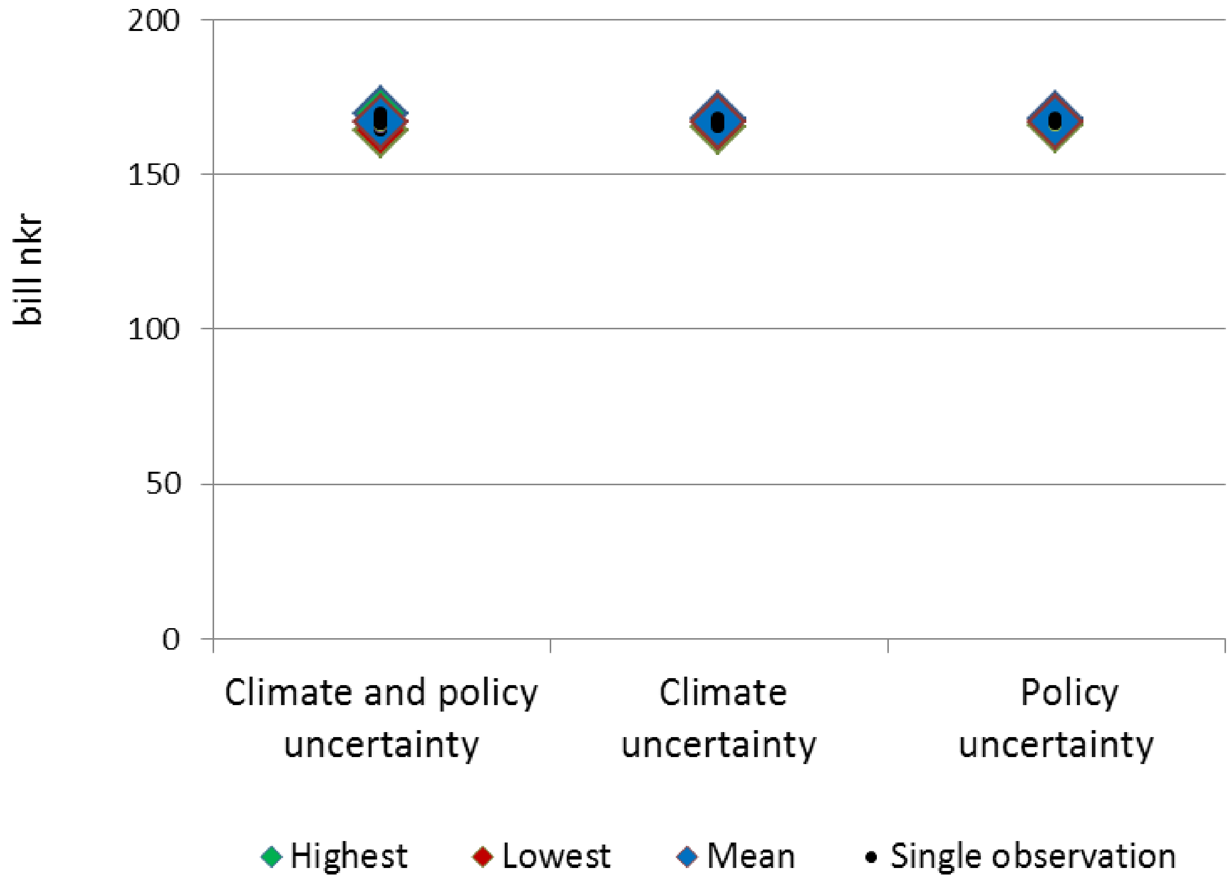
Results: Food consumption



Results: Food prices



Results: Social welfare



Discussion

- Introducing uncertainty in the sector model adds considerable complexity
- From the farmer's perspective, climate uncertainty not necessarily more important than policy uncertainty
- Climate uncertainty does not seem to affect national food security given well-functioning trade systems
- Food security is foremost a global, not a national, problem