Opportunities and challenges for agriculture in a warming, wetter world

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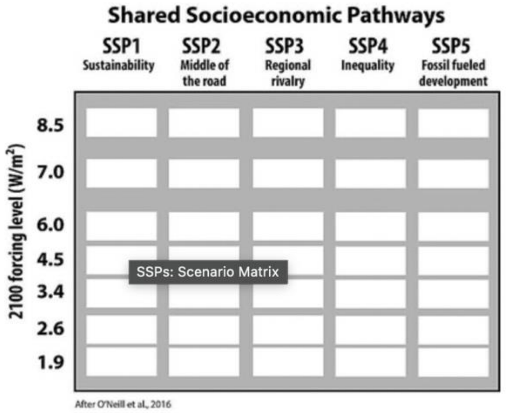
Farming in a Warming, Wetter World
14 May 2025

Photo credit: Kai Pilger

Climate change will affect agricultural production worldwide

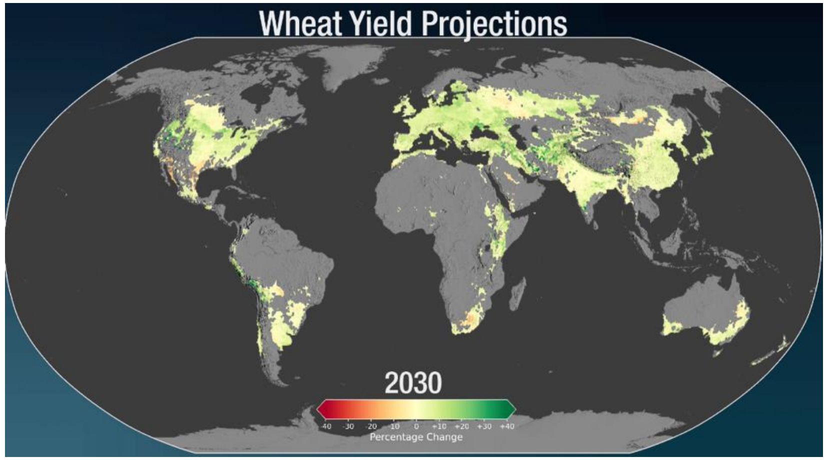
Wheat yield

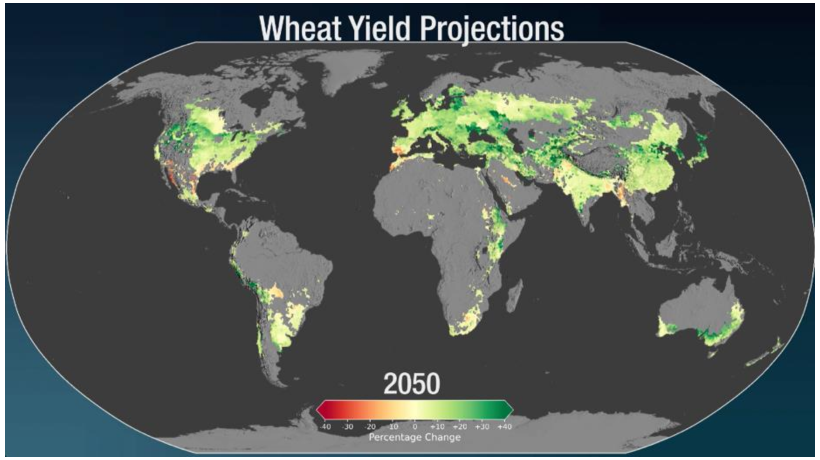


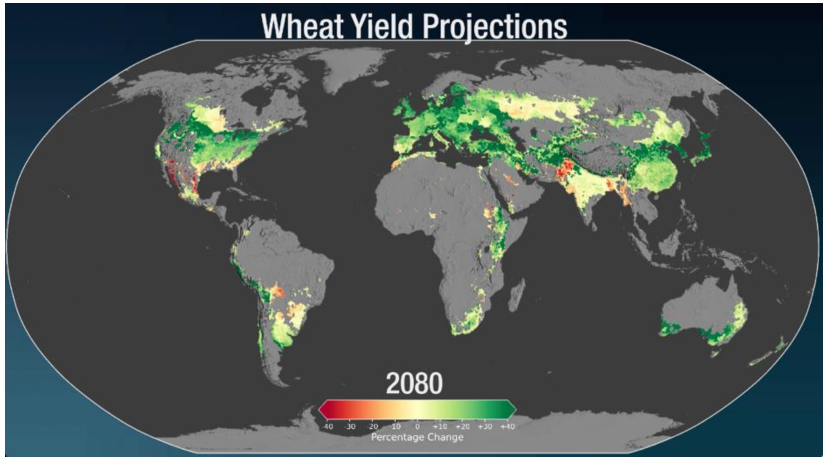
Mean end-of-century wheat productivity is +9% shifted to +18% (SSP5 8.5) and may experience a broader area where it can be grown but this gain may level off mid-century

The change in yields is due to the projected:

- increase in temperature (affects the length of growing seasons and accelerates crop maturity)
- shift in rainfall patterns
- elevated surface carbon dioxide concentrations (positive effect on photosynthesis and water retention)



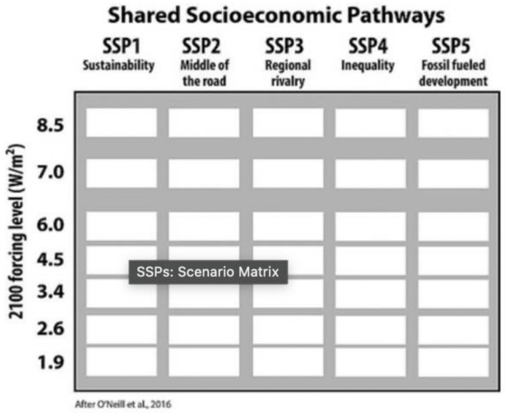




Jägermeyr, J. *et al*. (2021) *Nature Food* **2**, 873–885.
https://svs.gsfc.nasa.gov/4914/

Photo credit: Ash Willson

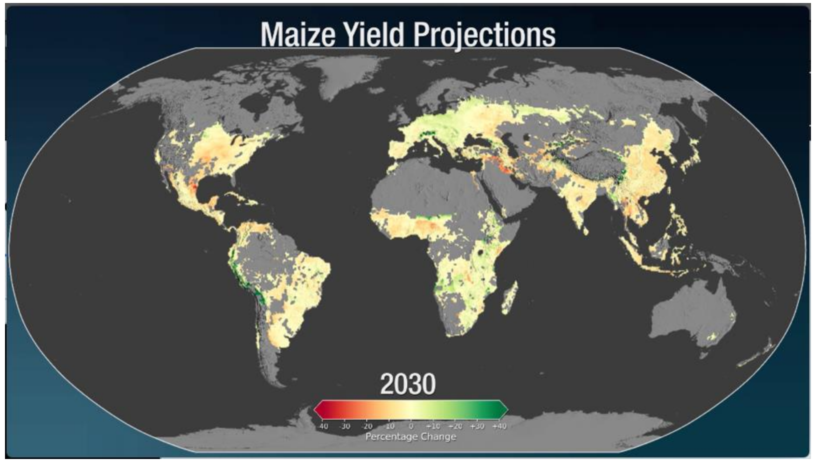
Maize yield

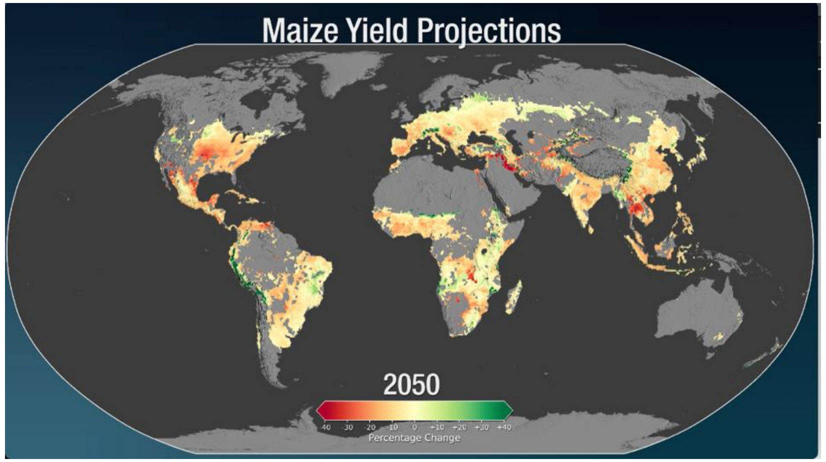


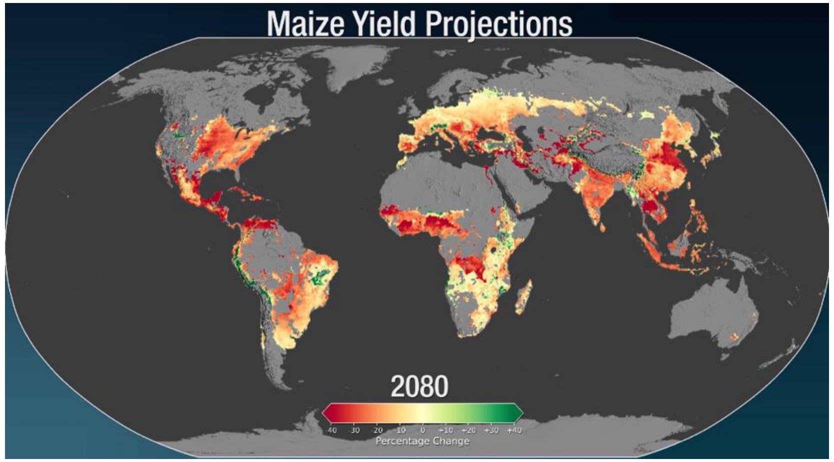
Mean end-of-century maize productivity is shifted from +5% to −6% (SSP1 2.6) and from +1% to −24% (SSP5 8.5)

Projected increases in temperature, shifts in rainfall patterns and elevated surface carbon dioxide concentrations make it more difficult to grow maize in the tropics

North and Central America, West Africa, Central Asia, Brazil and China will potentially see their maize yields decline as average temperatures increase, putting more stress on maize plants







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Compound climate stress thresholds in potato yields

FARMWISE

Future Agricultural Resource Management and Water Innovations for a Sustainable Europe

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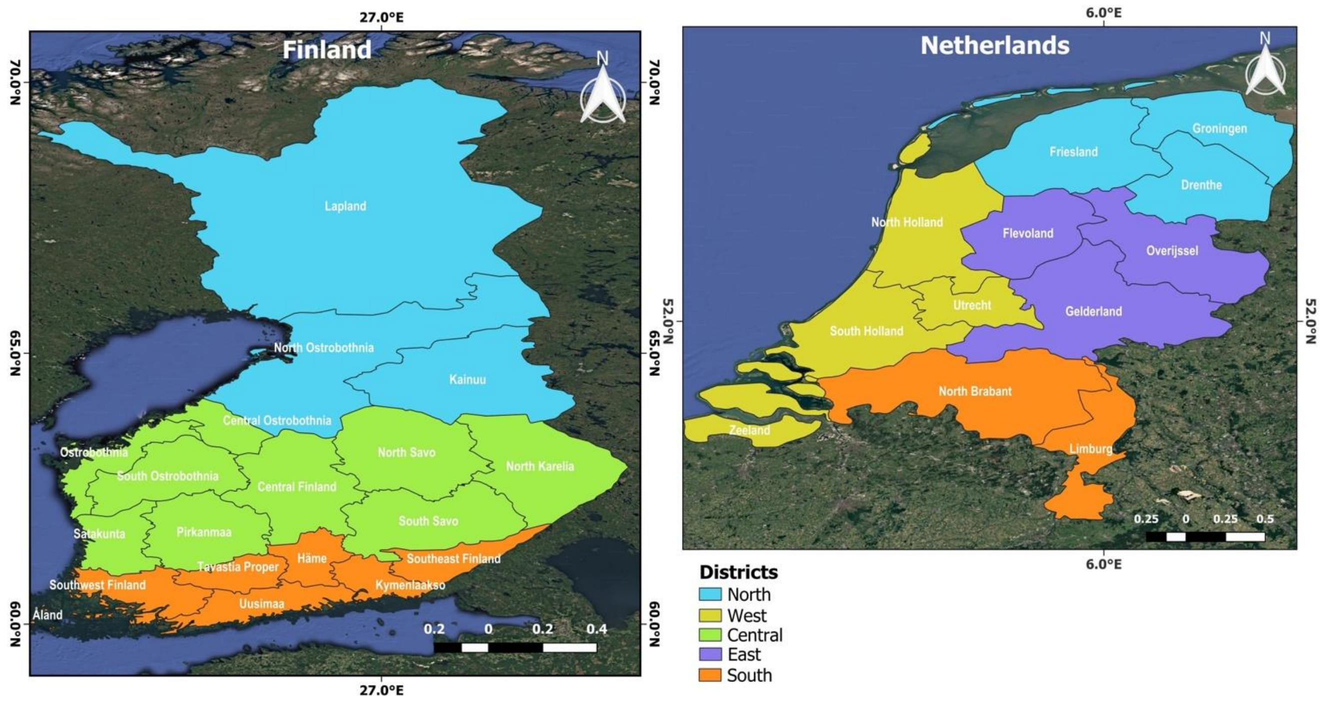
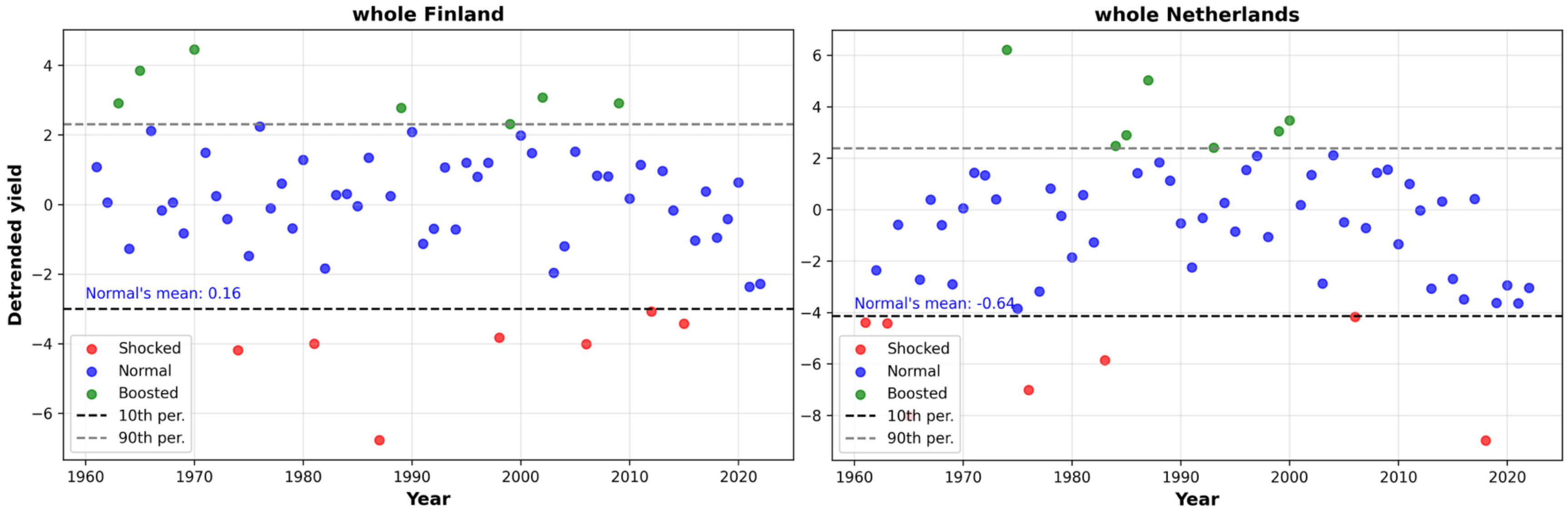




Datasets for provincial potato yields and harvested areas exist for 1999–2022 for Finland and 1994–2022 for the Netherlands

Datasets extended backwards with FAO national-level data (1961–2022)

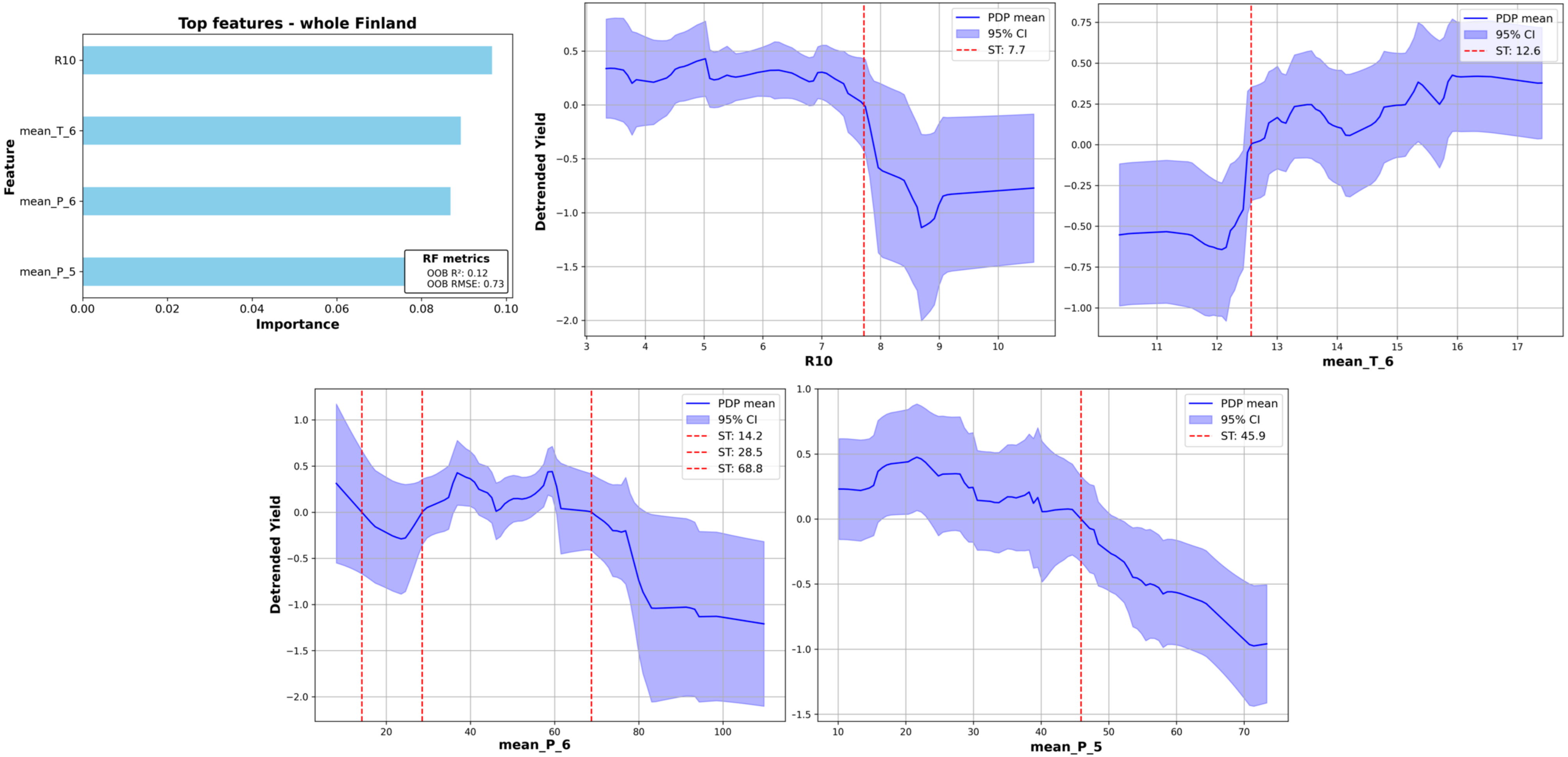
Potato growing season: May-September

Saboori *et al*. (Submitted) *Earth's Future*.

Stress thresholds for Finland

Saboori *et al*. (Submitted) *Earth's Future*.

R10: No. days when ppt ≥ 10 mm during the growing season
mean_T: Monthly mean temp during the growing season
mean_P: Monthly mean ppt during the growing season



Precipitation-based stress indicators are the dominant drivers of yield shocks, particularly heavy rainfall events and excessive early-season precipitation

- mean_P_6 (outside ~ 28.5–69 mm) and R10 (> 7.5) strongly differentiated Shocked yields from Normal or Boosted yields

Stress thresholds for the Netherlands

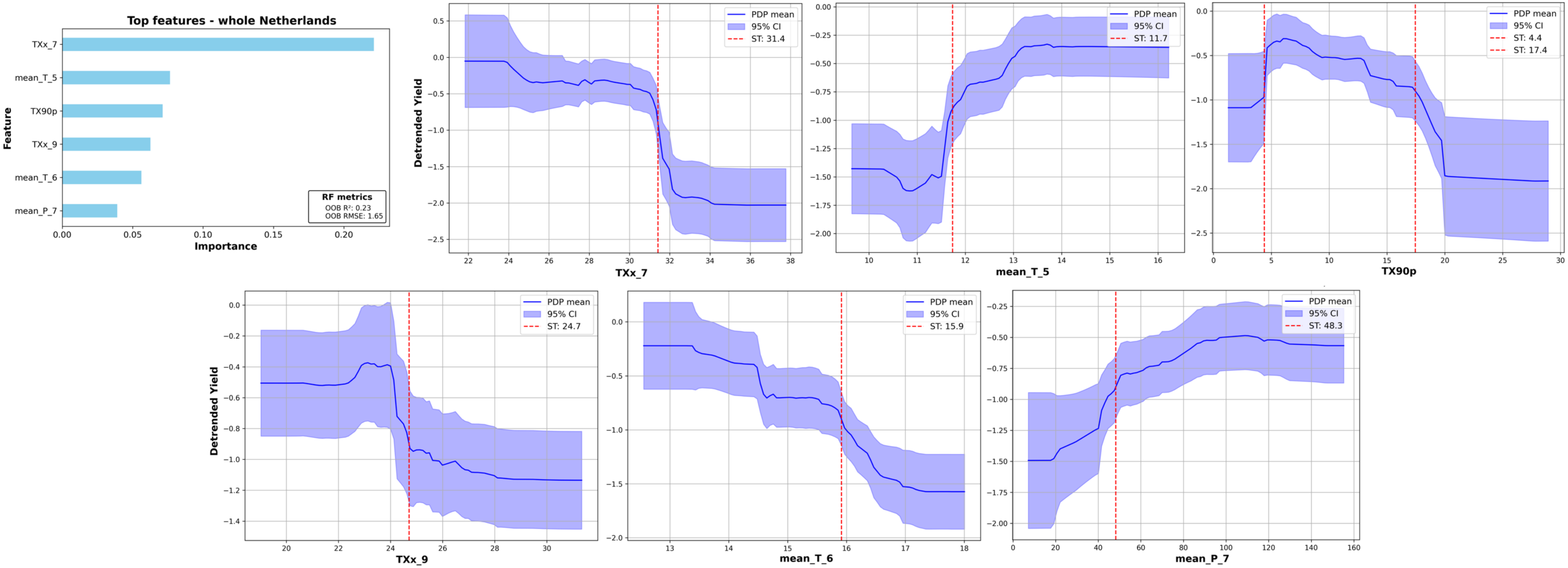
Saboori *et al*. (Submitted) *Earth's Future*.

TXx: Monthly max value of daily max temp

TX90p: Percentage time when daily max temp >90th percentile during the growing season

mean_T: Monthly mean temp during the growing season

mean_P: Monthly mean ppt during the growing season



Greater sensitivity to temperature extremes

- At the national scale, yields declined when TXx_7 exceeded ~31.5 °C, TX90p surpassed ~4.5–17.5%, or mean_P_7 dropped below ~48.5 mm

UK Centre for Ecology & Hydrology

Tyndall°Centre for Climate Change Research

National Horizon Scanning for Future Crops Under a Changing UK Climate

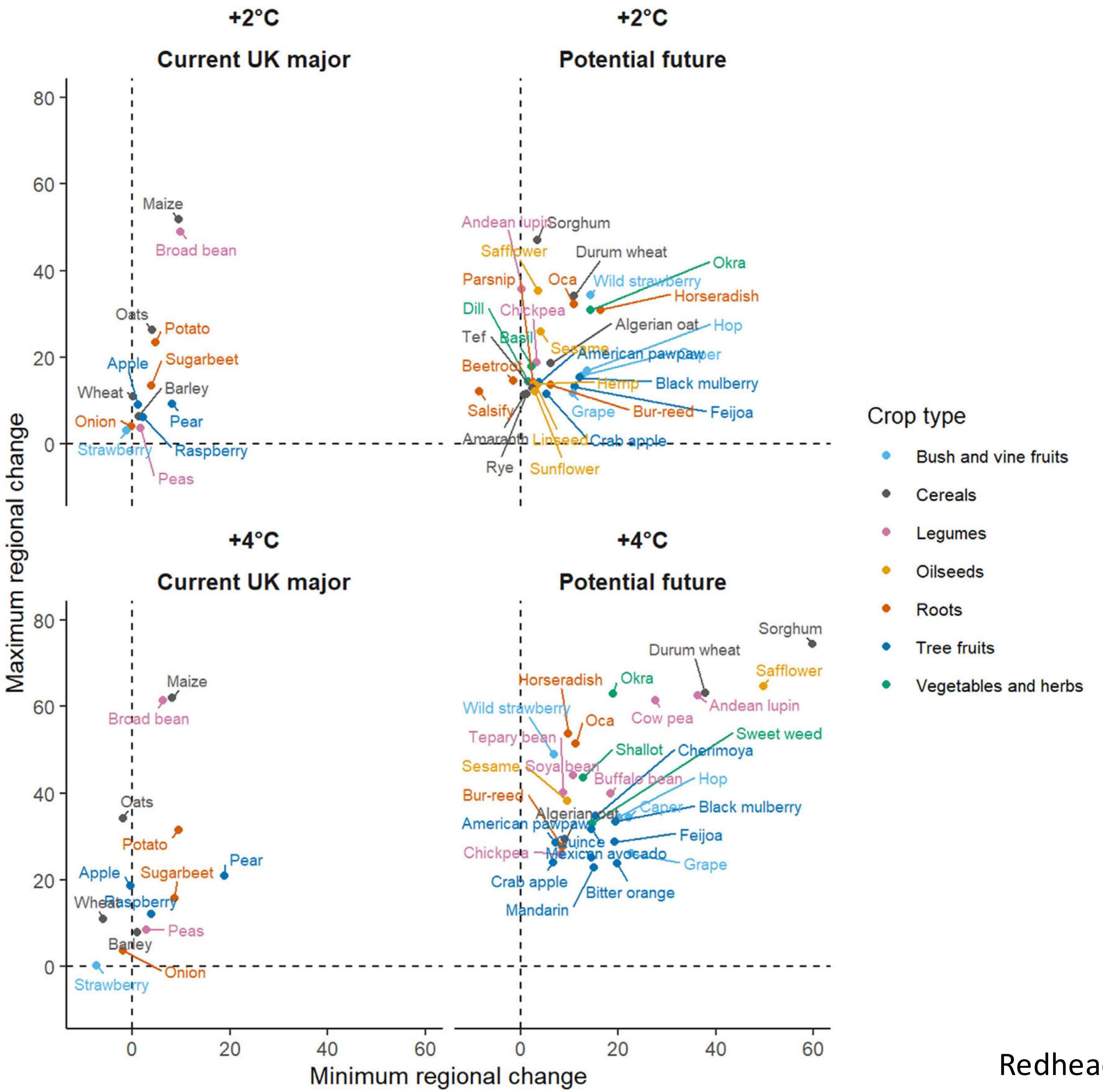
Redhead *et al*. (2025) *Climate Resilience and Sustainability* **4**: e70007.

Median change per region in modelled suitability scores for 13 UK major crops

+2◦C and +4◦C warming scenarios

+2°C					+4°C				
Crop	**SW**	**NW**	**NE**	**SE**	**Crop**	**SW**	**NW**	**NE**	**SE**
Maize	14.65	43.35	51.84	9.55	Maize	17.77	50.52	62.03	8.23
Broad bean	24.39	49.00	44.42	9.90	Broad bean	23.71	61.35	59.10	6.35
Oats	8.45	19.23	26.35	4.06	Oats	1.16	24.48	34.23	−1.94
Potato	12.08	23.32	21.61	4.68	Potato	12.29	30.61	31.42	9.48
Sugarbeet	6.71	9.03	13.52	3.94	Pear	21.00	18.87	19.16	20.48
Wheat	0.19	6.39	10.90	1.19	Apple	5.32	18.55	12.71	−0.35
Pear	9.29	8.19	8.48	9.23	Sugarbeet	8.65	15.65	15.68	10.90
Apple	5.10	9.10	7.23	1.23	Raspberry	7.81	12.13	3.94	5.55
Barley	1.29	3.84	6.39	1.71	Wheat	−5.90	5.45	11.00	0.39
Raspberry	4.00	6.06	2.97	2.19	Peas	8.39	7.29	2.97	5.19
Onion	−0.23	0.61	3.97	1.06	Barley	1.03	4.39	7.84	3.55
Peas	3.65	3.10	1.90	1.77	Onion	−1.90	0.55	3.65	1.84
Strawberry	−1.15	−0.29	3.00	1.31	Strawberry	−7.23	−4.84	−0.40	0.19

Note: Rows are ordered in descending order of maximum regional change per scenario. Cells shaded on a diverging colour ramp, with grey indicating values near zero, reds indicating negative values and greens indicating positive values.



Regional variation (min *vs* max regional median change) in ensemble mean suitability score change from the baseline (1980–2000) under +2◦C or +4◦C global warming scenarios

Climate change is likely to bring opportunities to diversify cropping systems

Many current and potential new crops show widespread increases in suitability under a +2◦C warming scenario

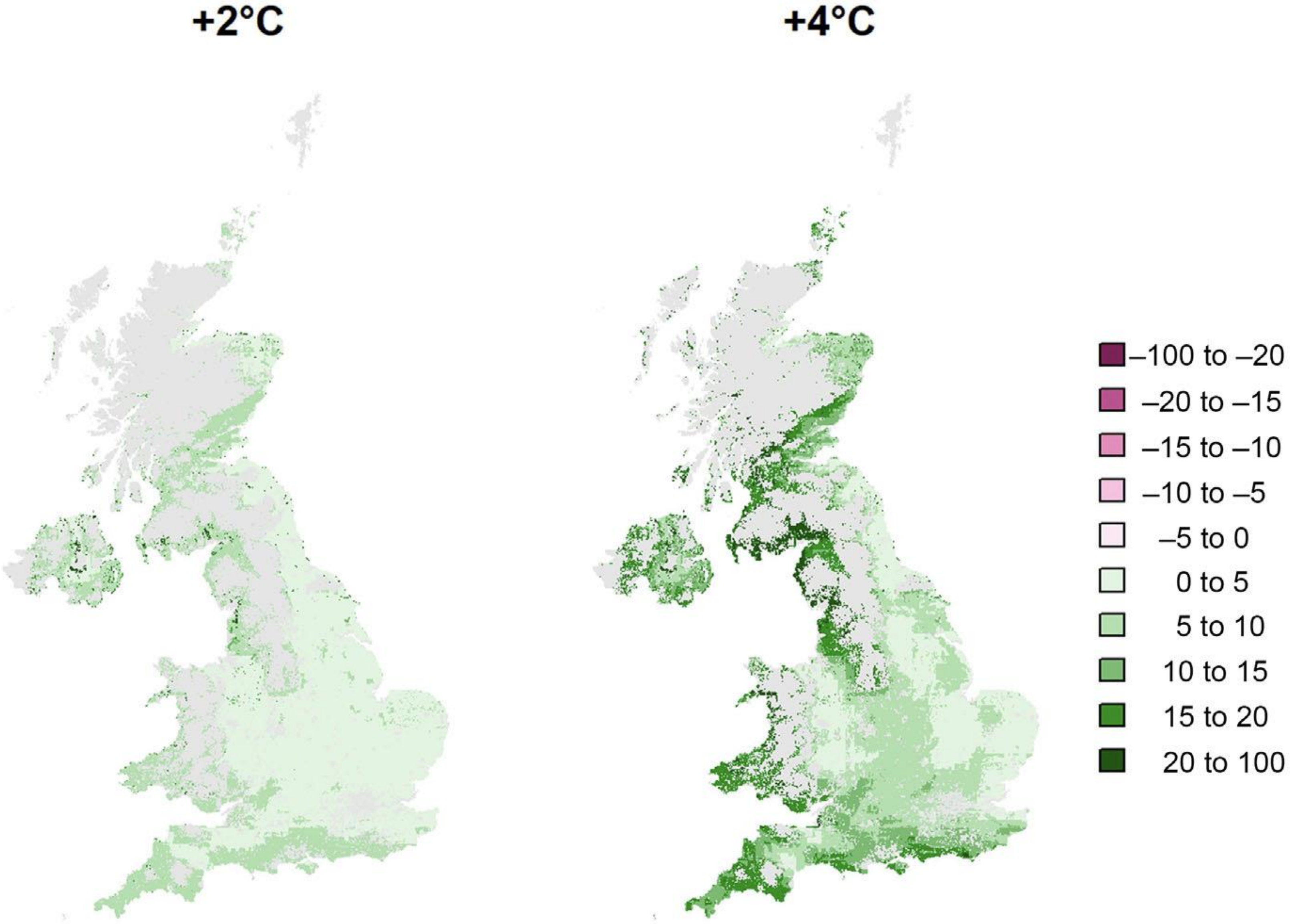
However, under a +4◦C scenario, several current crops (e.g. onions, strawberries, oats, wheat) begin to show declines in suitability in the region where most arable crops are currently grown

Redhead *et al*. (2025) *Climate Resilience and Sustainability* **4**: e70007.

Median change in suitability across all crops relative to the 1980–2000 baseline, under +2◦C and +4◦C warming scenarios

While some new crops with increasing suitability may offer viable alternatives (e.g., soy, chickpea, grapes), the greatest average increases in suitability across crops occur outside the UK's current areas of greatest agricultural production

Realising these opportunities would thus be likely to require substantial changes to current farming systems and supply chains



Redhead *et al*. (2025) *Climate Resilience and Sustainability* 4: e70007.

WATER RESOURCES EAST

University of East Anglia

Eastern England is...

Driest region in the UK

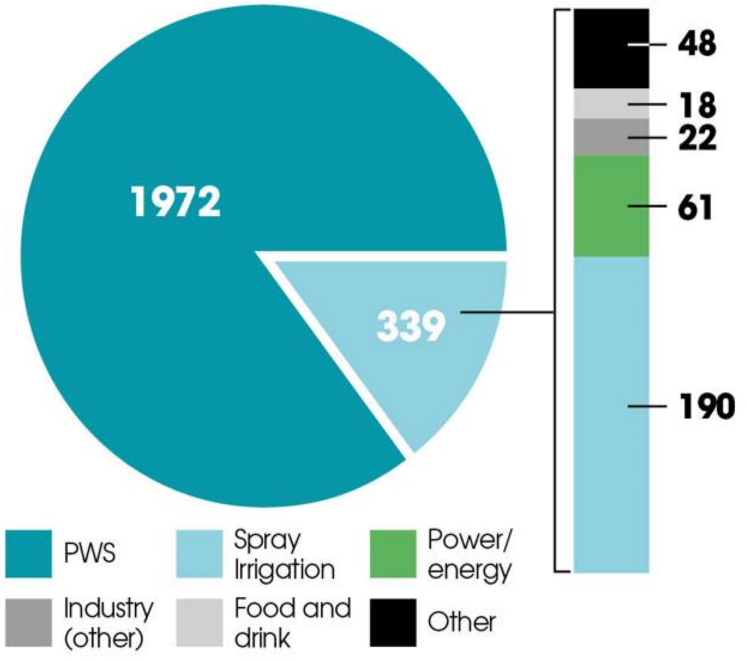
Seriously water stressed

Highest forecast growth outside London

Leading agricultural producer

Internationally important environments

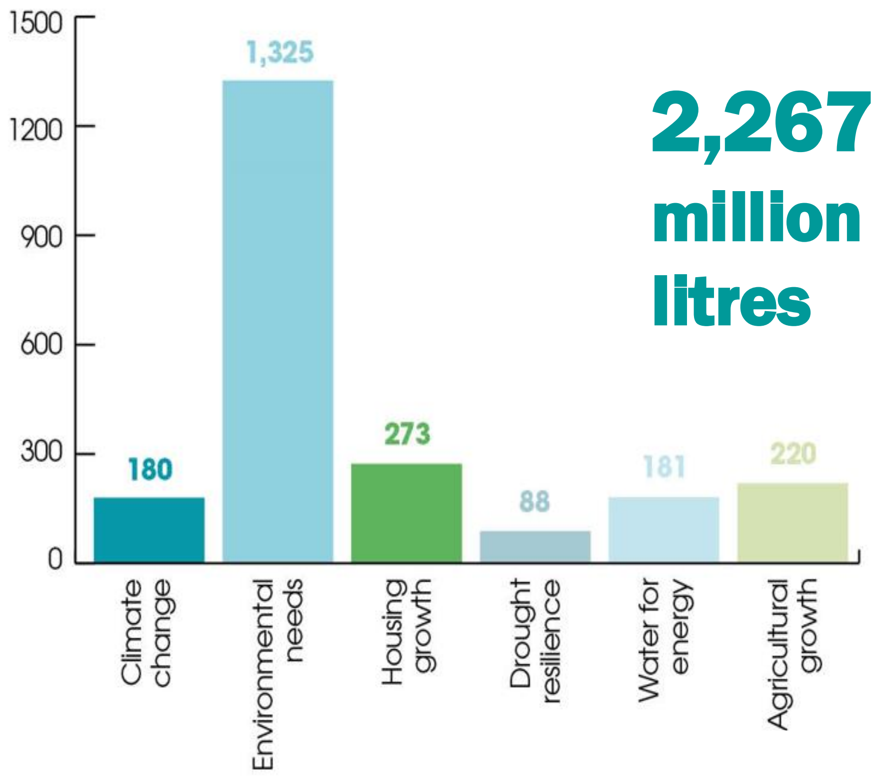
How water is used in Eastern England today



Average daily water consumption in our region is currently estimated at

2,311 million litres

Potential additional water needs in 2050



2,267 million litres

Technological Adaptations to Climate Change in Agriculture

Climate-Resilient Crops

- Drought-resistant and heat-tolerant crop varieties
- Flood- and salt-tolerant species
- Genetic modification and selective breeding

Photo credit: Adham Fathi

Precision Agriculture

- Satellite imagery and drones for crop monitoring
- AI and machine learning for predictive analytics
- Automated machinery and variable rate technology

Photo credit: Bernd Dittrich

Soil Management and Carbon Sequestration

- Biochar amendment
- Microbial soil enhancement
- Cover crops and min-till farming

Photo credit: Kevin Hiscock

Water Management Innovations

- Drip and smart irrigation systems
- Rainwater harvesting and desalination
- Water recycling and efficient irrigation

Photo credit: Being Organic in EU

Controlled Environment Agriculture

- Vertical farming, hydroponics and aeroponics
- Climate-controlled greenhouses
- Resource-efficient indoor farming

Photo credit: Markus Spiske

Climate Forecasting and Early Warning Systems

- AI-driven climate forecasting
- Pest and disease monitoring systems
- Decision-support tools for farmers

Photo credit: FarmSense

Circular Agriculture and Waste Reduction

- Upcycling food and agricultural waste
- Methane digesters for livestock waste
- Sustainable nutrient recycling

Photo credit: Biogas Products

Renewable Energy in Farming

- Solar-powered irrigation
- Wind and biogas energy use
- Energy-efficient farming equipment

Photo credit: Josh McCausland

Summary I

1. Globally, future yield estimates remain uncertain but modelling suggests that major food producing regions will face the emergence of climate impacts before 2040

2. Compound climate stressors increasingly threaten potato yields. Precipitation-based stressors drive yield shocks in Finland while the Netherlands exhibited greater sensitivity to temperature extremes

3. Adaptation strategies include improved drainage in rainfall-prone regions (Finland) or adopting heat-tolerant cultivars in regions susceptible to high temperatures (Netherlands)

Summary II

University of East Anglia

4. The greatest average increases in suitability across all crops occur outside the UK's current areas of greatest agricultural production and thus would require substantial changes to current farming systems and supply chains

5. Technological adaptations provide a pathway for resilient, productive and sustainable agriculture

6. In East Anglia, improved water management, increased storage capacity and efficient water use in agriculture are important as well as opportunities to engage in carbon sequestration and explore new crops or renewable energy enterprises