

Climate change impacts and adaptation opportunities for European agriculture

Alvaro Calzadilla, Zein Khraizat & Olivier Dessens

UCL Institute for Sustainable Resources

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Introduction / Motivation

Climate change impacts on agriculture

- Global crop yield reduction is around 1% per decade
- The effects on crop yield vary greatly within each crop, timeframe and Representative Concentration Pathway (RCP)
- Climate change will disproportionally affect crop yield among regions, with more negative than positive impacts

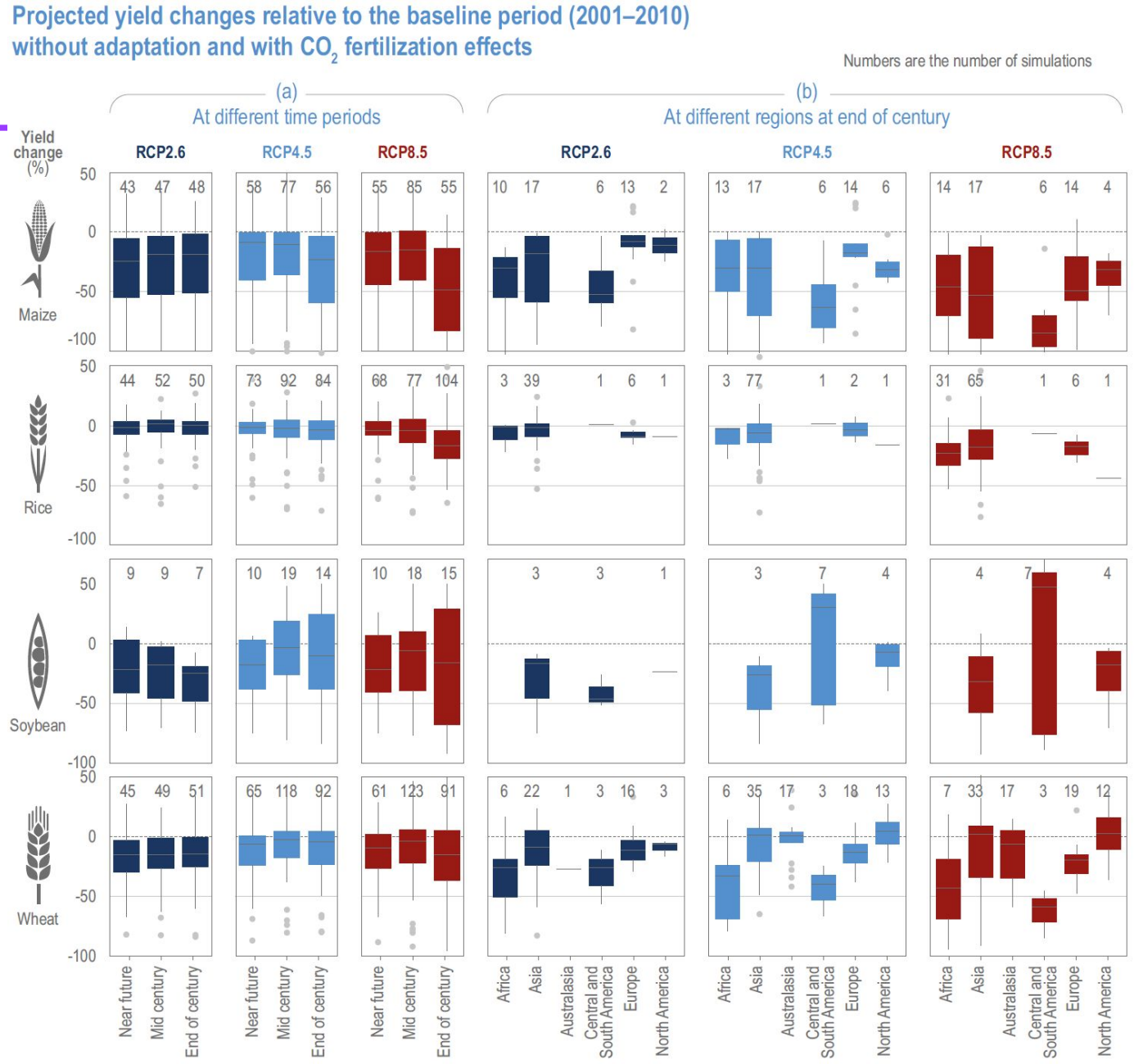
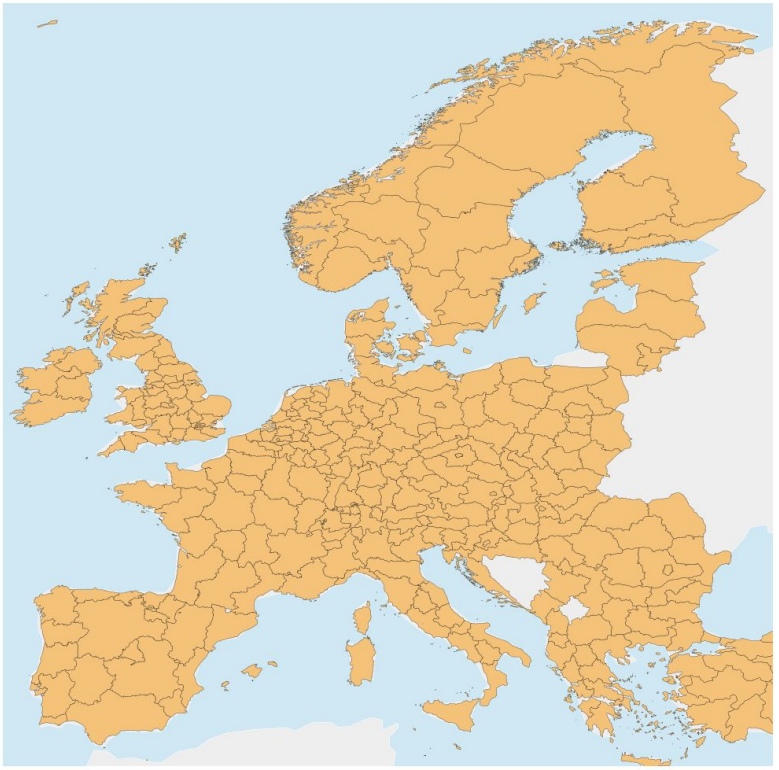


Figure 5.6 | Projected yield changes relative to the baseline period (2001–2010) without adaptation and with CO_2 fertilisation effects (Hasegawa et al., 2021b). The box is the interquartile range (IQR), and the middle line in the box represents the median. The upper and lower end of whiskers are median 1.5 × IQR ± median. Open circles are values outside the 1.5 × IQR. **(a)** At different time periods (near future, NF, baseline to 2039; mid-century, MC, 2040–2069; end-century, EC, 2070–2100) under three RCPs, and **(b)** at different regions at EC.

Methodology – Subnational-ENGAGE model (Dataset)

Spatial coverage (subnational heterogeneity)

- 237 NUTS-2 EU regions
- 46 NUTS-2 UK regions
- 17 main EU trade partners
- 1 Rest of the World



Agricultural production

- Agriculture is disaggregated into six primary commodity groups, including: Wheat, Rice, Oil Seeds, Other Cereals, Other crops, Other Agriculture

Industry and services sectors

- Extractive industries, Manufacturing, Construction, Transport and Services

Data and calibration

- Eurostat economic accounts
- Figaro tables
- FADN informing agricultural production and income composition
- 7 annual benchmark years (2018-2023)
- Million Euros

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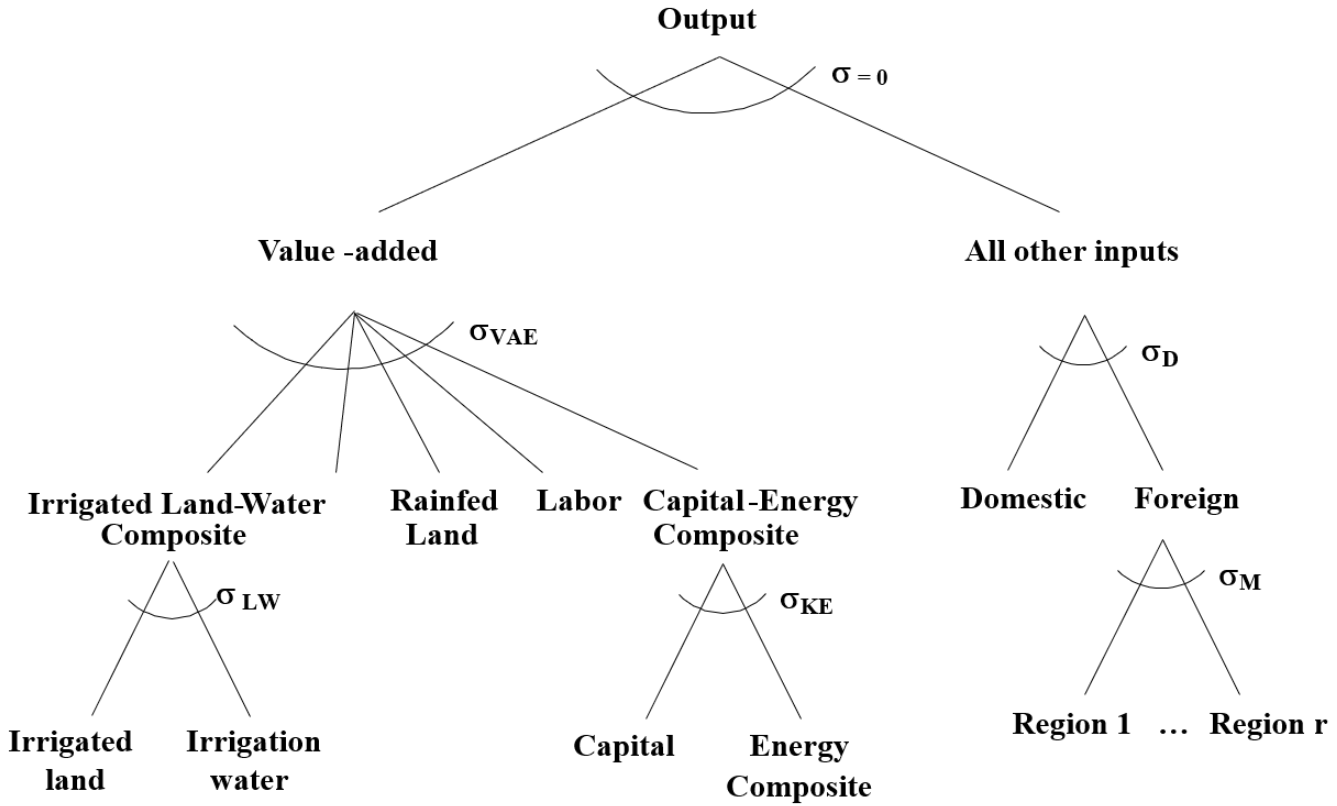
Methodology – Subnational-ENGAGE model (Model)

Subnational-ENGAGE model

- UCL Subnational Environmental Global Applied General Equilibrium model
- Standard static CGE model of the world economy (EU NUTS2 representation)
- Based on the GTAP6.2 version (Hertel et al. 2003) and GTAP-W (Calzadilla et all 2011)
- Calibrated to 2023 using the ENGAGE Nuts2 dataset (Million Euros)

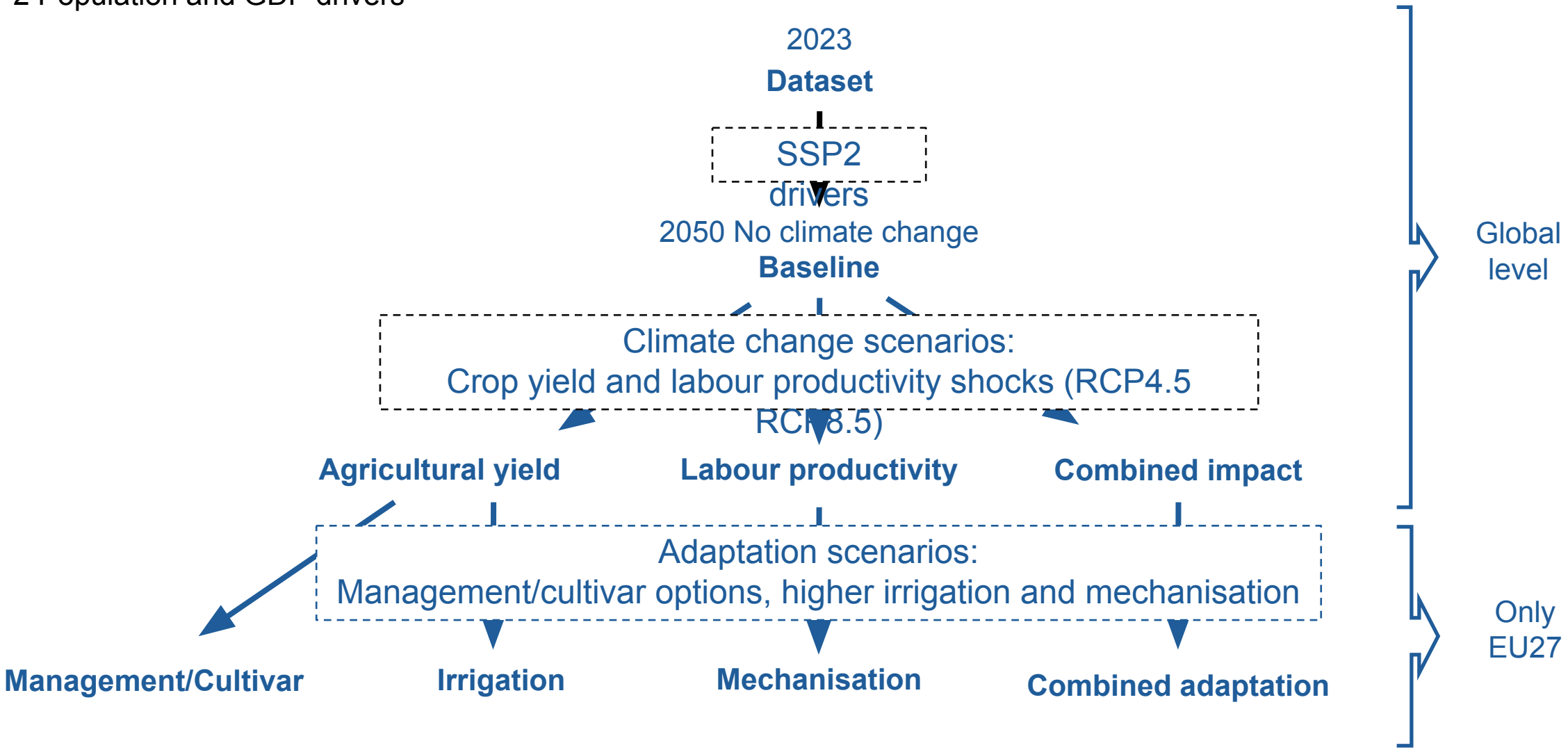
- Aggregation: - 301 regions
  - 11 Sectors (5 crops)
  - 5 factors of production



Scenarios

Baseline

- SSP2 Population and GDP drivers

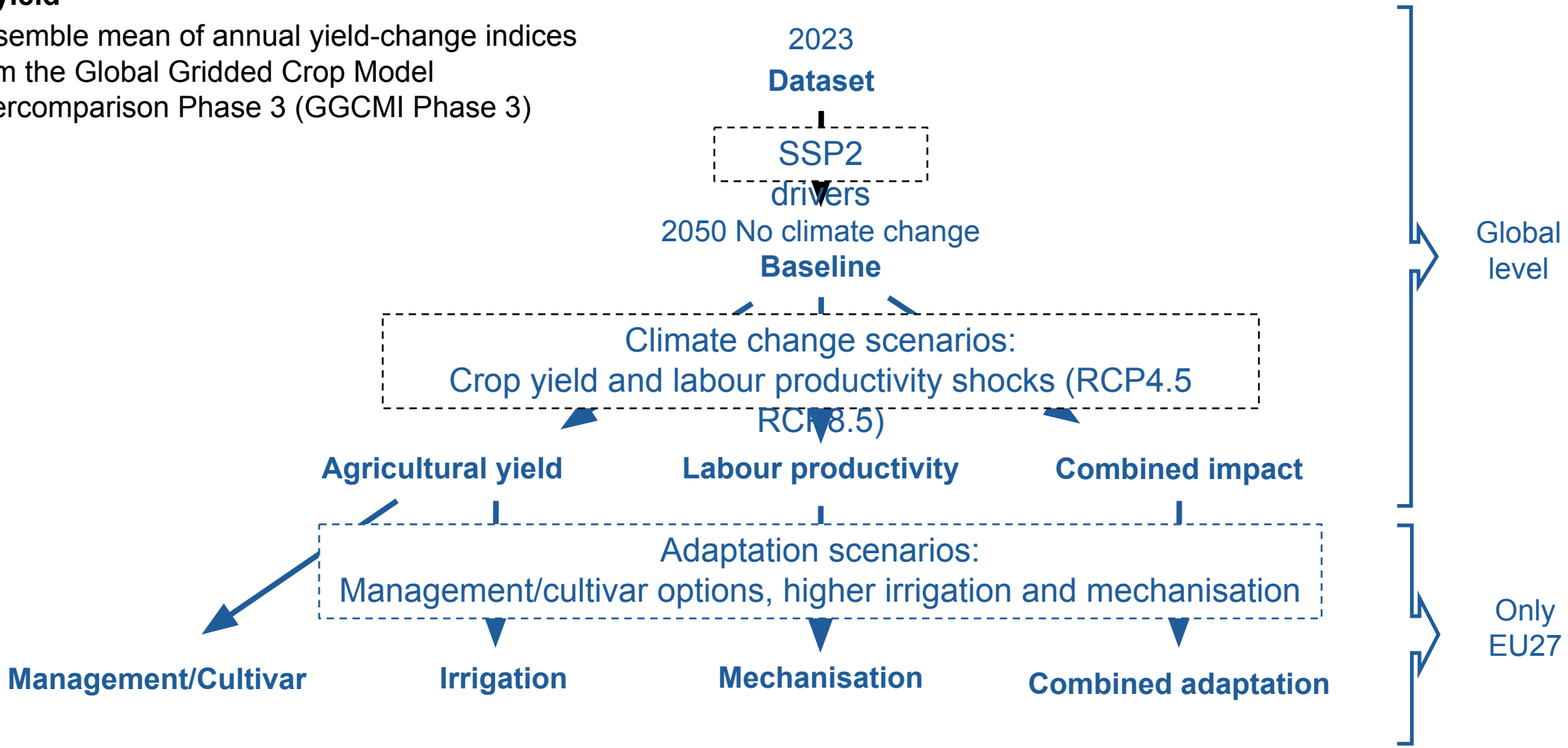


Scenarios

Climate change scenarios (RCP4.5 and RCP8.5):

Crop yield

- Ensemble mean of annual yield-change indices from the Global Gridded Crop Model Intercomparison Phase 3 (GGCMI Phase 3)

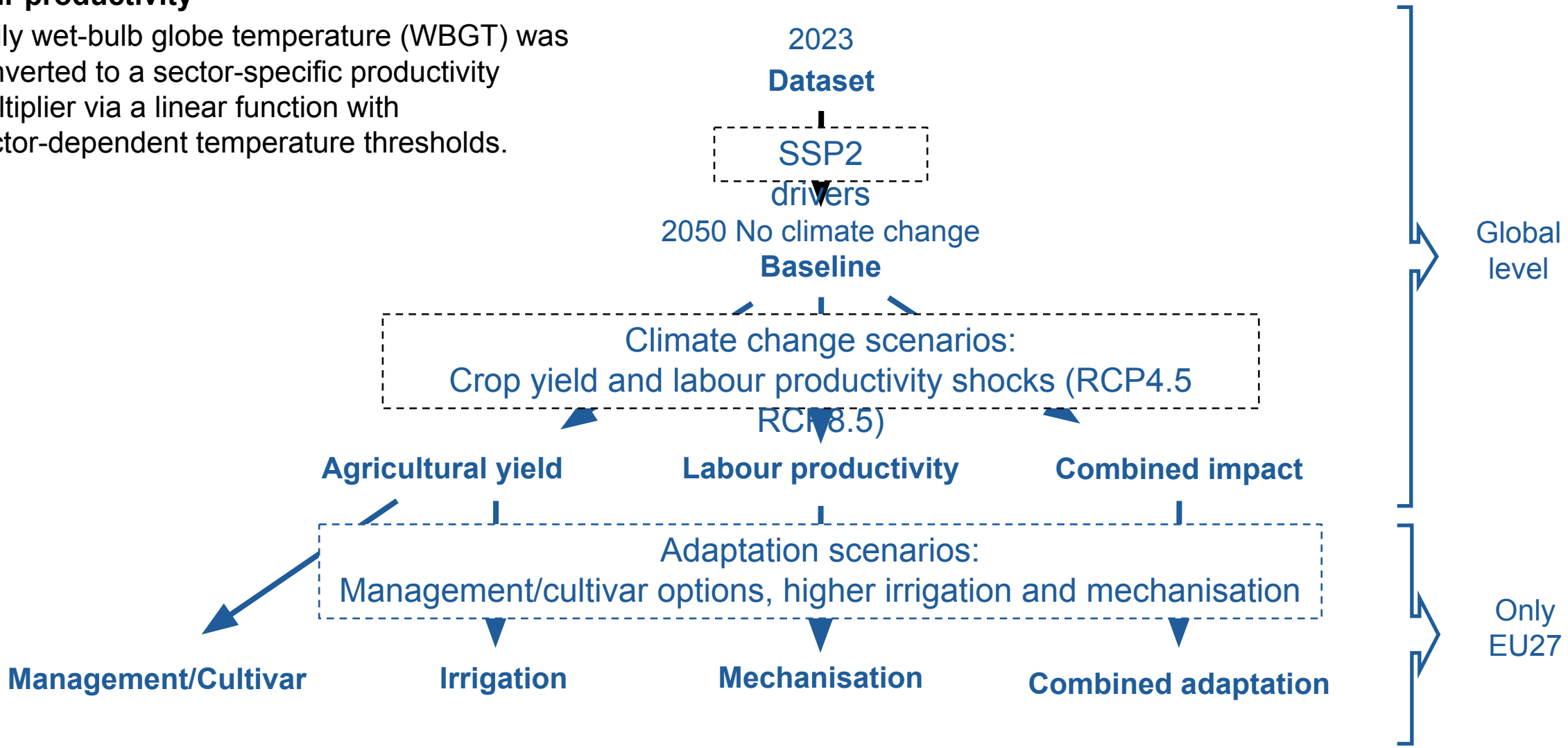


Scenarios

Climate change scenarios (RCP4.5 and RCP8.5):

Labour productivity

- Daily wet-bulb globe temperature (WBGT) was converted to a sector-specific productivity multiplier via a linear function with sector-dependent temperature thresholds.

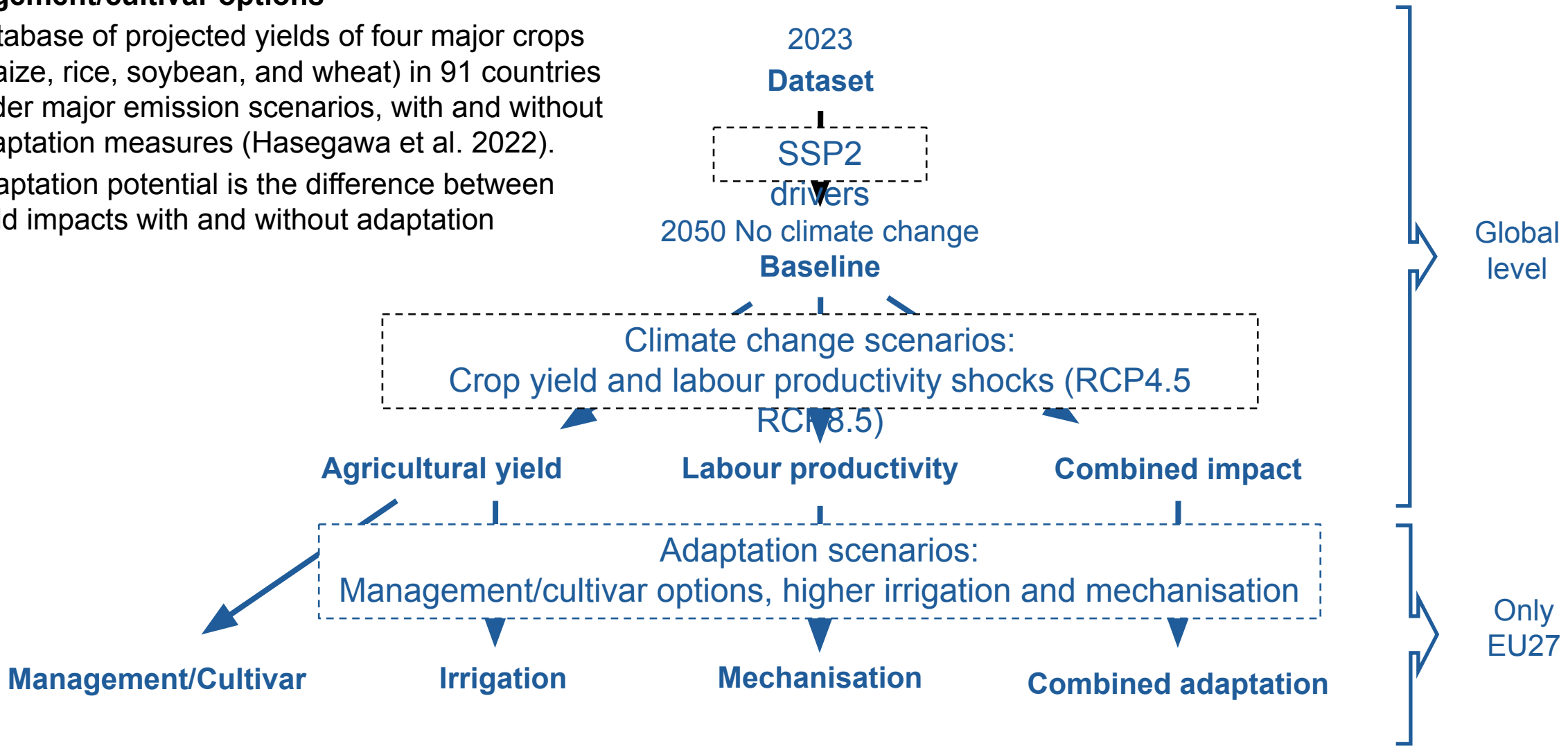


Scenarios

Adaptation scenarios (only EU27):

Management/cultivar options

- Database of projected yields of four major crops (maize, rice, soybean, and wheat) in 91 countries under major emission scenarios, with and without adaptation measures (Hasegawa et al. 2022).
- Adaptation potential is the difference between yield impacts with and without adaptation

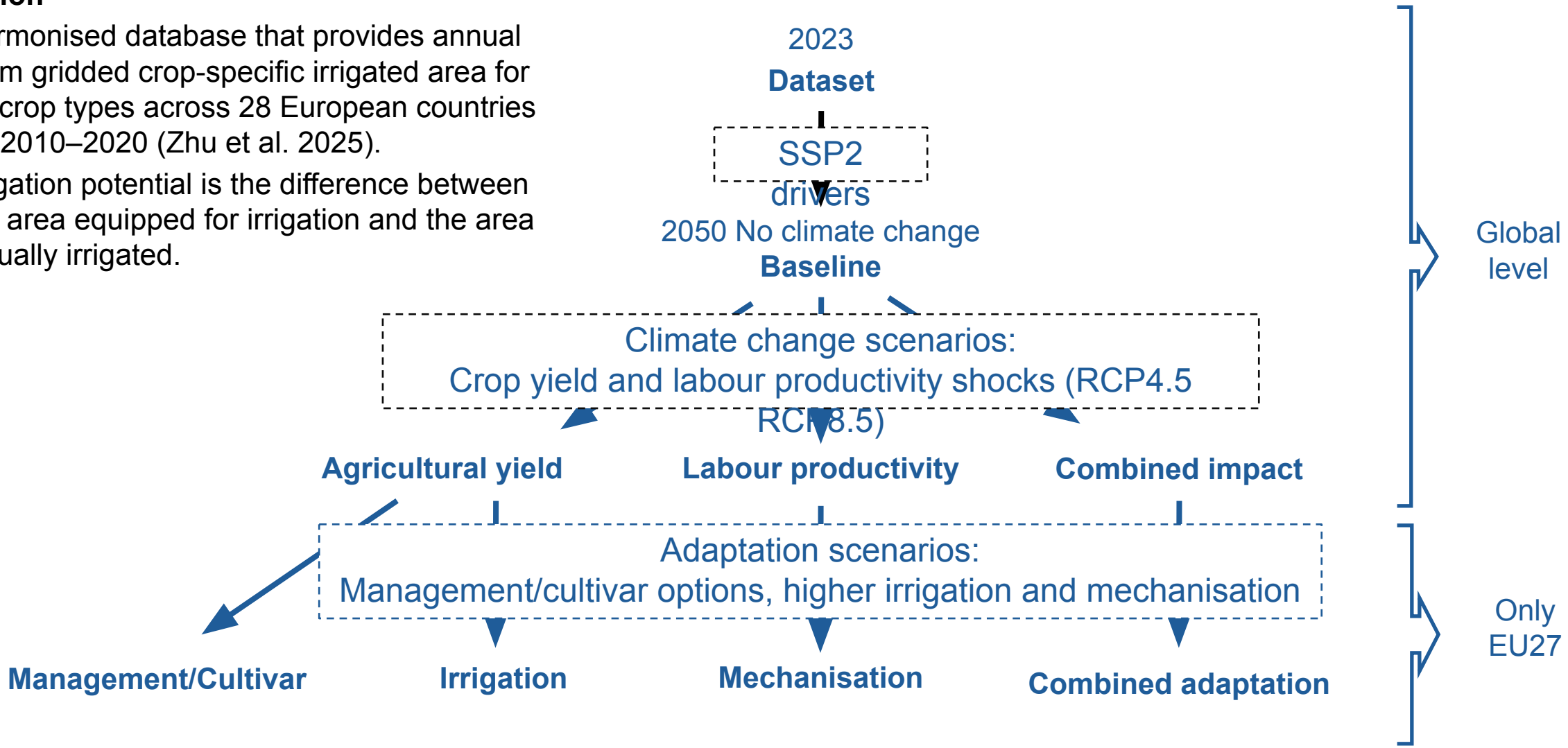


Scenarios

Adaptation scenarios (only EU27):

Irrigation

- Harmonised database that provides annual 1-km gridded crop-specific irrigated area for 16 crop types across 28 European countries for 2010–2020 (Zhu et al. 2025).
- Irrigation potential is the difference between the area equipped for irrigation and the area actually irrigated.

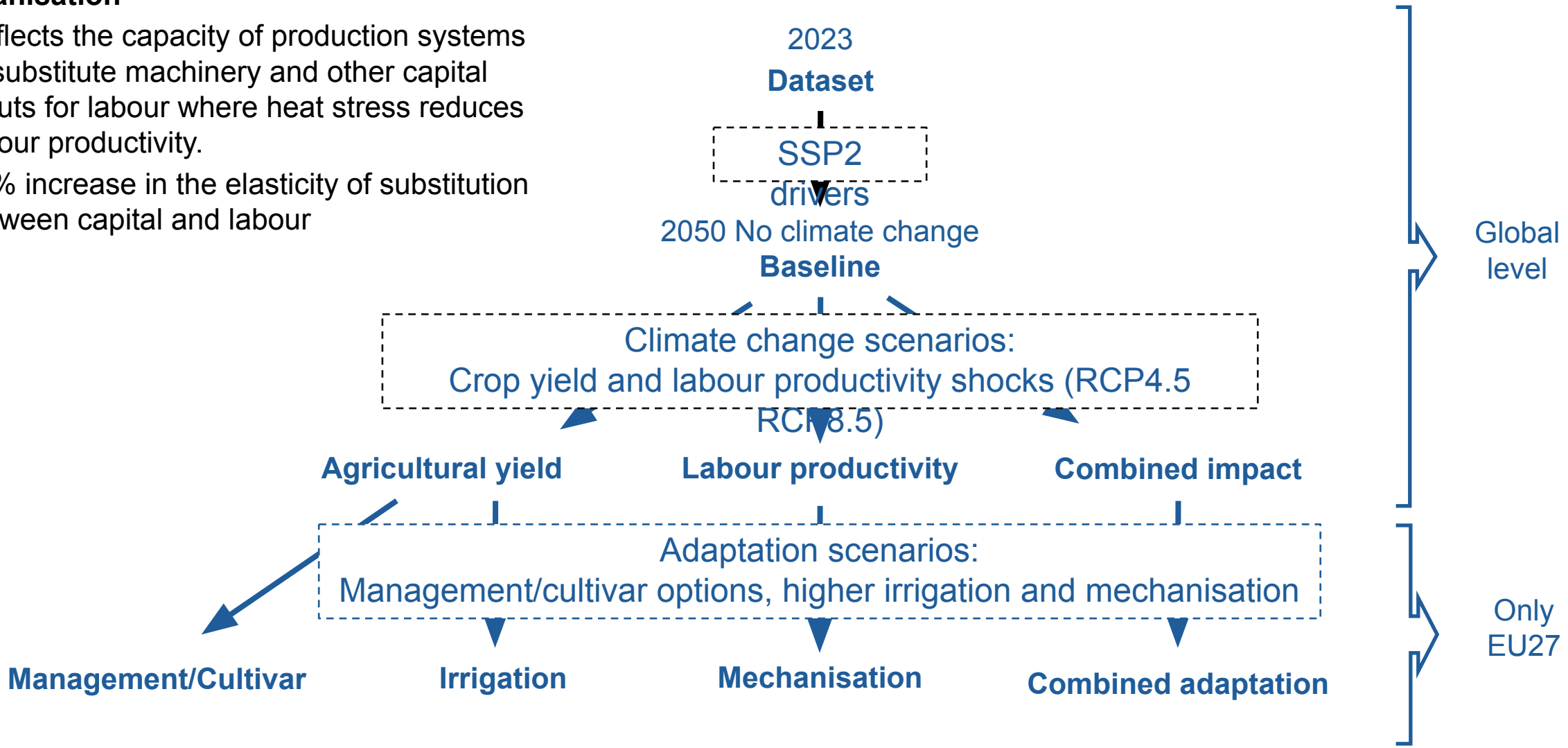


Scenarios

Adaptation scenarios (only EU27):

Mechanisation

- Reflects the capacity of production systems to substitute machinery and other capital inputs for labour where heat stress reduces labour productivity.
- 30% increase in the elasticity of substitution between capital and labour



Climate shocks – Crop yield changes

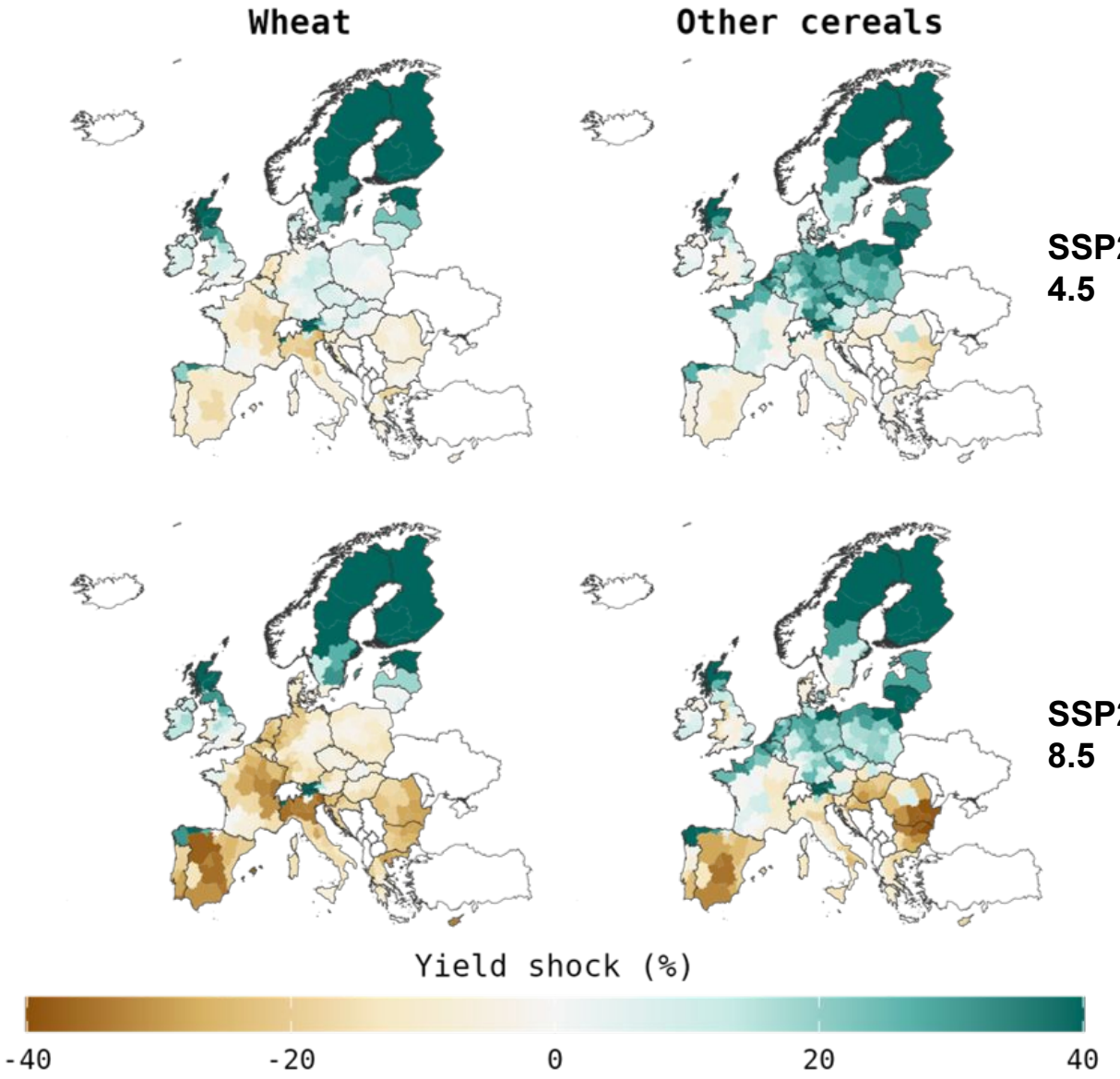


Figure: End-of-century yield changes for wheat and other cereals under SSP2-4.5 and SSP2-8.5 across EU27+UK NUTS2 regions relative to 1981-2010 baseline

Climate shocks – Labour productivity changes

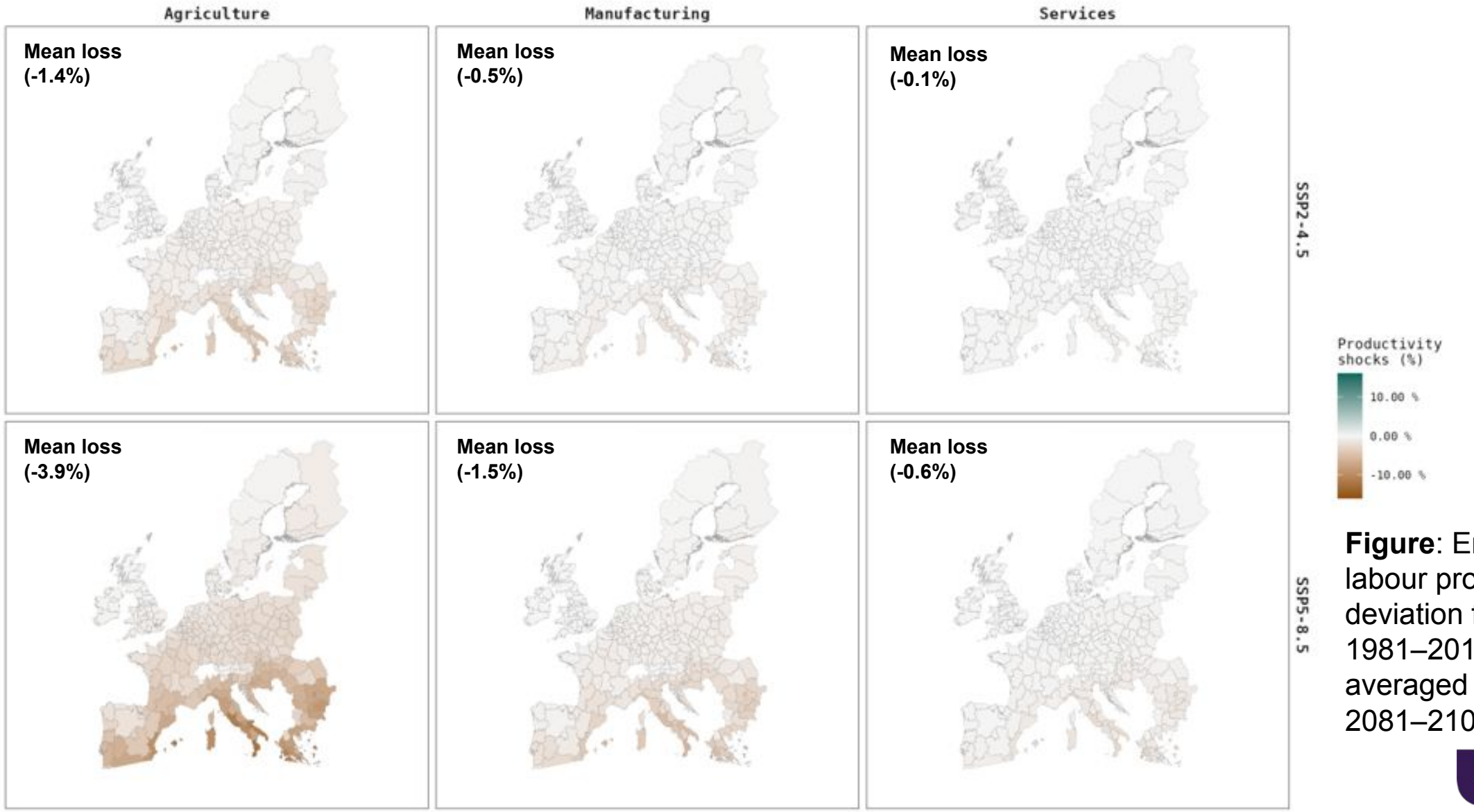
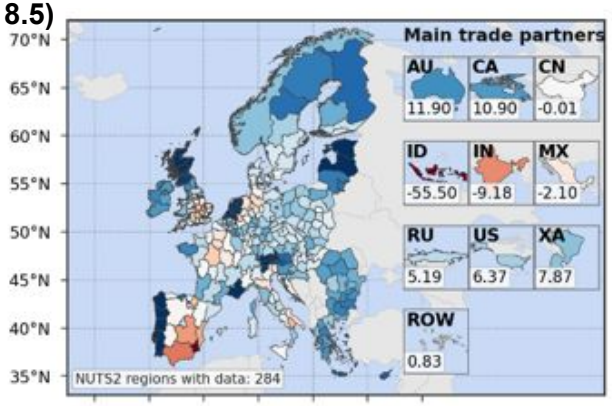


Figure: Ensemble-mean labour productivity deviation from the 1981–2010 baseline (%), averaged over 2081–2100,

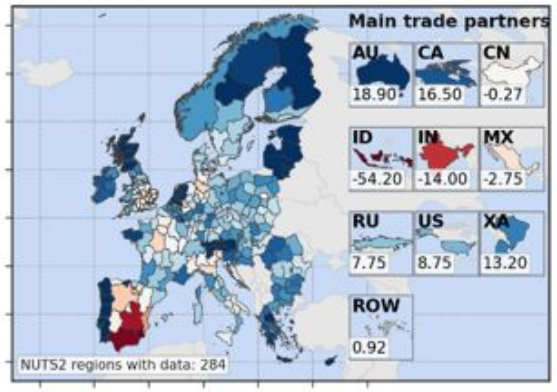
Results climate change impacts & adaptation (Combined scenario) - Production

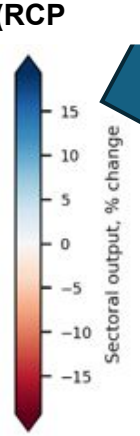
Wheat

Climate impacts – Combined scenario (RCP 4.5)



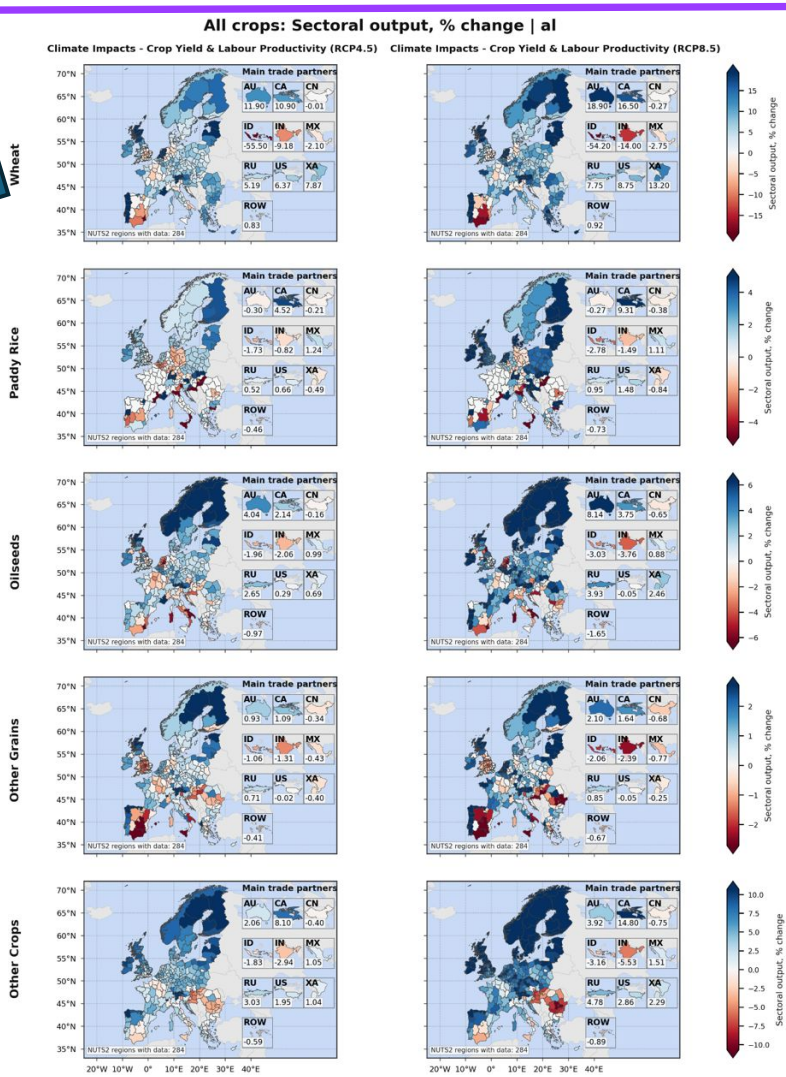
Climate impacts – Combined scenario (RCP 8.5)





RCP 8.5 Scenario

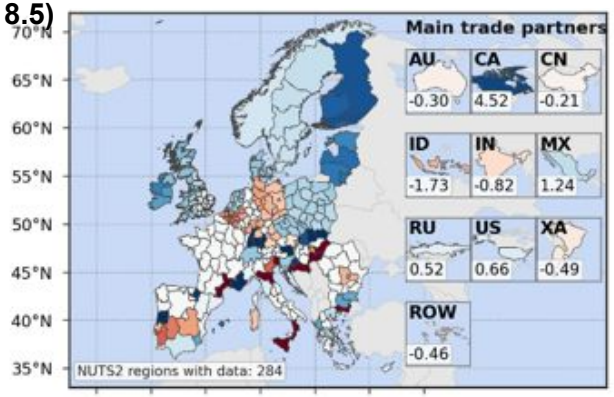
Wheat (WHT) Top ten producers (20%)		Climate change		Adaptation	
ES41	Castilla y Leon	↓	-4.8%	↓	-15.5%
FRB0	Centre Val de Loire	↓	-4.1%	↓	-21.8%
FRE2	Picardie	↓	-1.1%	↓	-0.2%
FRG0	Pays de la Loire	↑	7.0%	↑	3.3%
ES61	Andalucia	↓	-18.1%	↓	-23.0%
FRF2	Champagne-Ardenne	↑	2.0%	↑	14.0%
RO31	Sud-Muntenia	↑	5.7%	↓	-40.6%
FRE1	Nord-Pas de Calais	↑	4.5%	↑	23.4%
FRI3	Poitou-Charentes	↑	2.8%	↓	-1.7%
TLF3	Mardin	↑	0.6%	↓	-19.6%



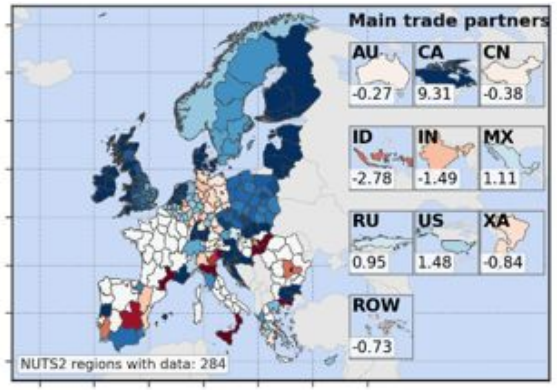
Results climate change impacts & adaptation (Combined scenario) - Production

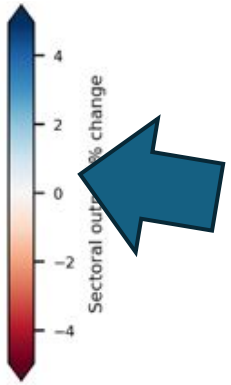
Paddy Rice

Climate impacts – Combined scenario (RCP 4.5)



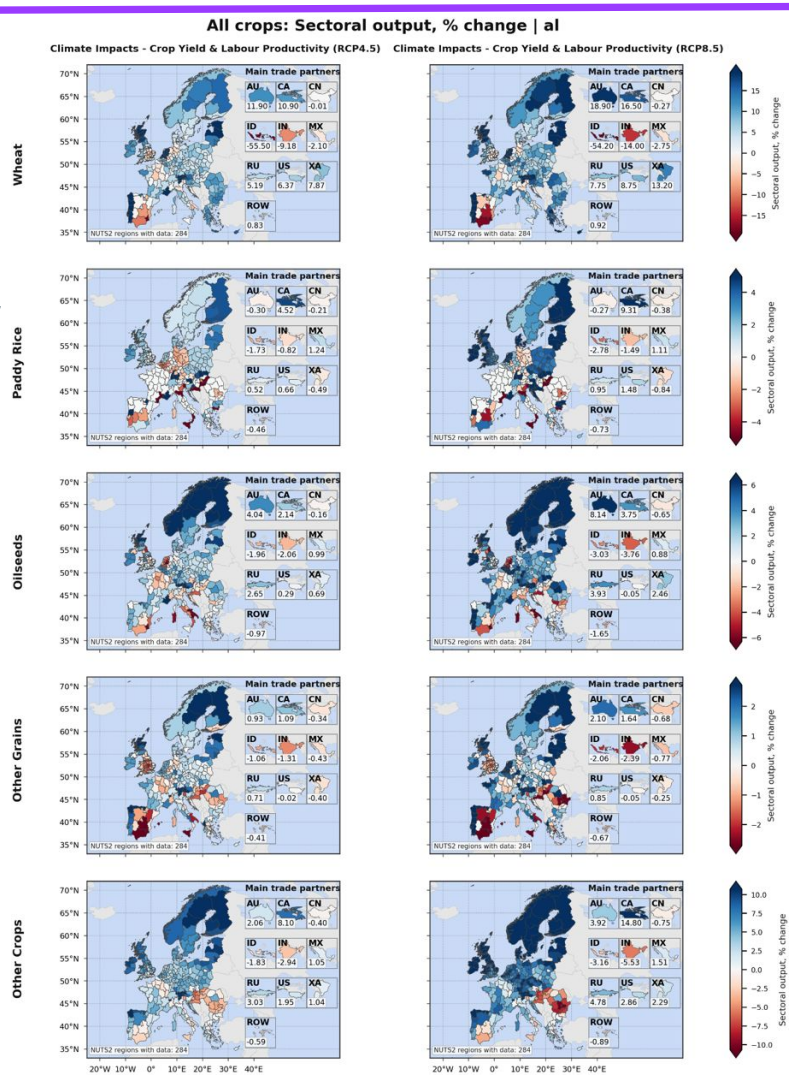
Climate impacts – Combined scenario (RCP 8.5)





RCP 8.5 Scenario

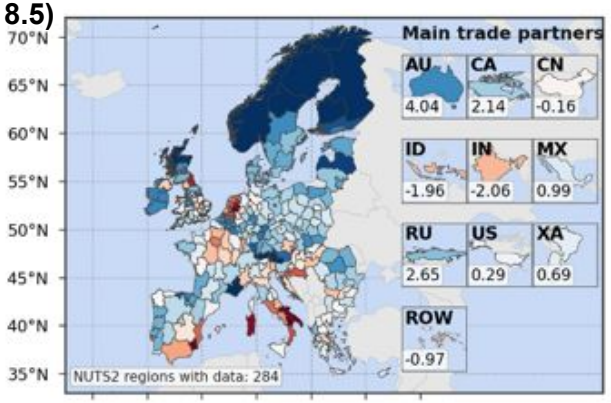
Paddy rice (PDR) Top ten producers (86%)		Climate change	Adaptation
ITC1	Piemonte	1.4%	3.2%
ITC4	Lombardia	-1.2%	3.2%
ES52	Comunidad Valenciana	-1.0%	-3.0%
ES51	Cataluna	0.2%	8.9%
ES43	Extremadura	-0.2%	13.4%
FRL0	Provence-Alpes-Cote d'Azur	20.6%	-73.1%
ITG2	Sardegna	-0.1%	-25.8%
ITH5	Emilia-Romagna	-14.3%	-14.2%
EL52	Kentriki Makedonia	2.1%	7.6%
RO31	Sud-Muntenia	-2.8%	-40.4%



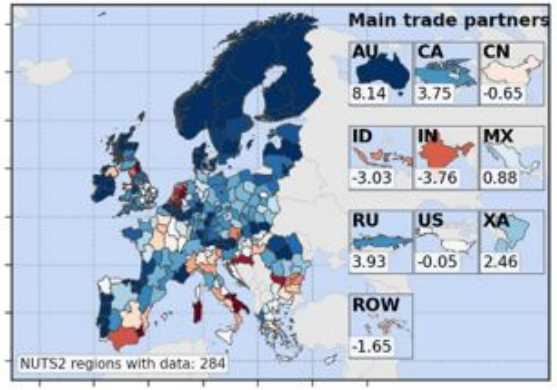
Results climate change impacts & adaptation (Combined scenario) - Production

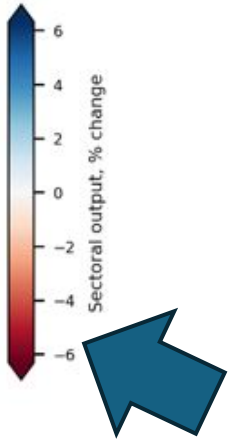
Oilseeds

Climate impacts – Combined scenario (RCP 4.5)



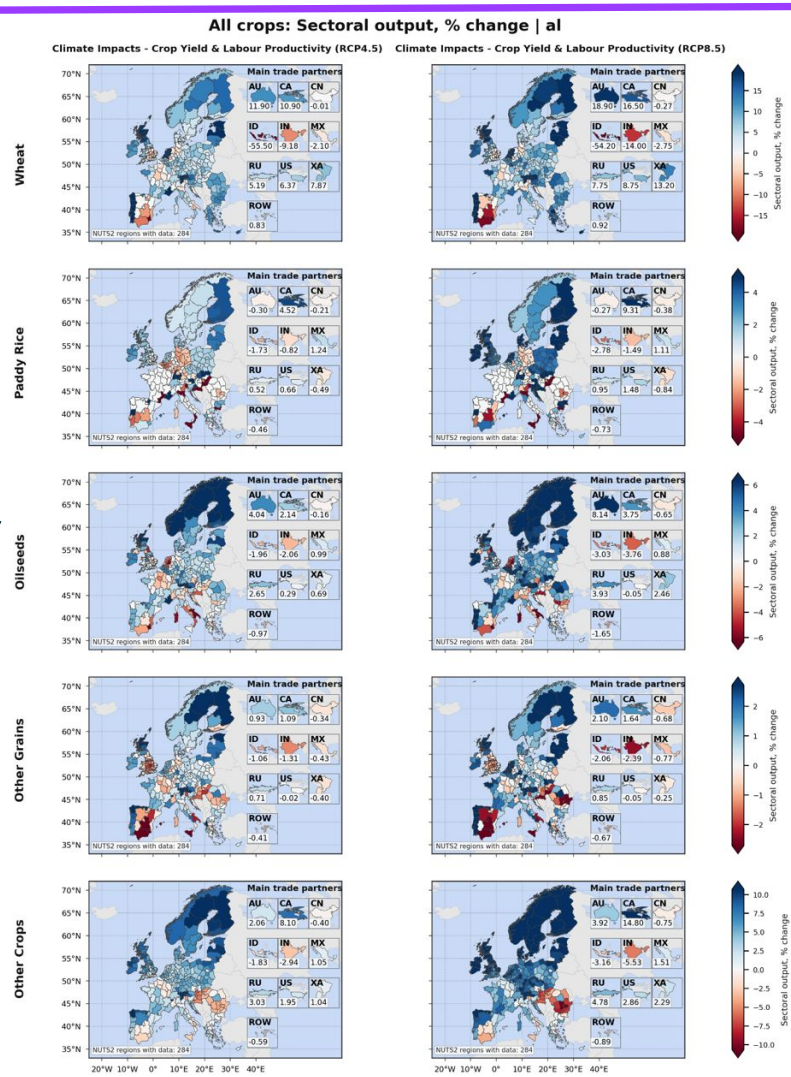
Climate impacts – Combined scenario (RCP 8.5)





RCP 8.5 Scenario

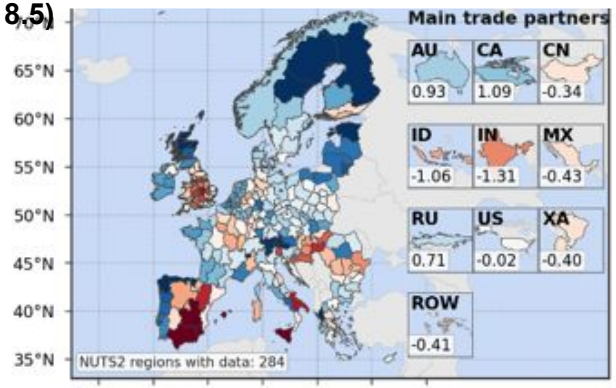
Oilseeds (OSD) Top ten producers (47%)		Climate change	Adaptation
ES41	Castilla y Leon	2.0%	0.0%
ITH3	Veneto	-1.5%	-4.9%
EL51	Anatoliki Makedonia, Thraki	0.3%	-0.7%
ES61	Andalucia	-4.0%	-4.8%
ITC4	Lombardia	-0.6%	-4.7%
ITH4	Friuli-Venezia Giulia	-2.7%	5.5%
ES42	Castilla-La Mancha	-1.0%	-6.0%
EL52	Kentriki Makedonia	0.4%	1.9%
ITH5	Emilia-Romagna	-2.5%	-21.9%
FRB0	Centre Val de Loire	-1.4%	-14.7%



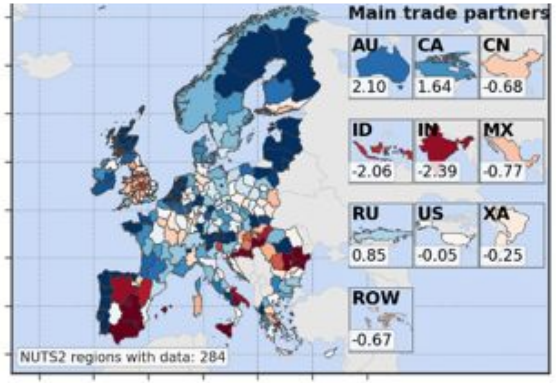
Results climate change impacts & adaptation (Combined scenario) - Production

Other Grains

Climate impacts – Combined scenario (RCP 4.5)

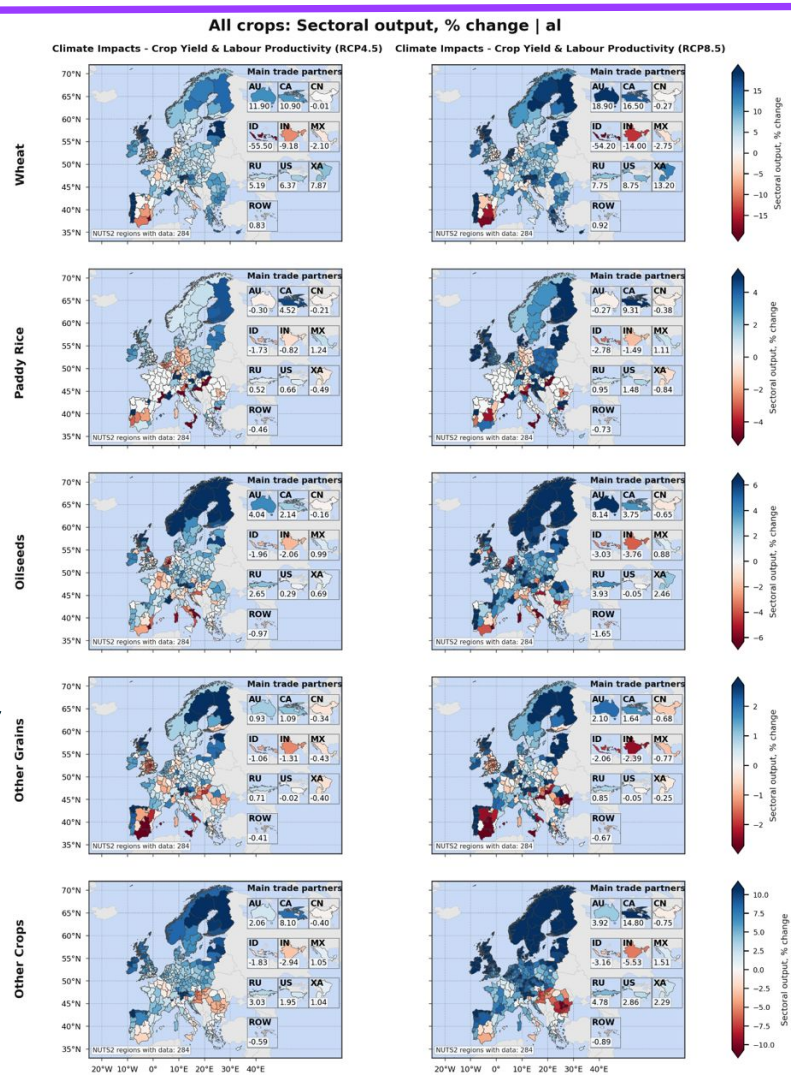


Climate impacts – Combined scenario (RCP 8.5)



RCP 8.5 Scenario

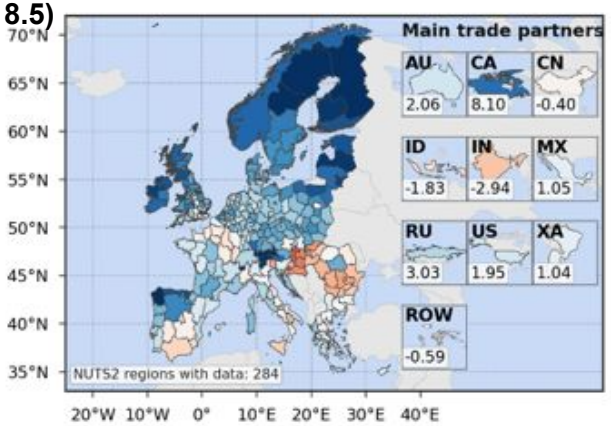
Other grains (GRO) Top ten producers (23%)		Climate change	Adaptation
ES41	Castilla y Leon	-2.4%	-3.8%
PL41	Wielkopolskie	0.6%	0.1%
ITC4	Lombardia	1.4%	10.8%
ITH3	Veneto	0.9%	10.1%
ES24	Aragon	-2.2%	0.6%
ITC1	Piemonte	-0.5%	5.6%
FRB0	Centre Val de Loire	0.2%	0.0%
PL92	Mazowiecki regionalny	1.0%	-0.2%
ES42	Castilla-La Mancha	-8.3%	-15.5%
FRI1	Aquitaine	2.2%	3.5%



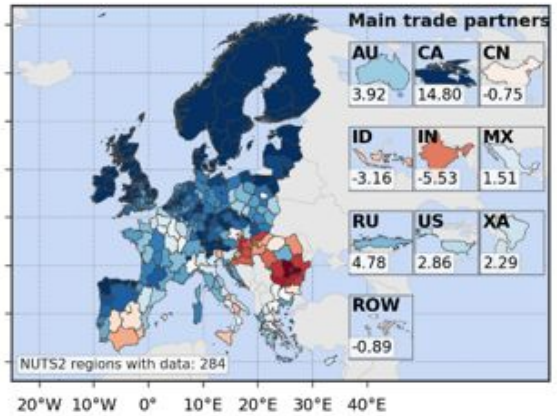
Results climate change impacts & adaptation (Combined scenario) - Production

Other Crops

Climate impacts – Combined scenario (RCP 4.5)

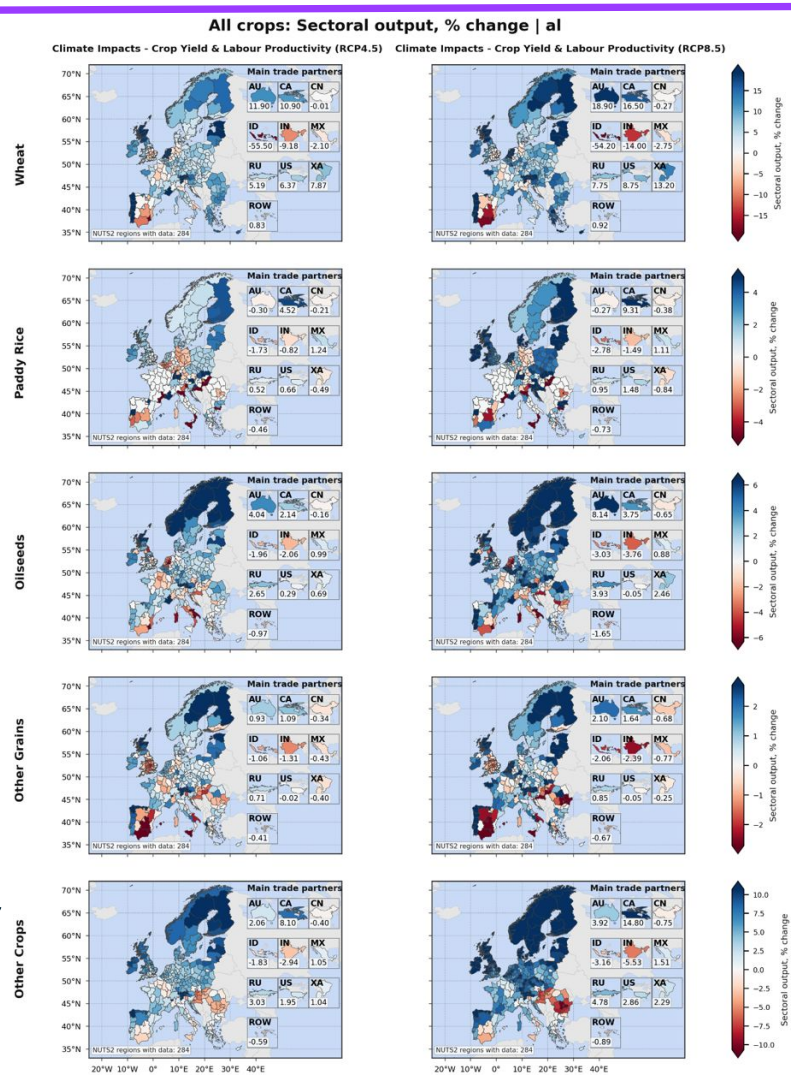


Climate impacts – Combined scenario (RCP 8.5)



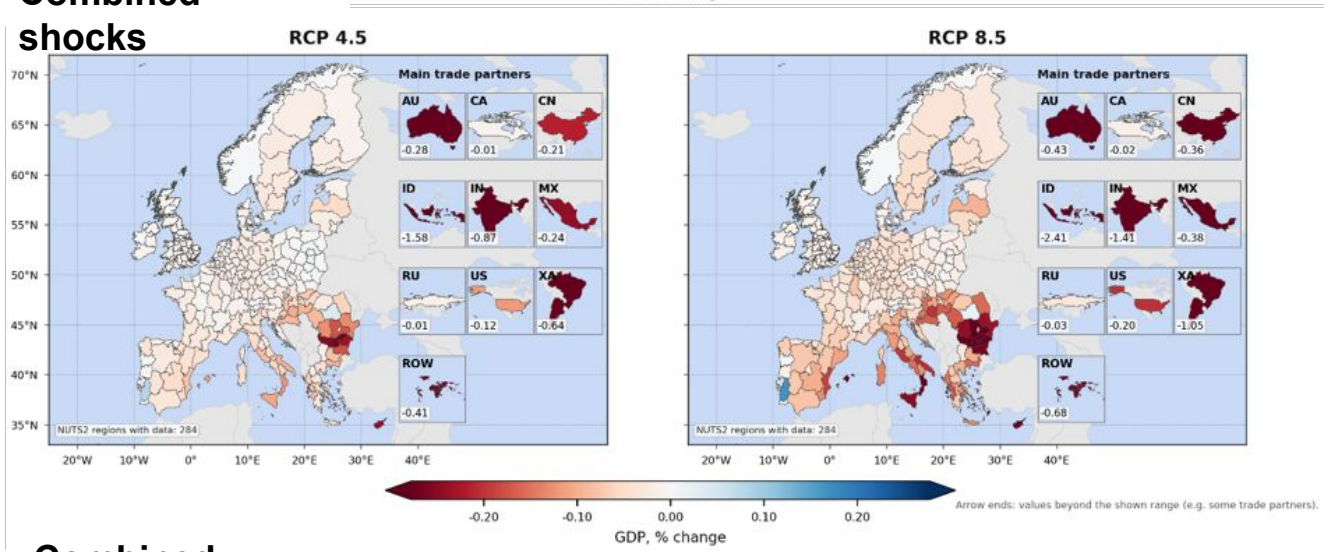
RCP 8.5 Scenario

Other crops (OCR) Top ten producers (21%)		Climate change	Adaptation
ES61	Andalucia	-4.0%	-2.5%
FRF2	Champagne-Ardenne	0.7%	1.1%
ITG1	Sicilia	-3.0%	-2.8%
NL36	Flevoland	8.2%	4.0%
FRI1	Aquitaine	7.2%	-0.5%
ITH3	Veneto	1.8%	5.8%
ITF4	Puglia	2.2%	-12.9%
FRL0	Provence-Alpes-Cote d'Azur	5.8%	-6.3%
FRC1	Bourgogne	1.3%	3.9%
ES42	Castilla-La Mancha	-1.5%	4.4%

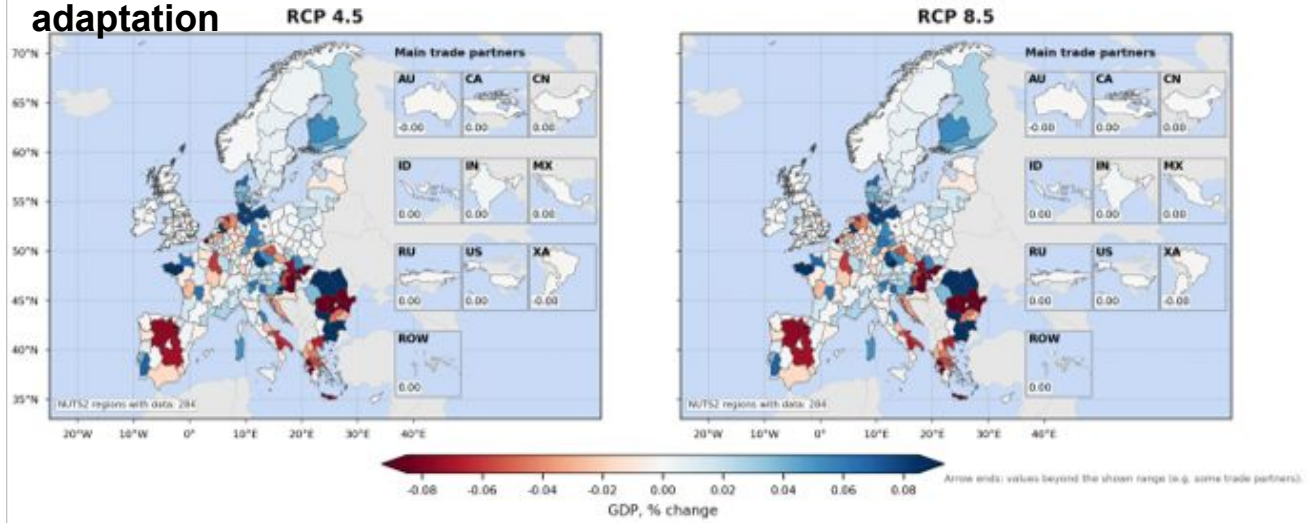


Results climate change impacts (Combined scenario) - GDP

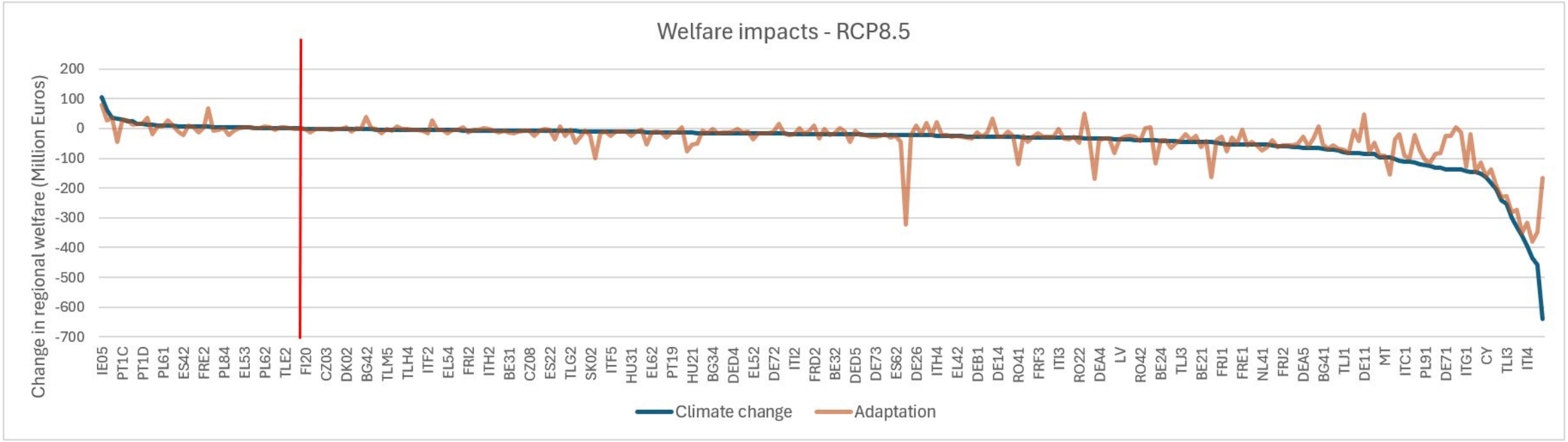
Combined shocks



Combined adaptation



Results climate change impacts (Combined scenario) - Welfare



Conclusions & limitations

Conclusions

- Climate change generates risks and opportunities for European farmers
- The impact of climate change and adaptation depends on the relative change in biophysical conditions (direct) and economic conditions (indirect)
- Targeted adaptation is necessary to mitigate the impacts of climate change in the most productive regions
- The most effective adaptation option depends on the region. However, larger positive impacts are expected with irrigation enhancement.

Limitations

- Do not consider costs associated to adaptation options
- Do not consider environmental impacts
- Every NUTS2 region is modelled independently to the country it belongs.

Thank you



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