

Necesidades para modelizar el impacto del cambio climático en la agricultura

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Proyecto ARCO

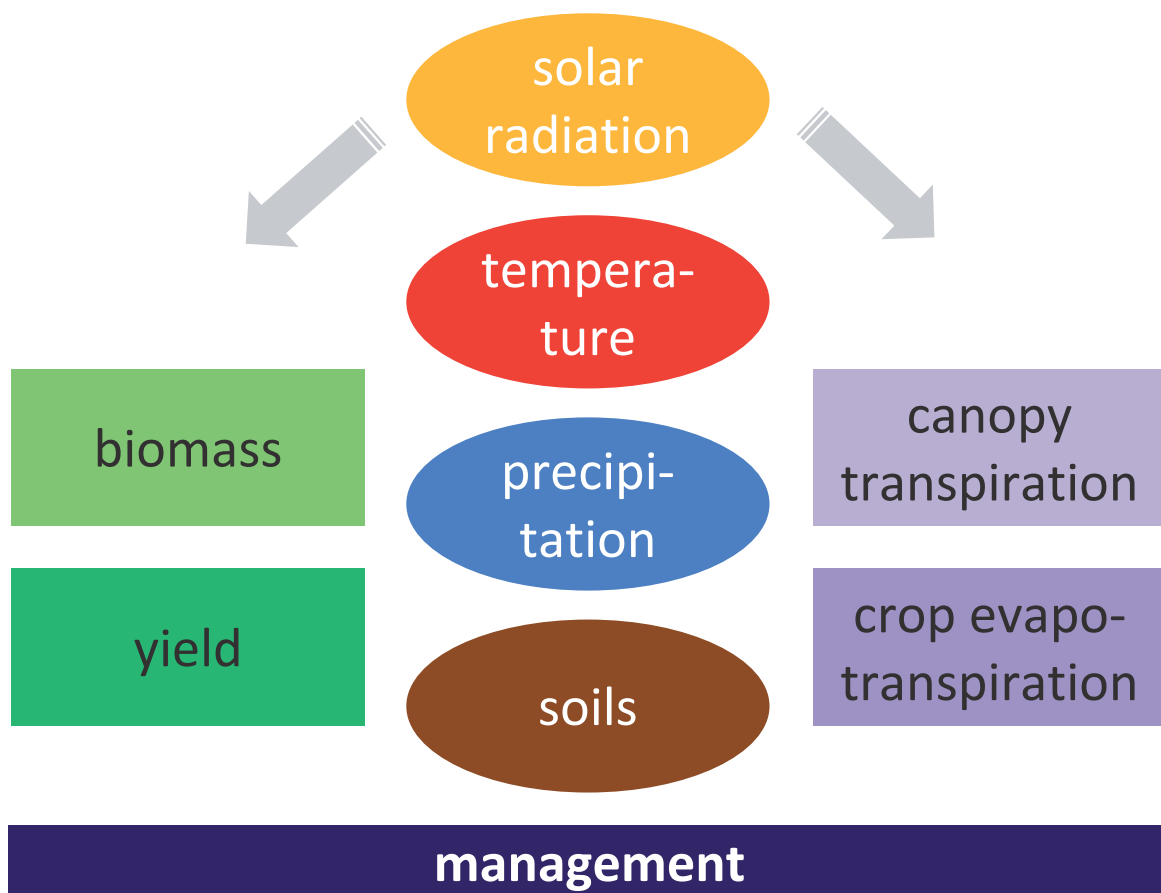
April 2011

TALLER TÉCNICO SOBRE ESCENARIOS CLIMÁTICOS Y
REGIONALIZACIÓN

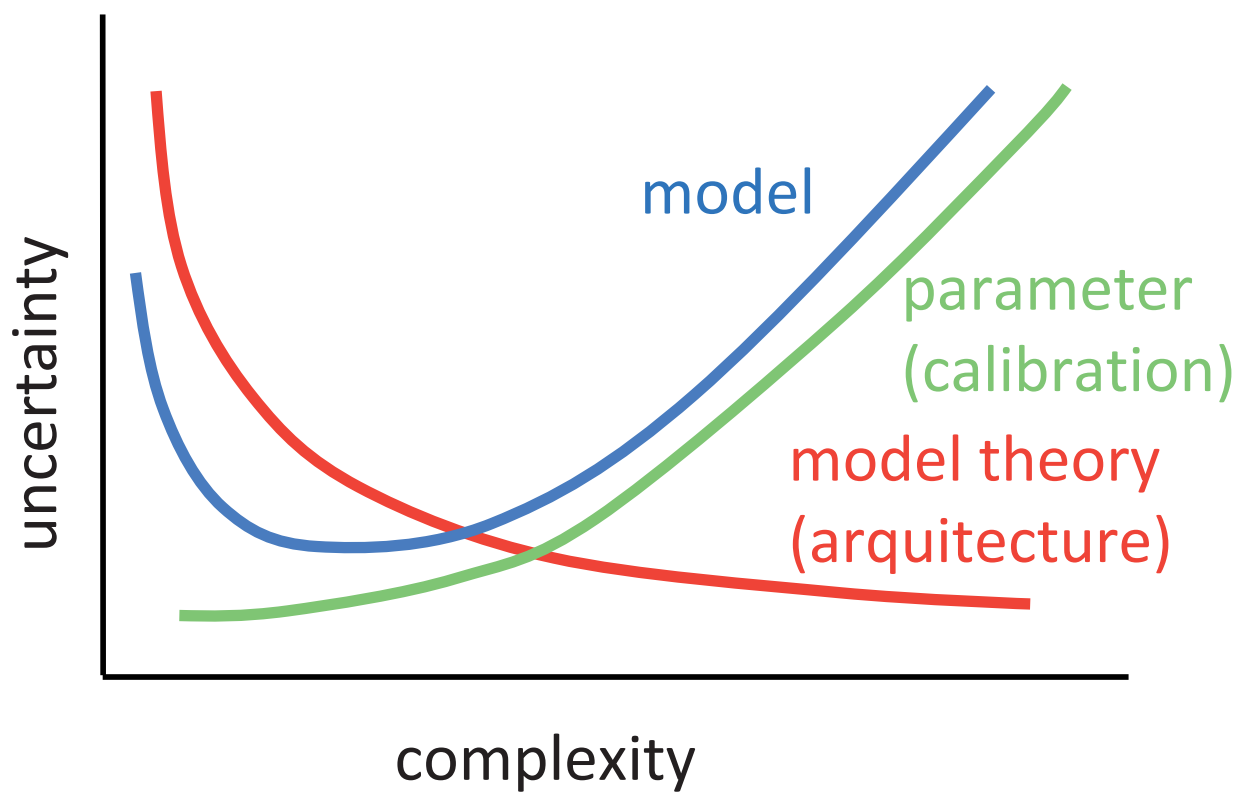
Valsaín, 27-29 de abril de 2011

Reasons for concern

	Possible effect	Confidence level
Optimal location of crops (zones)	change	high
Crop productivity	change	high
Irrigation requirements	increase	high
Soil salinity and erosion	increase	medium
Damage by extremes	increase	medium
Environmental degradation	increase	medium
Pests and diseases	increase	medium



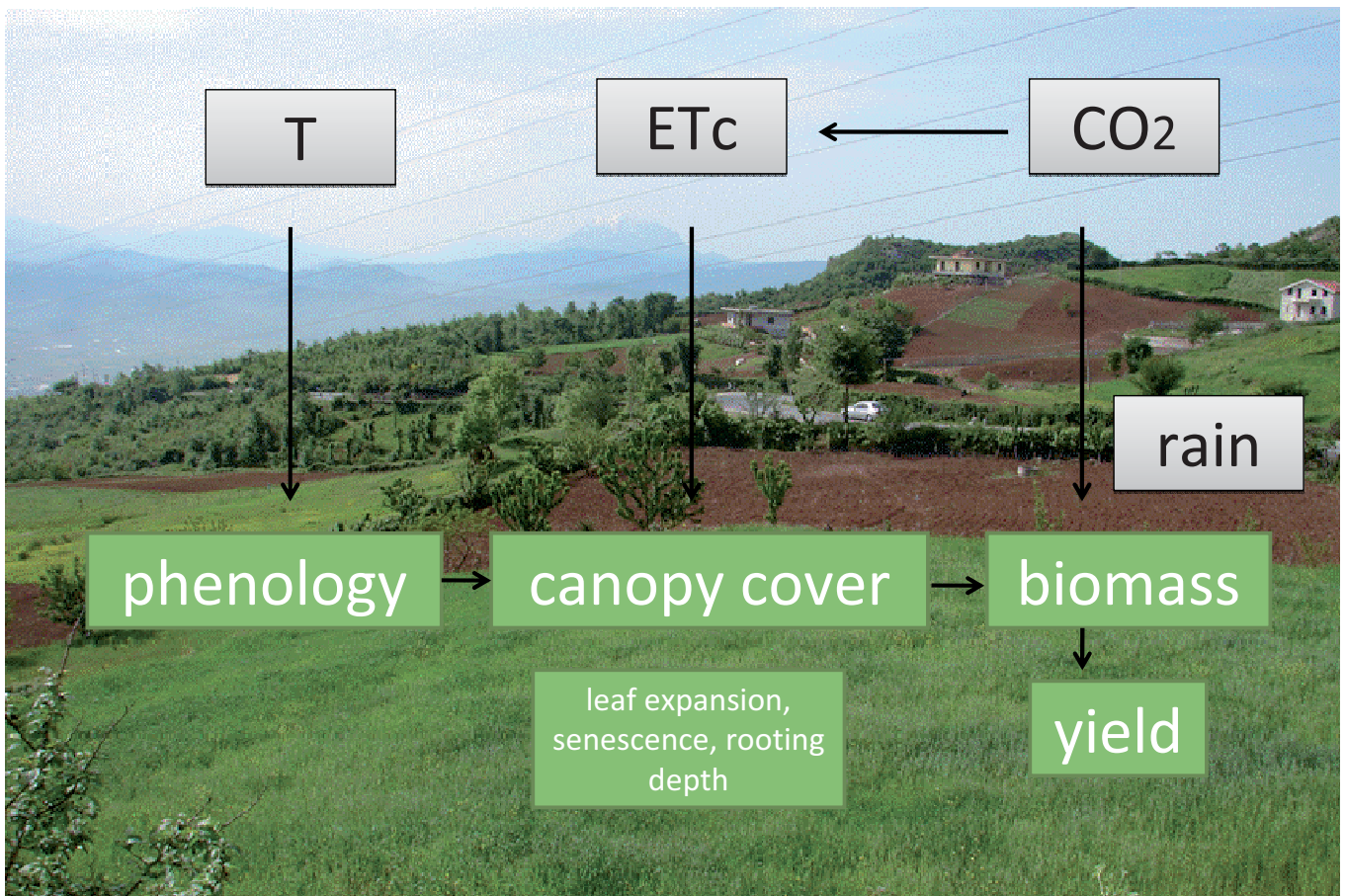




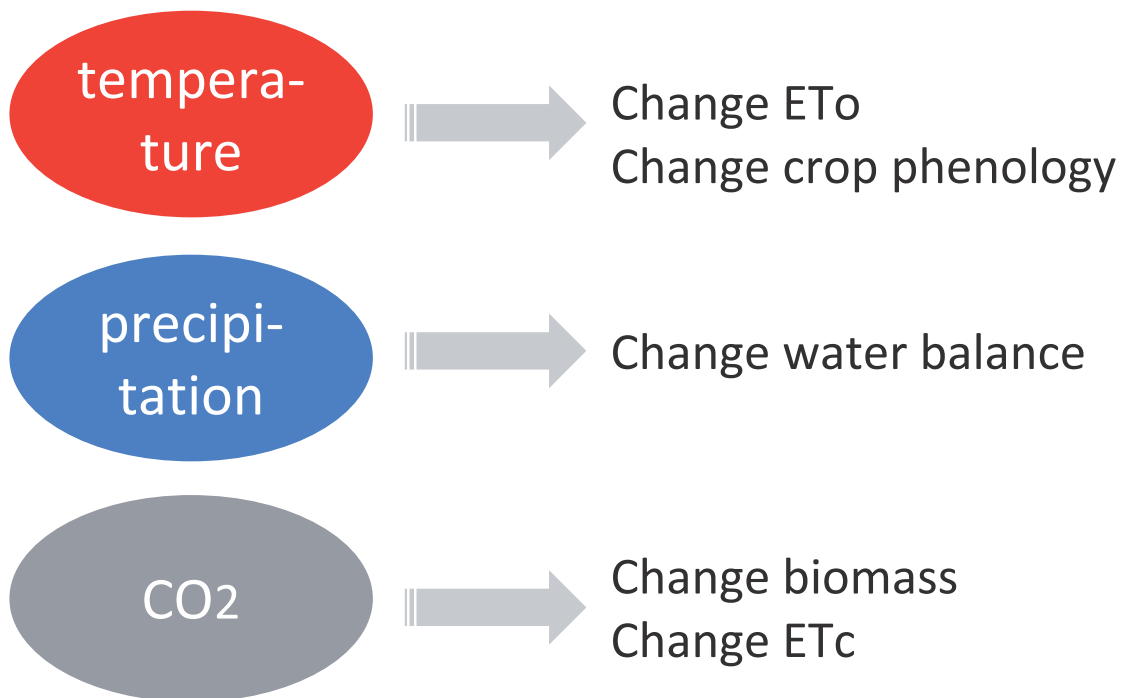
crop models: conceptual framework

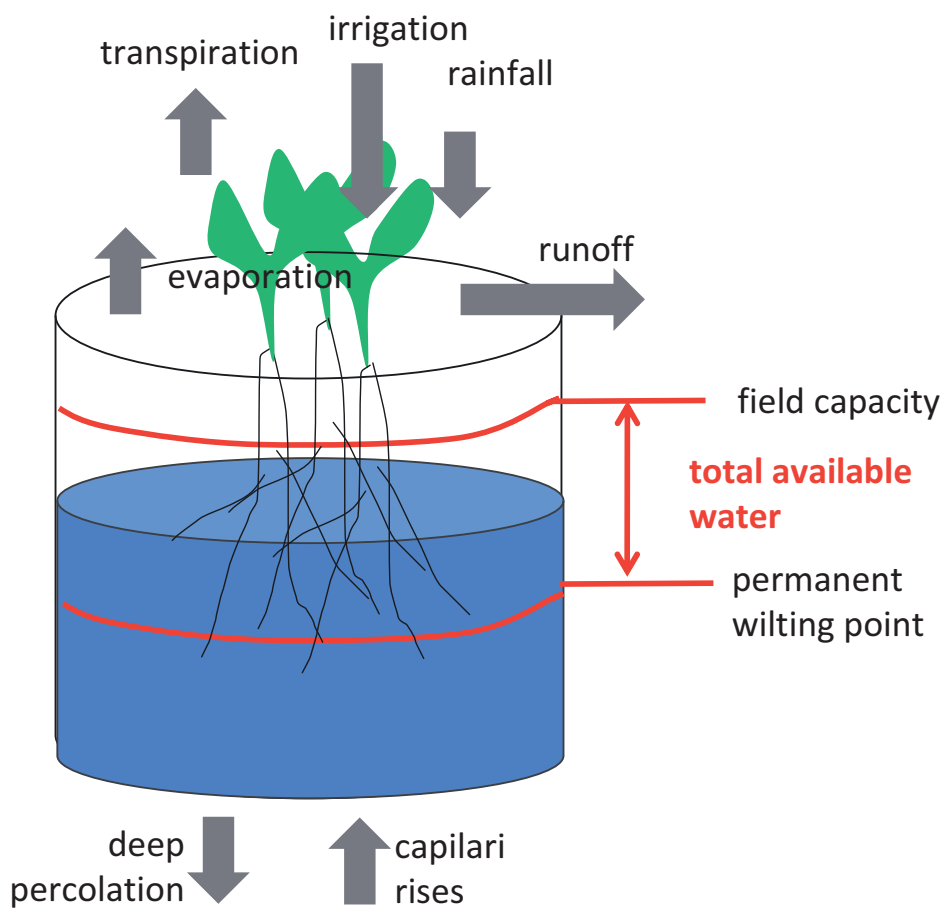


crop models: conceptual framework

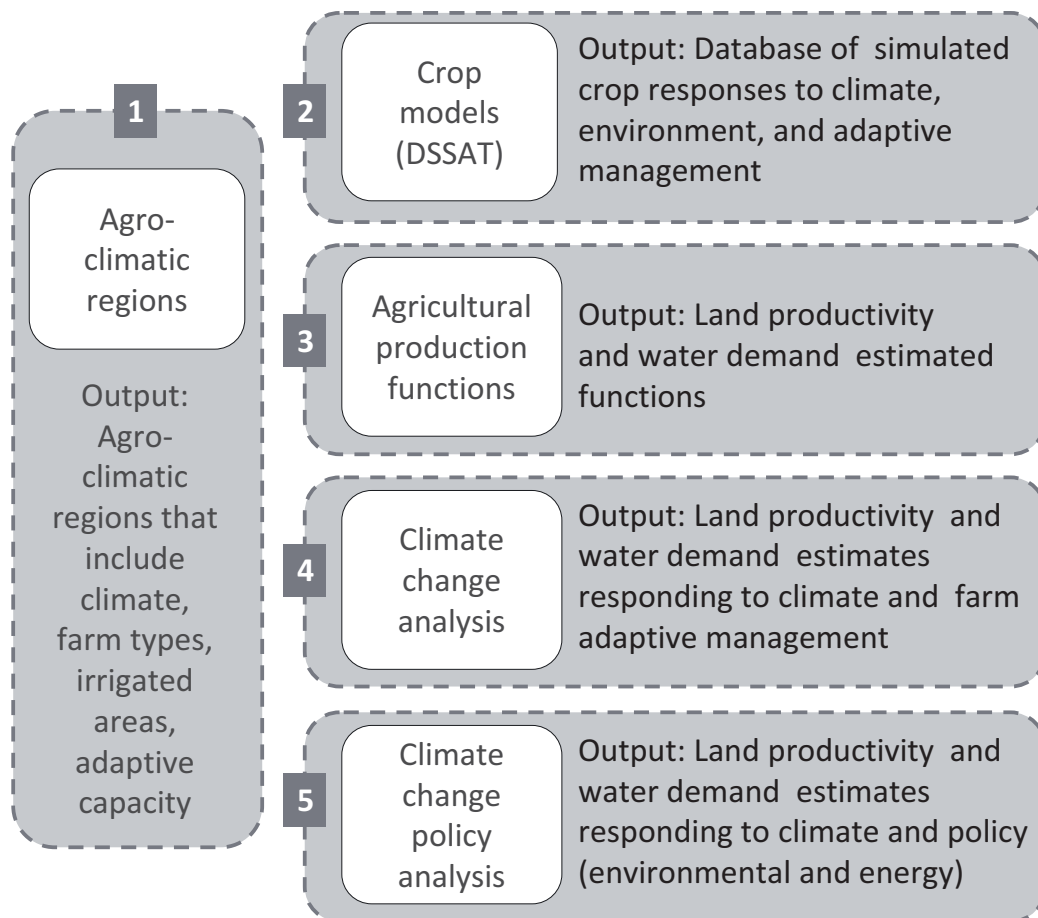


changes in climate, variability



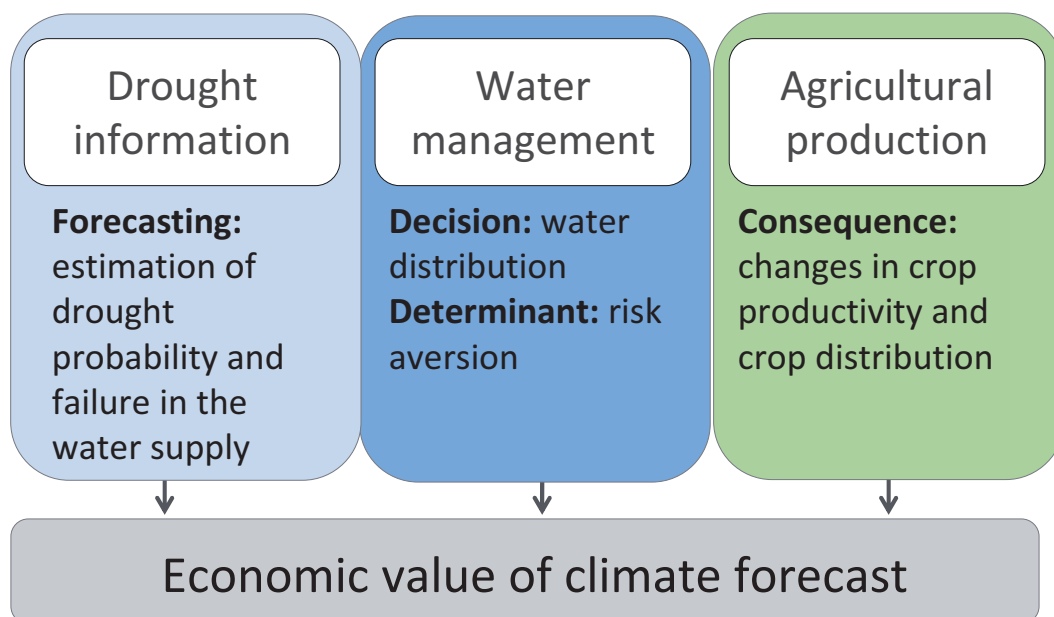


ClimateCrop model



Example 1: The economic value of climate forecast: a decision problem in the Ebro basin
(Quiroga et al., 2010, 2011)

- **Problem:** to adapt water management to the real availability (potential reduction as consequence of increased demand and climate change)
- **Decision:** We evaluate two management alternatives:
 1. Reduction of the **quantity** of water for irrigation
 2. Reduction of the **supply reliability**

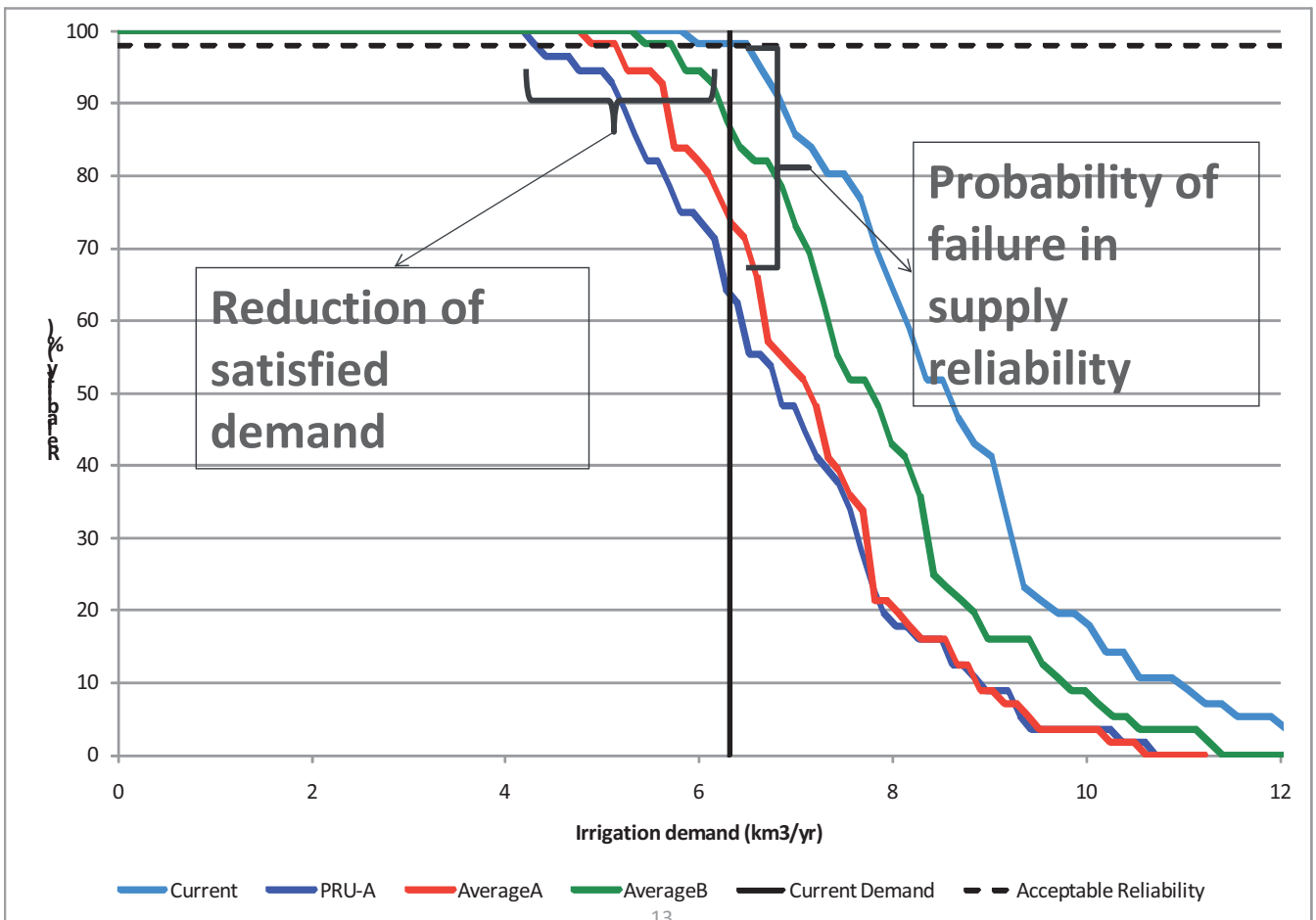


WAPA model: Trade-off between satisfied demand and supply reliability

Production function: Impact of water supplied and drought in crop production

Decision model: Optimal policy for irrigators

Economic value of climate information: About the change in probability of drought as consequence of climate change



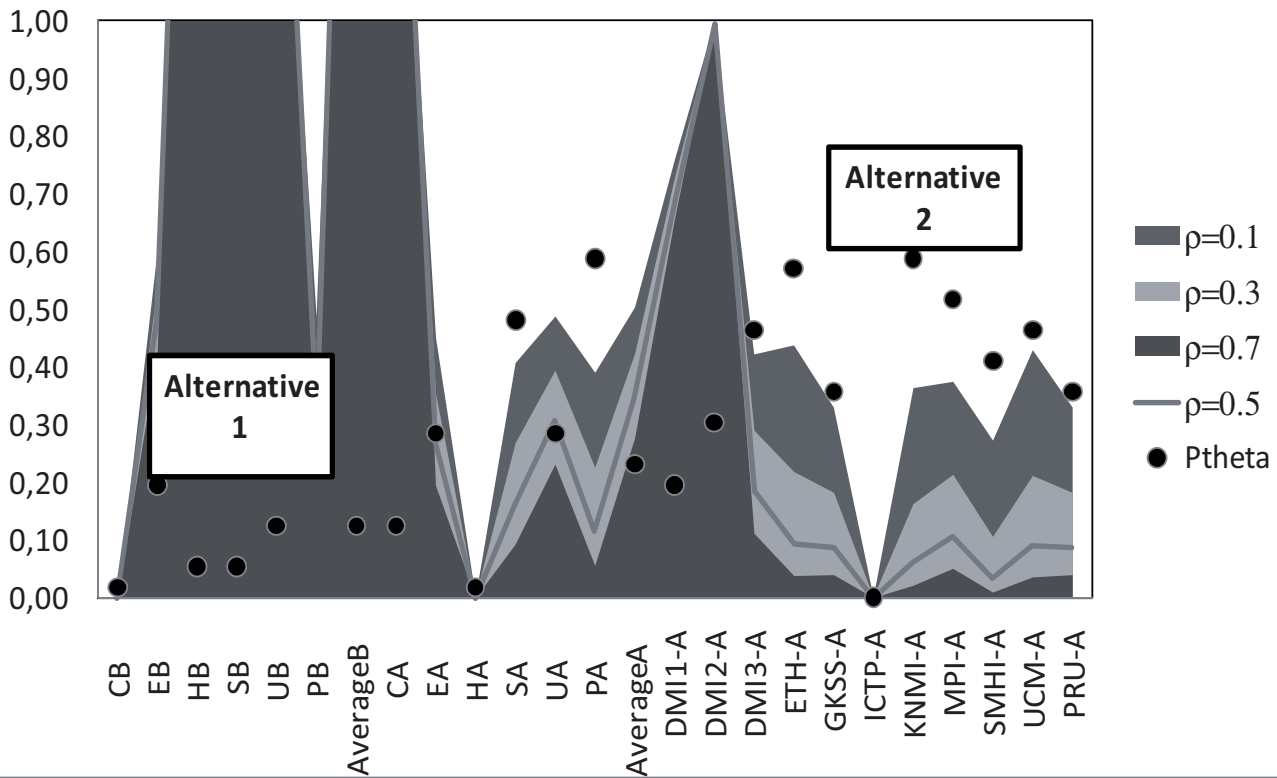
Productivity reduction as consequence of the two options

decision (scenario HadCM2 A2 2080)	No drought	Yes drought
Reduction of satisfied demand	3.2%	3.2%
Reduction of supply reliability	0%	7.8%

Risk aversion: CARA

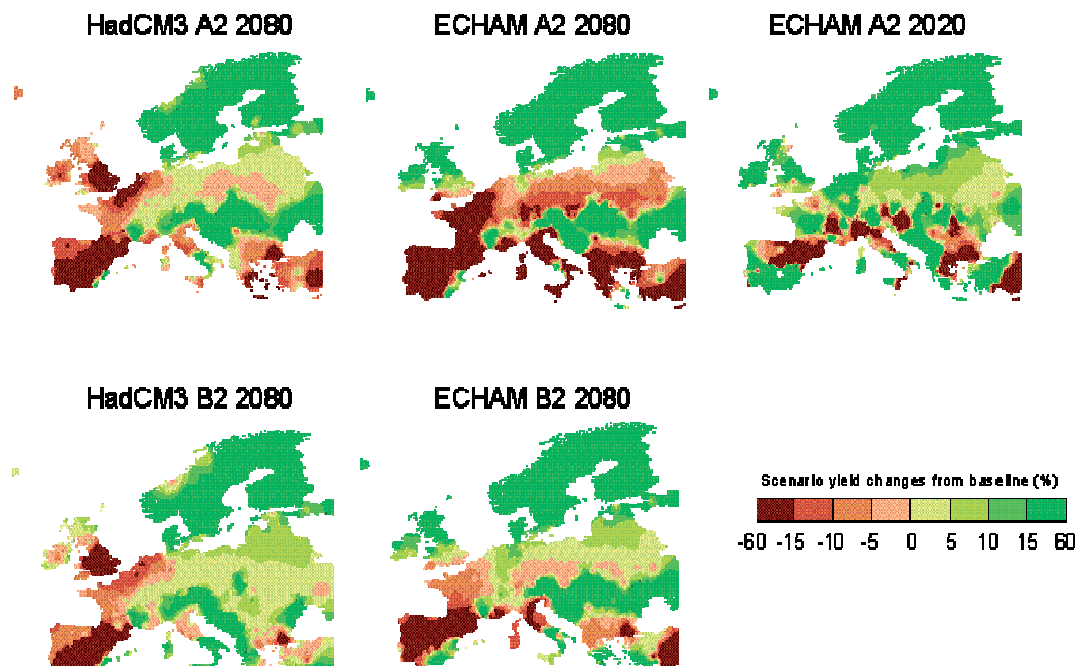
$$U(x) = -\exp\{-\rho x\}$$

Optimal decision



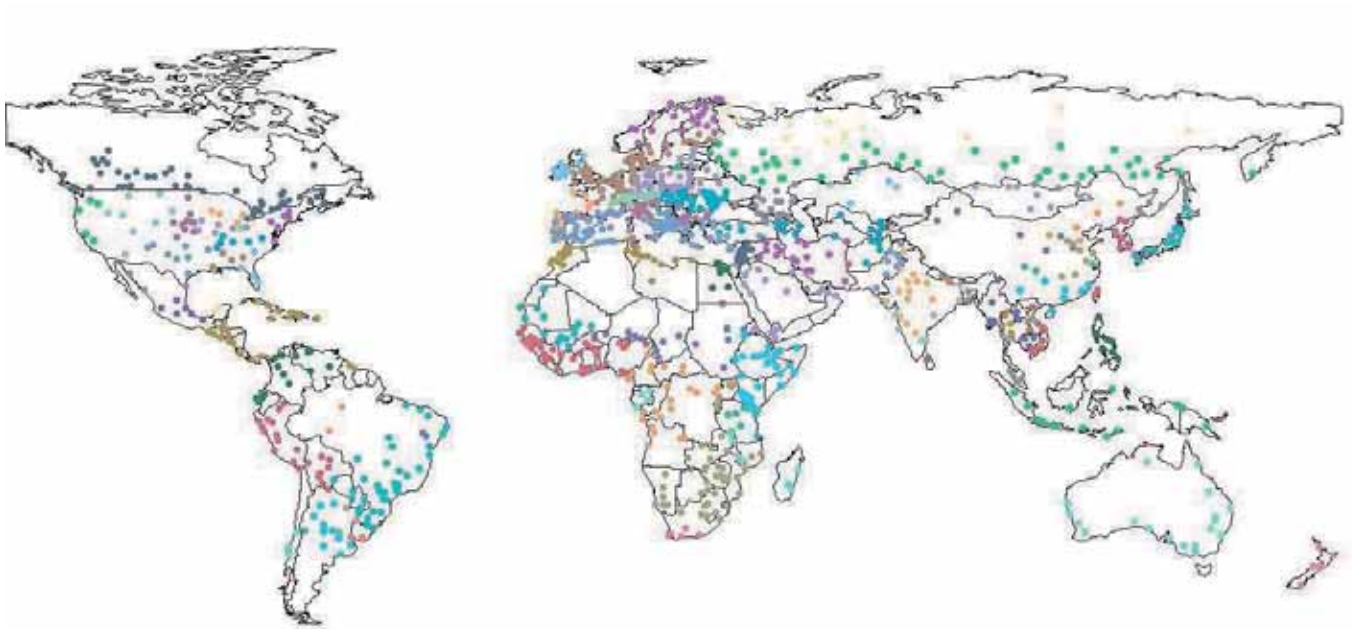
Example 2: Europe

(Iglesias et al., 2007, 2011)



Crop yield changes under the HadCM3/HIRHAM A2 and B2 scenarios for the 2080s and for the ECHAM4/ RCA3 A2 and B2 scenarios for the 2080s and ECHAM4/ RCA3 A2 scenario for the 2020s compared to baseline

Example 3: Global (Iglesias et al., 2011)



Stations (1141)
and agroclimatic zones (73)

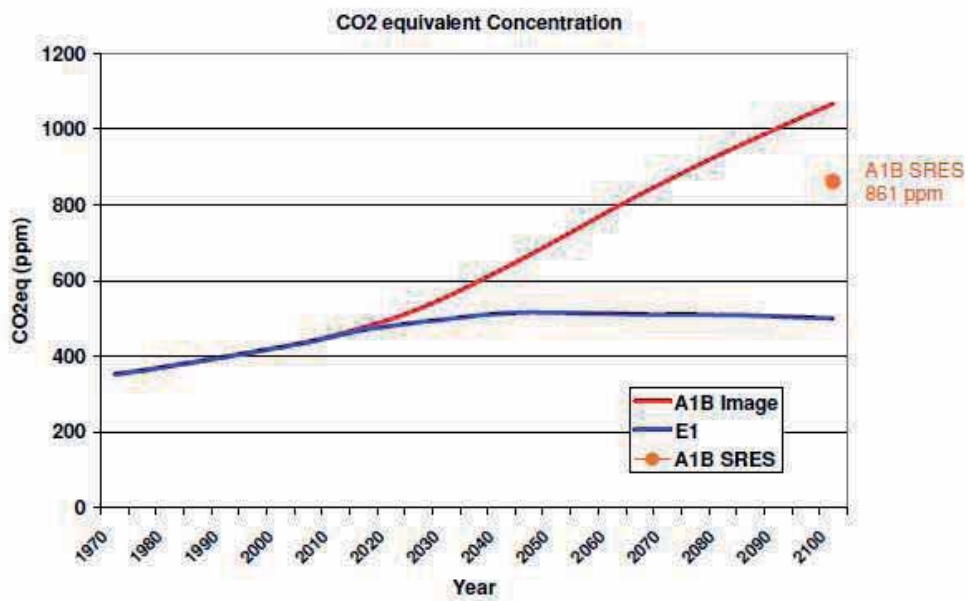
Representative Emmission Pahways (RPC)

- **A1B**
- A balanced emphasis on all energy sources.
- A1B 2080 = 712 ppm CO₂

- **E1**
- The so-called global “2 °C-stabilization” scenario is characterized by an atmospheric concentrations of 498 ppmv CO₂ in the 2080s)
- E1 2080 = 498 ppm CO₂



CO₂ equivalent concentrations



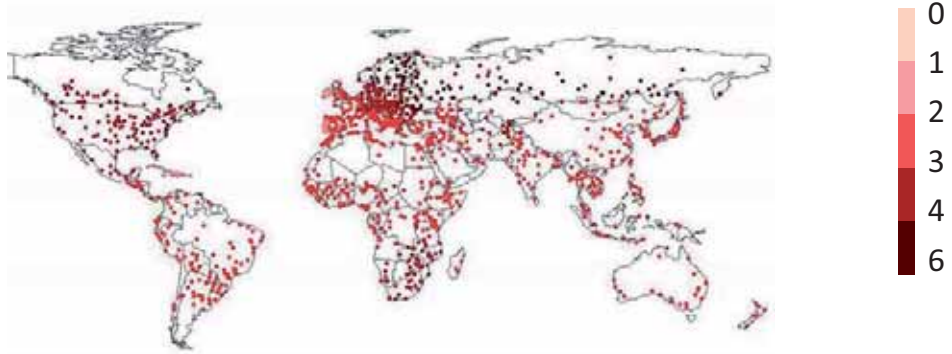
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Climate scenarios

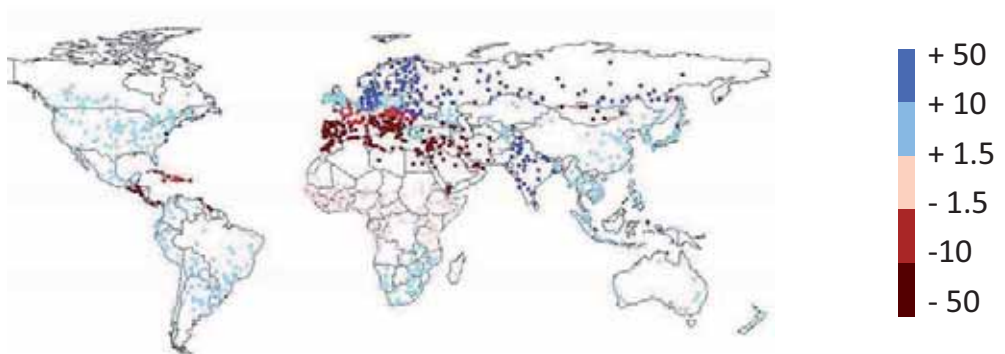
Climate Scenarios	Name	Climate Scenarios	Name
A1B.BCM2_1_M.2080	A1B_1	E1.CNCRM33_2_M.2080	E1_1
A1B.CNCRM3_1_M.2080	A1B_2	E1.DMICM3_1_M.2080	E1_2
A1B.DMIEH5_4_M.2080	A1B_3	E1.DMICM3_2_M.2080	E1_3
A1B.EGMAM_1_M.2080	A1B_4	E1.EGMAM2_2_M.2080	E1_4
A1B.EGMAM_2_M.2080	A1B_5	E1.EGMAM2_3_M.2080	E1_5
A1B.EGMAM_3_M.2080	A1B_6	E1.HADCM3C_1_M.2080	E1_6
A1B.HADGEM_1_M.2080	A1B_7	E1.HADGEM2_1_M.2080	E1_7
A1B.INGVSX_1_M.2080	A1B_8	E1.INGVCE_1_M.2080	E1_8
A1B.IPCM4_1_M.2080	A1B_9	E1.IPCM4v2_1_M.2080	E1_9
A1B.MPEH5_1_M.2080	A1B_10	E1.IPCM4v2_2_M.2080	E1_10
A1B.MPEH5_2_M.2080	A1B_11	E1.IPCM4v2_3_M.2080	E1_11
A1B.MPEH5_3_M.2080	A1B_12	E1.MPEH5C_1_M.2080	E1_12
		E1.MPEH5C_2_M.2080	E1_13
		E1.MPEH5C_3_M.2080	E1_14 ₂₀

Scenario A1B _1

Temp change (C)



Precip change (%)

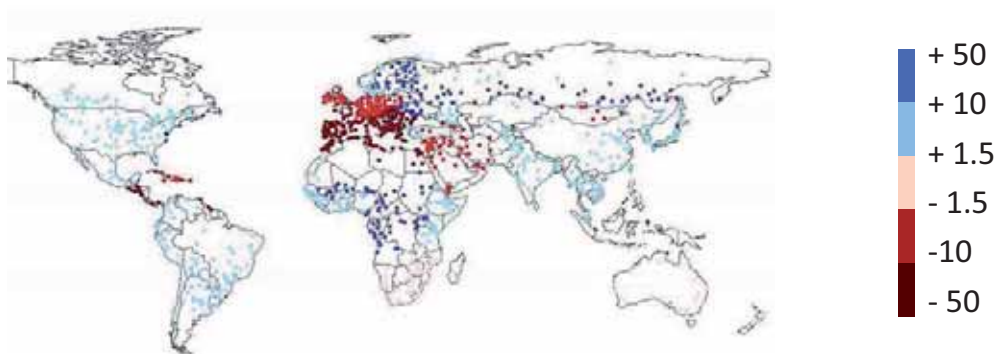


Scenario A1B_2

Temp change (C)



Precip change (%)

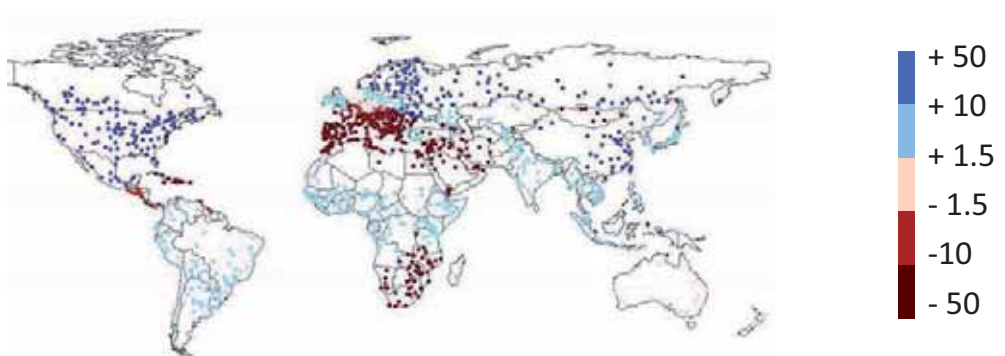


Scenario A1B_3

Temp change (C)



Precip change (%)

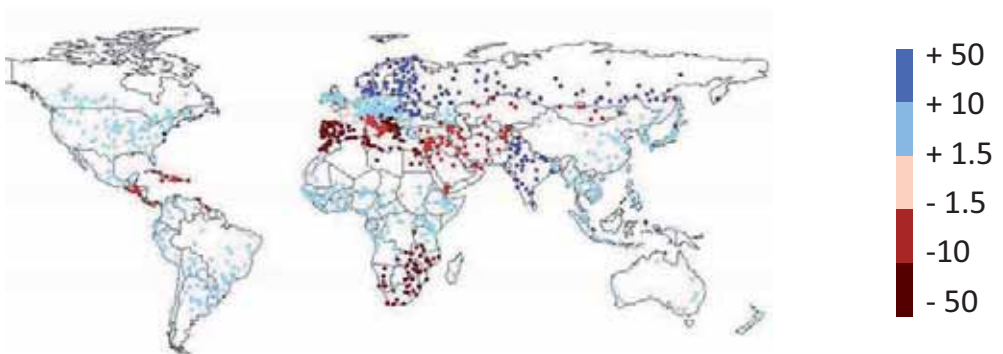


Scenario A1B_4

Temp change (C)



Precip change (%)

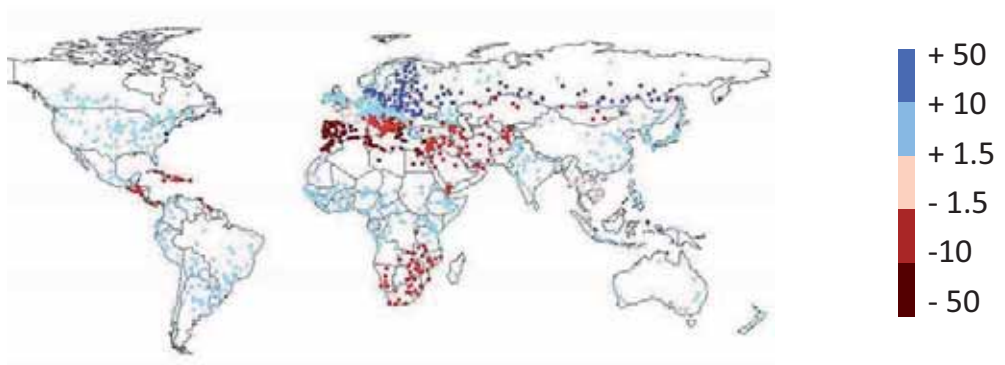


Scenario A1B_5

Temp change (C)



Precip change (%)

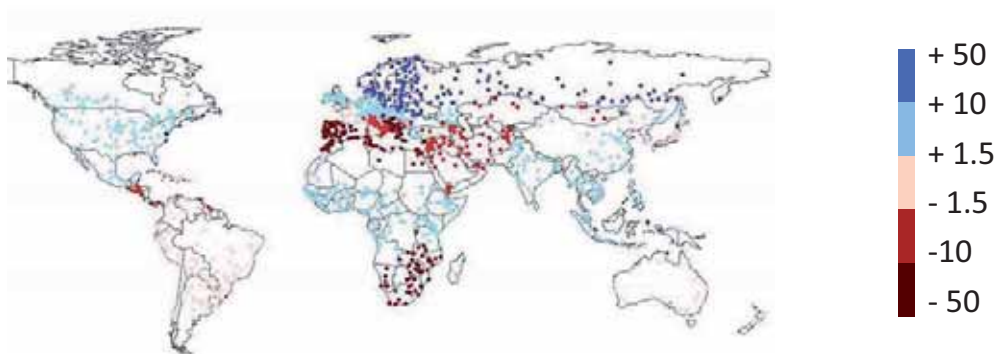


Scenario A1B_6

Temp change (C)



Precip change (%)

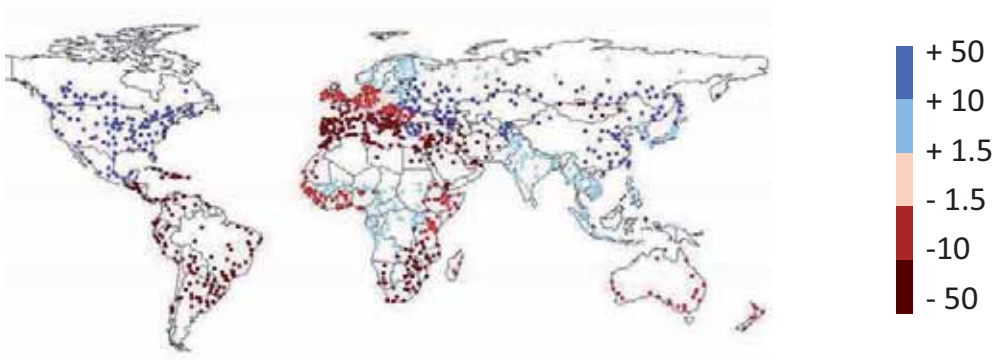


Scenario A1B_7

Temp change (C)



Precip change (%)

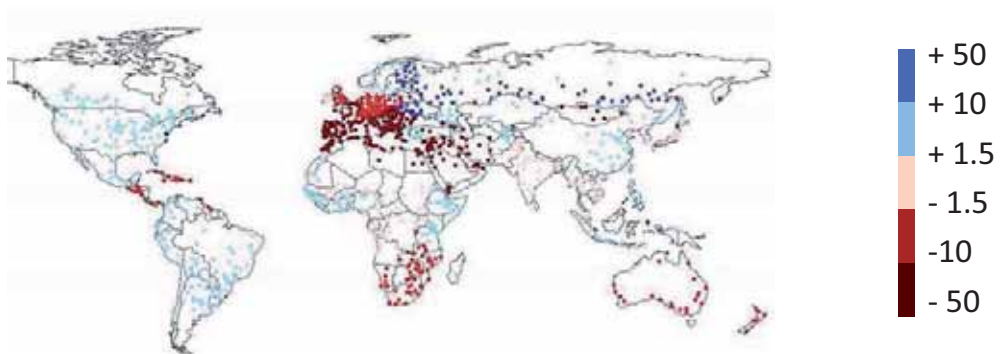


Scenario A1B_8

Temp change (C)



Precip change (%)

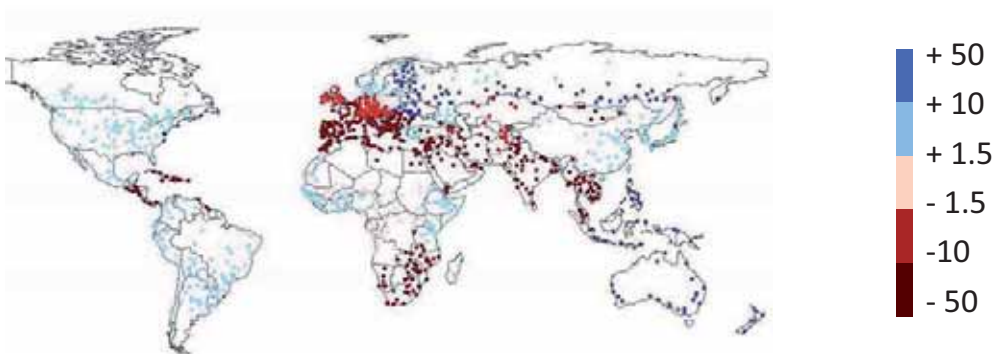


Scenario A1B_9

Temp change (C)



Precip change (%)

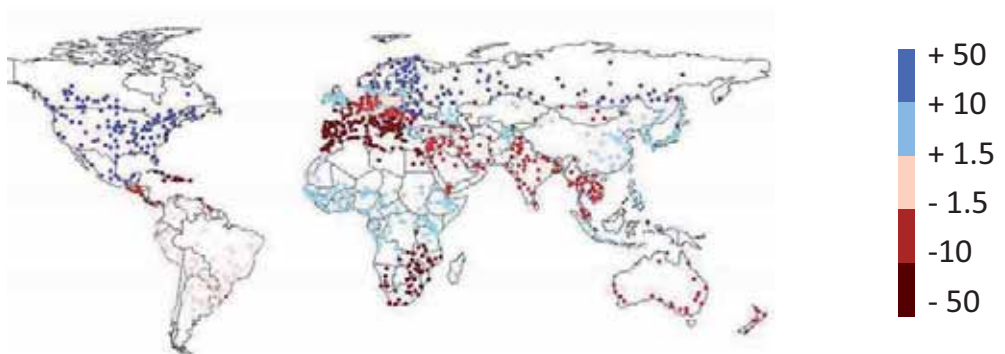


Scenario A1B_10

Temp change (C)



Precip change (%)

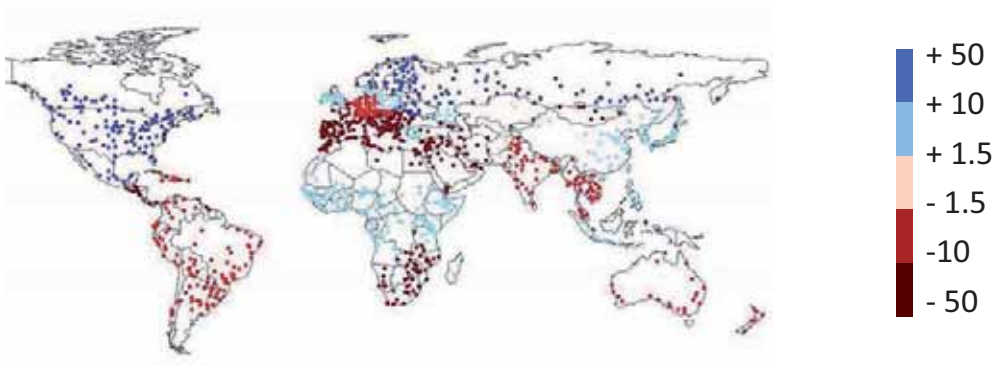


Scenario A1B_11

Temp change (C)



Precip change (%)

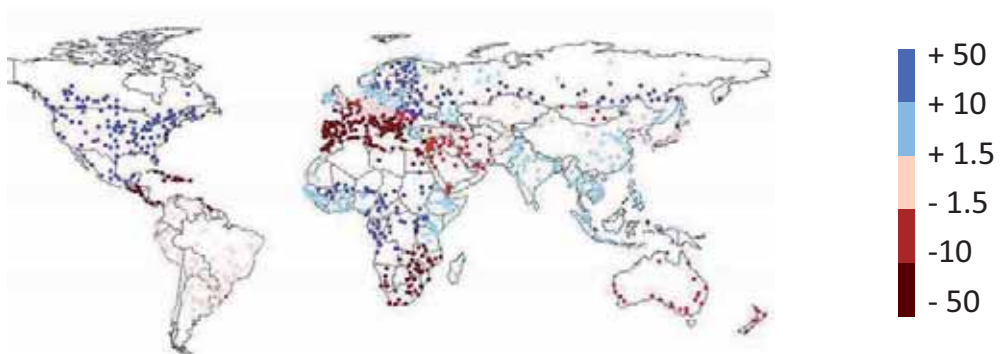


Scenario A1B_12

Temp change (C)

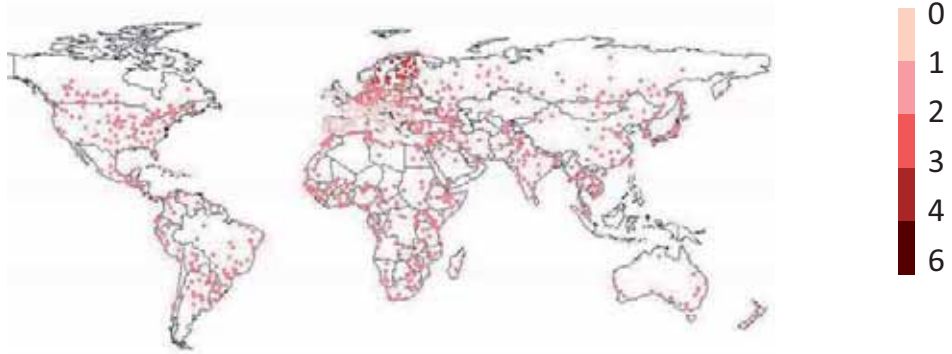


Precip change (%)

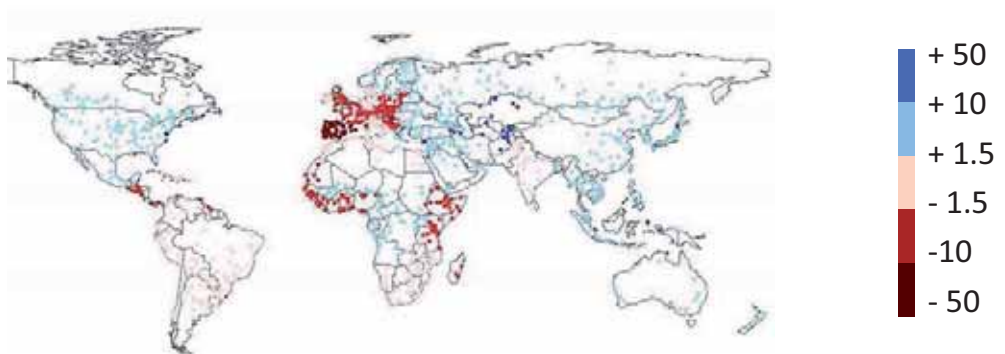


Scenario E1_1

Temp change (C)



Precip change (%)

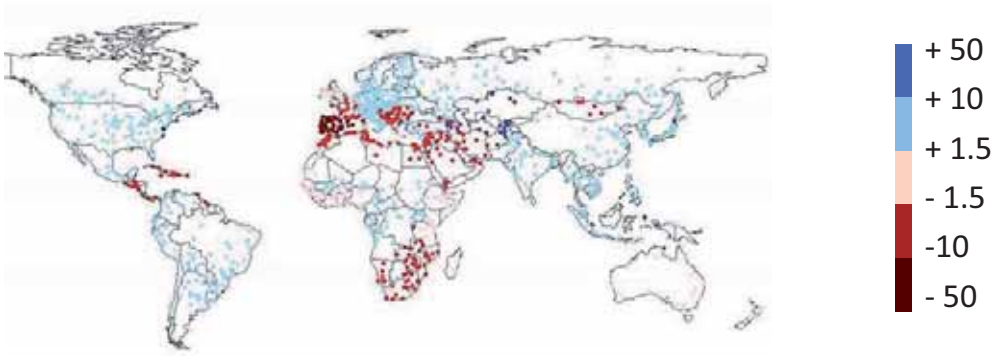


Scenario E1_2

Temp change (C)

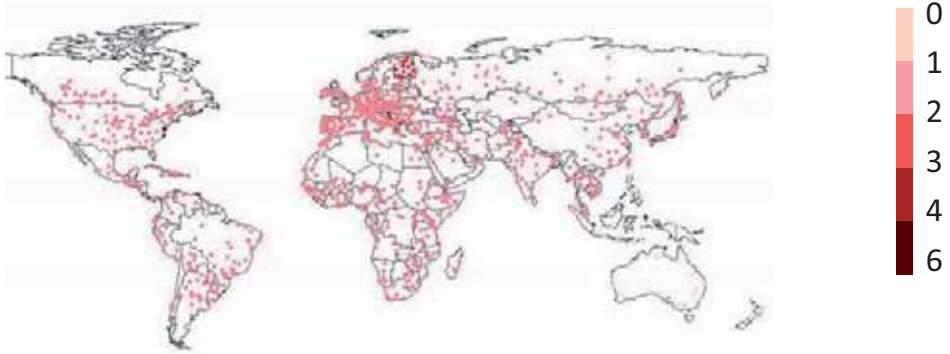


Precip change (%)

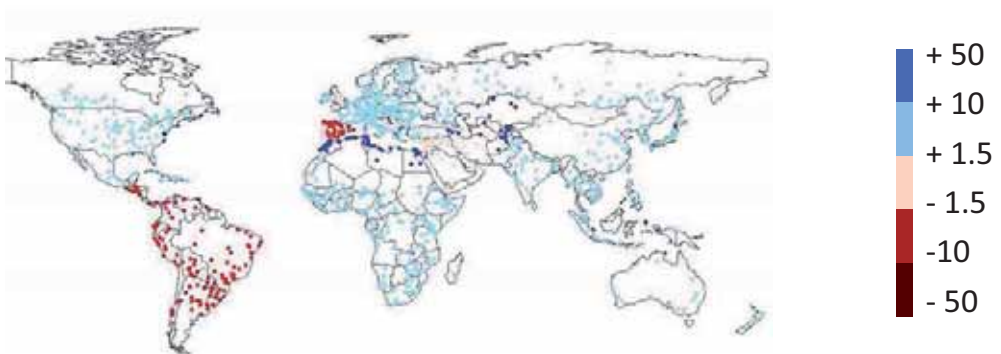


Scenario E1_3

Temp change (C)



Precip change (%)

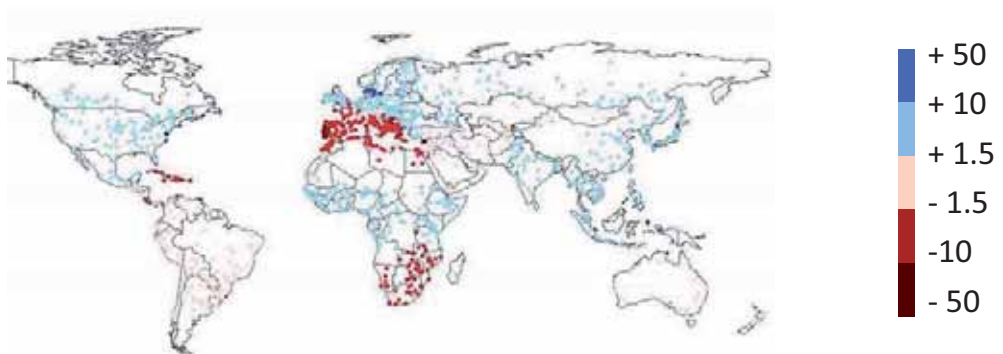


Scenario E1_4

Temp change (C)



Precip change (%)

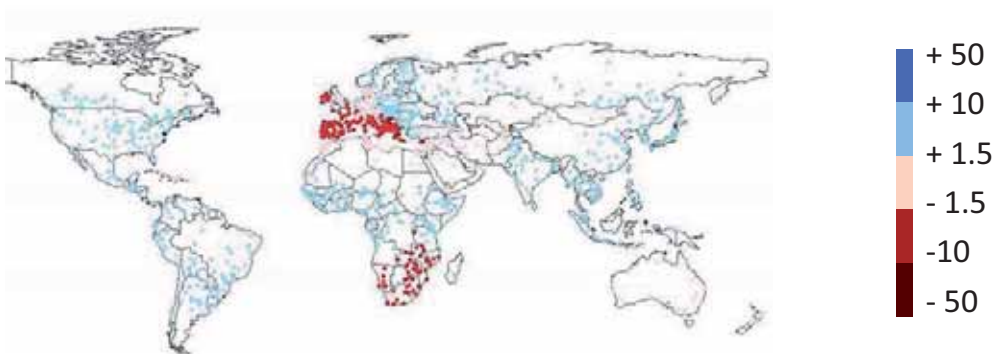


Scenario E1_5

Temp change (C)

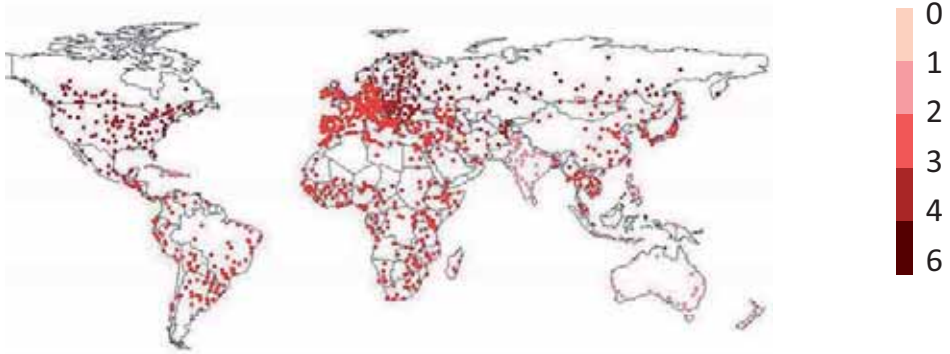


Precip change (%)

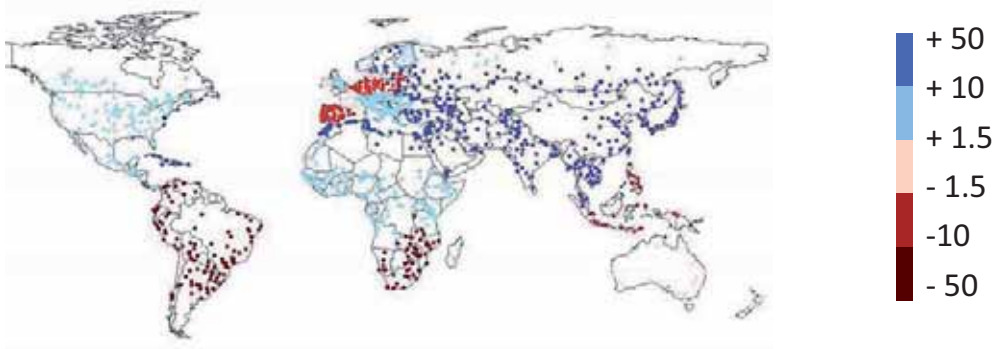


Scenario E1_6

Temp change (C)



Precip change (%)

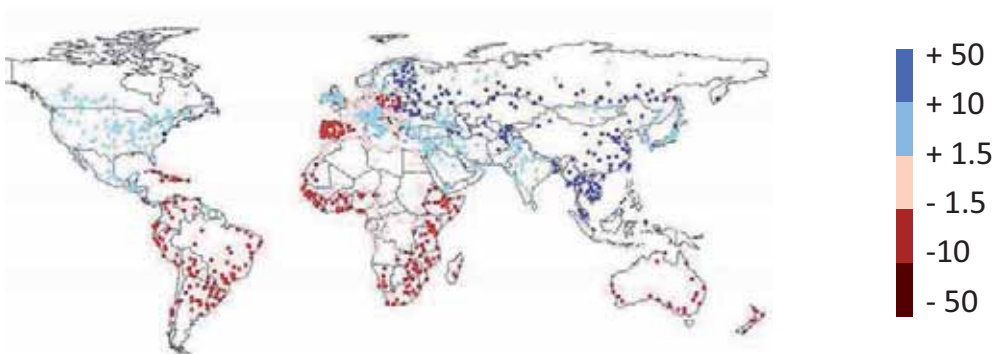


Scenario E1_7

Temp change (C)

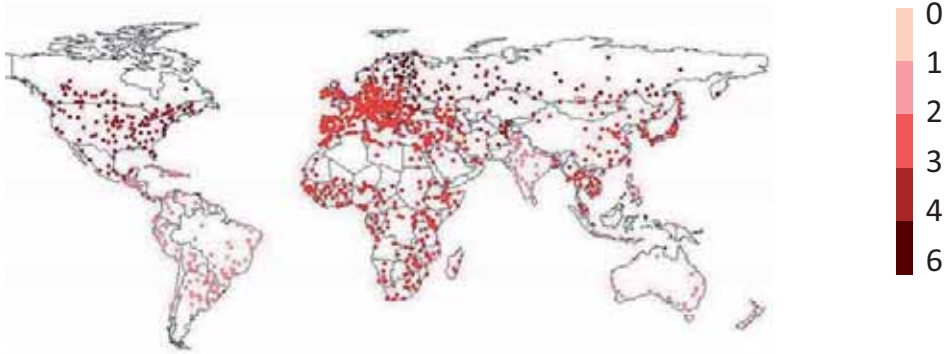


Precip change (%)

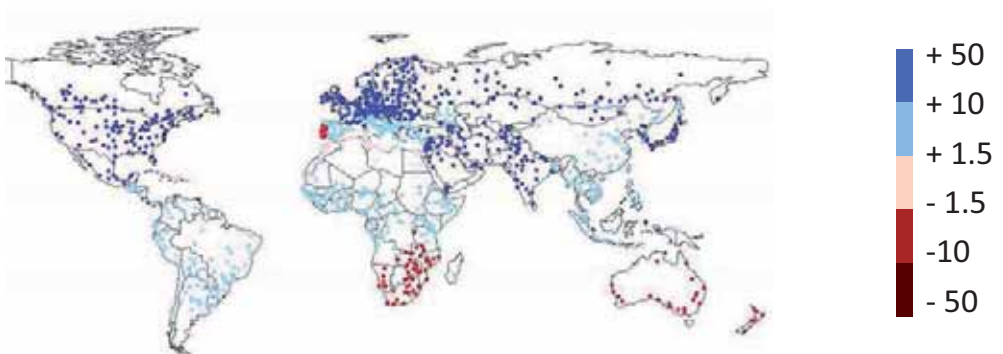


Scenario E1_8

Temp change (C)



Precip change (%)

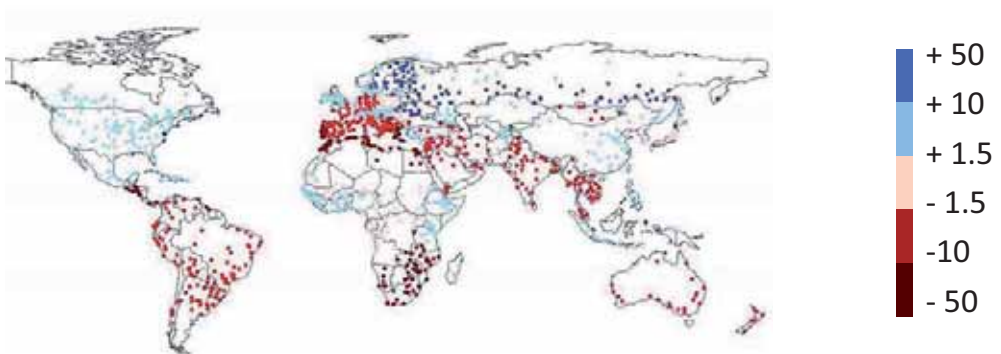


Scenario E1_9

Temp change (C)



Precip change (%)

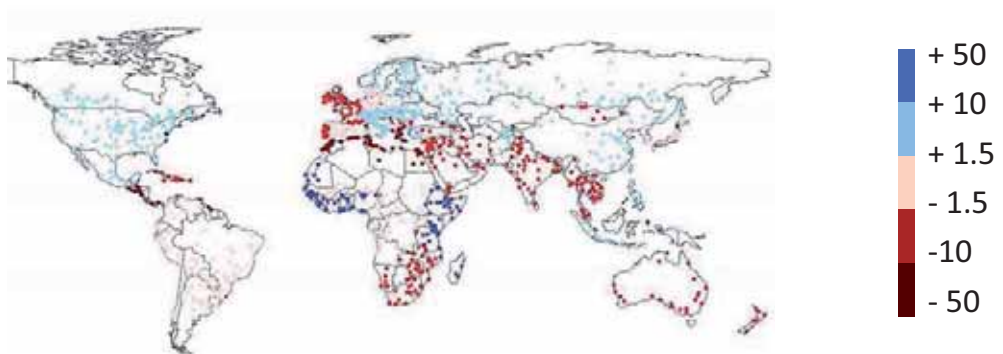


Scenario E1_10

Temp change (C)



Precip change (%)

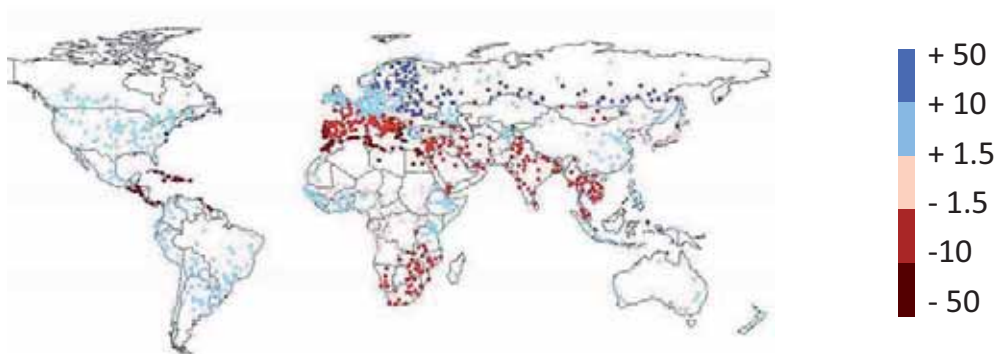


Scenario E1_11

Temp change (C)



Precip change (%)

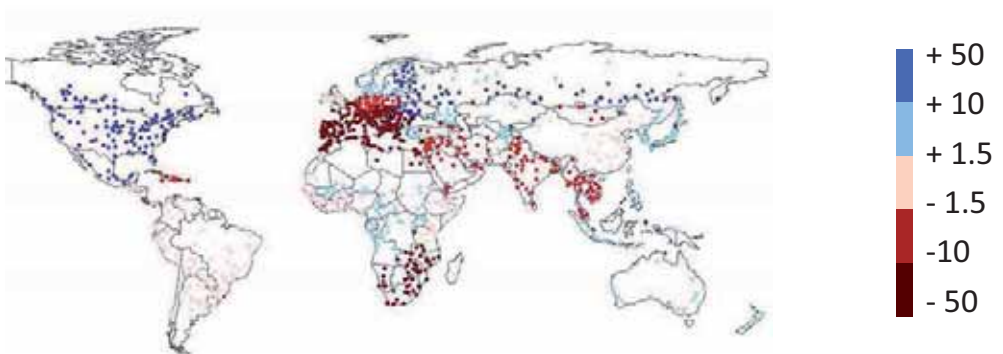


Scenario E1_12

Temp change (C)



Precip change (%)

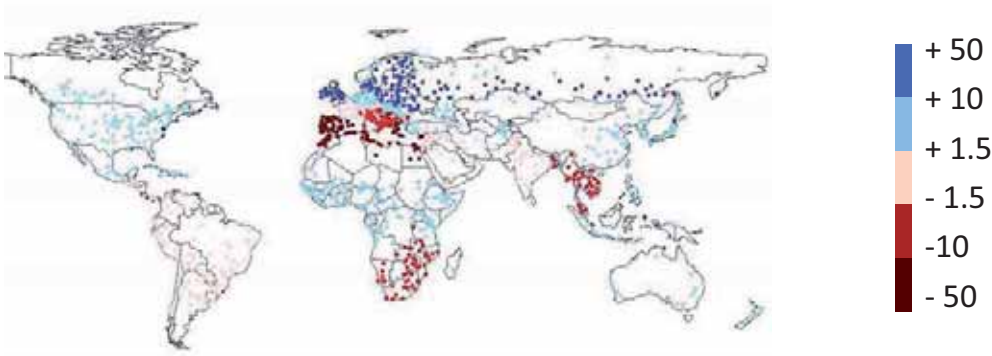


Scenario E1_13

Temp change (C)



Precip change (%)

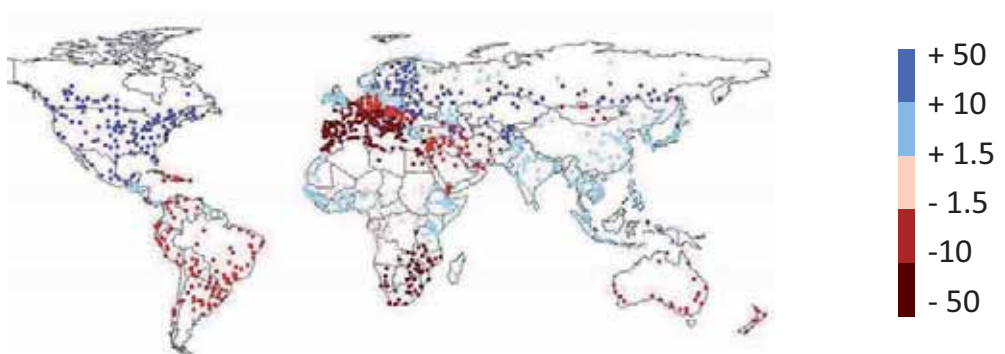


Scenario E1_14

Temp change (C)

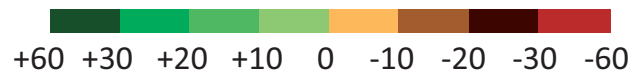
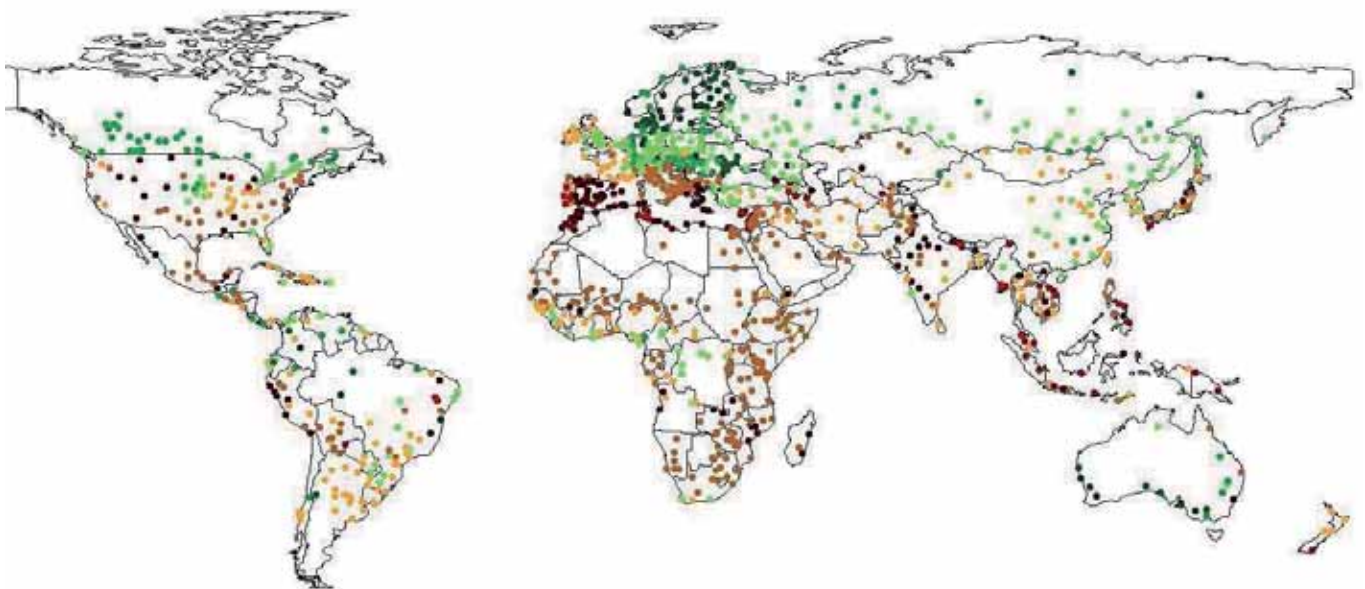


Precip change (%)



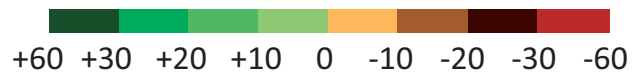
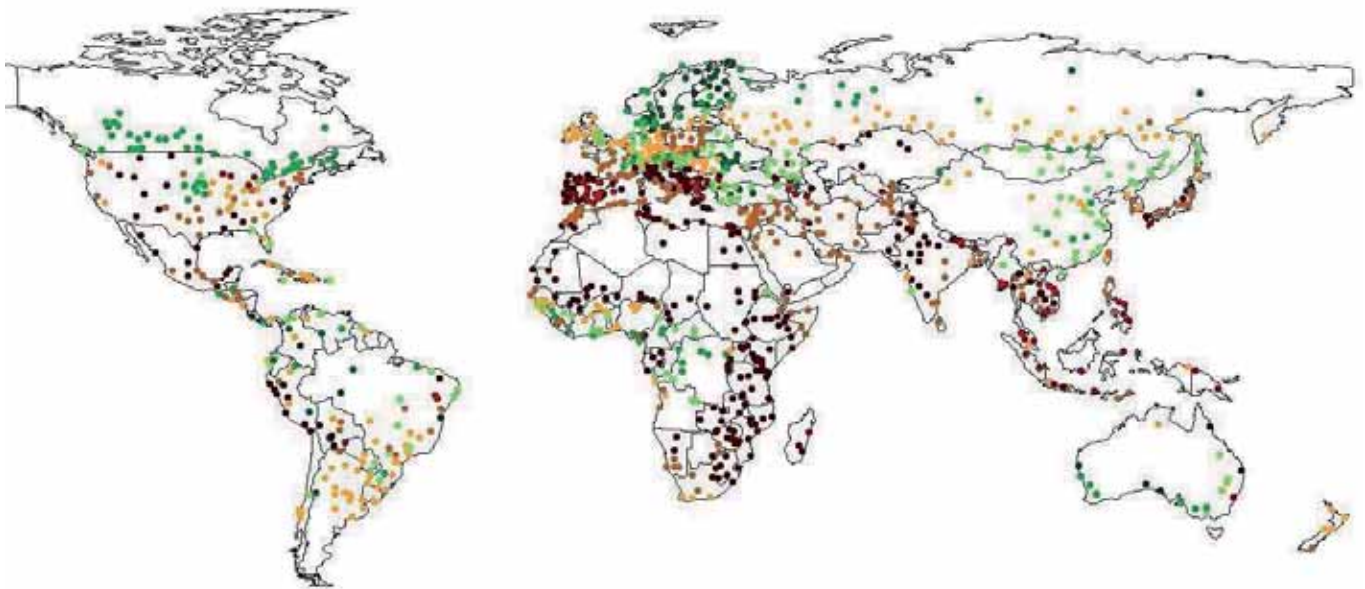
Scenario A1B_1

Agricultural productivity changes (% of baseline)



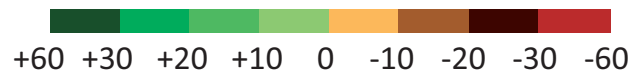
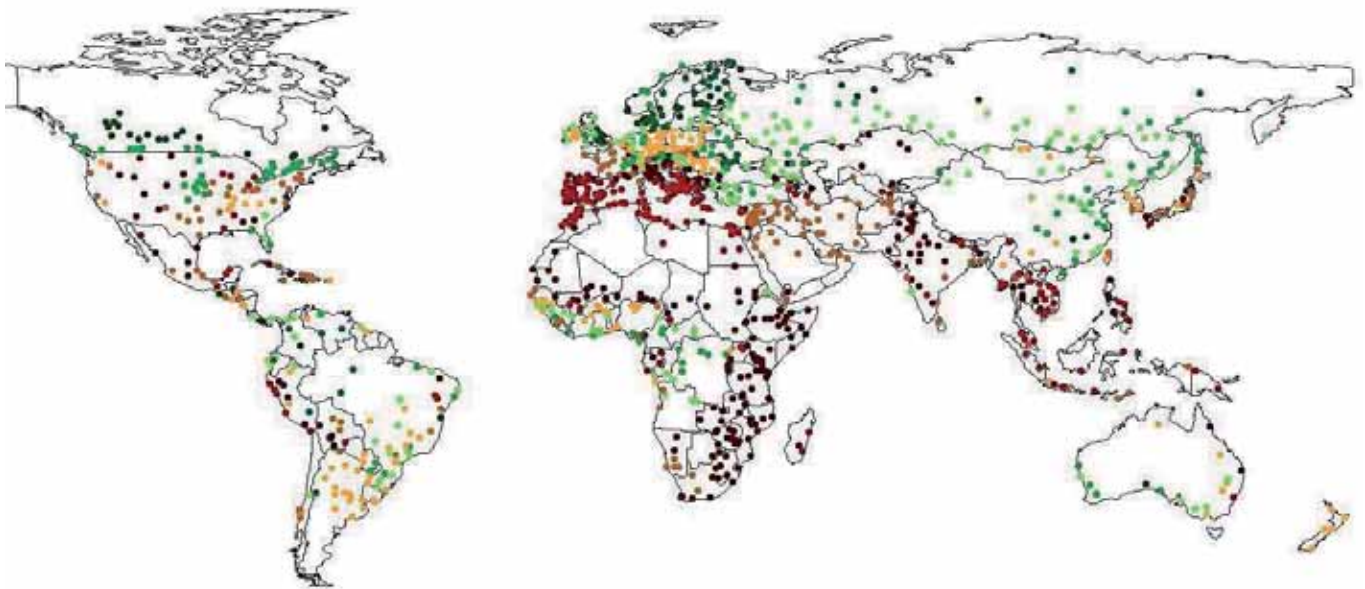
Scenario A1B_2

Agricultural productivity changes (% of baseline)



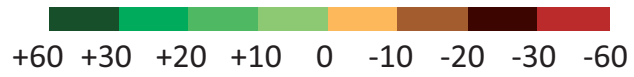
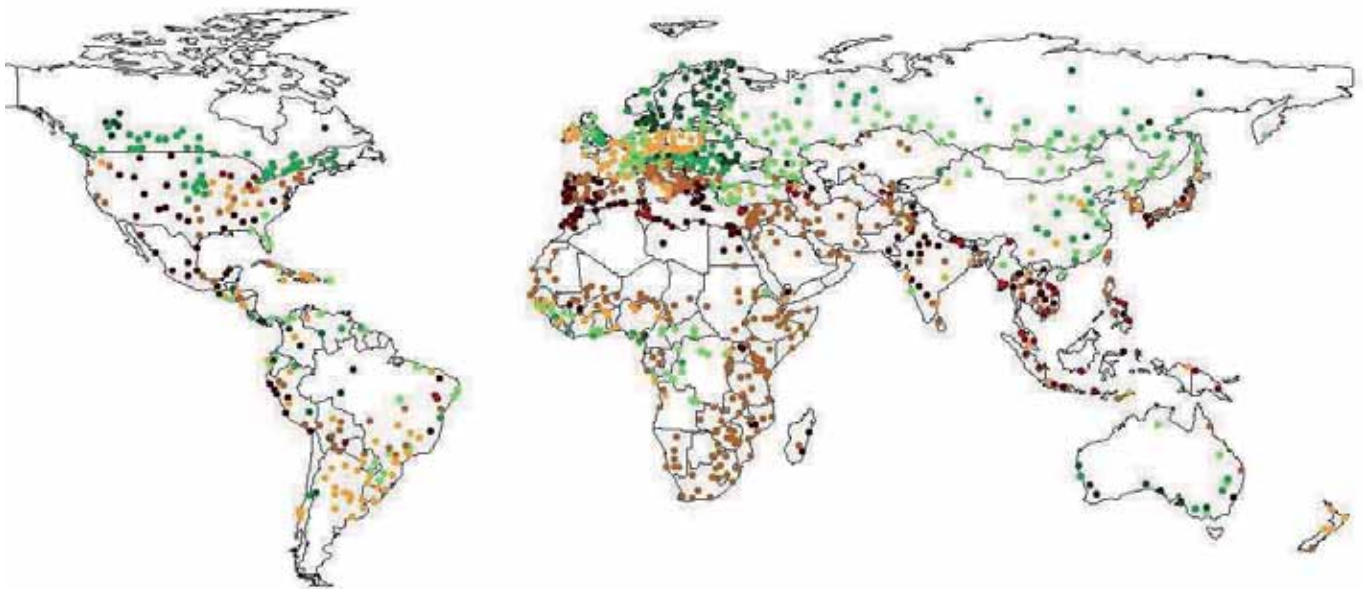
Scenario A1B_3

Agricultural productivity changes (% of baseline)



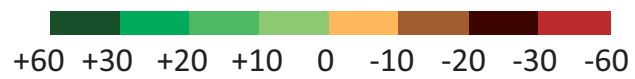
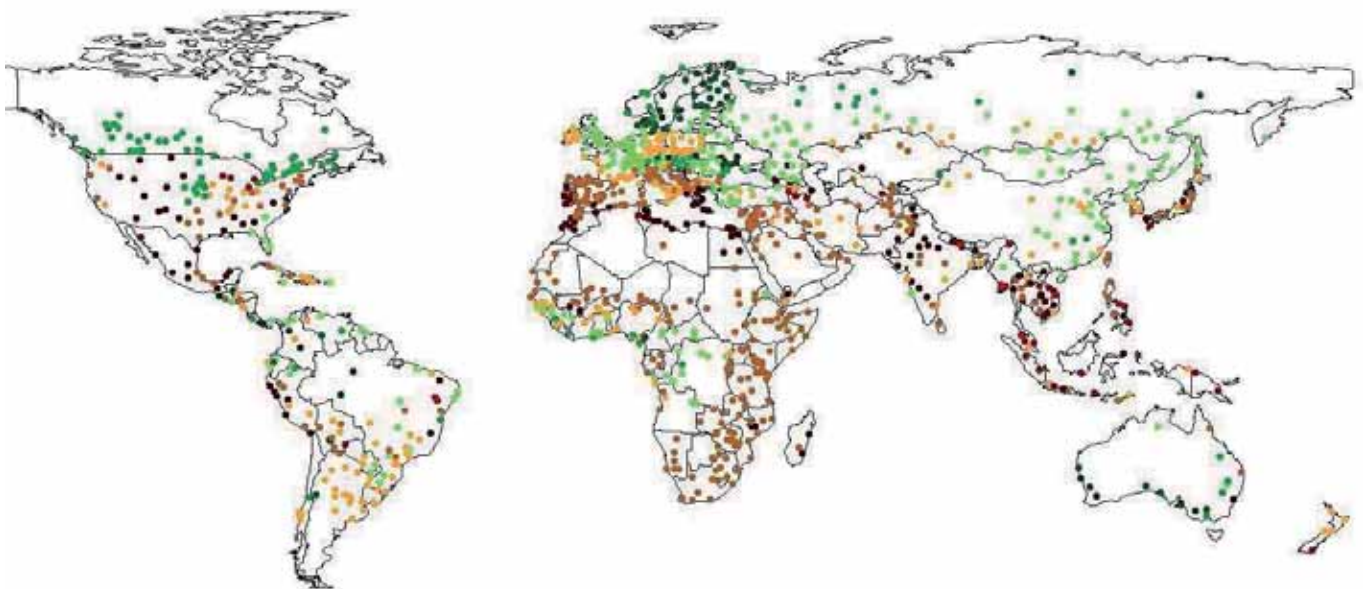
Scenario A1B_4

Agricultural productivity changes (% of baseline)



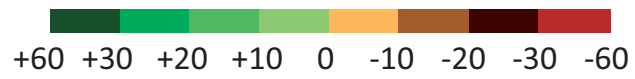
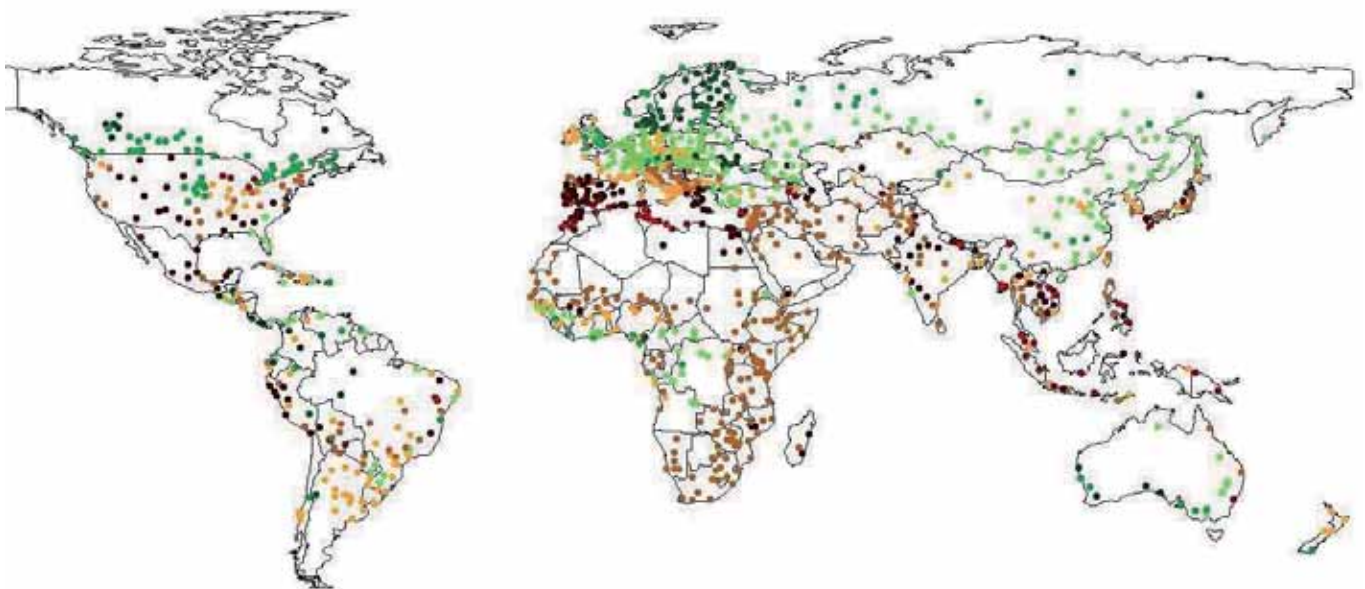
Scenario A1B_5

Agricultural productivity changes (% of baseline)



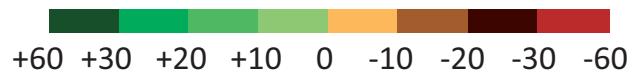
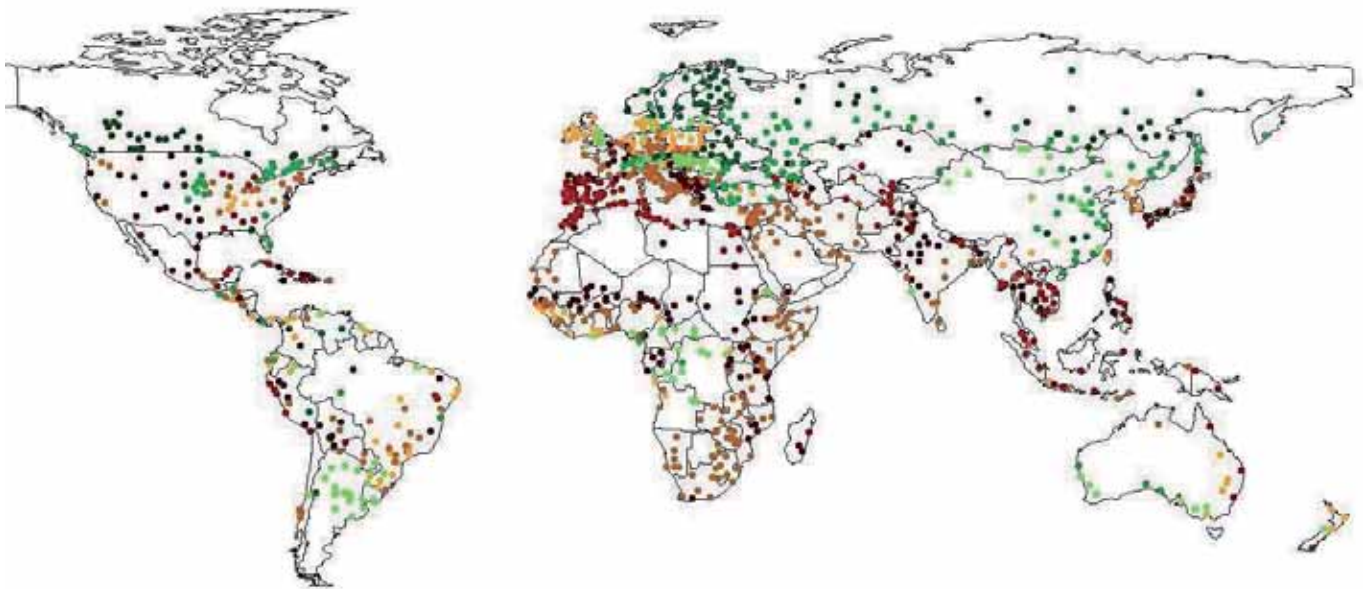
Scenario A1B_6

Agricultural productivity changes (% of baseline)



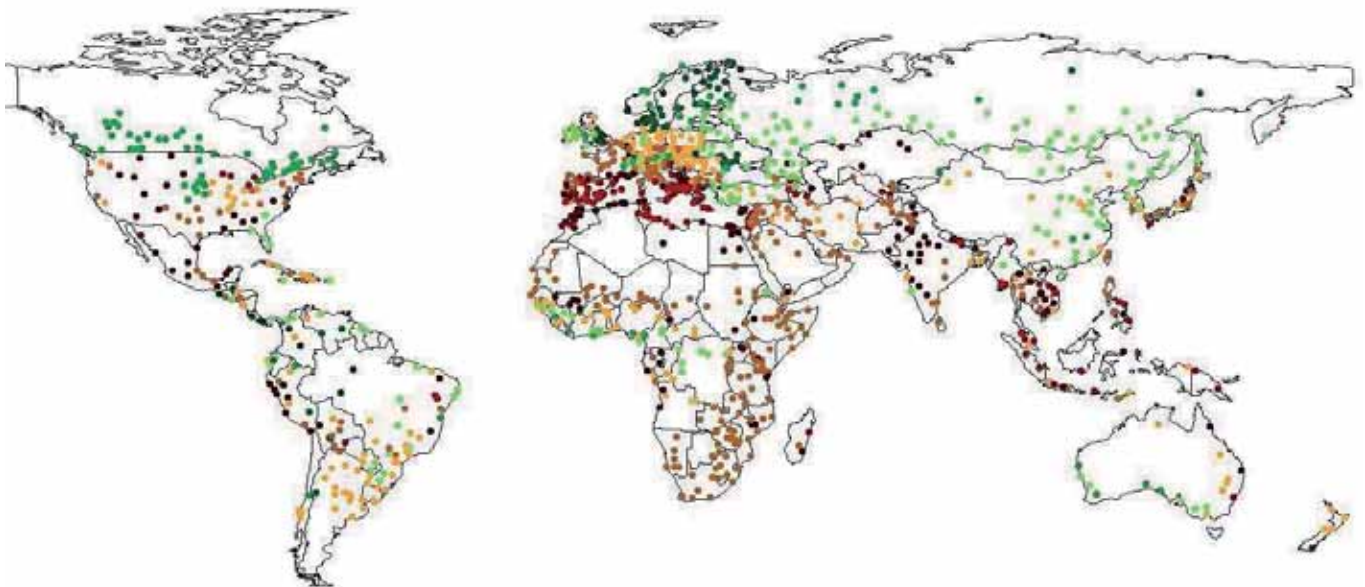
Scenario A1B_7

Agricultural productivity changes (% of baseline)



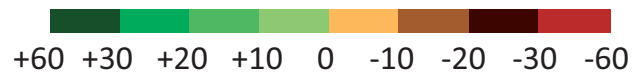
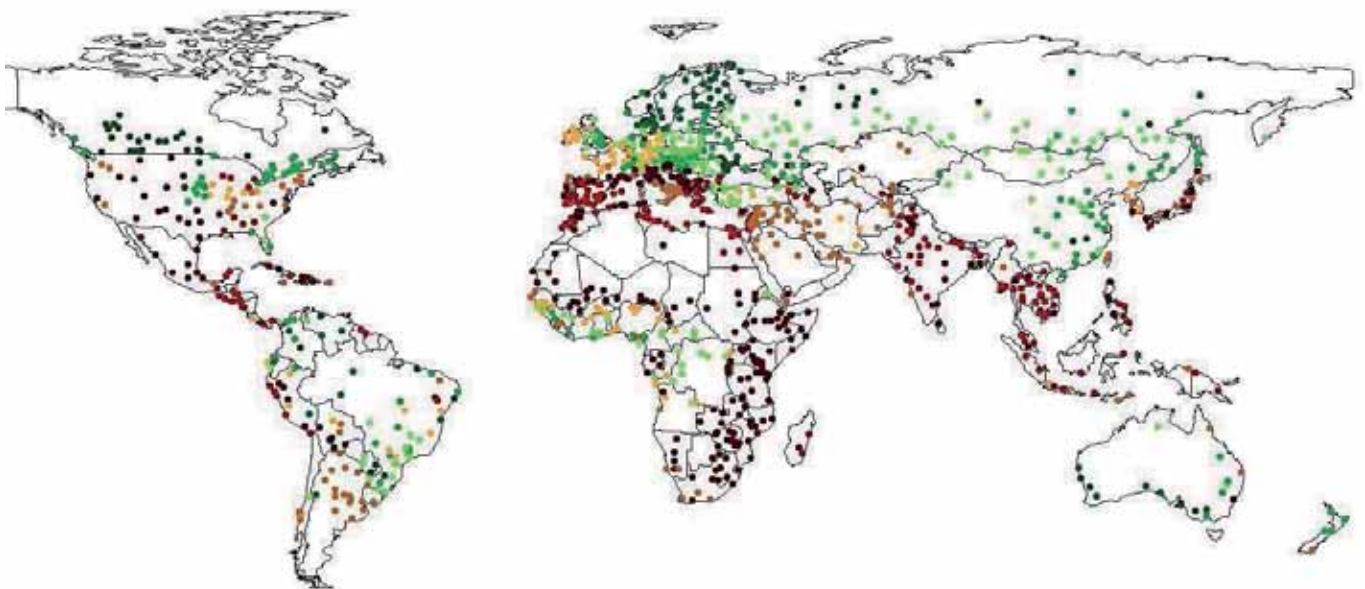
Scenario A1B_8

Agricultural productivity changes (% of baseline)



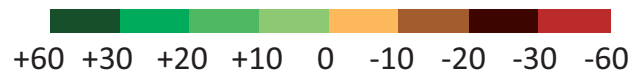
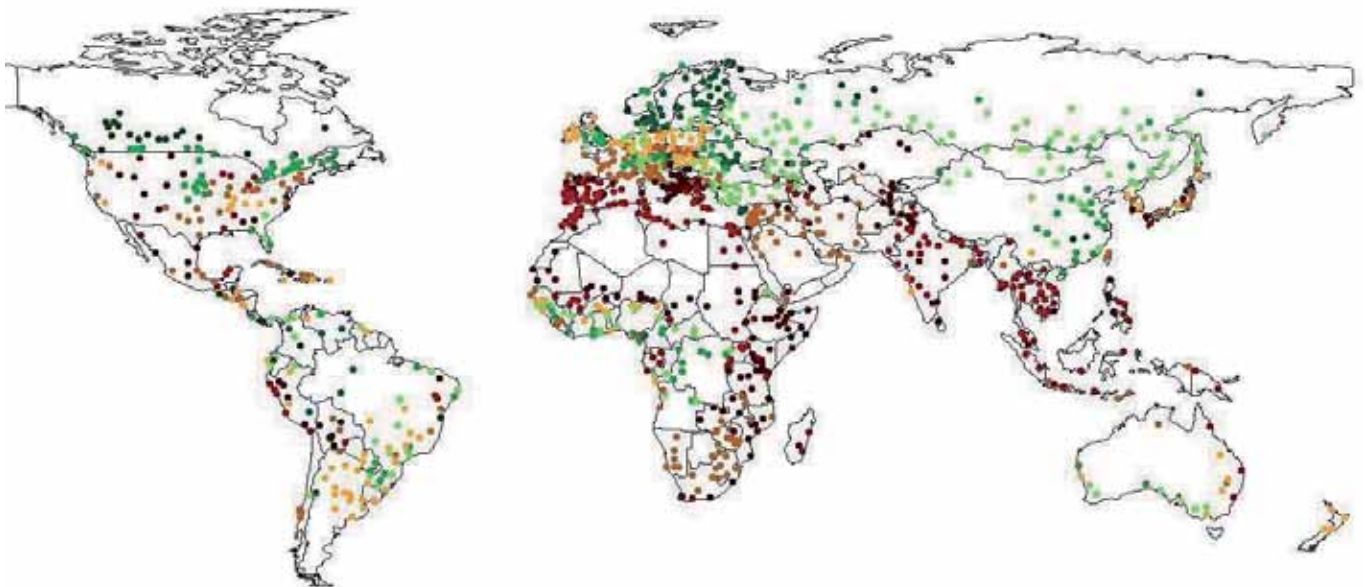
Scenario A1B_9

Agricultural productivity changes (% of baseline)



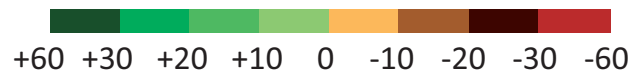
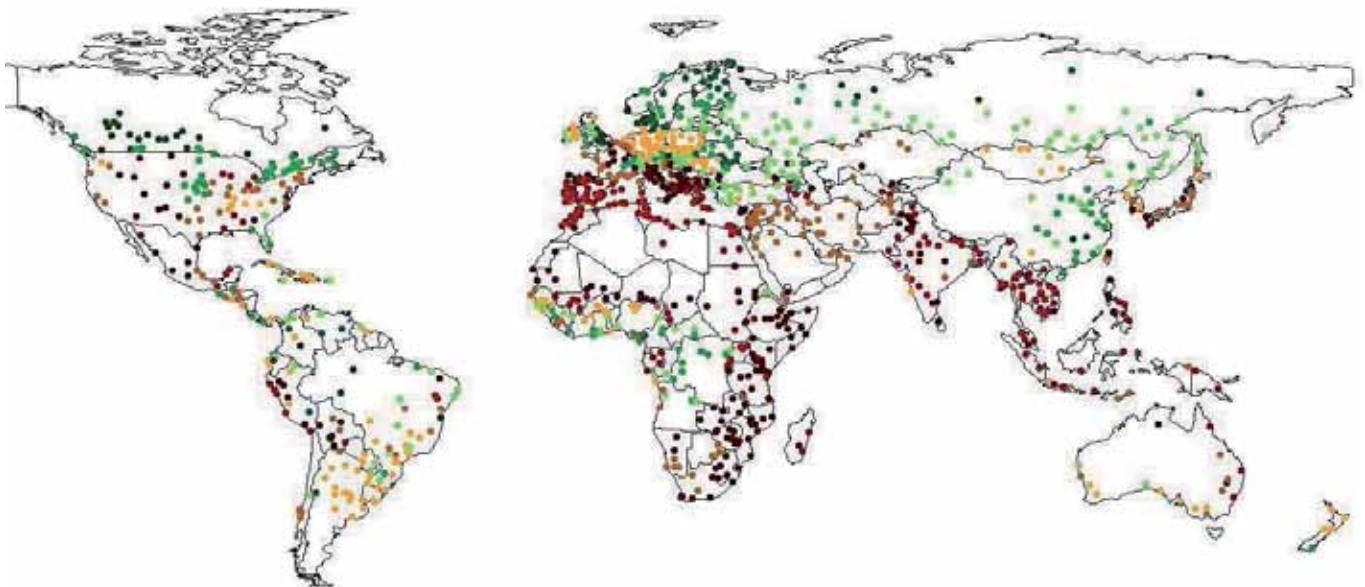
Scenario A1B_10

Agricultural productivity changes (% of baseline)



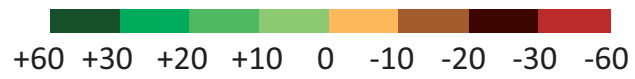
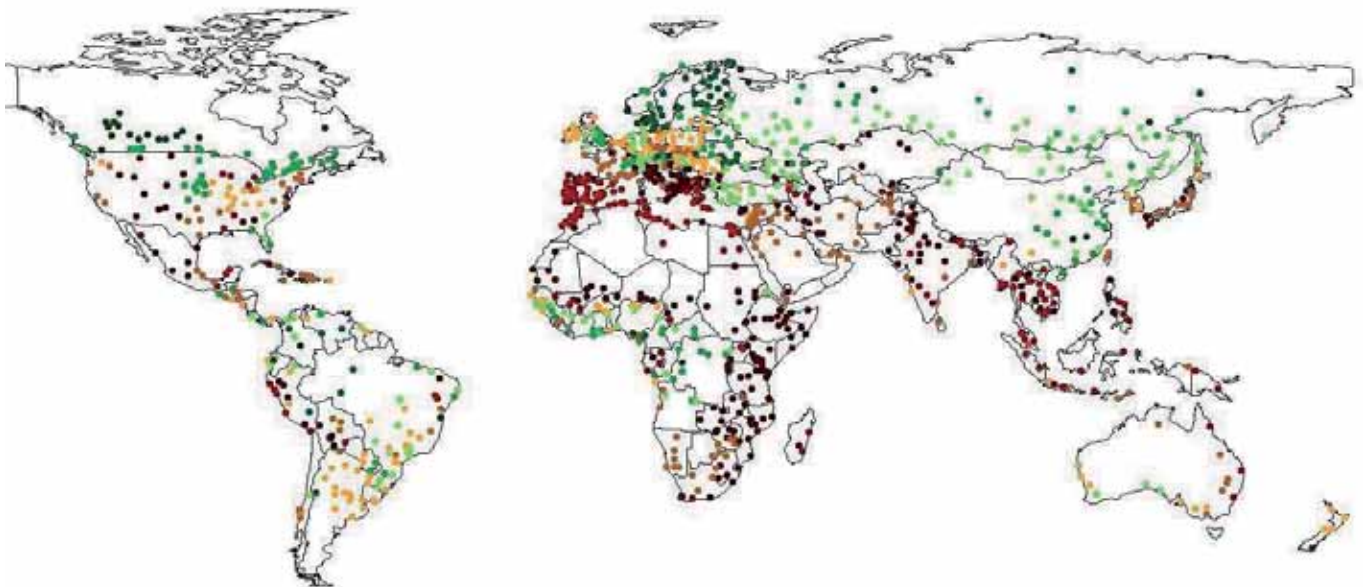
Scenario A1B_11

Agricultural productivity changes (% of baseline)



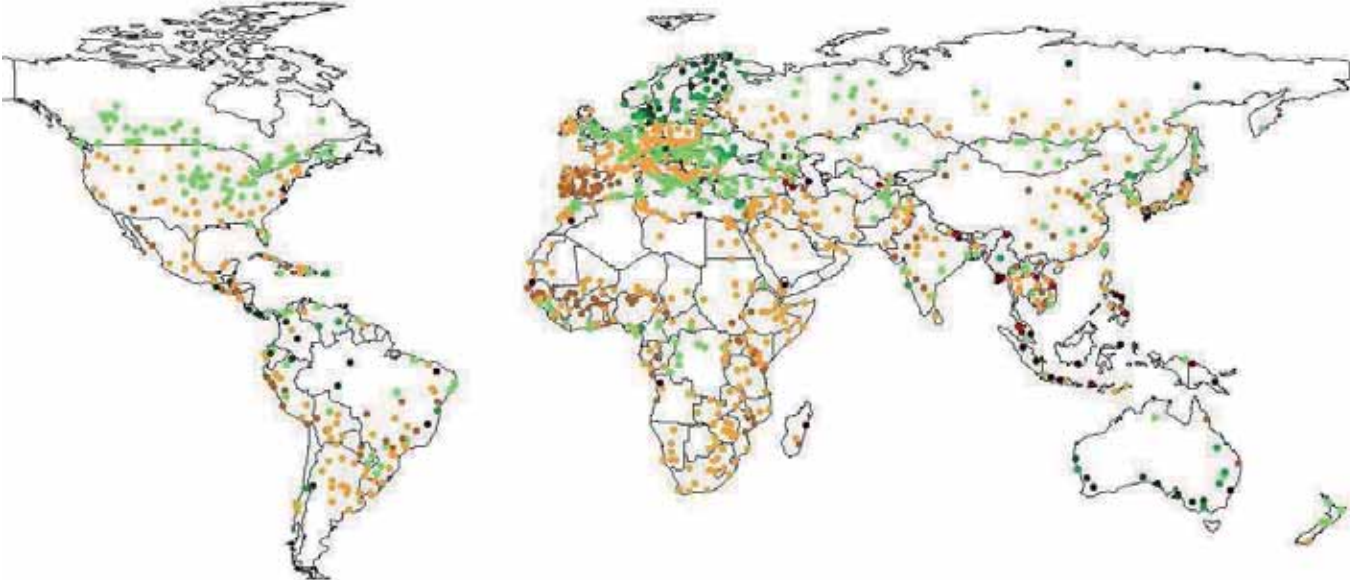
Scenario A1B_12

Agricultural productivity changes (% of baseline)



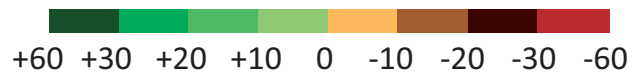
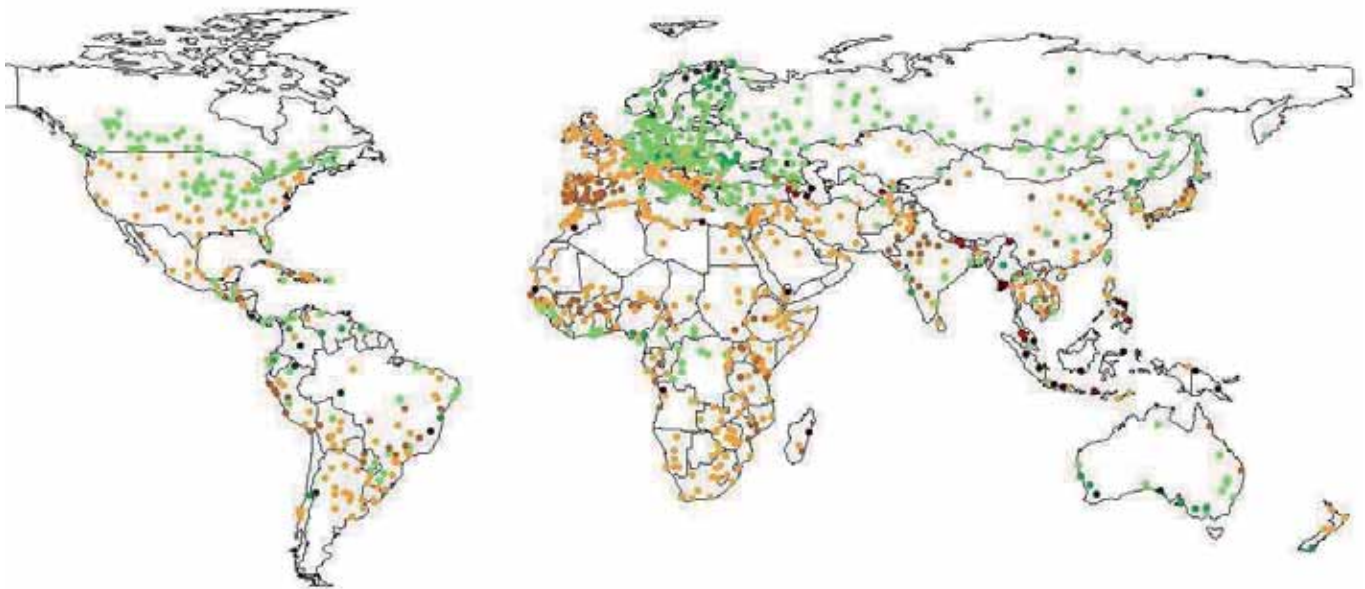
Scenario E1_1

Agricultural productivity changes (% of baseline)



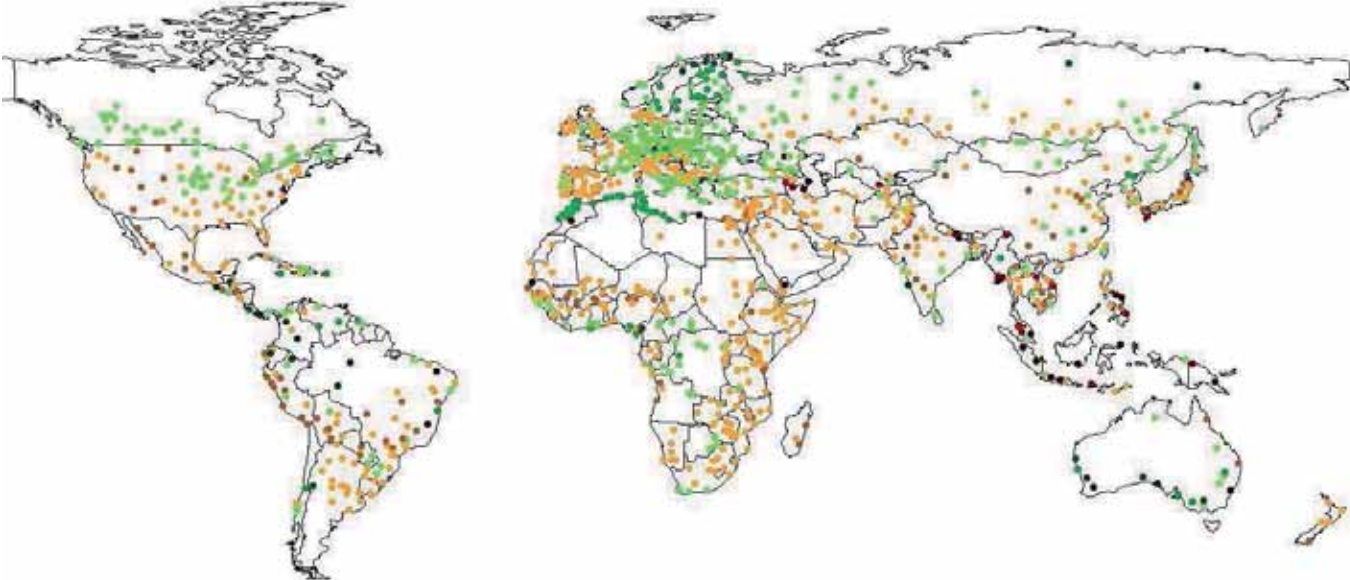
Scenario E1_2

Agricultural productivity changes (% of baseline)



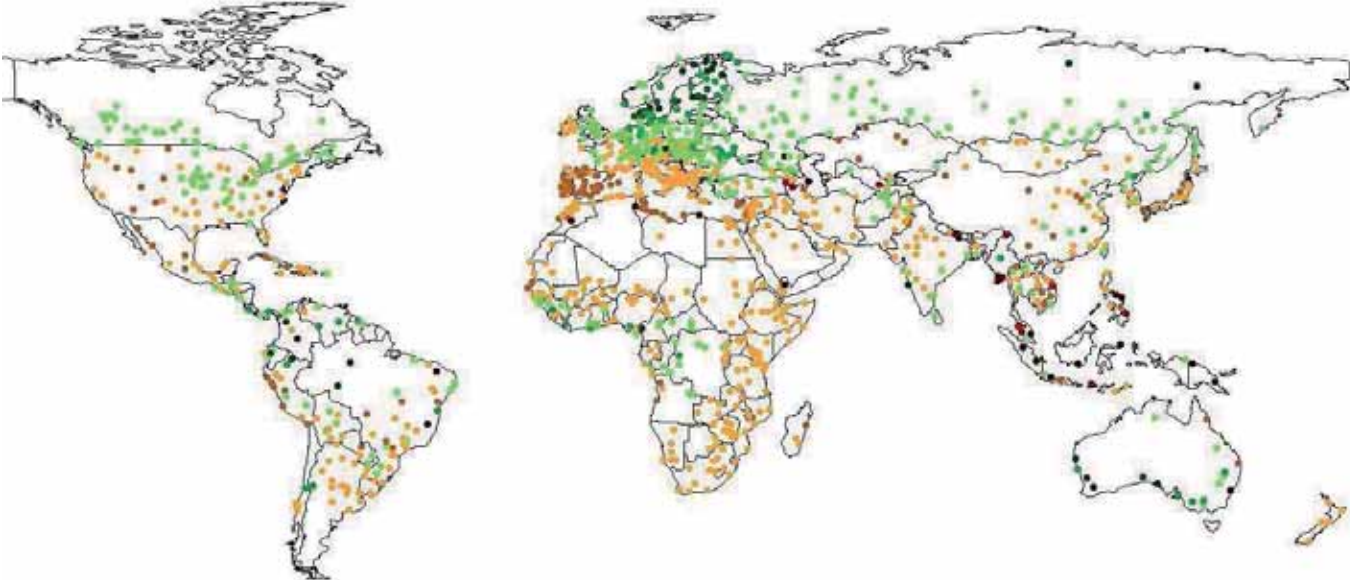
Scenario E1_3

Agricultural productivity changes (% of baseline)



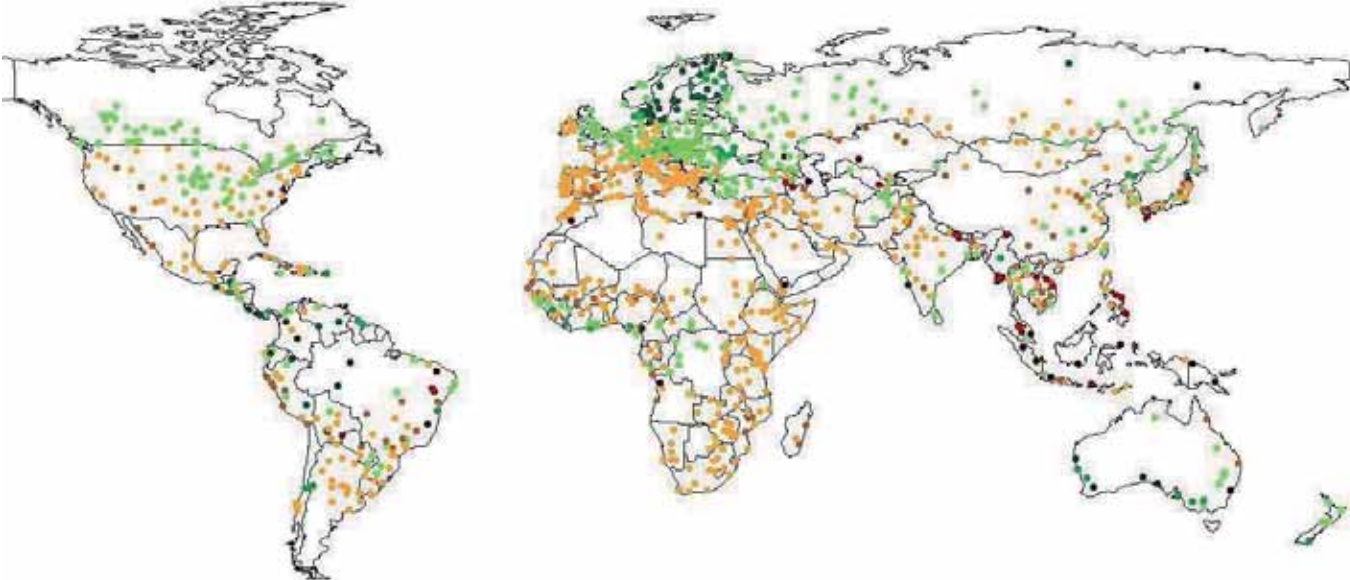
Scenario E1_4

Agricultural productivity changes (% of baseline)



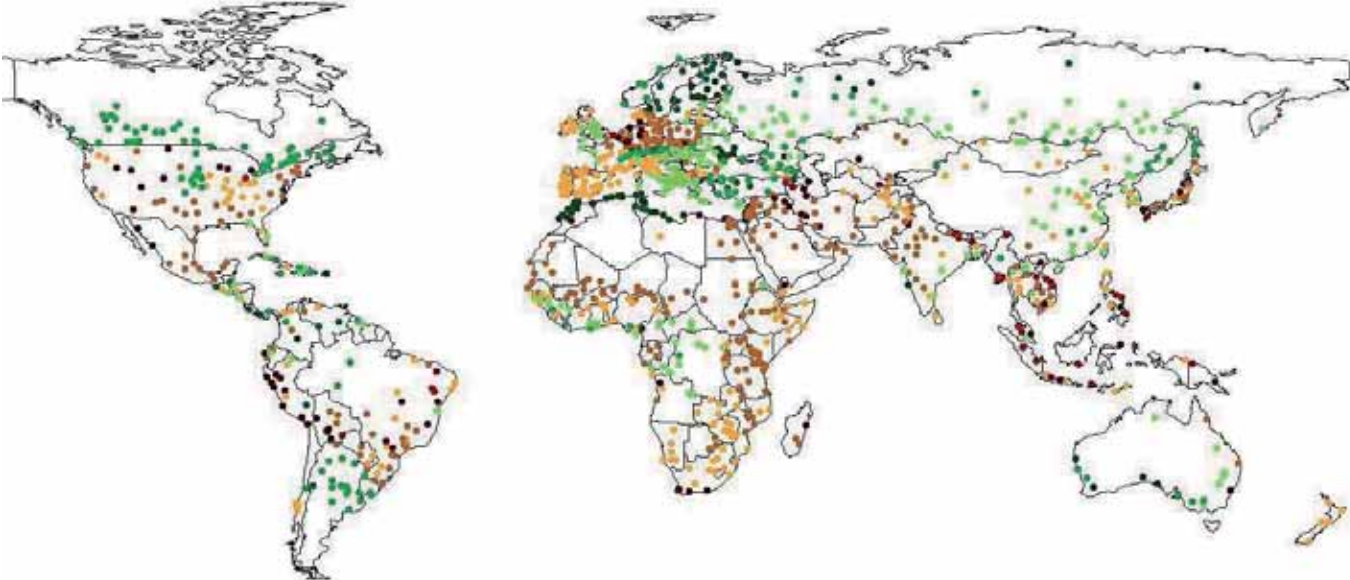
Scenario E1_5

Agricultural productivity changes (% of baseline)



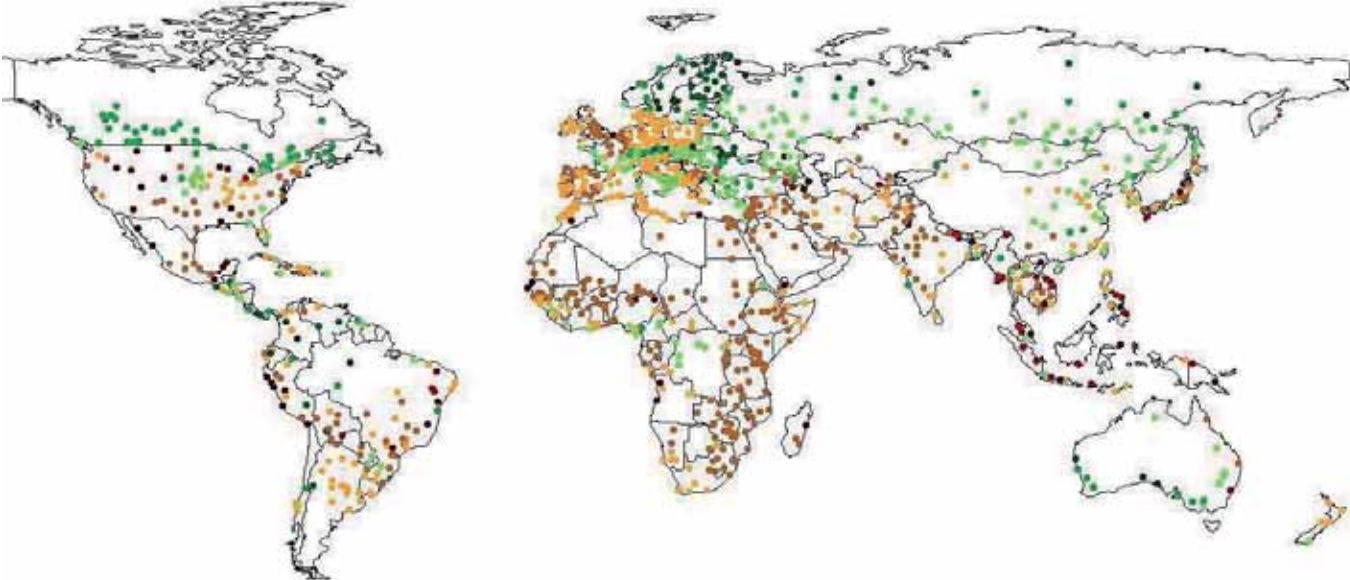
Scenario E1_6

Agricultural productivity changes (% of baseline)



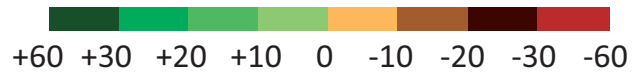
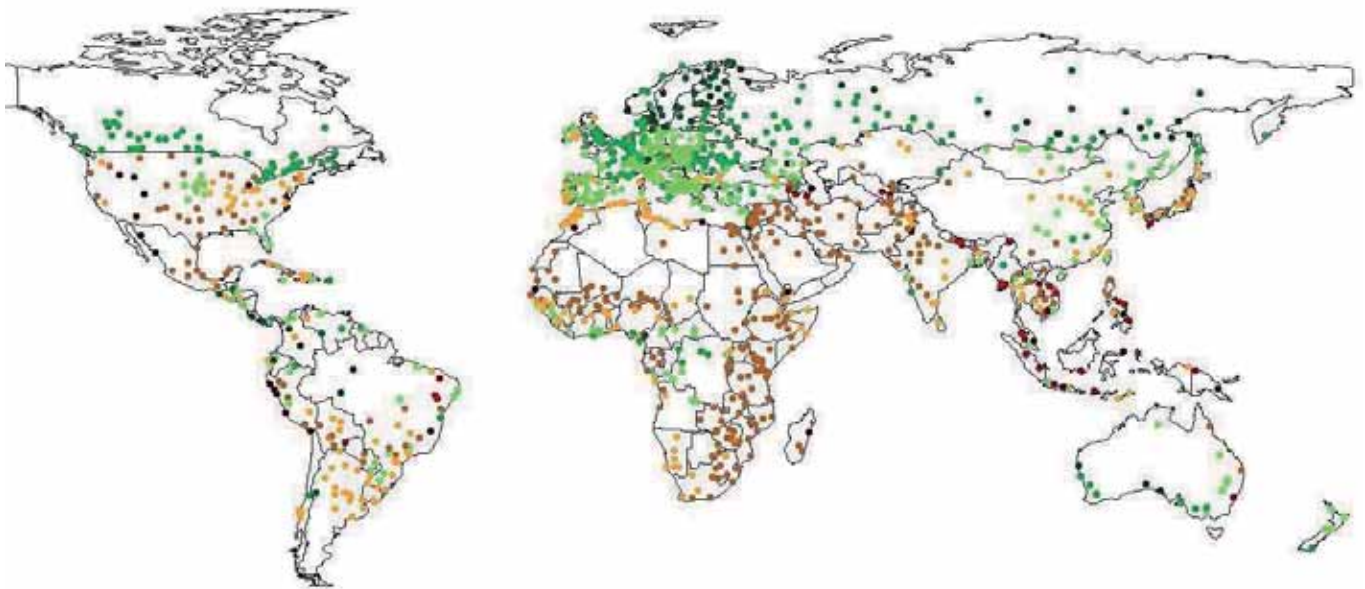
Scenario E1_7

Agricultural productivity changes (% of baseline)



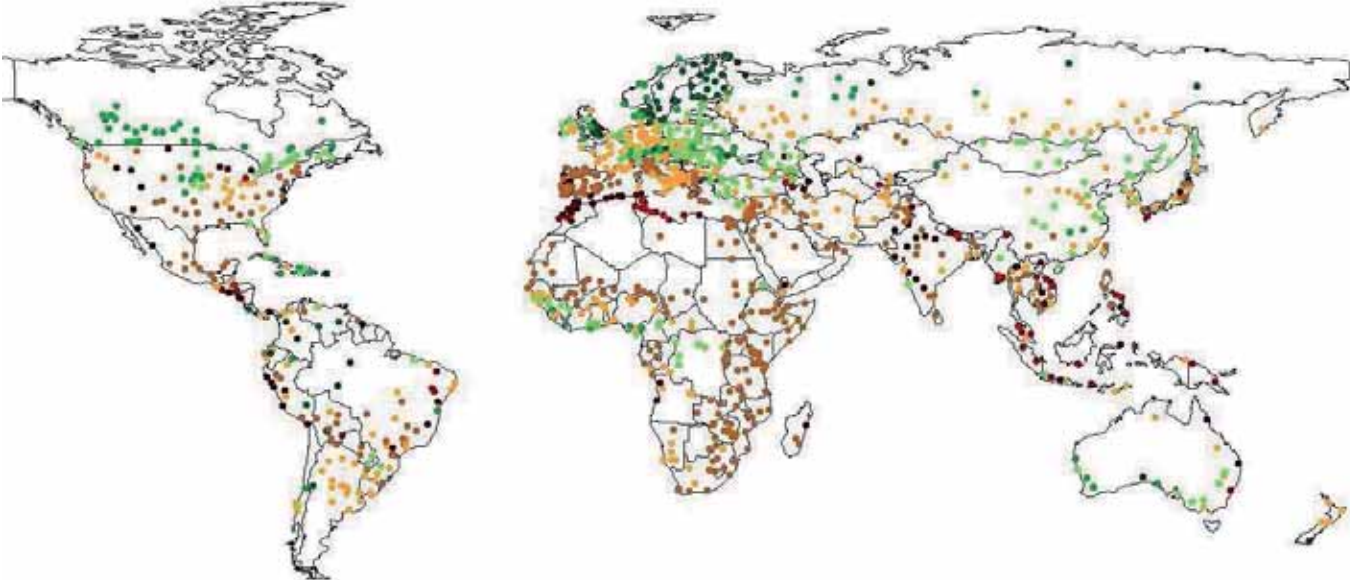
Scenario E1_8

Agricultural productivity changes (% of baseline)



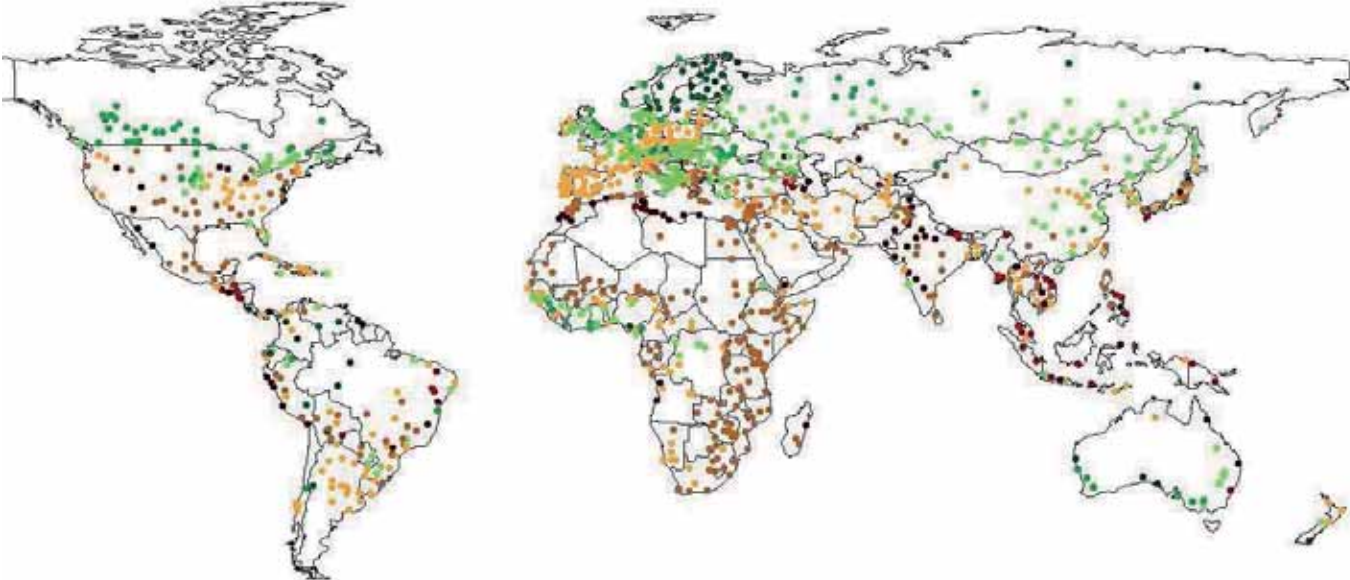
Scenario E1_9

Agricultural productivity changes (% of baseline)



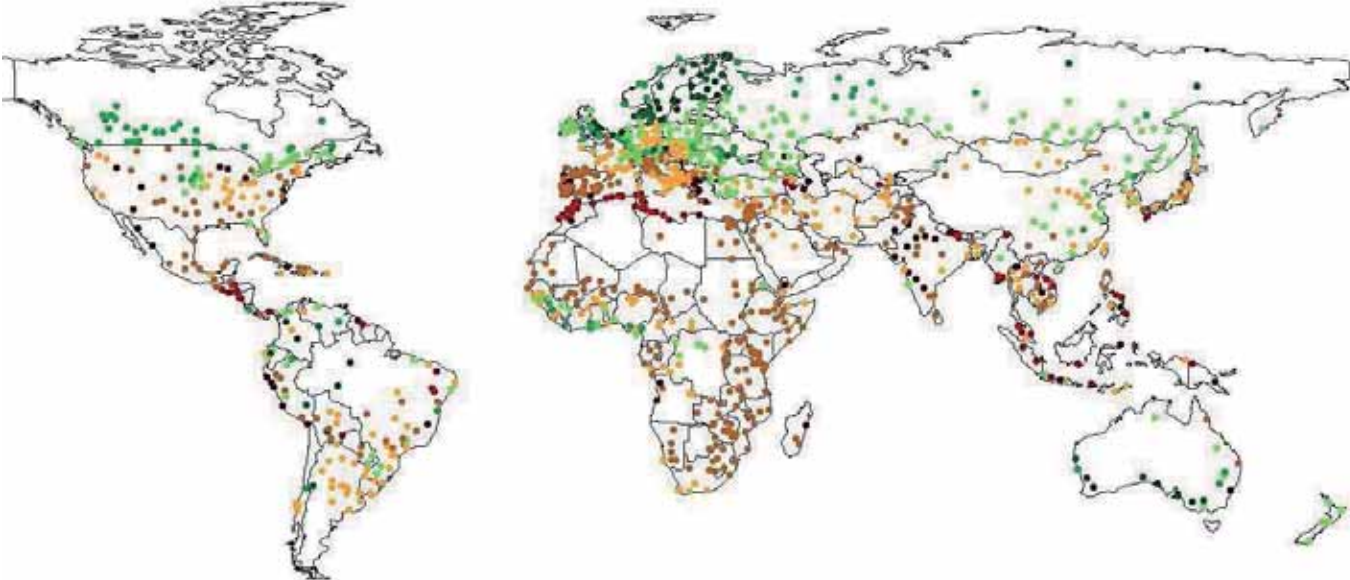
Scenario E1_10

Agricultural productivity changes (% of baseline)



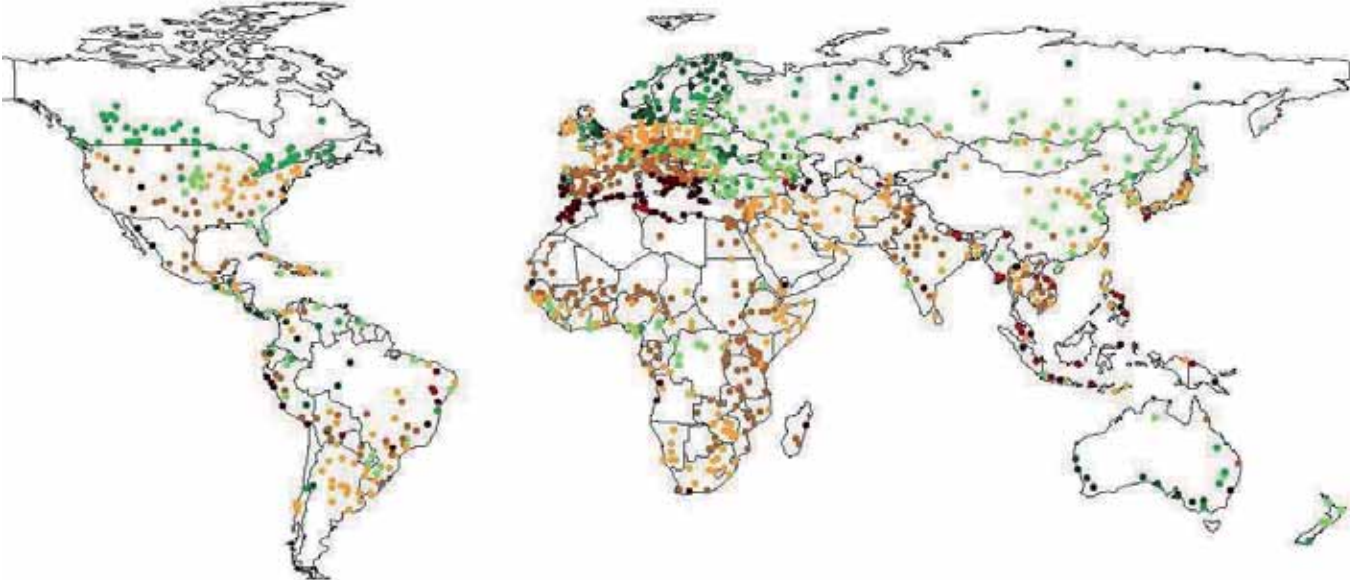
Scenario E1_11

Agricultural productivity changes (% of baseline)



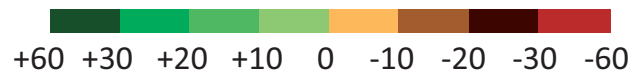
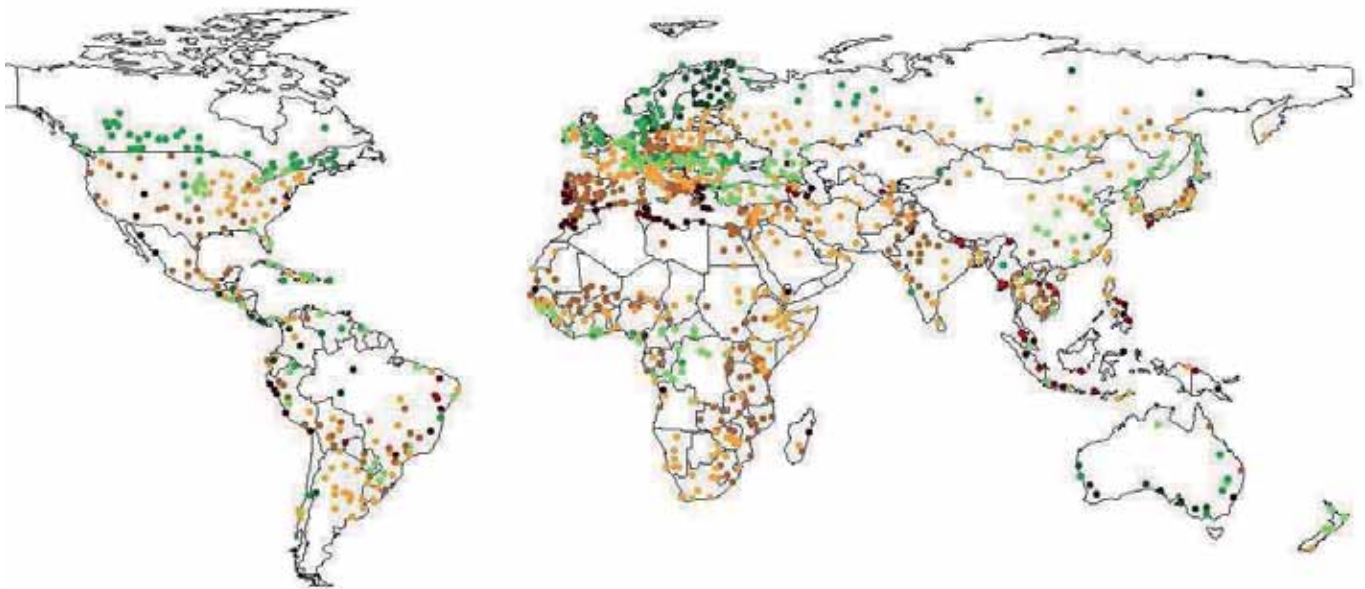
Scenario E1_12

Agricultural productivity changes (% of baseline)



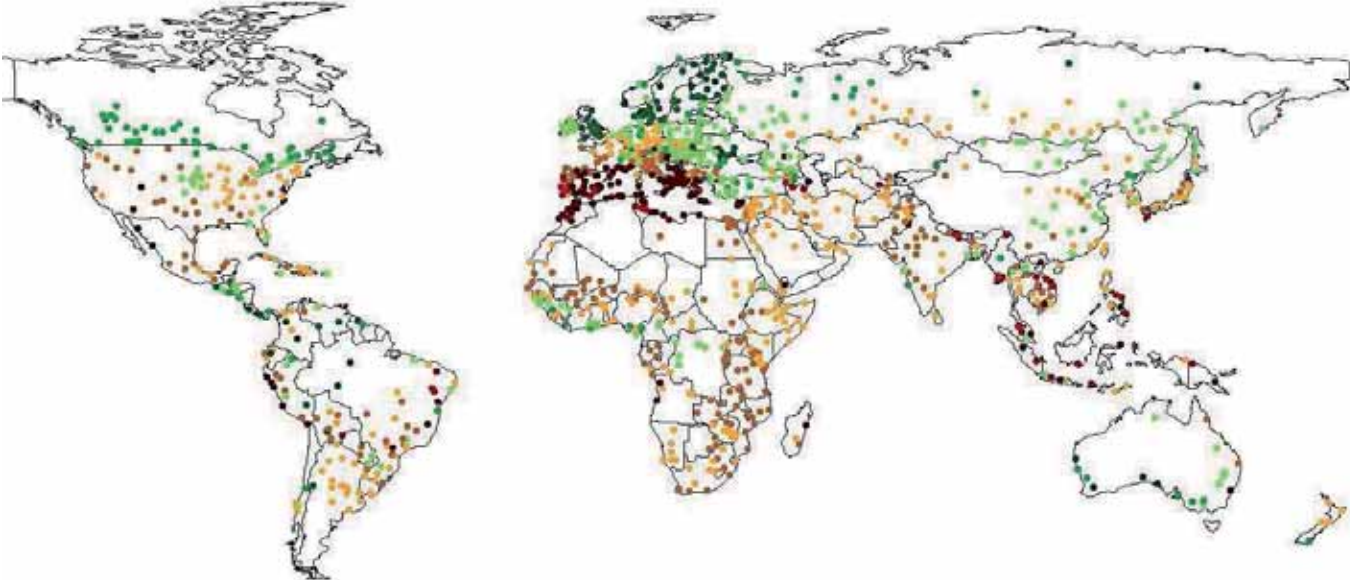
Scenario E1_13

Agricultural productivity changes (% of baseline)



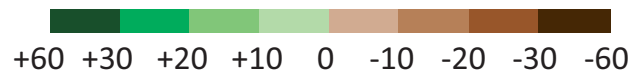
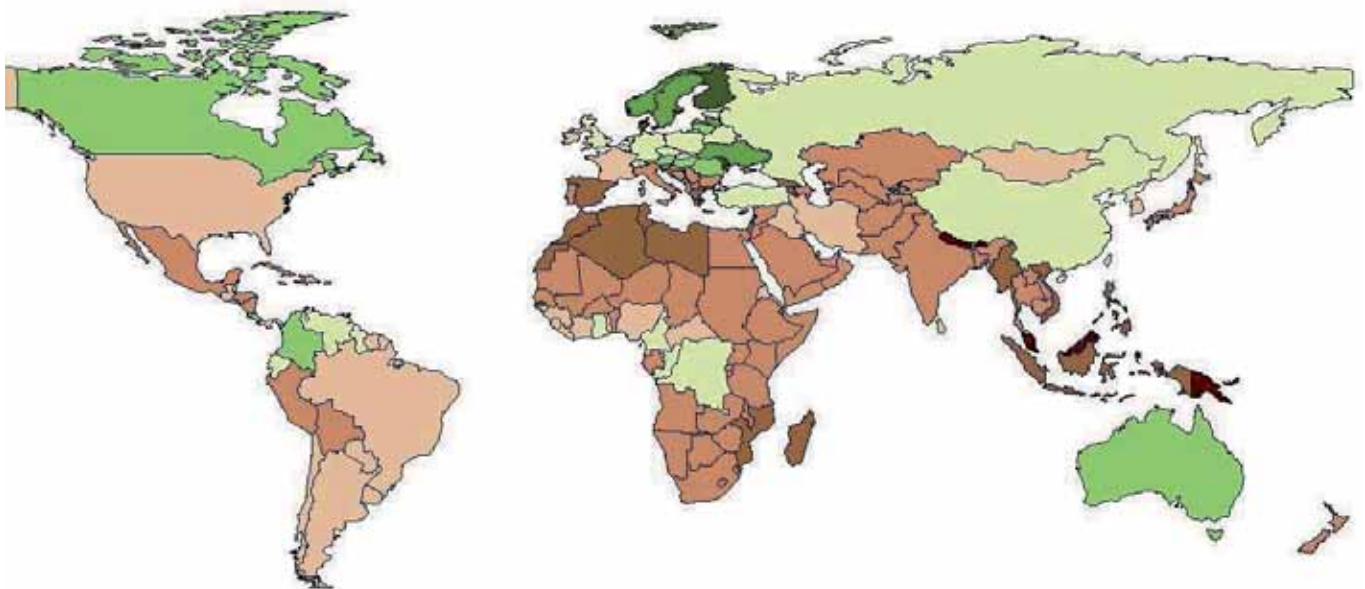
Scenario E1_14

Agricultural productivity changes (% of baseline)



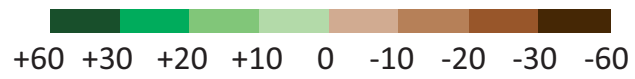
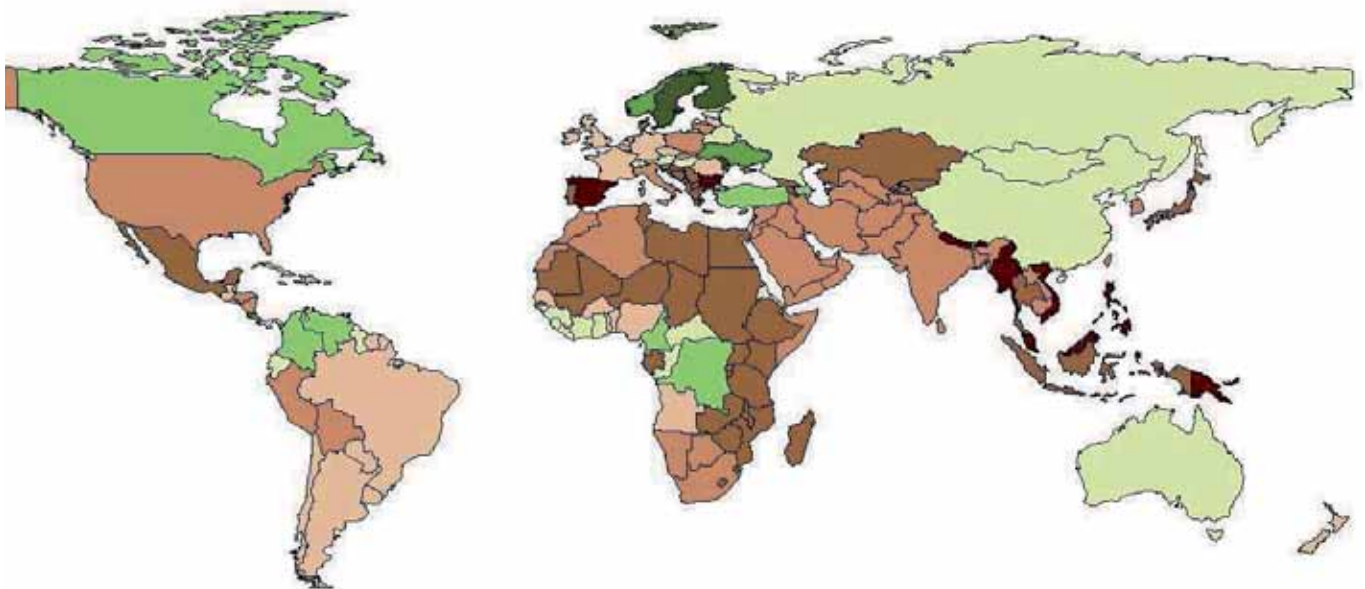
Scenario A1B_1

Agricultural productivity changes (% of baseline)



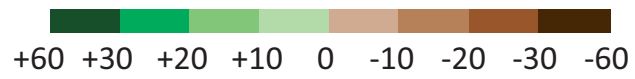
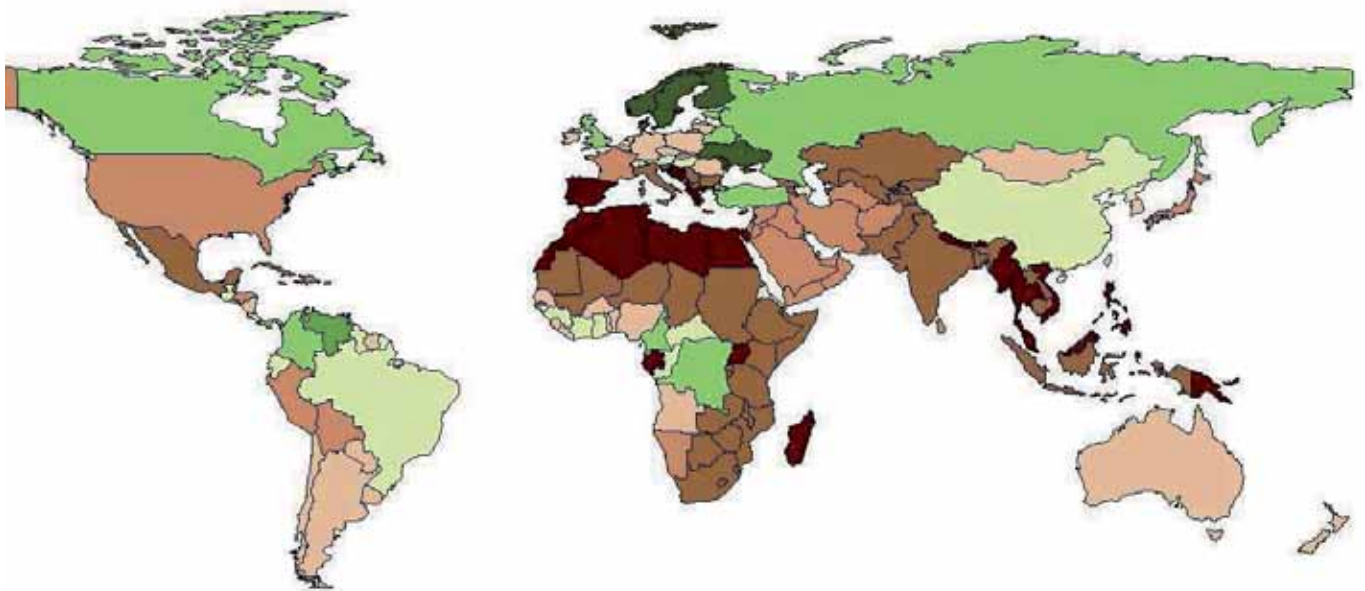
Scenario A1B_2

Agricultural productivity changes (% of baseline)



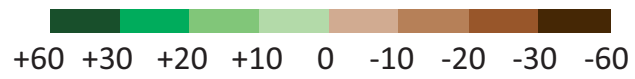
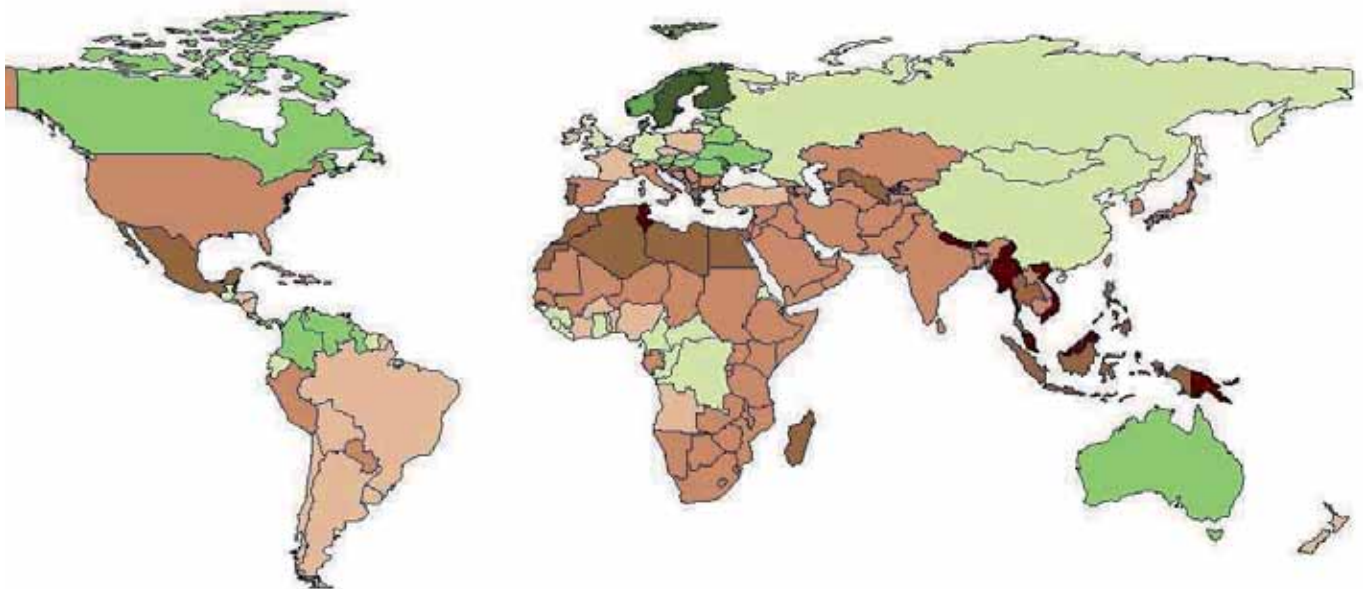
Scenario A1B_3

Agricultural productivity changes (% of baseline)



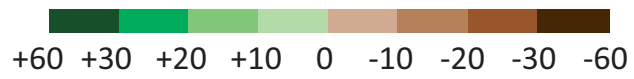
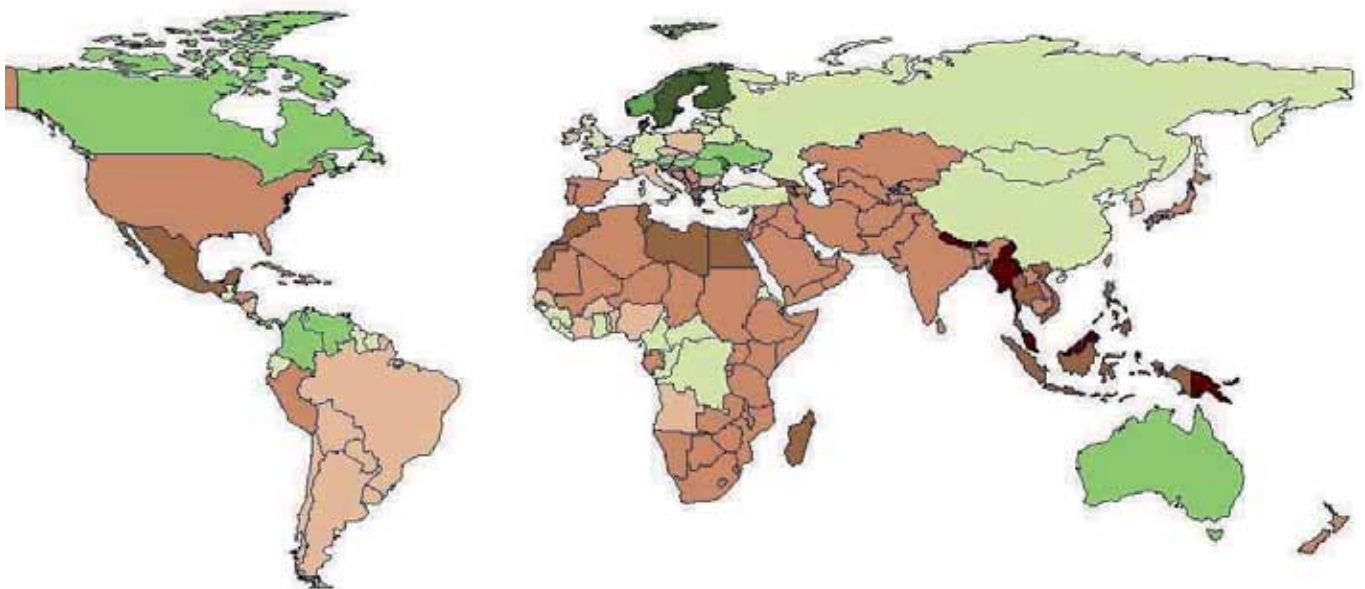
Scenario A1B_4

Agricultural productivity changes (% of baseline)



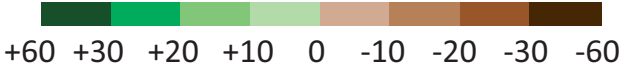
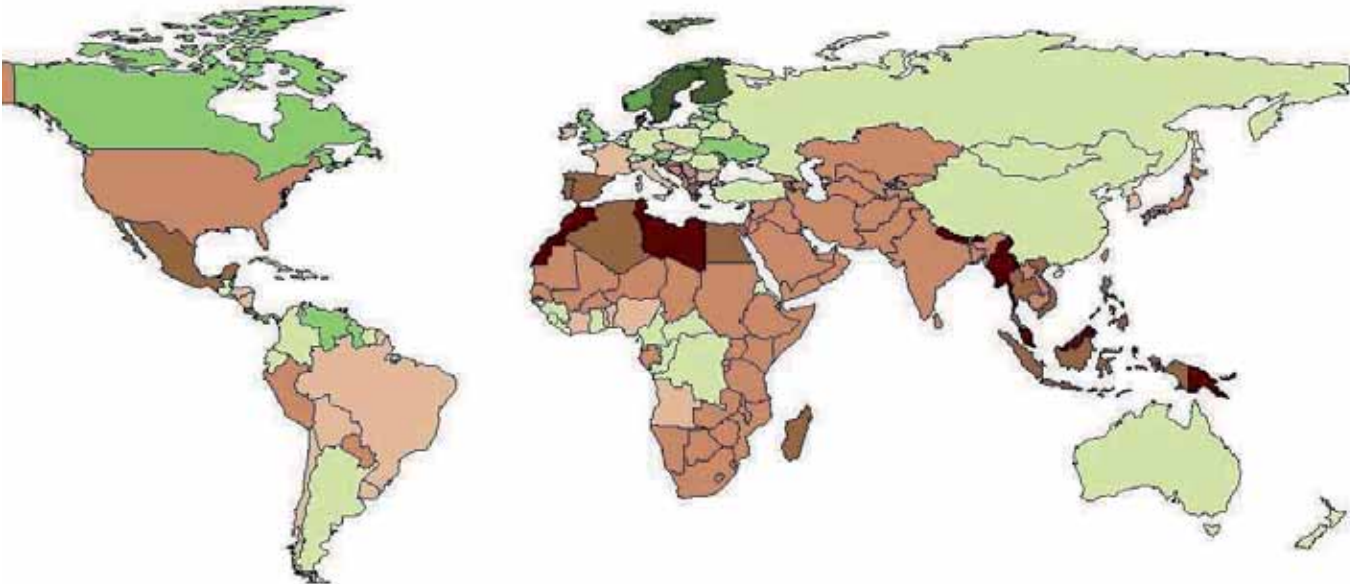
Scenario A1B_5

Agricultural productivity changes (% of baseline)



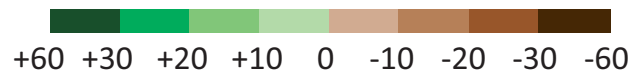
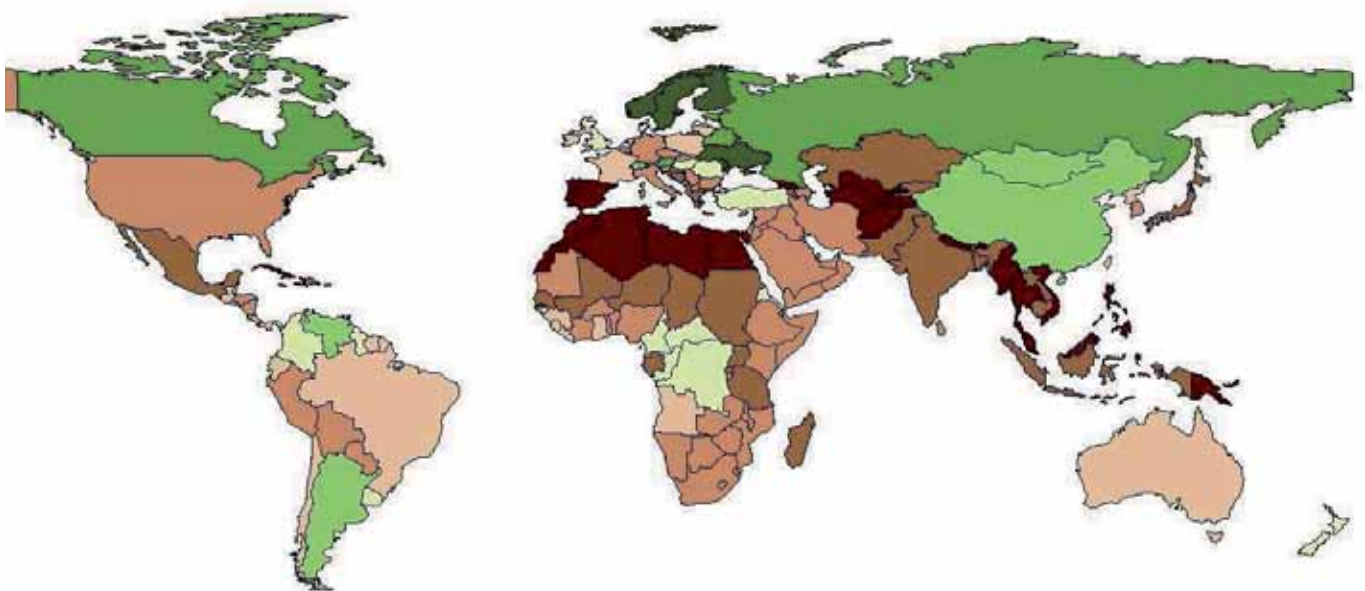
Scenario A1B_6

Agricultural productivity changes (% of baseline)



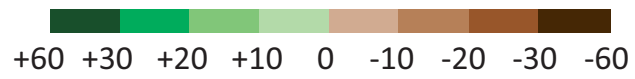
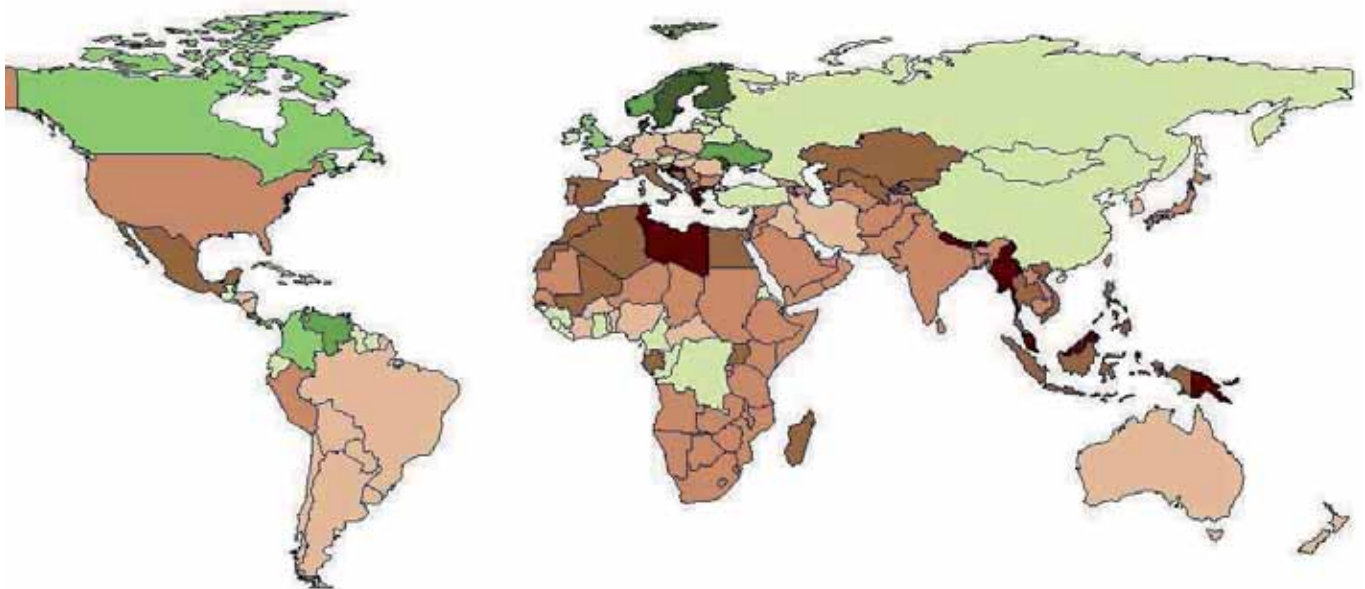
Scenario A1B_7

Agricultural productivity changes (% of baseline)



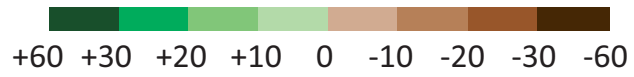
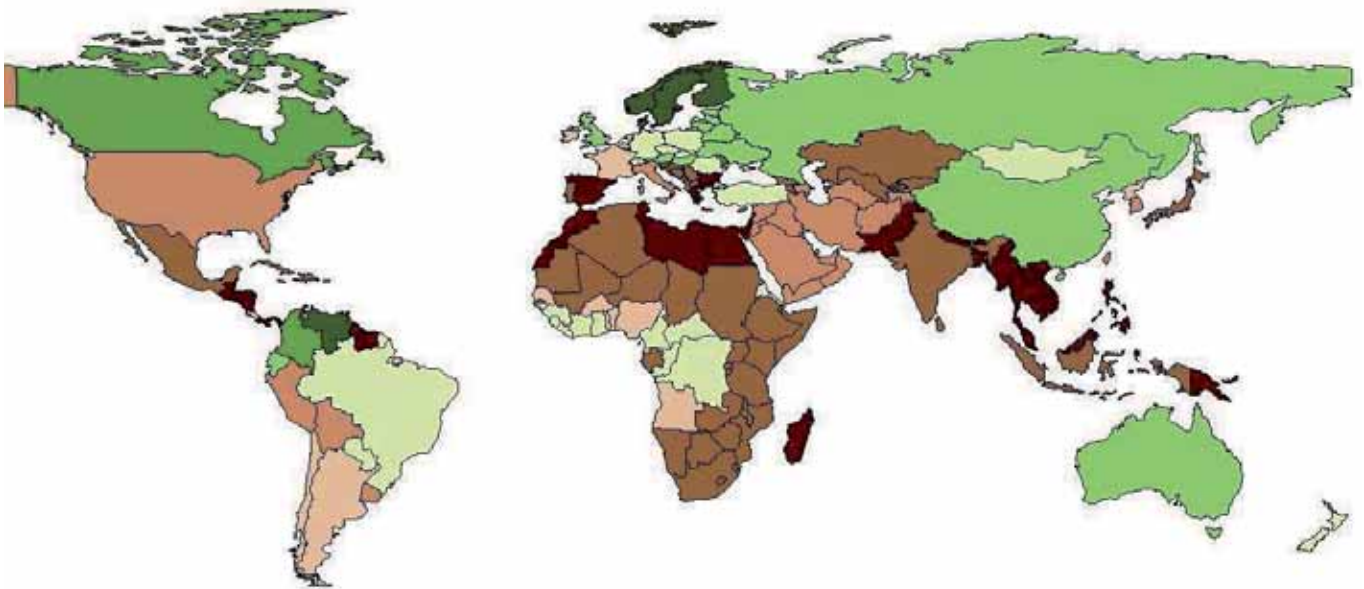
Scenario A1B_8

Agricultural productivity changes (% of baseline)



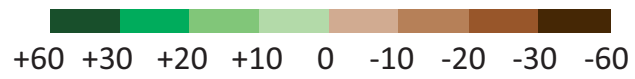
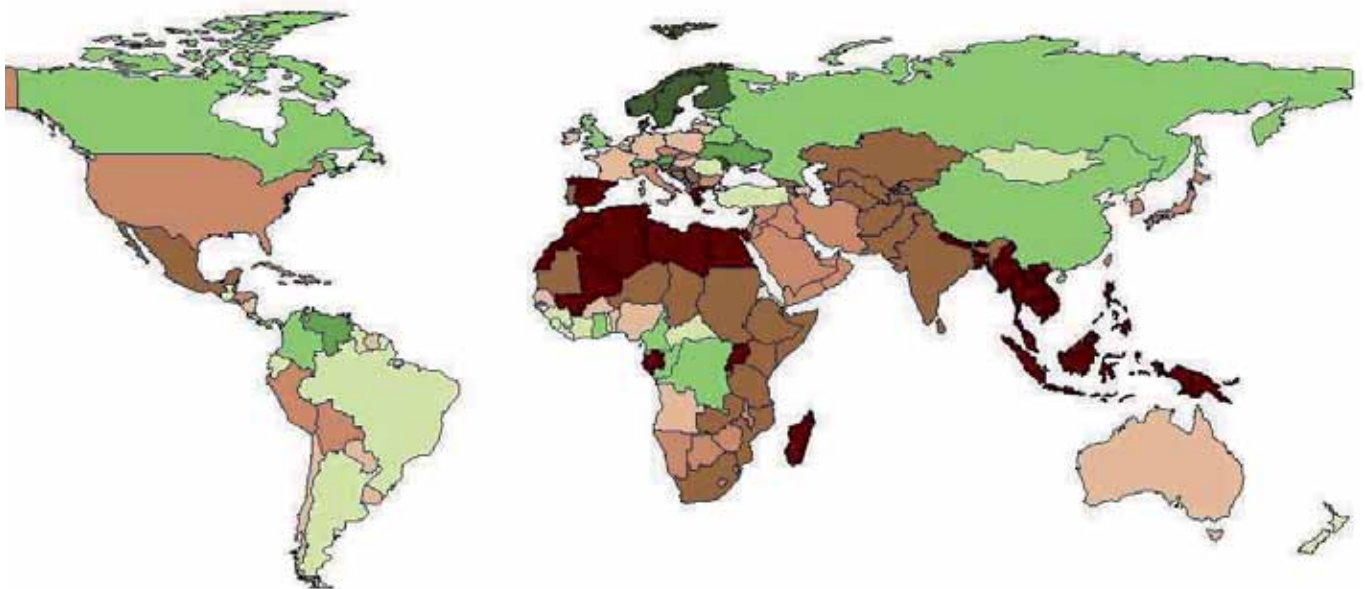
Scenario A1B_9

Agricultural productivity changes (% of baseline)



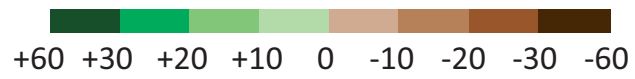
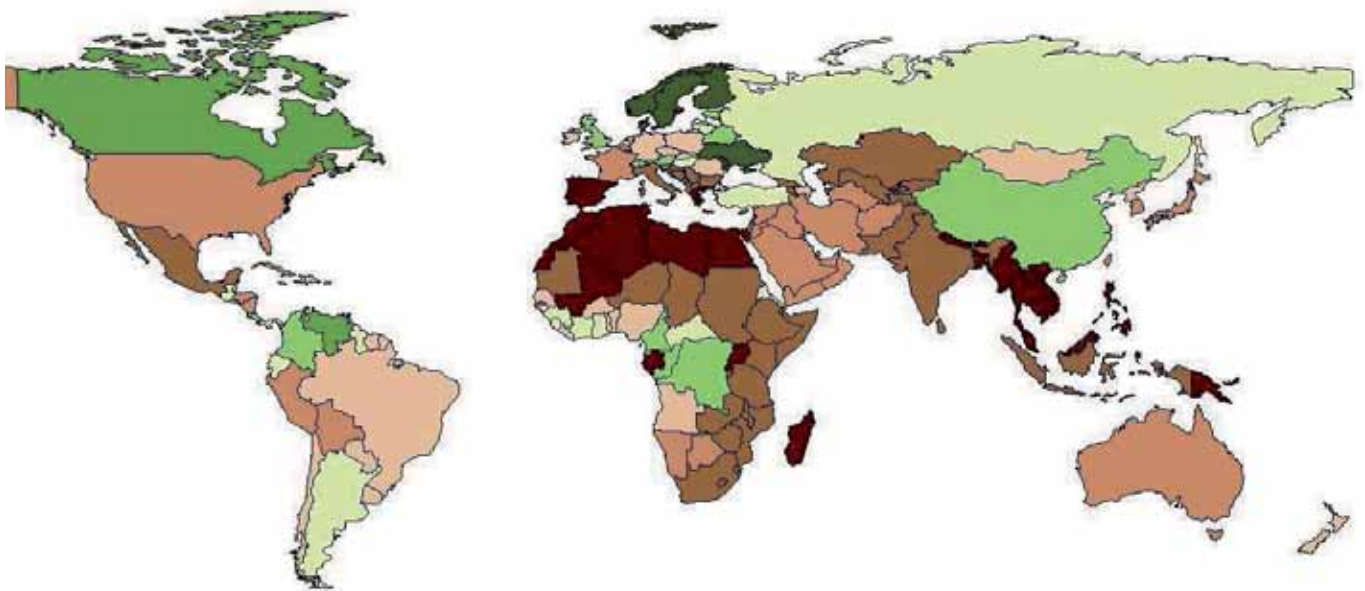
Scenario A1B_10

Agricultural productivity changes (% of baseline)



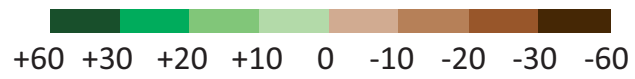
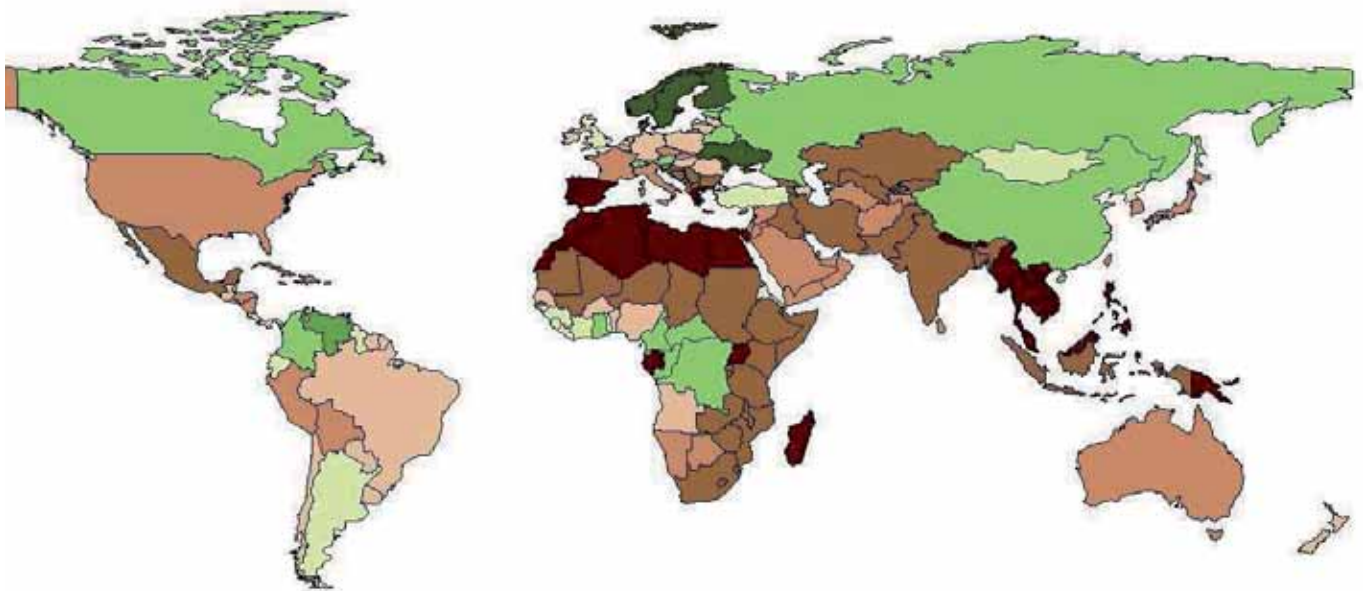
Scenario A1B_11

Agricultural productivity changes (% of baseline)



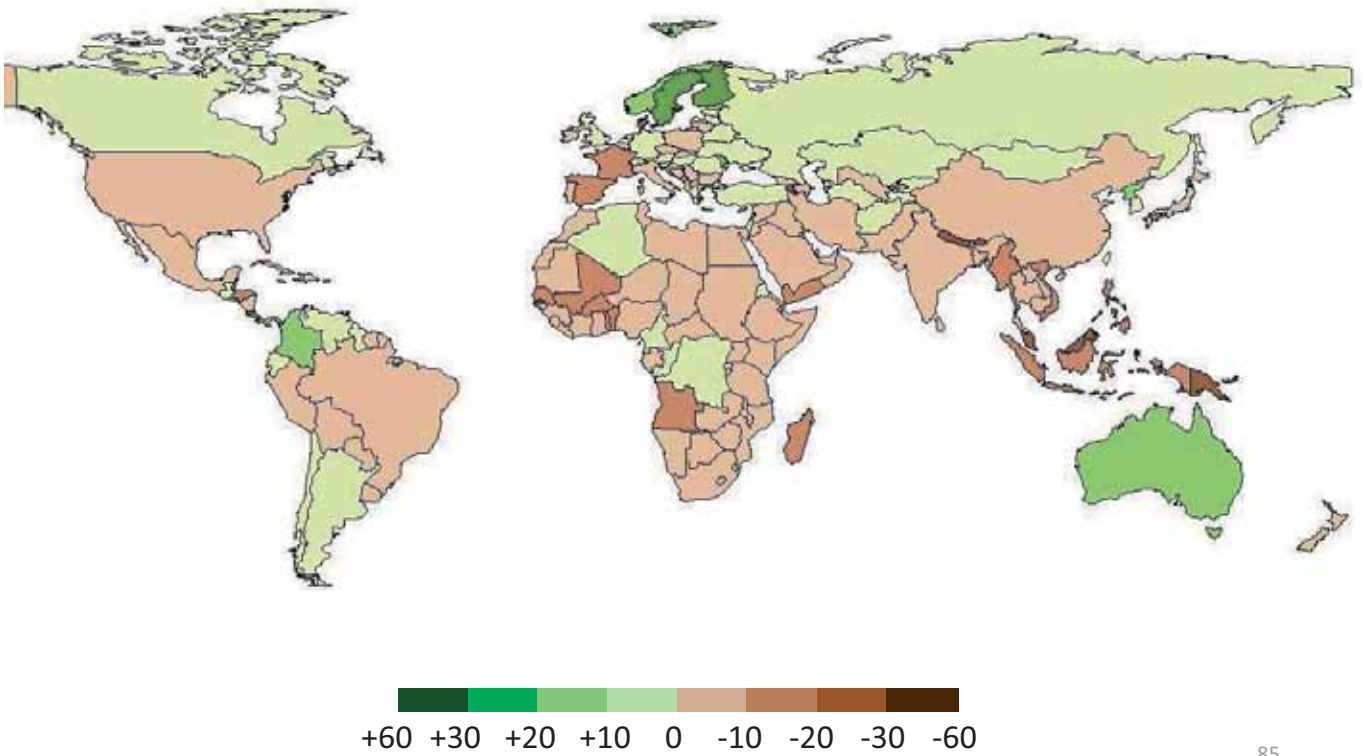
Scenario A1B_12

Agricultural productivity changes (% of baseline)



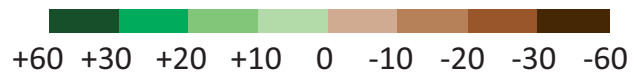
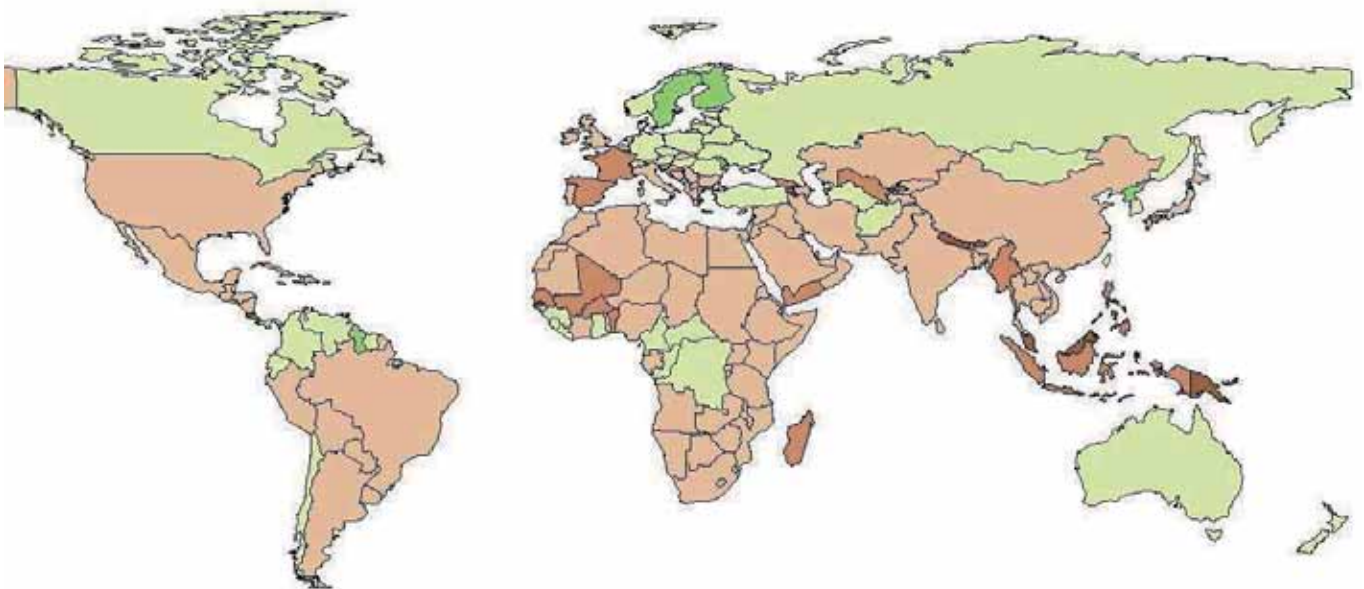
Scenario E1_1

Agricultural productivity changes (% of baseline)



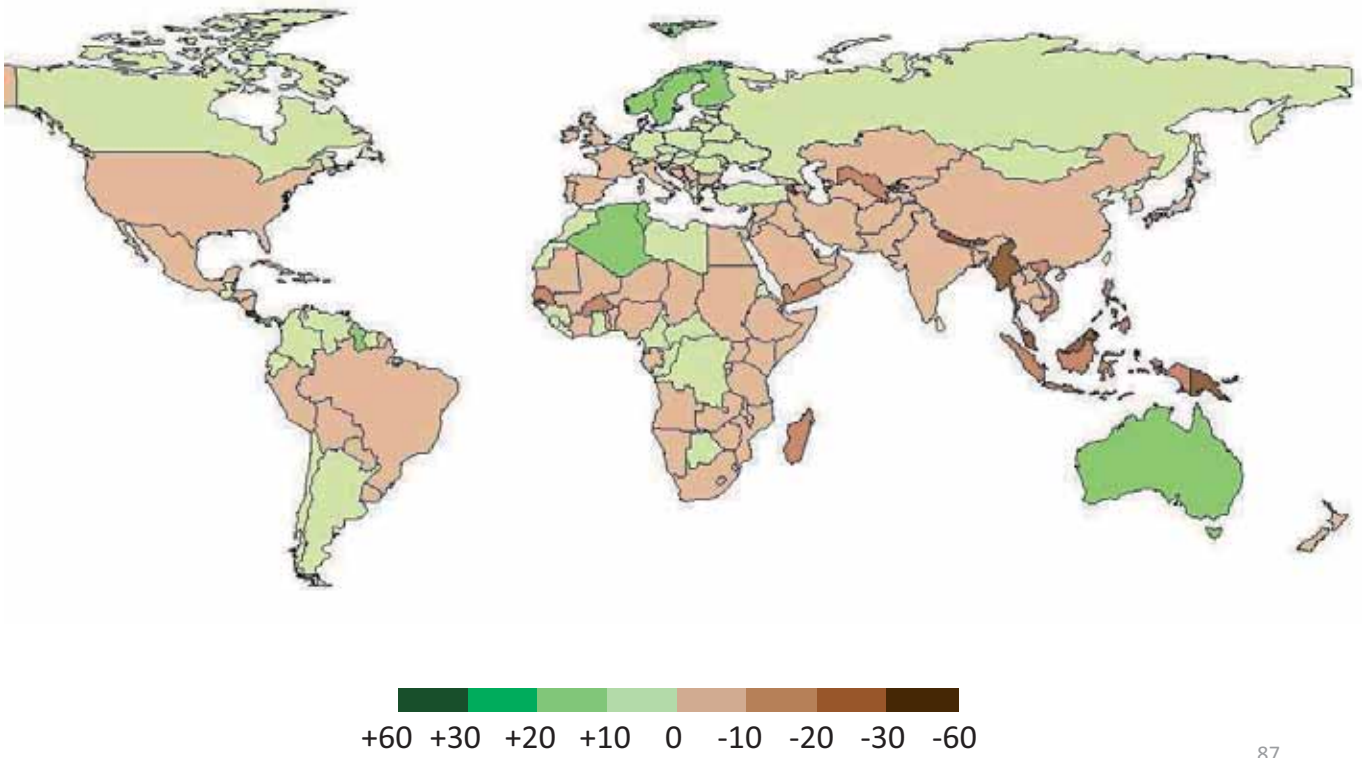
Scenario E1_2

Agricultural productivity changes (% of baseline)



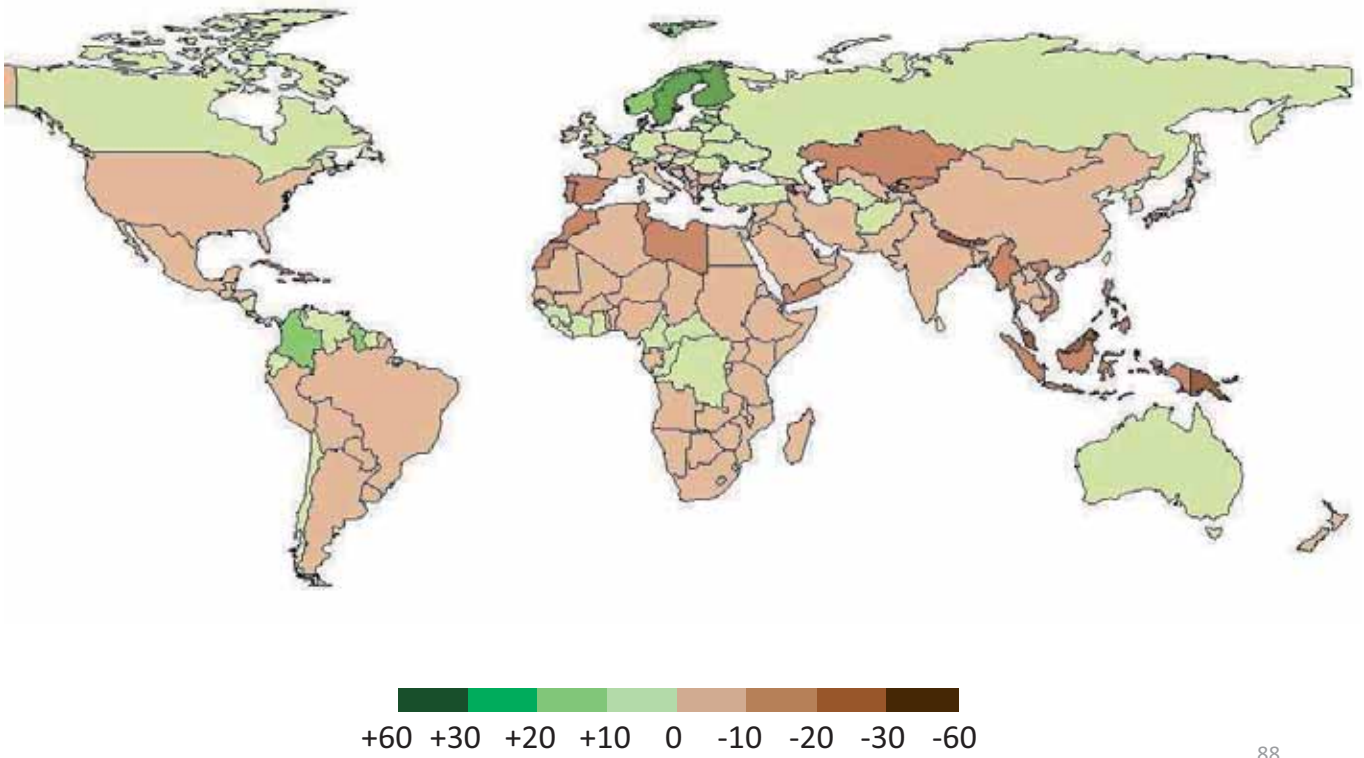
Scenario E1_3

Agricultural productivity changes (% of baseline)



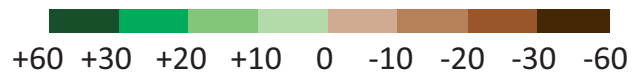
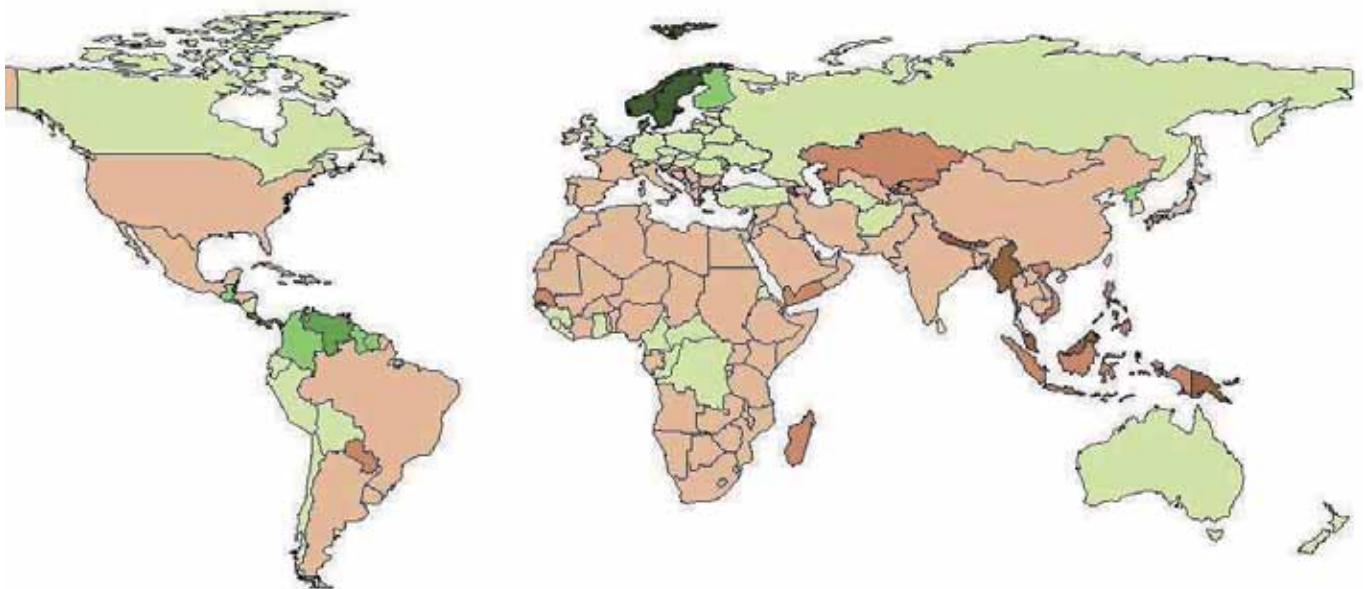
Scenario E1_4

Agricultural productivity changes (% of baseline)



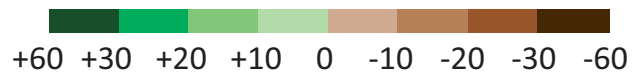
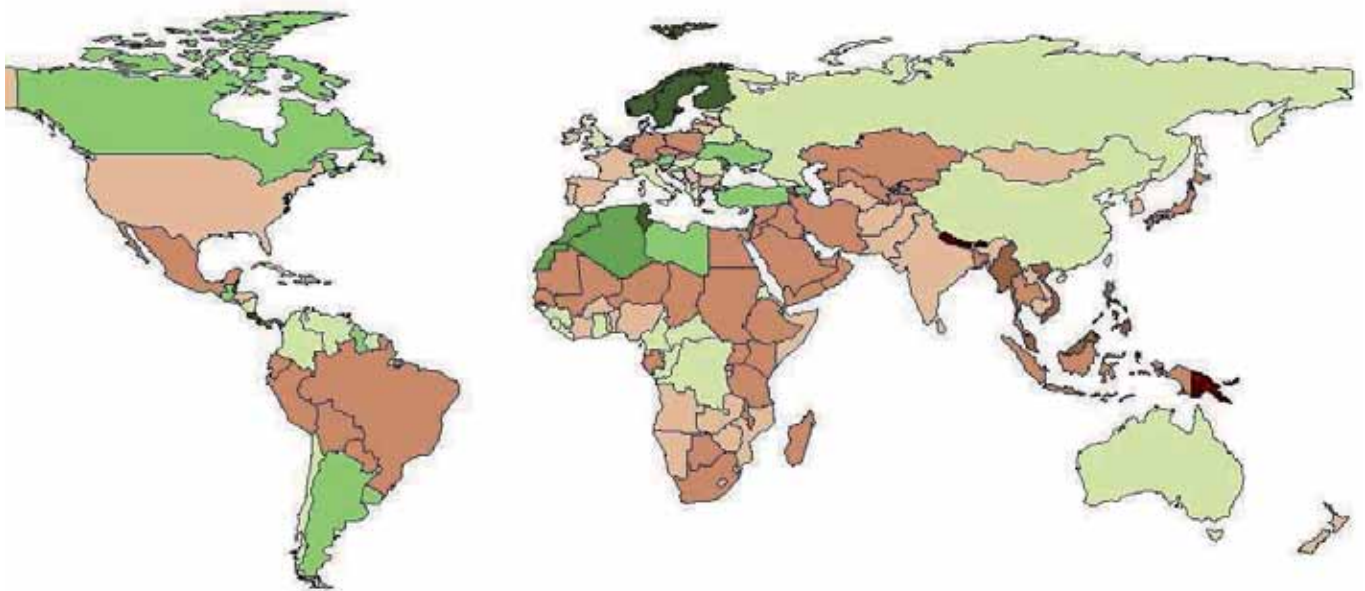
Scenario E1_5

Agricultural productivity changes (% of baseline)



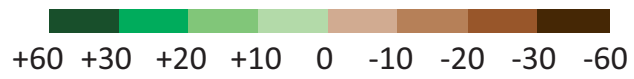
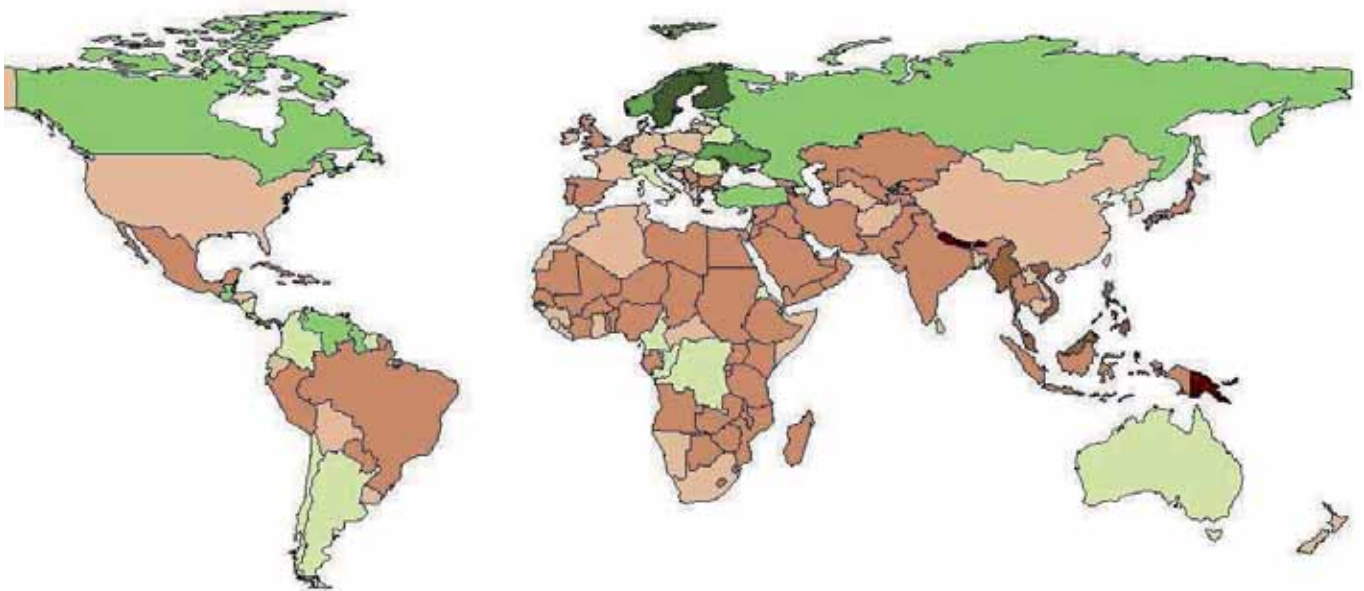
Scenario E1_6

Agricultural productivity changes (% of baseline)



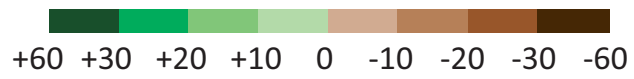
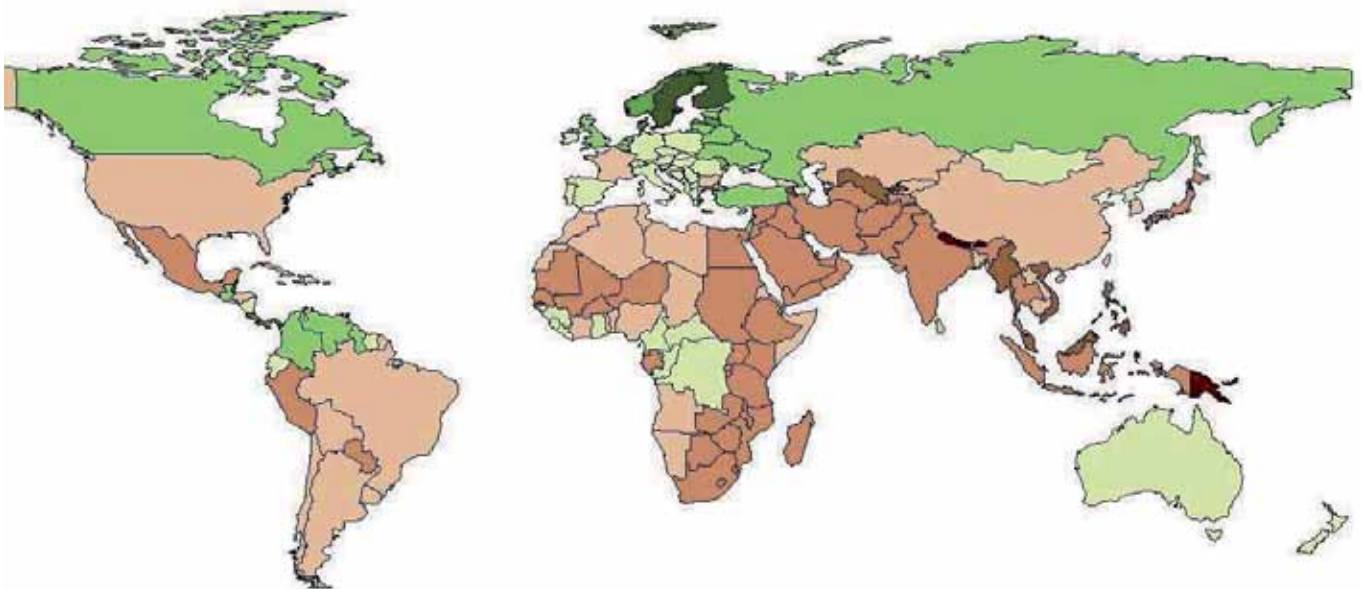
Scenario E1_7

Agricultural productivity changes (% of baseline)



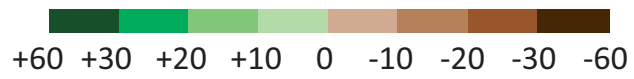
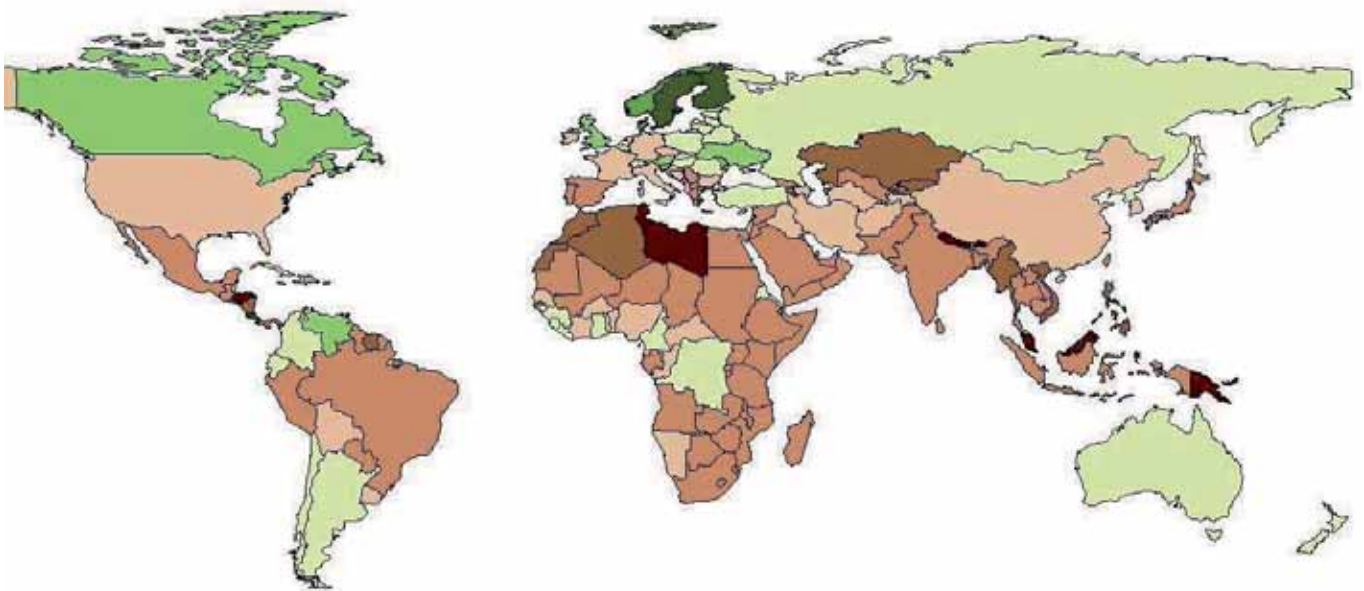
Scenario E1_8

Agricultural productivity changes (% of baseline)



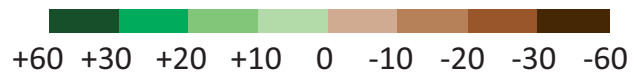
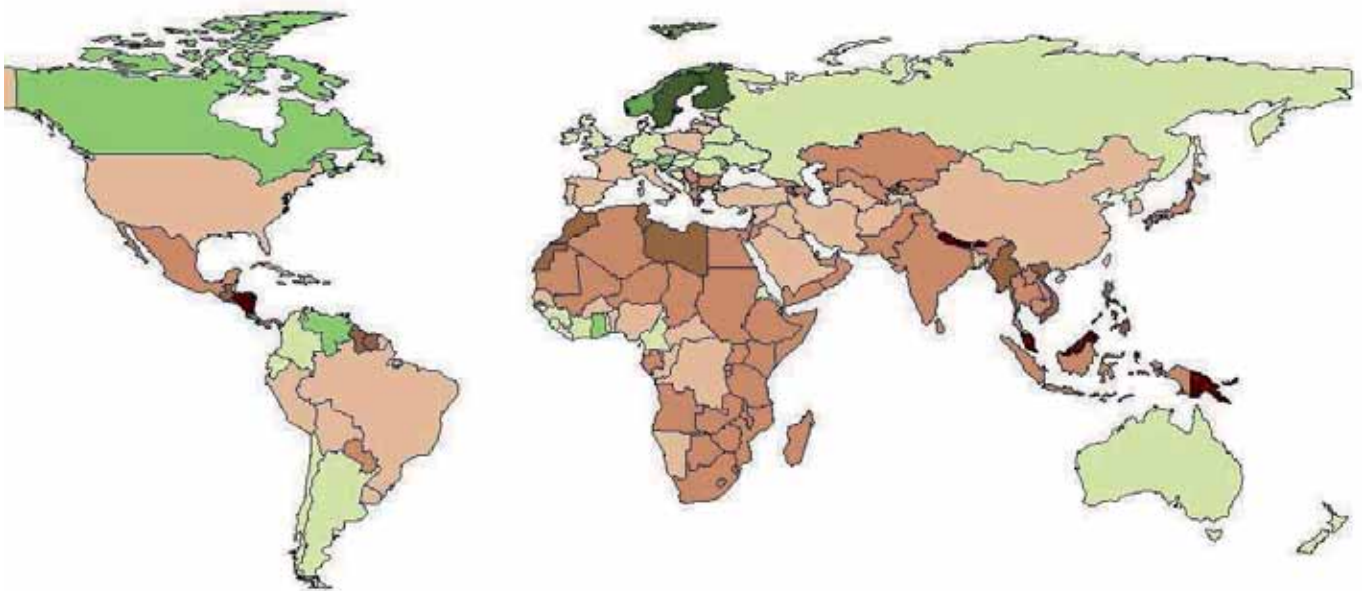
Scenario E1_9

Agricultural productivity changes (% of baseline)



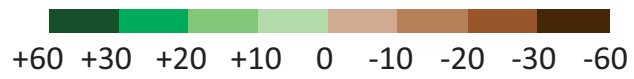
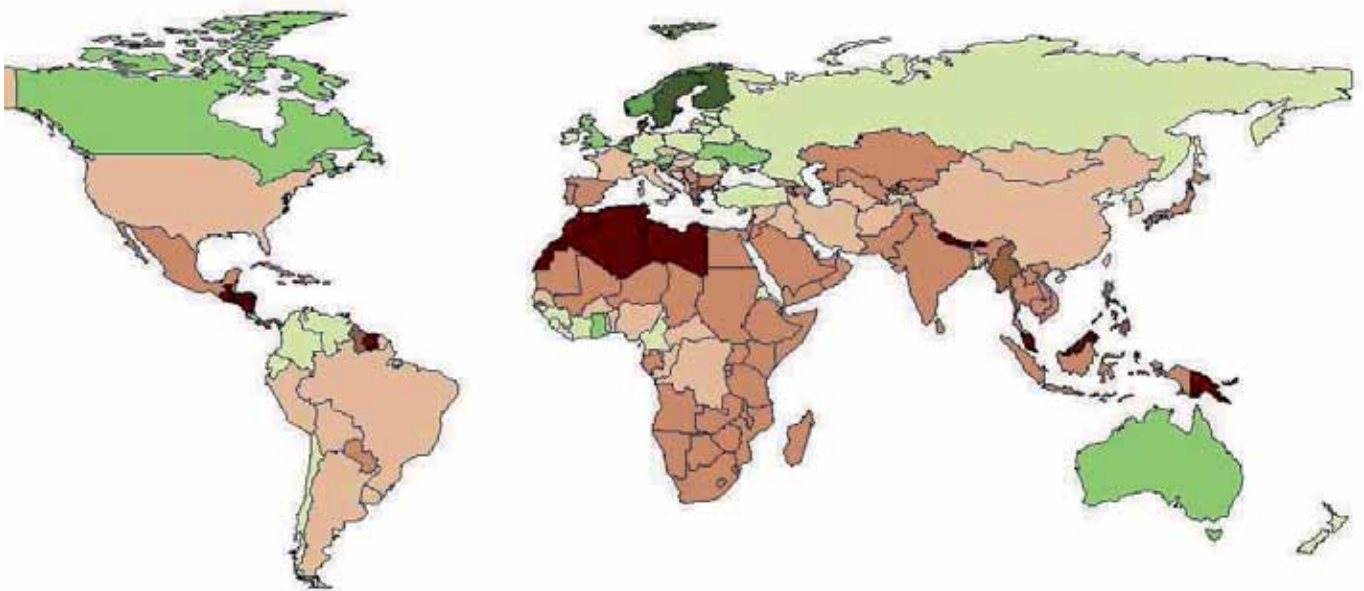
Scenario E1_10

Agricultural productivity changes (% of baseline)



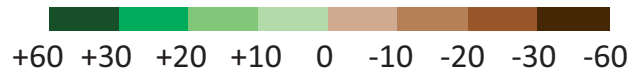
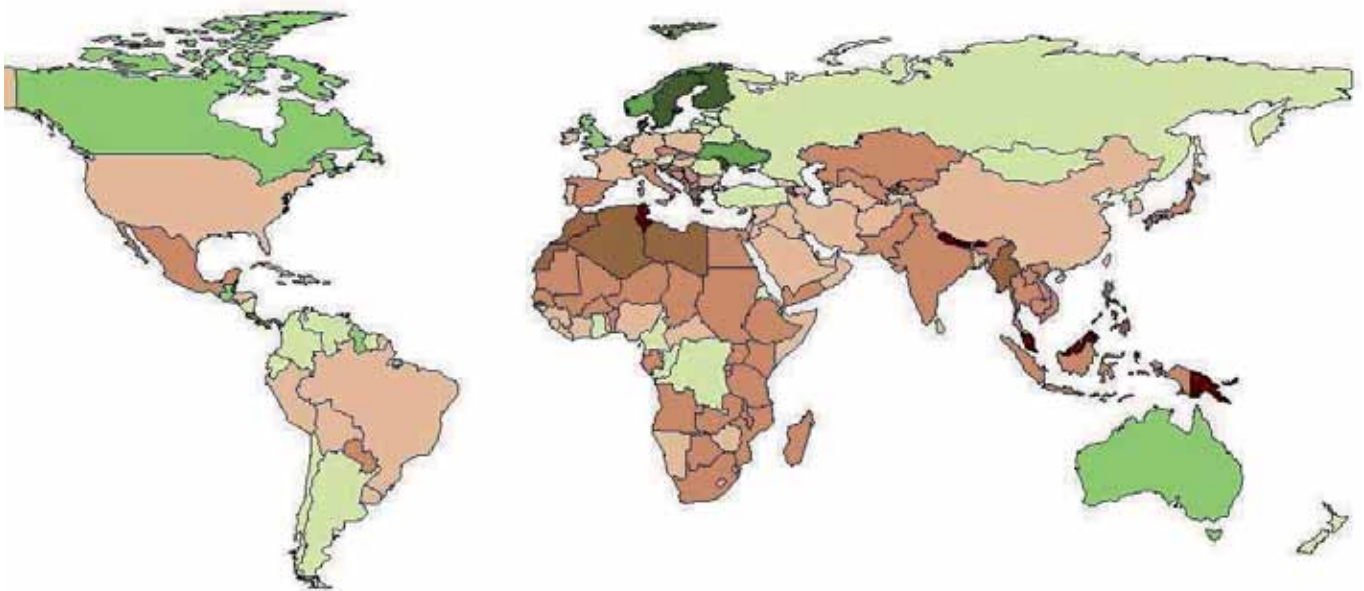
Scenario E1_11

Agricultural productivity changes (% of baseline)



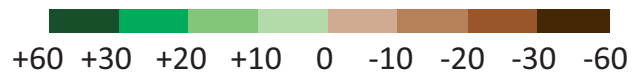
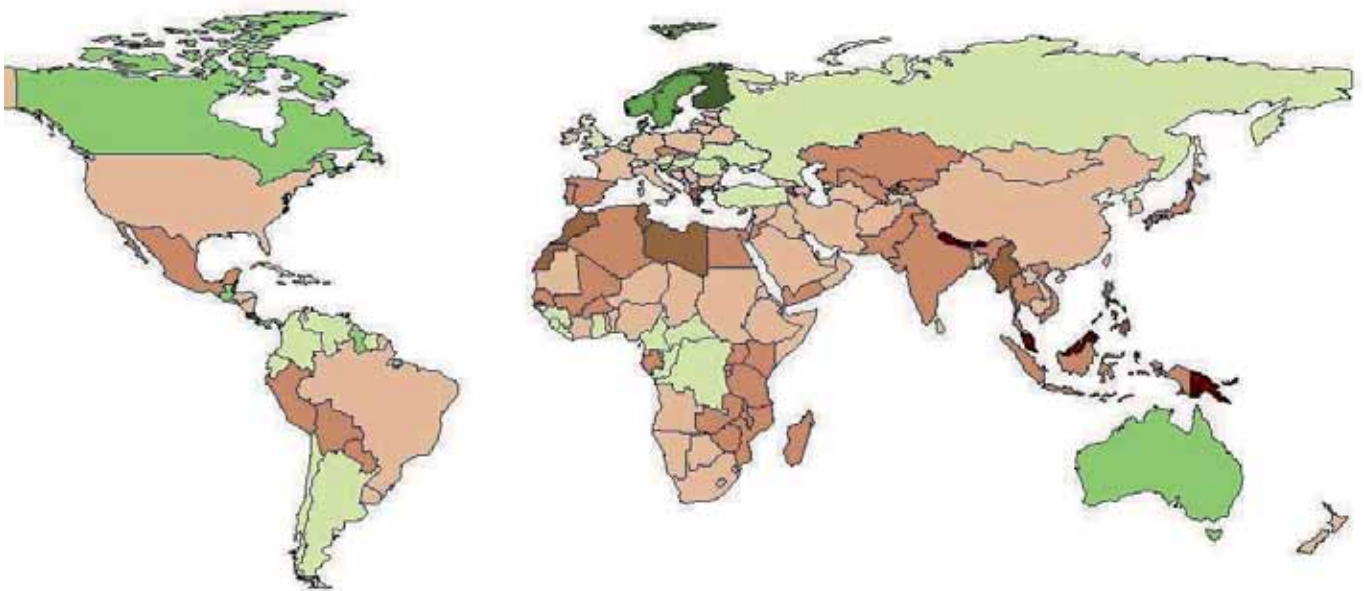
Scenario E1_12

Agricultural productivity changes (% of baseline)



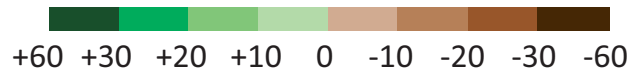
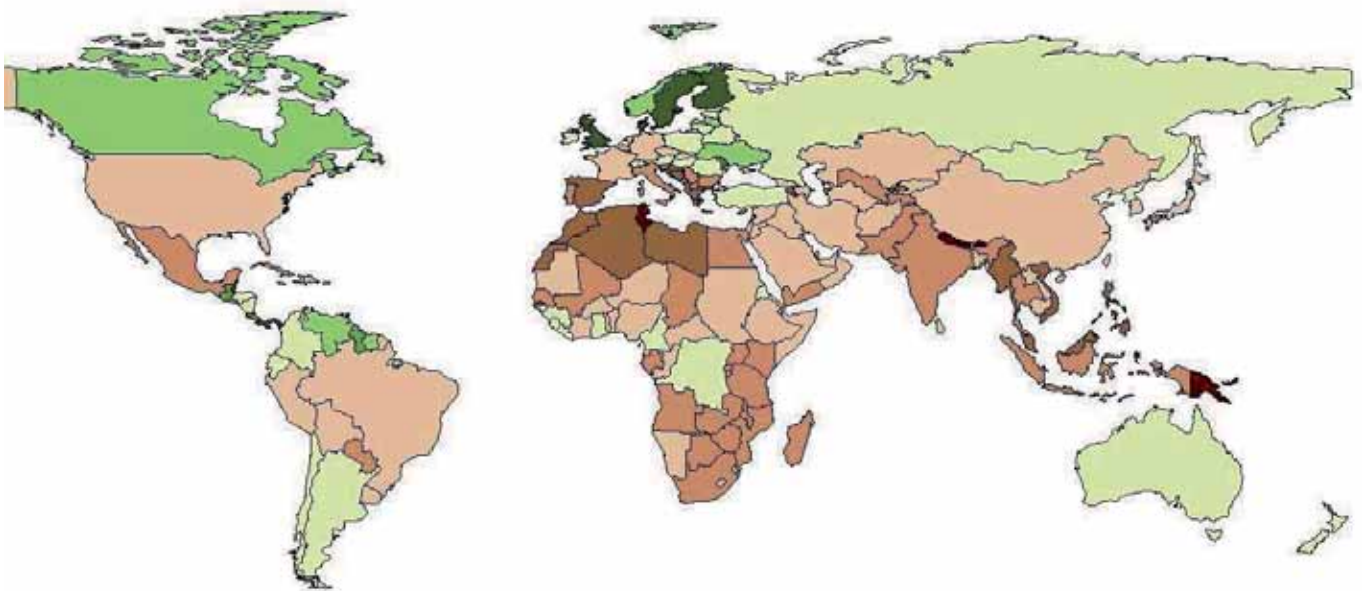
Scenario E1_13

Agricultural productivity changes (% of baseline)



Scenario E1_14

Agricultural productivity changes (% of baseline)



Adaptation options

Adaptation policy	Irrigation water assumptions	Fertiliser input assumptions	Environmental implications
Adaptation 1	Demand satisfaction according to assumptions on technological capacity of the country	No optimisation of fertiliser input	Optimisation of environmental water requirements
Adaptation 2	No room for changes in irrigation	Optimised	Potential increase of diffuse pollution
Adaptation 3	Demand satisfaction according to assumptions on technological capacity of the country	Optimised	Optimisation of environmental water requirements Potential increase of diffuse pollution

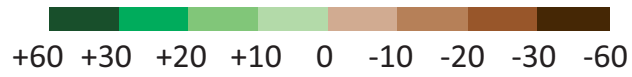
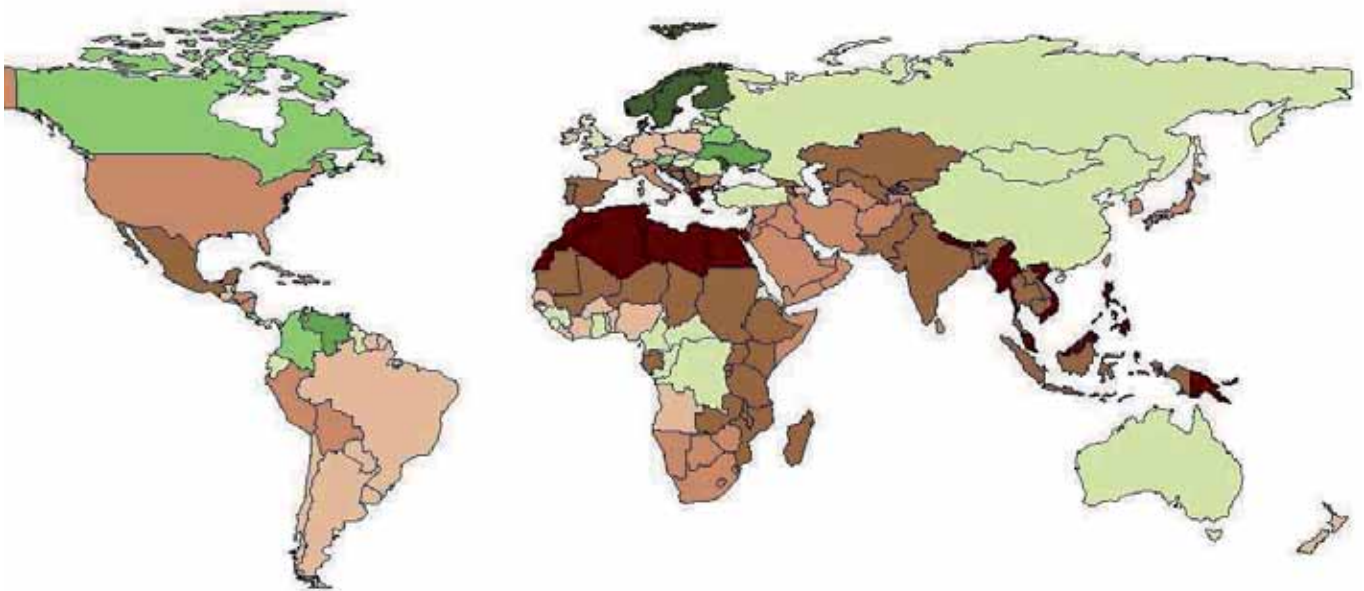
Adaptation of crop productivity to reduced water availability

- Assumptions:
 1. If the country has a very high irrigation efficiency based on advanced technology (i.e., Israel), a reduction of water availability will imply a reduction in irrigated area while maintaining the same level of productivity per unit area (in order to maintain the competitiveness of agricultural markets)
 2. If a country has margin to improve its water efficiency and can afford the required technology (i.e., Spain), a reduction of water availability will be compensated by an increase in irrigation efficiency
 3. If a country has margin to improve its water efficiency and cannot afford the required technology (i.e., Morocco), farmers will be exposed to a loss of productivity
- The reduction of demand satisfaction varies yearly and therefore a water limited scenario implies greater exposure to risk.

Scenario A1B_av

No adaptation

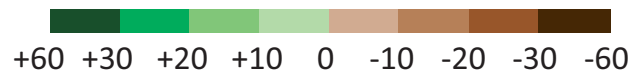
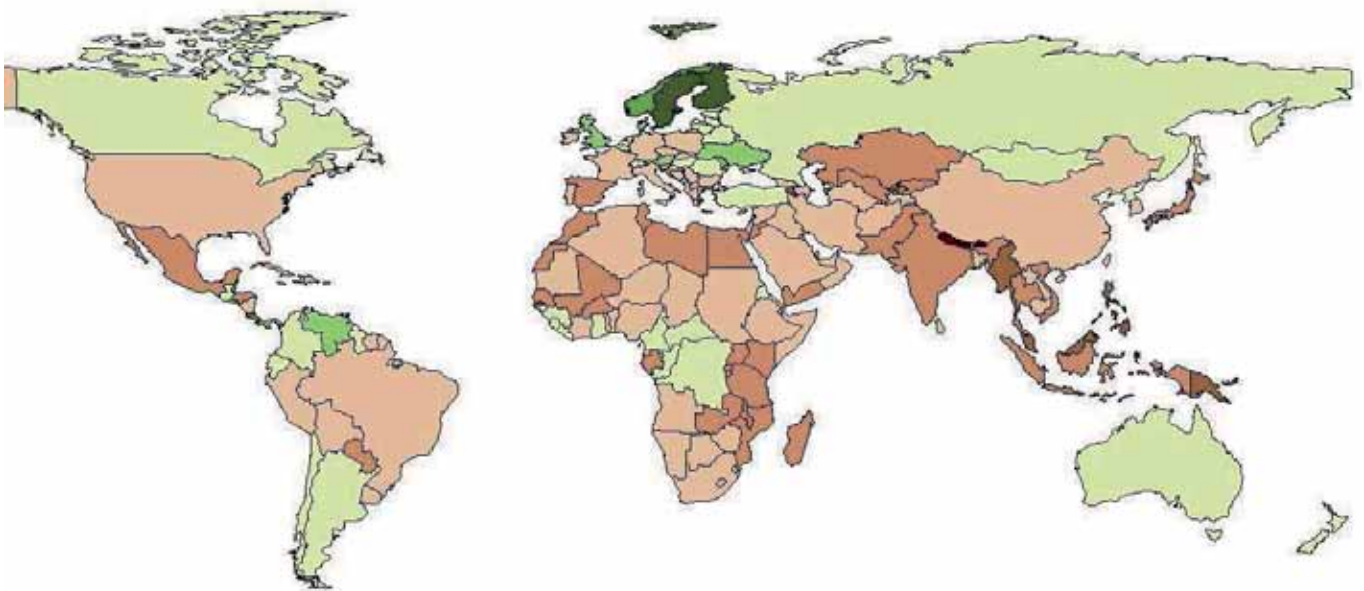
Agricultural productivity changes (% of baseline)



Scenario E1_av

No adaptation

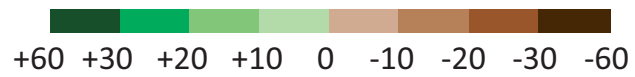
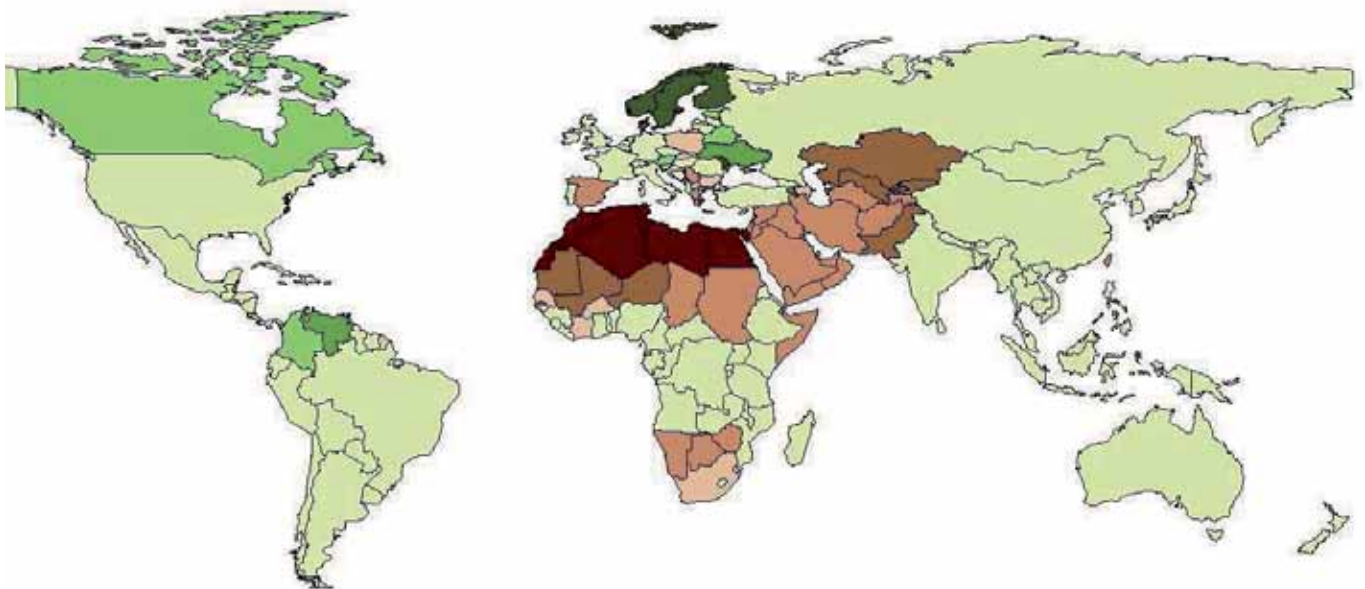
Agricultural productivity changes (% of baseline)



Scenario A1B_av

Adaptation 1

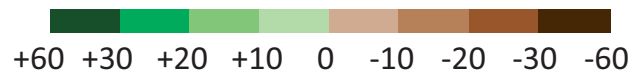
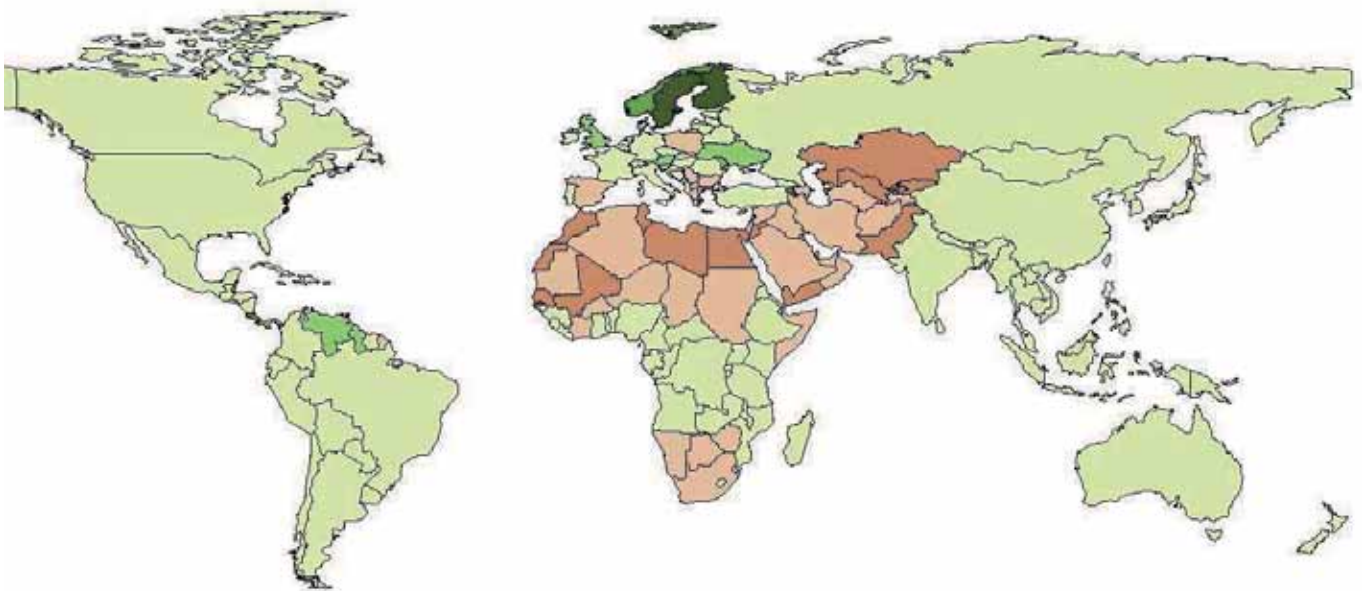
Agricultural productivity changes (% of baseline)



Scenario E1_av

Adaptation 1

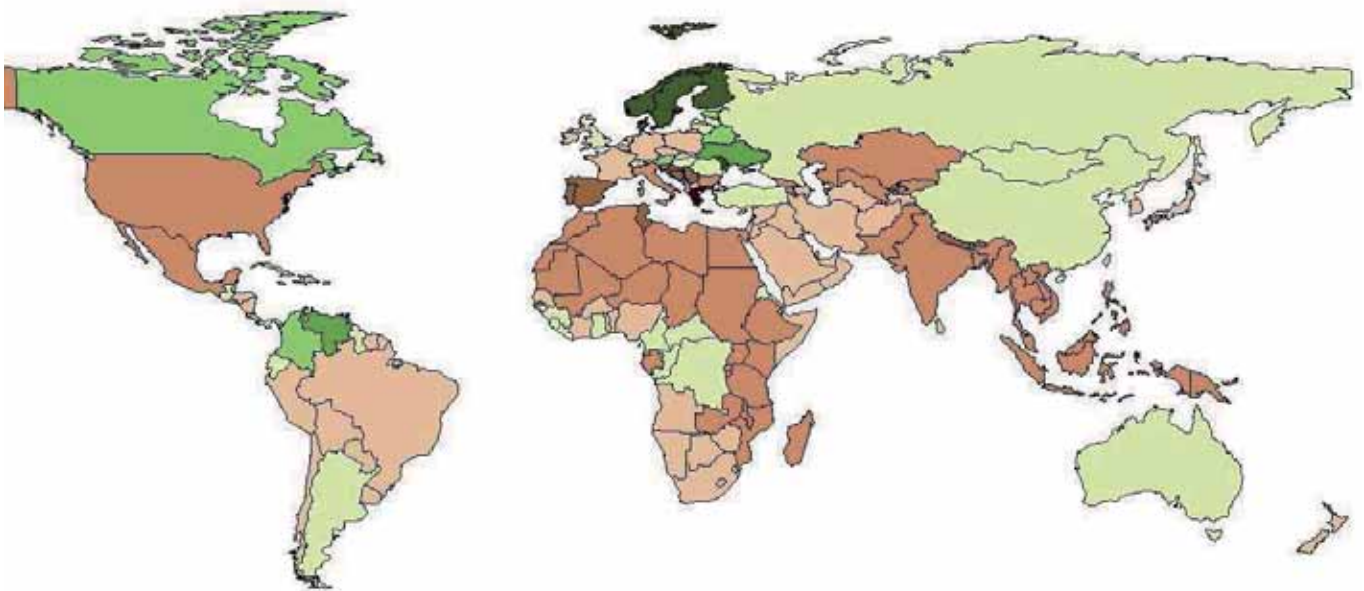
Agricultural productivity changes (% of baseline)



Scenario A1B_av

Adaptation 2

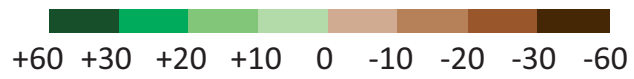
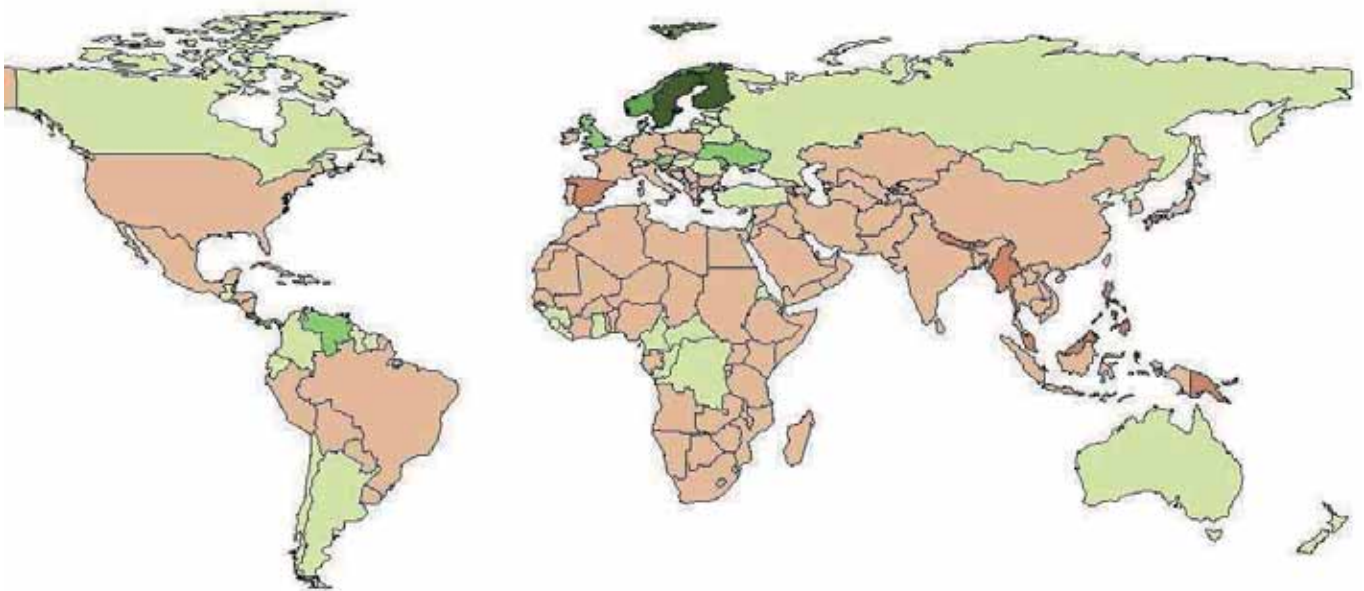
Agricultural productivity changes (% of baseline)



Scenario E1_av

Adaptation 2

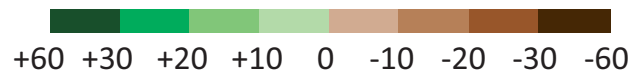
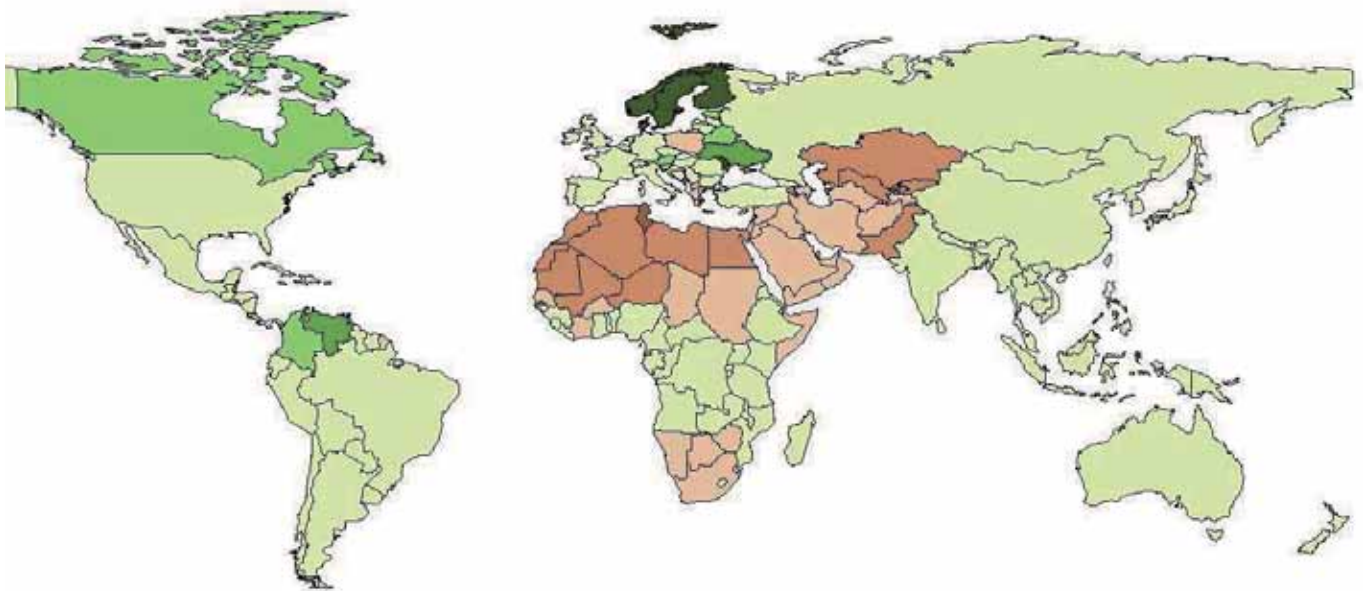
Agricultural productivity changes (% of baseline)



Scenario A1B_av

Adaptation 3

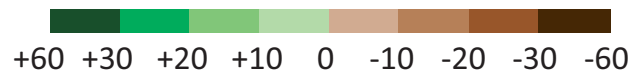
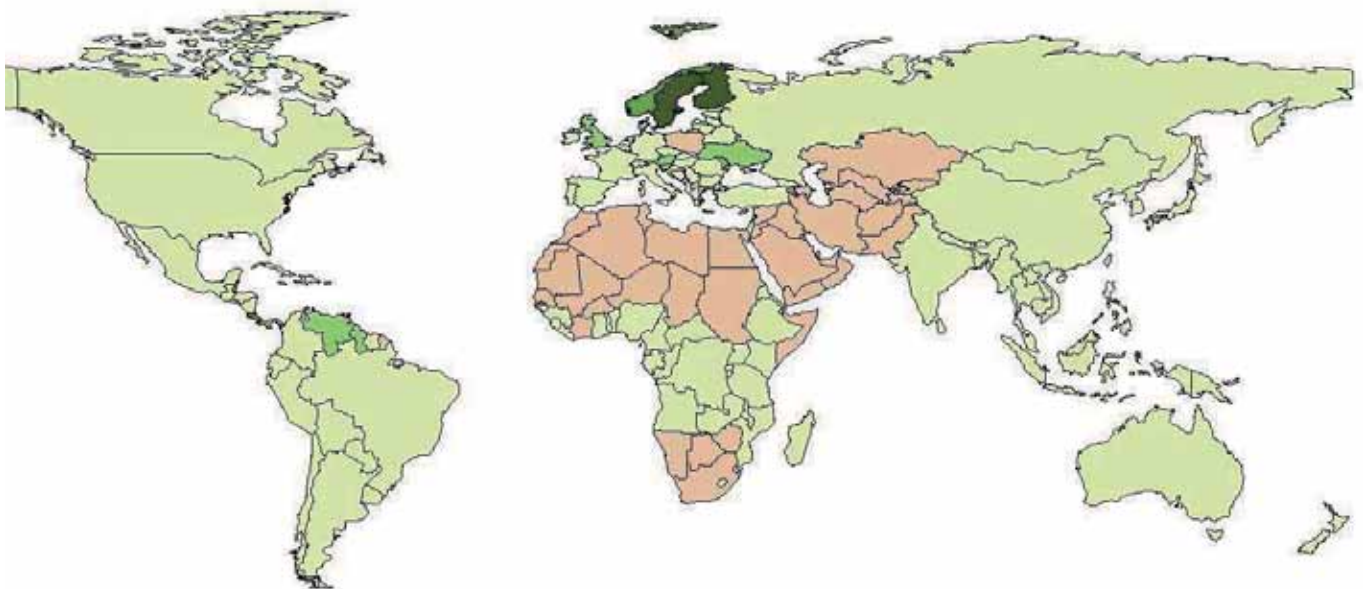
Agricultural productivity changes (% of baseline)



Scenario E1_av

Adaptation 3

Agricultural productivity changes (% of baseline)



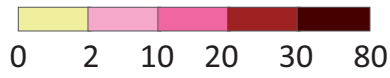
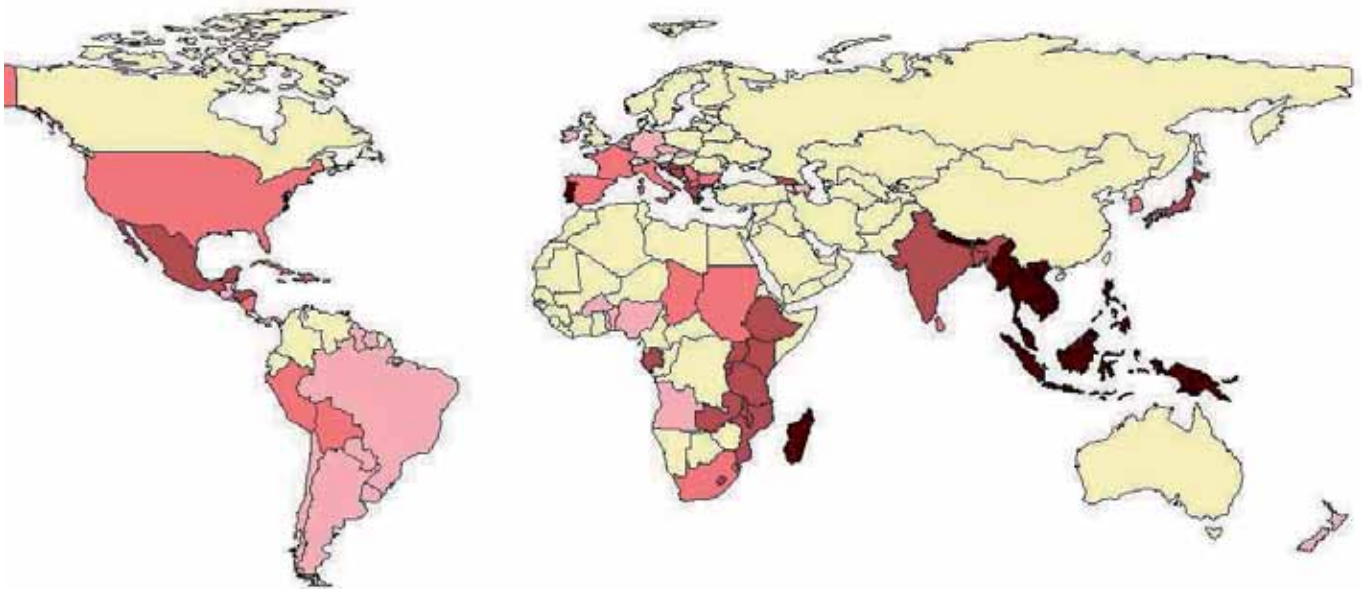
Agricultural water demand

- Water demand for agriculture is estimated by defining irrigation requirements under the climate scenarios.
- Water supply for rainfed agriculture depends on rainfall. But for irrigated agriculture depends on runoff and storage capacity.
- Water supply depends on infrastructure and regulation and these determinants are defined by environmental policy.
- We have included three adaptation scenarios with different levels of water availability for agriculture and nitrogen fertilisation. These adaptation scenarios represent different policy choices related to regulation and infrastructure.

Scenario A1B_av

Adaptation 1&3

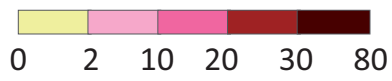
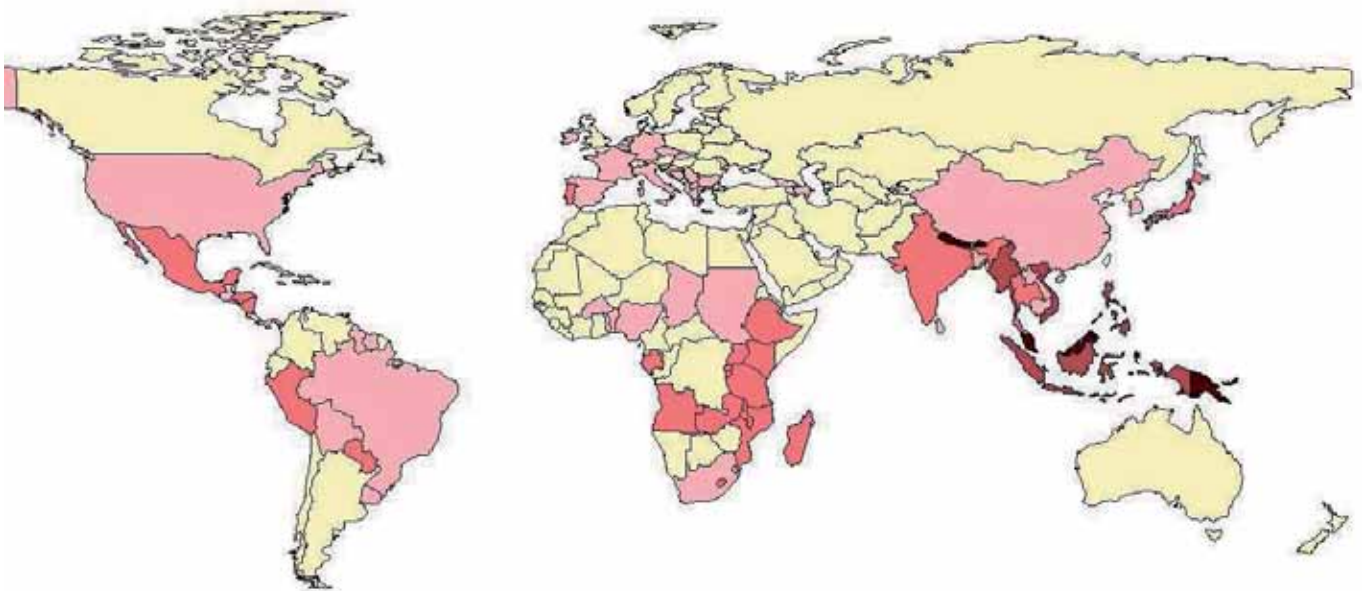
Irrigation water demand change (% of baseline)



Scenario E1_av

Adaptation 1&3

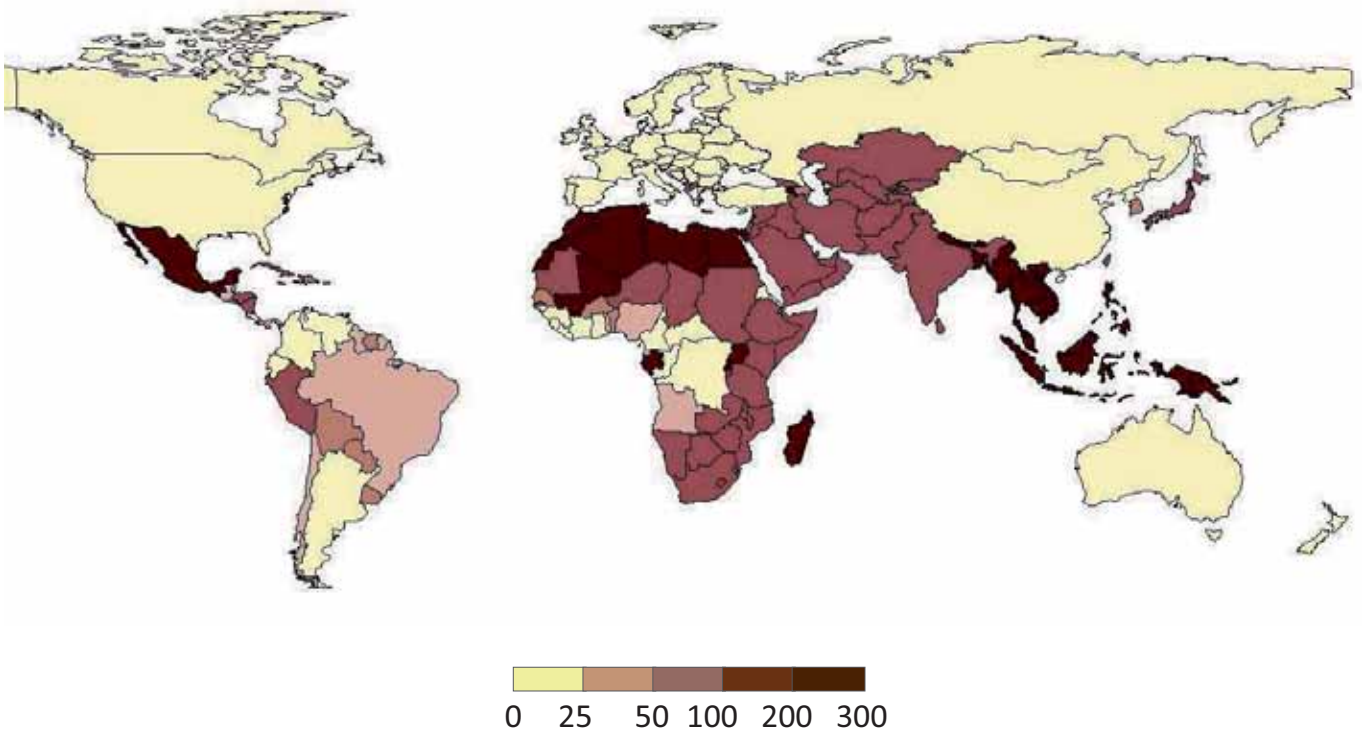
Irrigation water demand change (% of baseline)



Scenario A1B_av

Adaptation 2

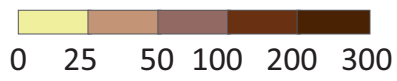
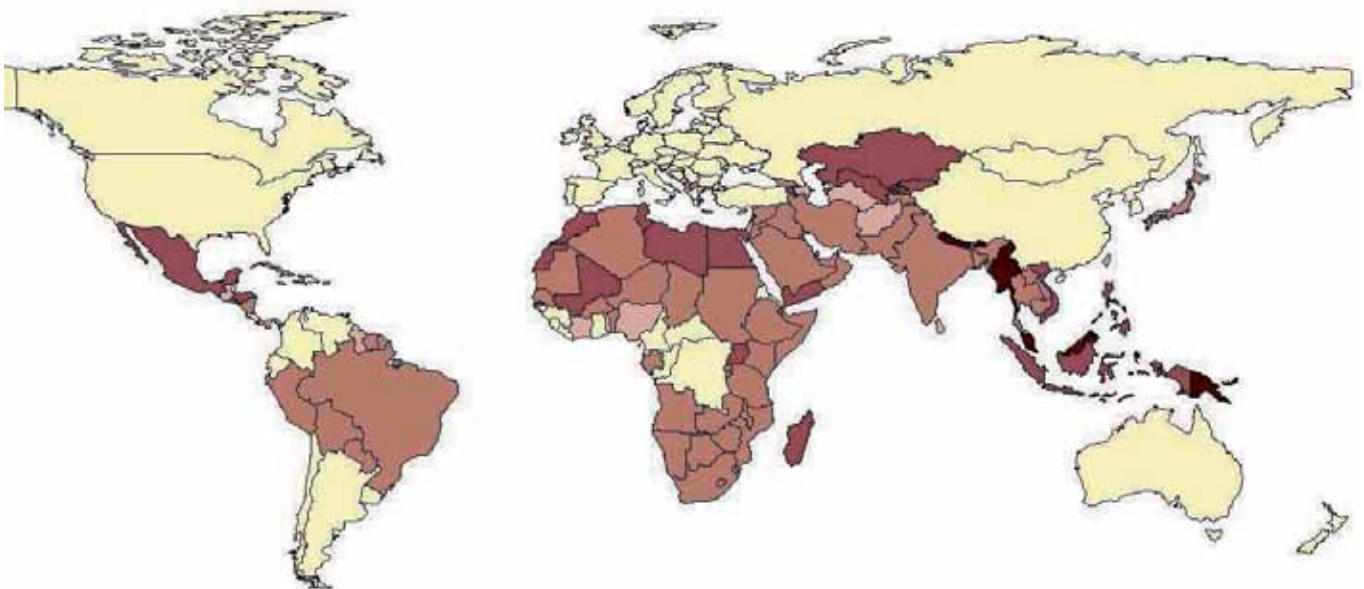
Nitrogen fertiliser change (% of baseline)



Scenario E1_av

Adaptation 2

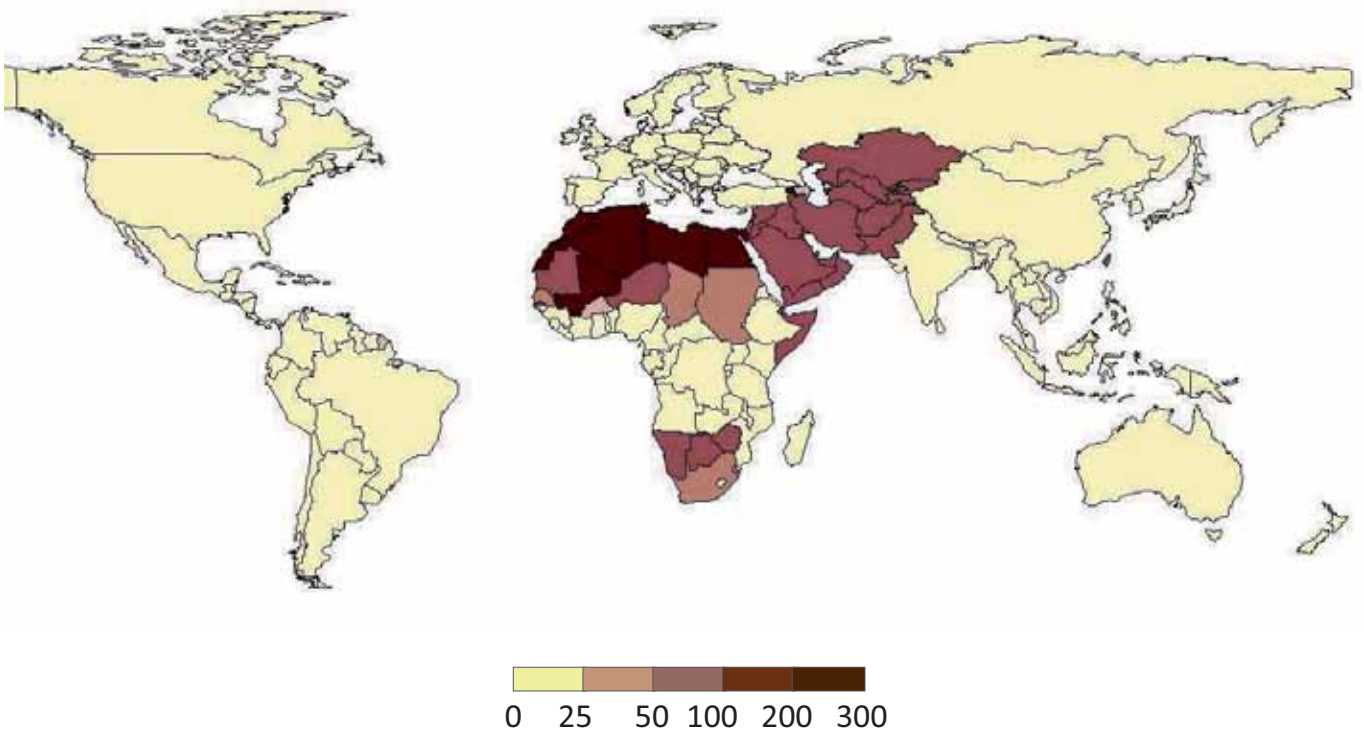
Nitrogen fertiliser change (% of baseline)



Scenario A1B_av

Adaptation 3

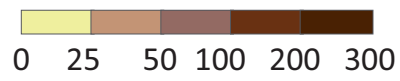
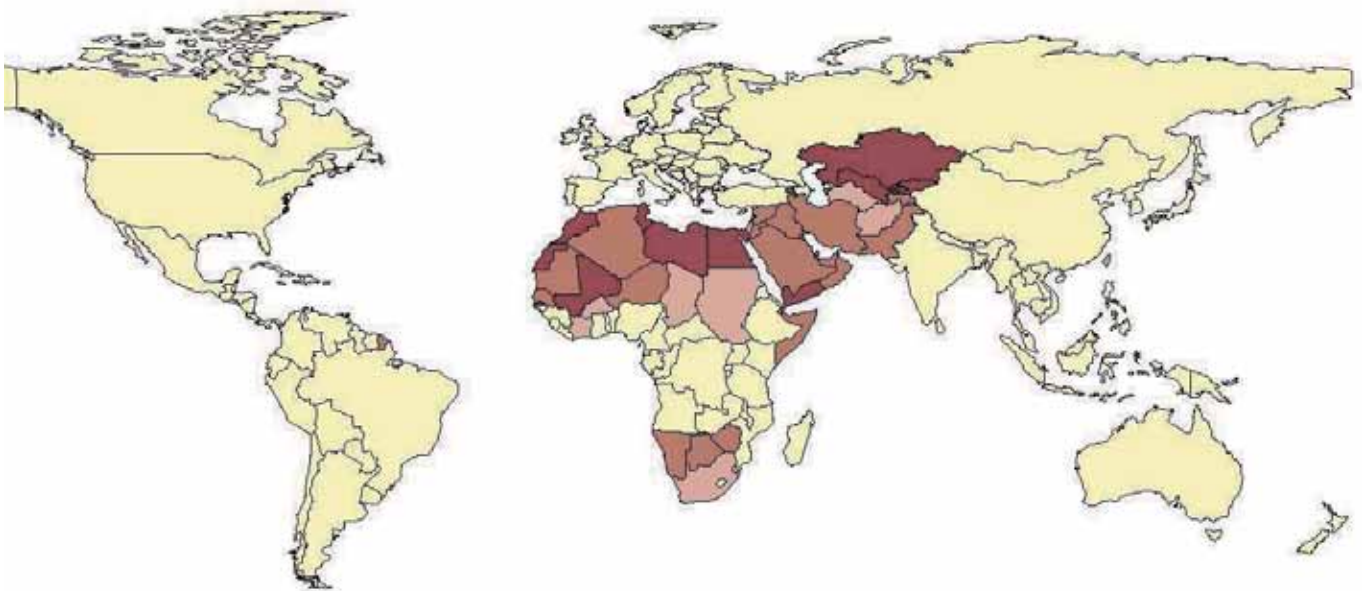
Nitrogen fertiliser change (% of baseline)

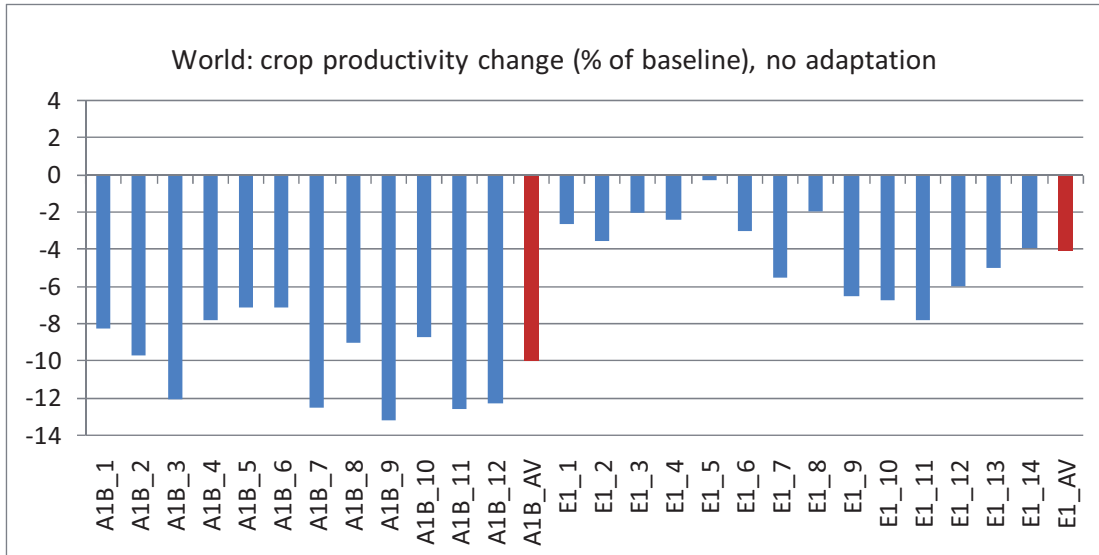


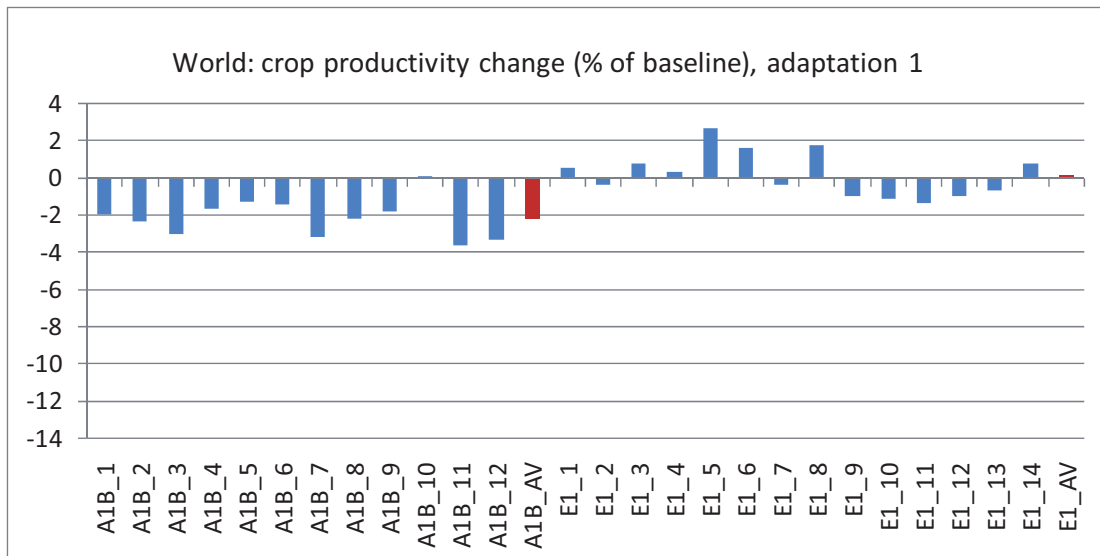
Scenario E1_av

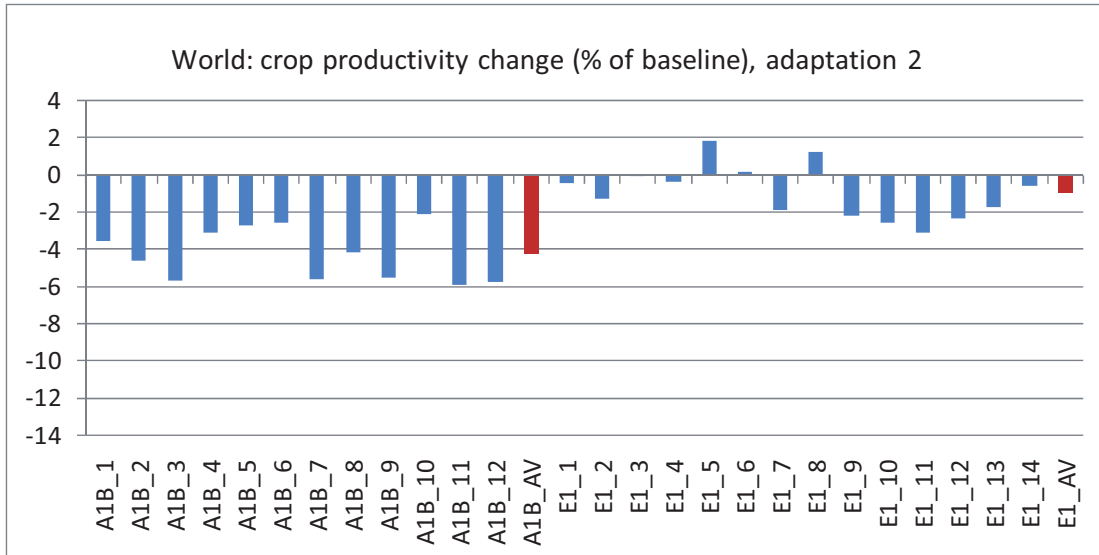
Adaptation 3

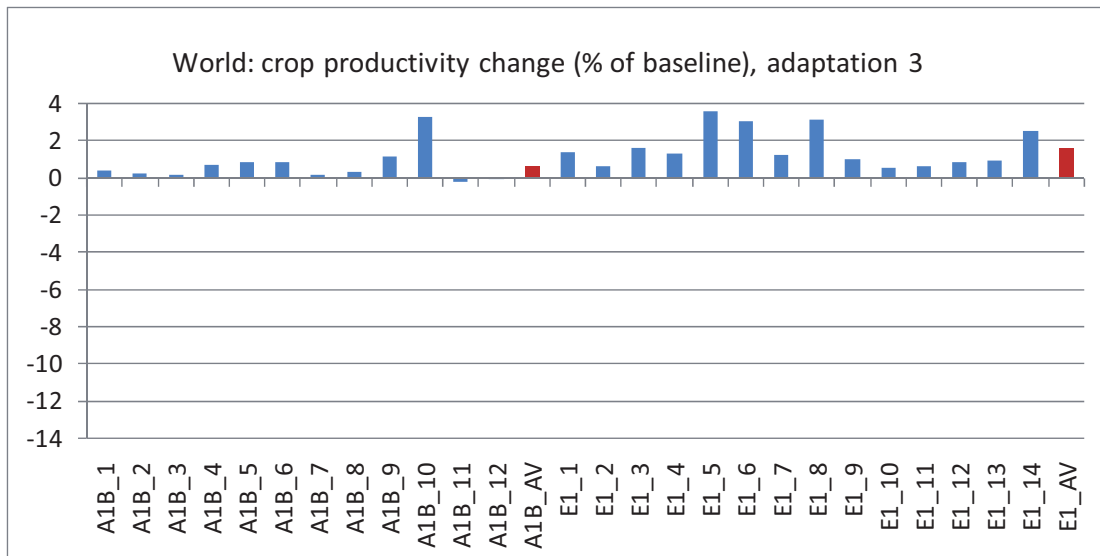
Nitrogen fertiliser change (% of baseline)











Example 4: Evaluation (and valuation) of policy action (Iglesias et al., 2010)

HadCM3/HIRHAM B2 scenario, 2071-2100, (% yield change)

Region	Adap.Policy Urban / Env (1)	Adap.Farm (2)	Adapt.Policy Econ /Rural Dev (3)
Boreal	25 to 30	34	35 to 40
Atlantic South	-10 to -10	-7	-5 to 0
Cont. North	0 to 5	4	5 to 10
Alpine	10 to 20	23	25 to 40
Med. South	-50 to -25	1	0 to 20

(1) Emphasis on water resources protection and urban development

(2) Farm adaptation without policy support (private)

(3) Emphasis on agricultural production and rural development

Policy evaluation (examples)

European Region	Land productivity changes (average of all crops)					
	Scenario +2C Adaptation with water restrictions		Scenario +2C Adaptation with water unlimited		Scenario +4C Adaptation with water restrictions	
	avg_ %	SD_ %	avg_ %	SD_ %	avg_ %	SD_ %
Boreal	30	23	5	27	42	24
Continental North	1	3	2	5	3	2
Continental South	6	5	4	22	7	11
Atlantic North	0	0	0	11	0	0
Atlantic Central	-1	6	6	26	4	1
Atlantic South	0	0	0	30	0	0
Alpine	8	7	13	8	16	15
Mediterranean North	-9	1	2	2	-19	-18
Mediterranean South	-2	10	11	9	- 22	-4

- Reasons for concern when we think about climate change
- Consequences are too **unequal**
- **Uncertainty**
- Deciding on the solutions that are appropriate (the **how** issue)