

Aiming for net zero in food & farming

– what are the wins and trade-offs?

The case of climate adaptation

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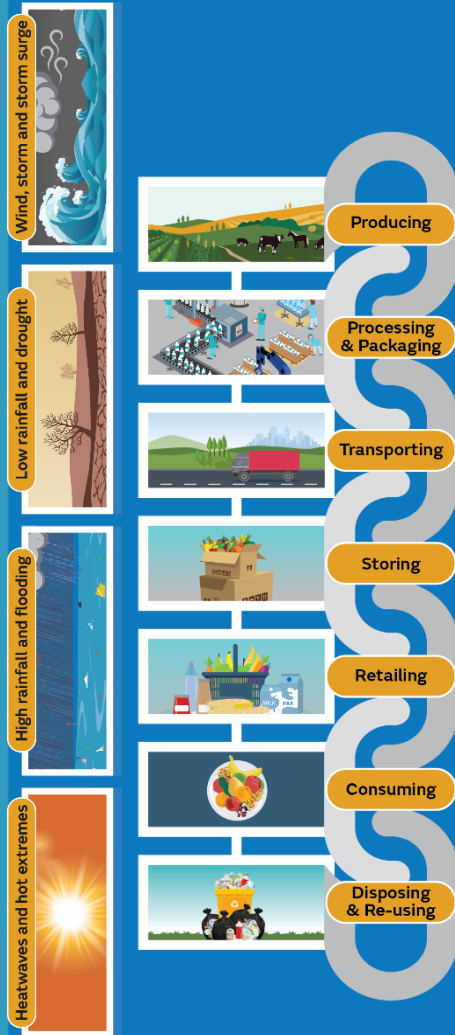
 University of
BRISTOL Associate Professor, School of Biology

 **Food
Drink
Devan**
Quality
Sustainability
Provenance
Sustainability Director

With thanks to: Andrew Cottrell, Tom Crocker, Jemma Davie (Met Office), Charles Ffoulkes, Hannah Oliver, James Clarke (RSK ADAS), Dan Bebber (University of Exeter), Carole Daline (UCL) and many others!



@PeteFalloon

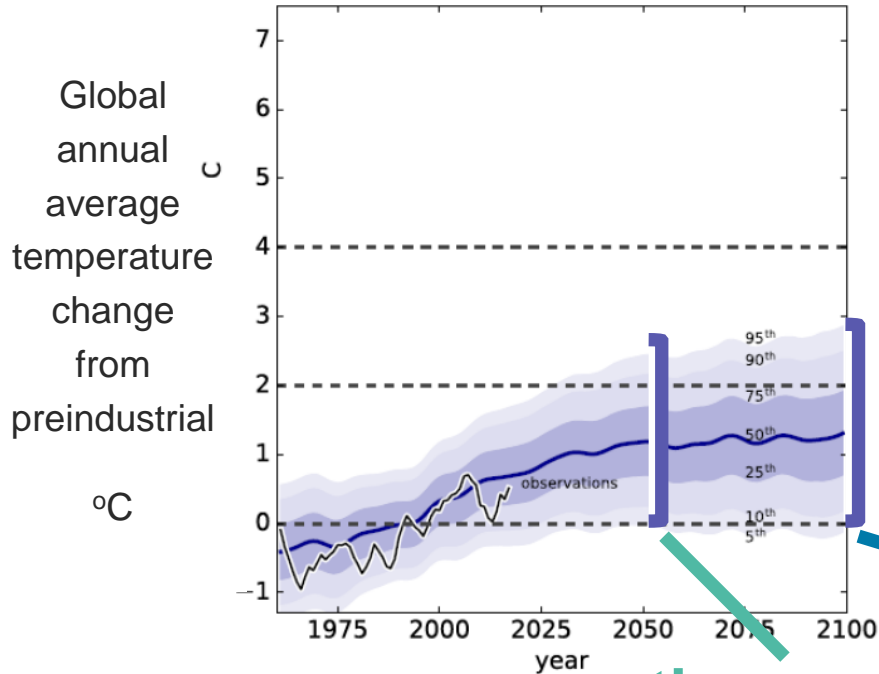


- Introduction
- Climate change – UK and overseas
- How will climate change affect UK agri-food systems?
 - Impacts and adaptation
 - Net zero
 - Win-wins, trade-offs and consequences

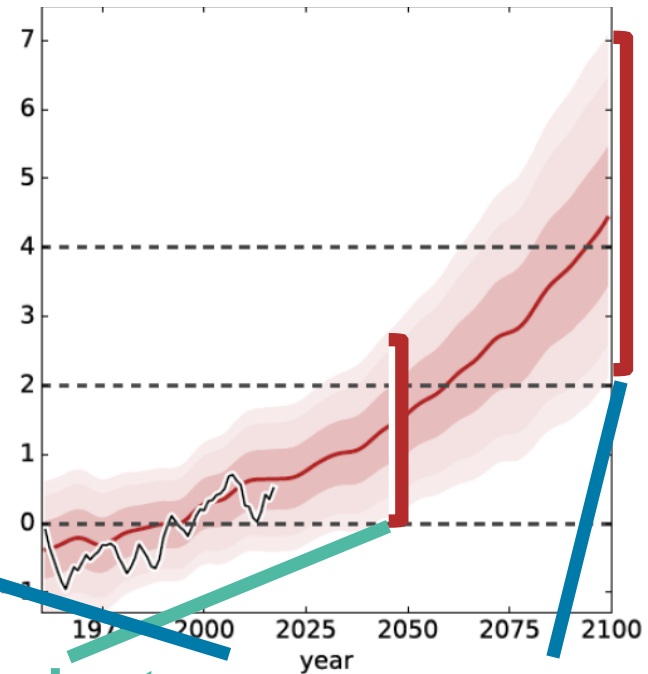


Climate change: emissions scenarios, adaptation and mitigation

Low emissions (RCP2.6)



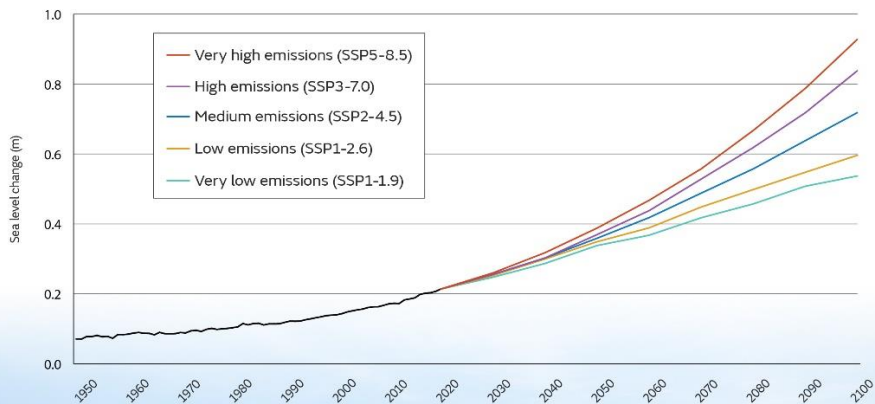
High emissions (RCP8.5)



the need to adapt.. the need to mitigate..

Adapting to climate change is essential

Global mean sea level change relative to 1900



On-going impacts

Those we are already experiencing

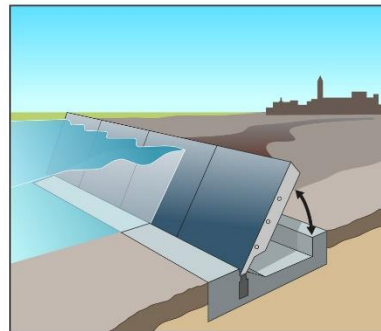
Committed impacts

Those that would occur even if emissions stopped today

Future warming

Planning for all possible outcomes - long-term, worst-case scenarios

Other examples of adaptation



Flood protection



Reinforced rail network



Sustainable buildings



Water management

Climate change and the food system



Climate change

Impacts on the Food System



Net zero

Non-food e.g. ecosystems, broader societal..

What do we do about it?

- Adaptation options
- Interventions
- Tools and solutions
- Policy



What are the consequences?

- Co-benefits **Net zero**
- Tradeoffs
- Feedbacks
- Unintended consequences..



How will the seasons change?

Summers



HOTTER

Winters



MILDER



DRIER



WETTER

How will extremes change?



Maximum temperature of a summer's day could increase by as much as 10°C in some places

Rainfall is expected to be more intense.



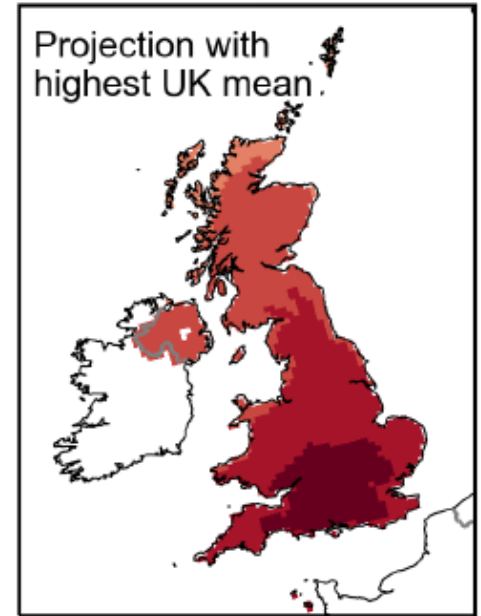
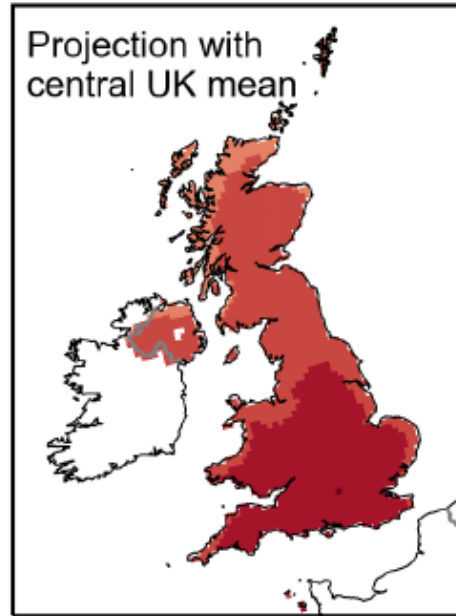
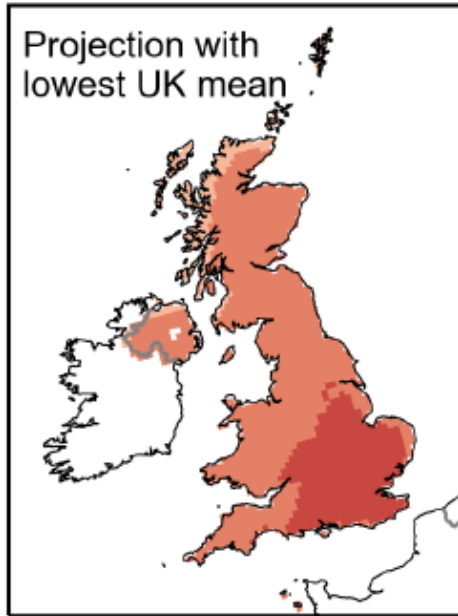
UK climate change: **temperature**

Change in
annual mean
temperature

2070s vs.
present day

High
emissions
scenario
(RCP8.5)

(12 regional projections)



Temperature anomaly, °C

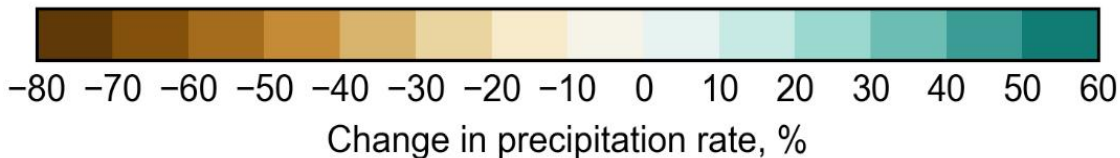
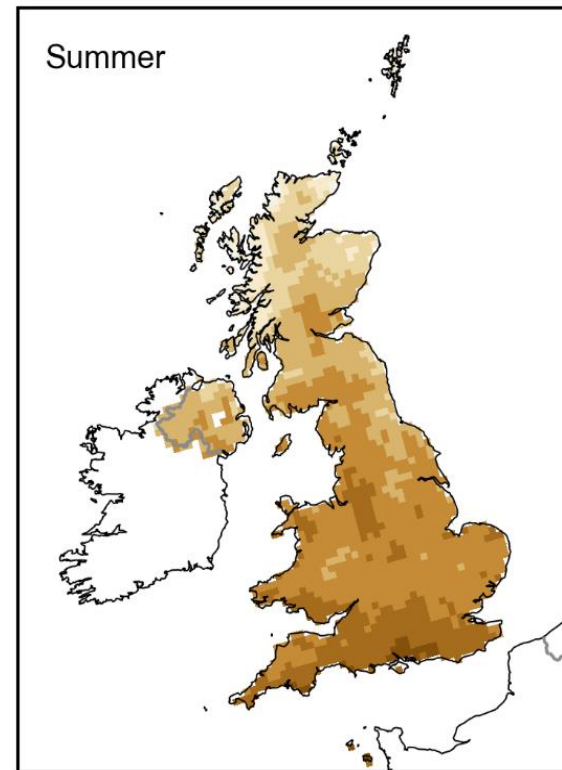
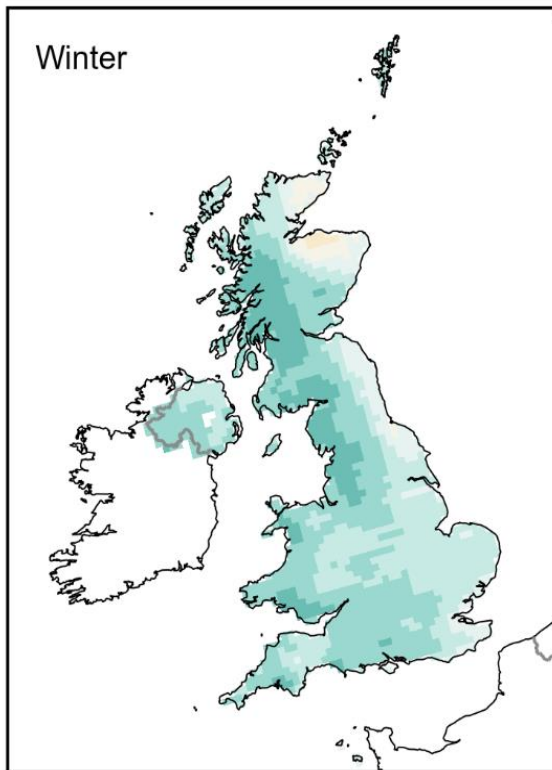


UK climate change: precipitation

% Change in seasonal mean
precipitation

2070s vs present day

High emissions scenario
(RCP8.5)



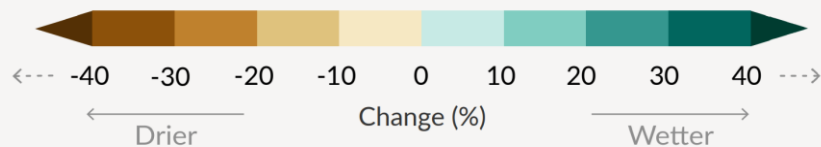
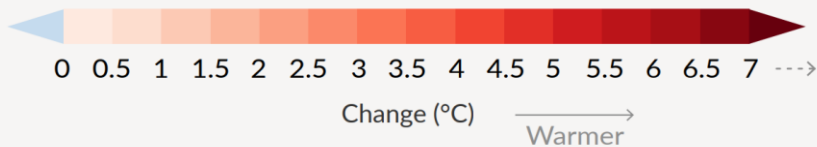
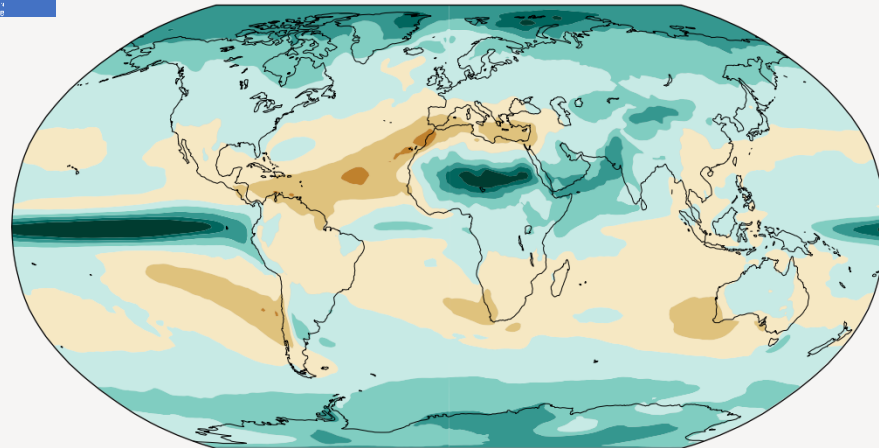
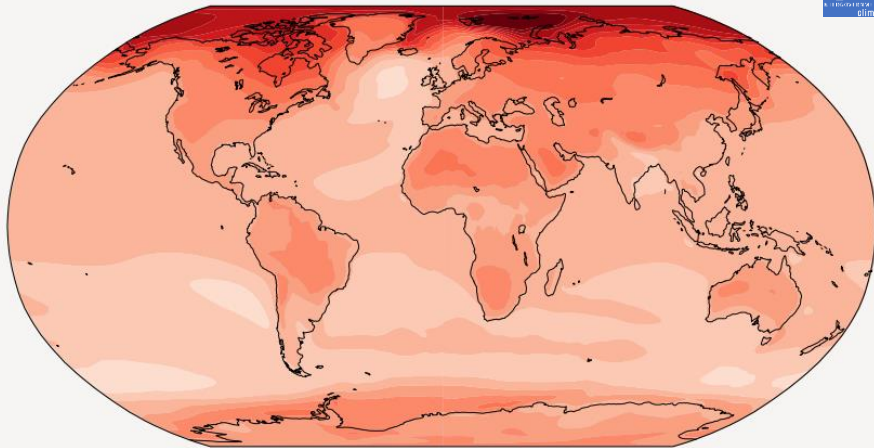
Met Office What will climate change mean overseas?

Simulated change at 2°C global warming
relative to 1850-1900

Annual mean temperature change (°C)



Annual mean precipitation change (%)





Defra Climate Service:
UK food, farming and natural environment

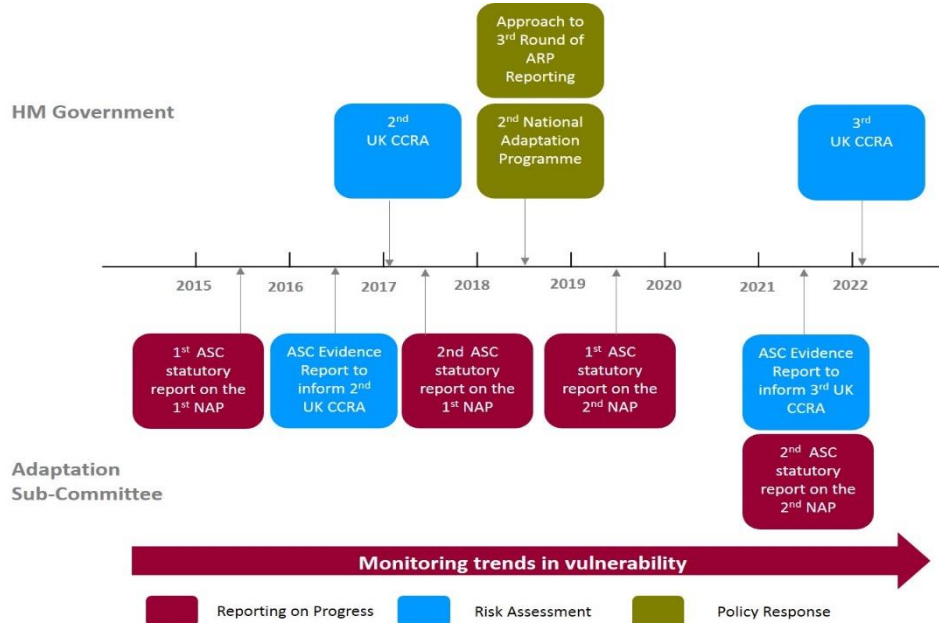
Informing policy and action since 2015

50%
Met Office

50%
Partner-ship



UK's Climate Adaptation Policy Cycle



UK Food Security Report



Climate change:

UK

agriculture and food

CCRA3/CCC (2022)



More action needed

Further investigation

Sustain current action

Maintain a
watching brief

Average UK wide scores

N4. Risk to soils from changing climatic conditions, including seasonal aridity and wetness.

N10. Risks to aquifers and agricultural land from saltwater intrusion.

N6. Risks and opportunities for agricultural and forestry productivity from extreme events and changing climatic conditions.

N7. Risks to agriculture from pests, pathogens and invasive non-native species.

N9. Opportunities for agricultural and forestry productivity from new/alternative species becoming suitable.

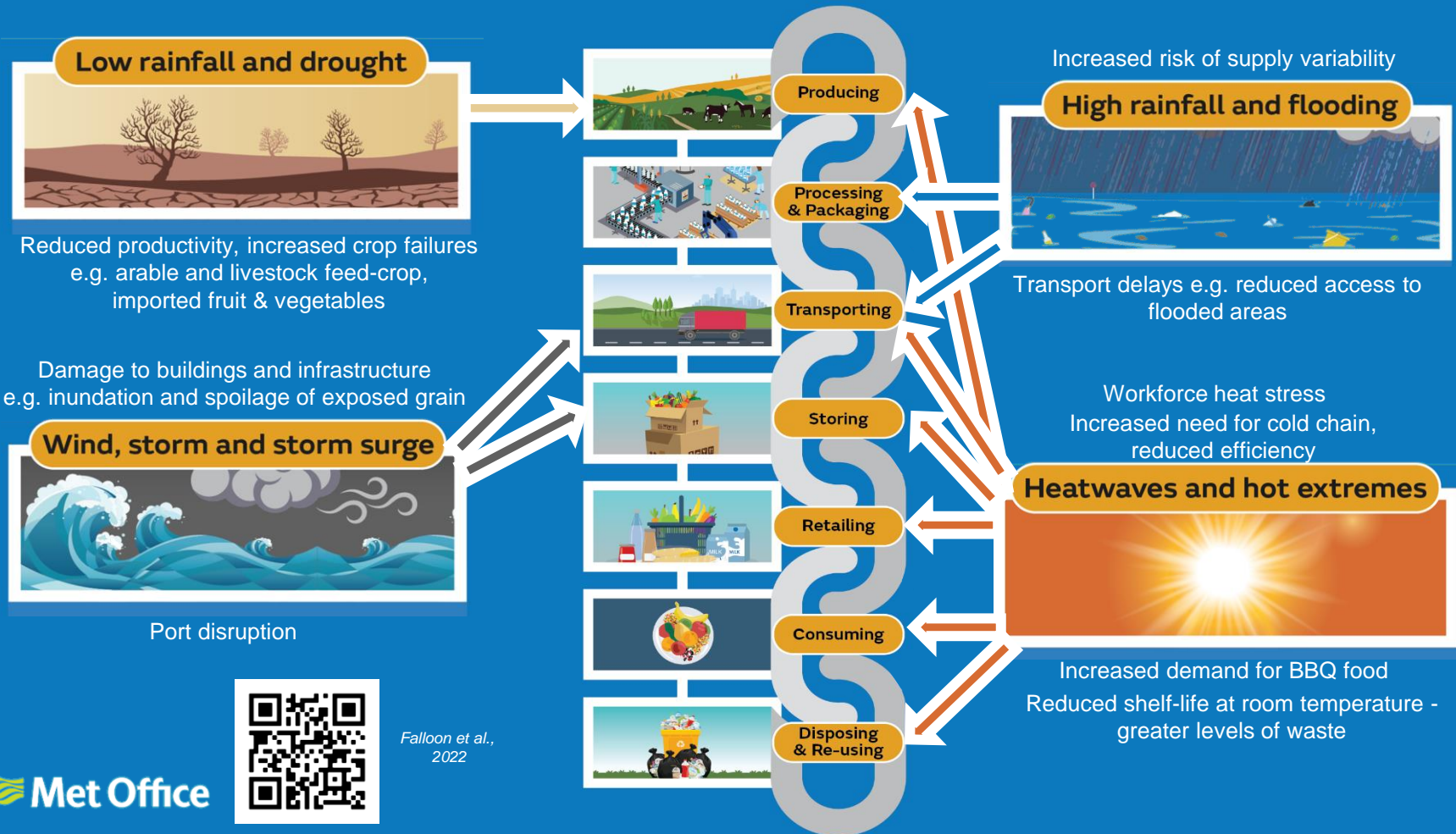
N18. Risks and opportunities from climate change to landscape character.

H9. Risks to food safety and food security from UK climate impacts.

ID1. Risks to UK food availability, safety, and quality from climate change overseas.

ID2. Opportunities for UK food imports or exports due to global climate change.

What do changing weather and climate extremes mean for the UK food system?



Falloon et al.,
2022



The climate adaptation challenge in UK food security...



Policies and plans
(inner)



Delivery and implementation
(outer)



Climate-driven changes in extreme weather events: one of the **highest-risk future shocks to the UK food system** (CCC, 2019)¹

Occurrence of future extreme events is **not a smooth trend** – clusters and long periods with very few new records

(Kendon et al. 2023)²

Climate adaptation plans and policies, delivery and implementation are **insufficient or limited** (CCC, 2023)³

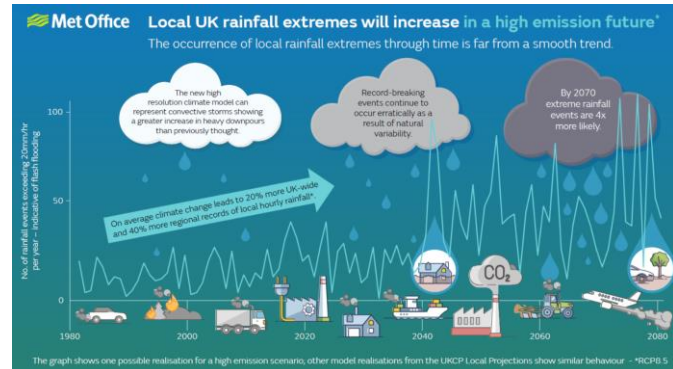
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2



3

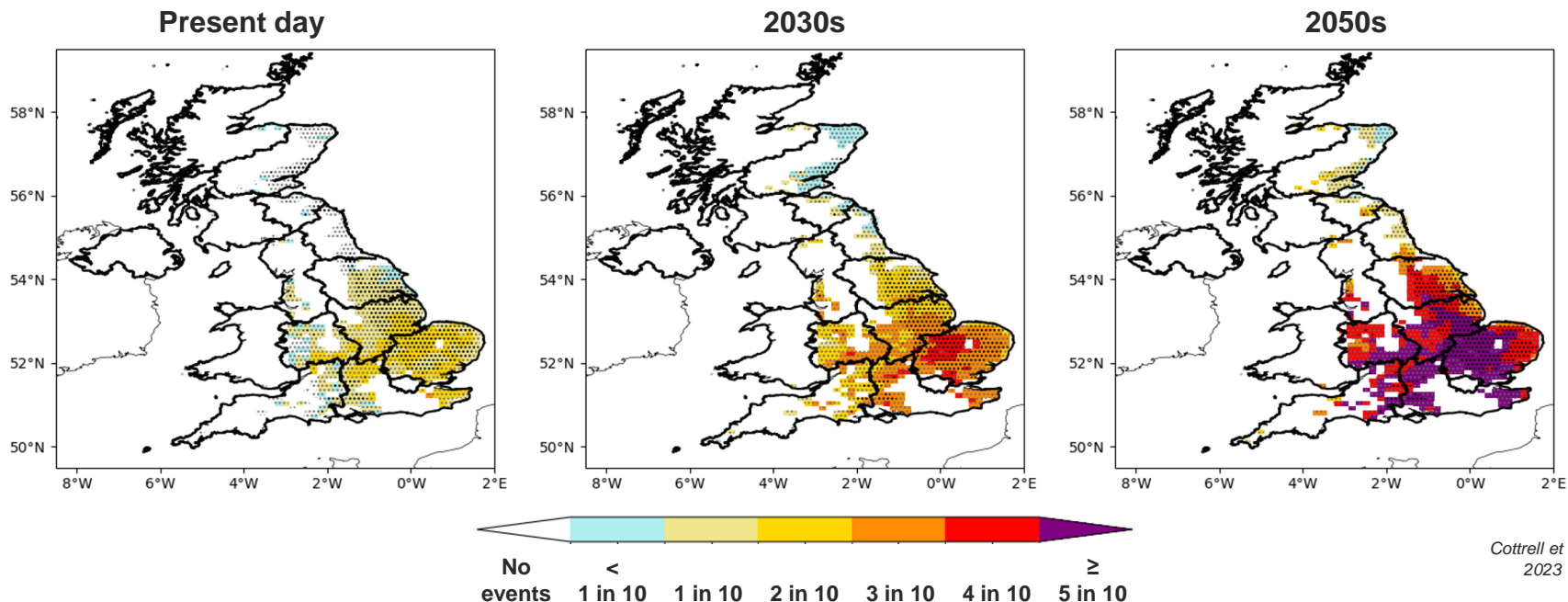




Understanding impacts, supporting adaptation

Heat stress events around anthesis: arable + horticulture areas

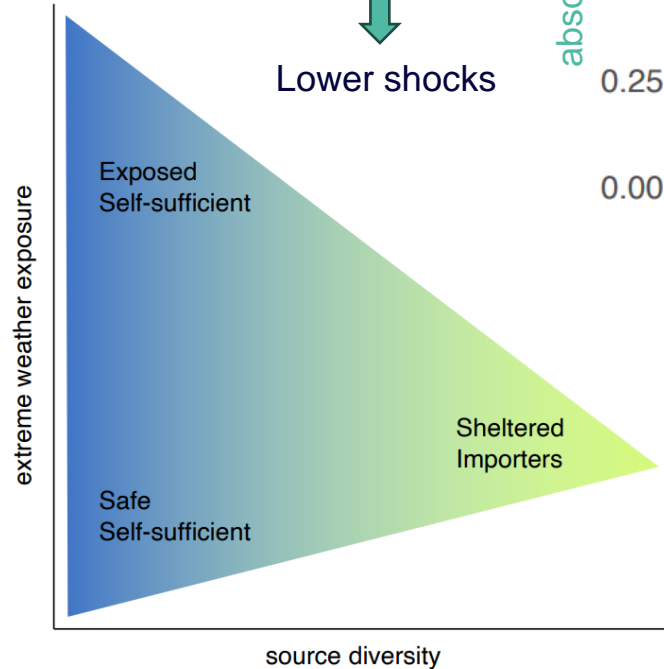
Proportion of years with 14 May-14 June max. daily temperature >27°C



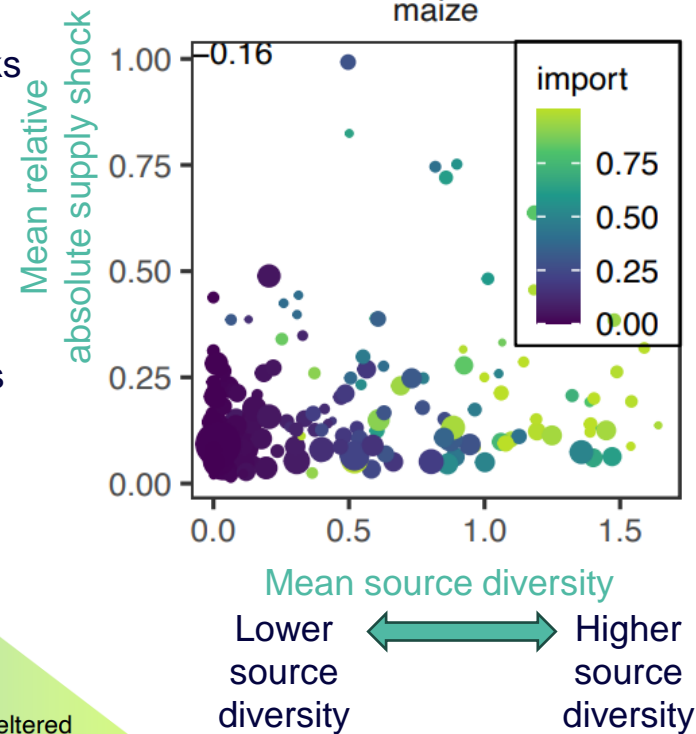
Cottrell et al., 2023

Does food supply diversity increase resilience to climate shocks?

- Detailed trade matrix + extreme weather indices (1987-2019)
- Countries with high source diversity have moderate exposure
- Wide range of exposure in countries reliant on domestic production
- Source diversification will increase resilience to supply shocks.



Greater shocks
 ↑
 ↓
 Lower shocks



Bebber et al. 2023, submitted.



Effectiveness of adaptation measures across farming systems

(drought, extreme heat & wildfires)

Upfront cost: high/moderate/low

Ffoulkes et al. 2023.

Quick wins



IMPACT	Low	<ul style="list-style-type: none"> 55. Adaptive management plan 64. Monitor weather forecasts 91. Rainwater harvesting 94. Water supply maintenance 		69. Diversify
	Medium	<ul style="list-style-type: none"> 60. Insurance 62. Farm advisory service 65. Monitor climate forecasts 70. Fire breaks 84. Spread suppliers 99. Emergency water bodies 	<ul style="list-style-type: none"> 28. Flexible operations 43. Change shift patterns 66. Implement emergency action plans 96. Upgrade water system 102. Farm level water management 	103. Water storage
	High		<ul style="list-style-type: none"> 44. Air-conditioning 	58. Restore degraded land
		Easy	Moderate	Difficult
EASE OF IMPLEMENTATION				

Quick-wins to adapt to heat stress and drought

General adaptations for all farms:

- Improve on-farm **water management**
- Ensure tractor cabs are **air-conditioned**
- Implement **fire breaks** between fields, hedgerows and woodland areas

Adaptations for crops:

- **Establish crops early**
- Choose **slow maturing** varieties
- **Water crops** at night
- **Increase irrigation** to aid harvesting in dry ground
- **Avoid harvesting** in the hottest parts of the day

Adaptations for livestock:

- Increase **diversity of forage** mix
- Use **deeper rooting forage** species to maintain pasture
- Plan to **transport animals at night**



Quick-wins to adapt to flooding and wet conditions

General adaptations for all farms:

- Improve **runoff containment** and drainage
- Develop a flood **contingency plan**
- Review power supply **flood resilience**



Adaptations for livestock:

- **Vaccinate** against new and prevalent diseases
- Develop a **control plan with vet** to help avoid key issues e.g. lameness in wet conditions
- **Plan grazing** to ensure spare paddocks are available during wet periods
- Improve **feed bin cleanliness and design** to reduce feed deterioration in wet conditions
- Install **free draining material** around housing to prevent waterlogging and flooding

Adaptations for crops:

- Increase **use of compost**, green manures and mulches
- Increase **soil organic matter**

Co-benefits of climate actions: land, ocean and ecosystems



EUROPE

		(Co)benefit or Trade-off Category				
		Economic	Ecosystem	Energy	Health	Socio-cultural
Land, Ocean and Ecosystems	Intervention / Action					
	+ A/M Agriculture and aquaculture improvements					
	+ M Dietary changes					
	+ A Nature-based solutions / Ecosystem-based adaptations					
	+ A/M Water and land resource management					

Potential for trade-offs or co-benefits

- Insufficient evidence
- Risk of trade-offs
- Mix of trade-offs and co-benefits
- Potential for co-benefits

Confidence

- Limited or no evidence
- Low confidence
- Medium confidence
- High confidence
- Very high confidence

Context sensitivity

- Unknown / limited evidence
- Low context sensitivity
- High context sensitivity

Adaptation / mitigation

- Adaptation only
- Mitigation only
- Adaptation and Mitigation

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Adaptation	Arable	Horticulture	Grazed livestock	Housed livestock	Wider food system	Net zero interactions
1. Changing location within the UK of different agricultural production types	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat; Excess rain		? +
2. New varieties / breeds of crops / livestock	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat	Drought; Heat		? / NA
3. Alternative crops	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat; Excess rain			+
4. Water management: Irrigation, water storage, drainage, and flood defences	Drought; Excess rain	Drought; Excess rain	Drought; Excess rain	Drought; Excess rain		-
5. Livestock housing			Heat	Heat		-
6. Agroforestry	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat		+
7. Controlled-environment agriculture		Drought; Heat; Excess rain				-
8. Transport and storage	Heat	Heat	Heat	Heat	Heat	-
9. Day-to-day operational decisions	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat; Excess rain	Drought; Heat; Excess rain		? +
10. Resilient international supply chains					Drought; Heat; Excess rain	?

Agroforestry and Soil Carbon

Climate adaptation, net zero and other implications

Agroforestry

- Carbon stored in soil & trees.
- Shade for animals during heatwaves
- Future-proofed species
- Water use?



Soil Carbon

- Carbon stored in soil
- Improved water retention – more drought/flood resilience
- Better productivity, healthier soil ecosystem
- Consider climate impacts on soil processes



2022 UK heatwave: agri-food impacts, adaptation and net-zero

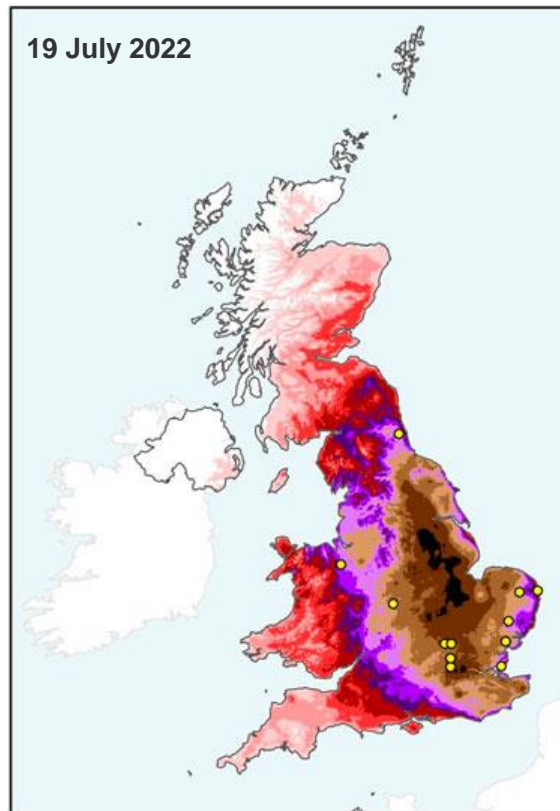
Poultry:

- Meat production 9% lower in July 2022 (vs. July 2021)
- Increased energy costs in production, refrigeration failures
- **Adaptation:** heat tolerant breeds, lower stocking density, **dehumidification cooling and misting systems**, nutritional supplements, **retail refrigeration resilience and efficiency**.

Wheat:

- Yields 8% higher than 2017–2021 average.
- Smaller increases in the South and East
- **Adaptation:** earlier maturing and heat/drought tolerant varieties, earlier autumn sowing, **targeted irrigation**, **soil/water conservation measures**.

Davie et al. 2023.



● Supermarket stores experiencing refrigeration issues

Building understanding of impacts, adaptation and trade-offs

Interdisciplinary community workshops: adaptation, policy,
trade-offs and consequences

Met Office

Impacts of weather and climate extremes on the UK food chain – scoping adaptation and policy responses and their consequences

13 and 20 January 2023



Audience-specific webinars
on building resilience



Countryside COP3
Enhancing Climate Resilience in UK agriculture: Webinar Series
Hosted by ADAS and the Met Office



Enhancing climate resilience on-farm: What's the challenge and how can we adapt to the changes?

Creating resilient agriculture supply chains:
Whose job is it to do what?

Supporting a resilient agri-food sector:
What are the big questions decision makers face?

- **Cold chain and storage** (carbon costs)
- **Local** (economy, climate risks) vs. **international food systems** (novel food safety risks)
- **Waste reduction & re-use**
- **'Costs' of resilience** – performance under 'normal' conditions



Video part 1 of 4
Links to parts 2-4 in comments

Concluding thoughts

- **Risks and opportunities for UK food security** – domestic and overseas
- **Whole food chain, systemic approaches and evidence** needed that consider all of:
 - **adaptation and resilience**
 - **net zero**
 - **Broader win-wins/trade-offs and consequences**
- **We need to work together to support adoption, and implementation** amongst farmers & wider industry – needs effective dialogue and co-design

