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Key Issues in Agricultural Science

Professor John Beddington

Chief Scientific Adviser to HM Government and
Head of the Government Office for Science

5 January 2010
The Frank Parkinson Lecture
Oxford Farming Conference

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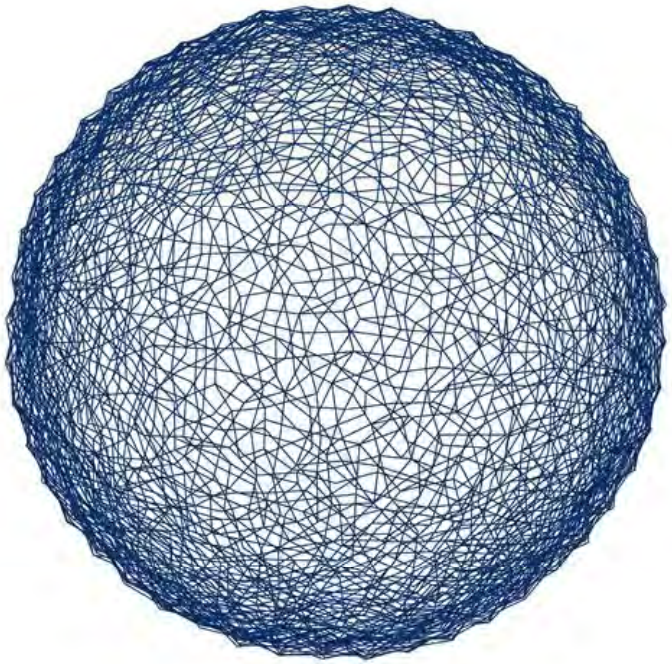
Post Copenhagen?



COP15
COPENHAGEN
UN CLIMATE CHANGE CONFERENCE 2009

The Copenhagen Accord provided a commitment to hold the increase in global temperatures below 2^0C, but key questions remain:

- What is the role of farming practices in mitigation and adaptation?
- How can science and engineering support the farming industry?
- What are the key research needs to fill the technology gaps?

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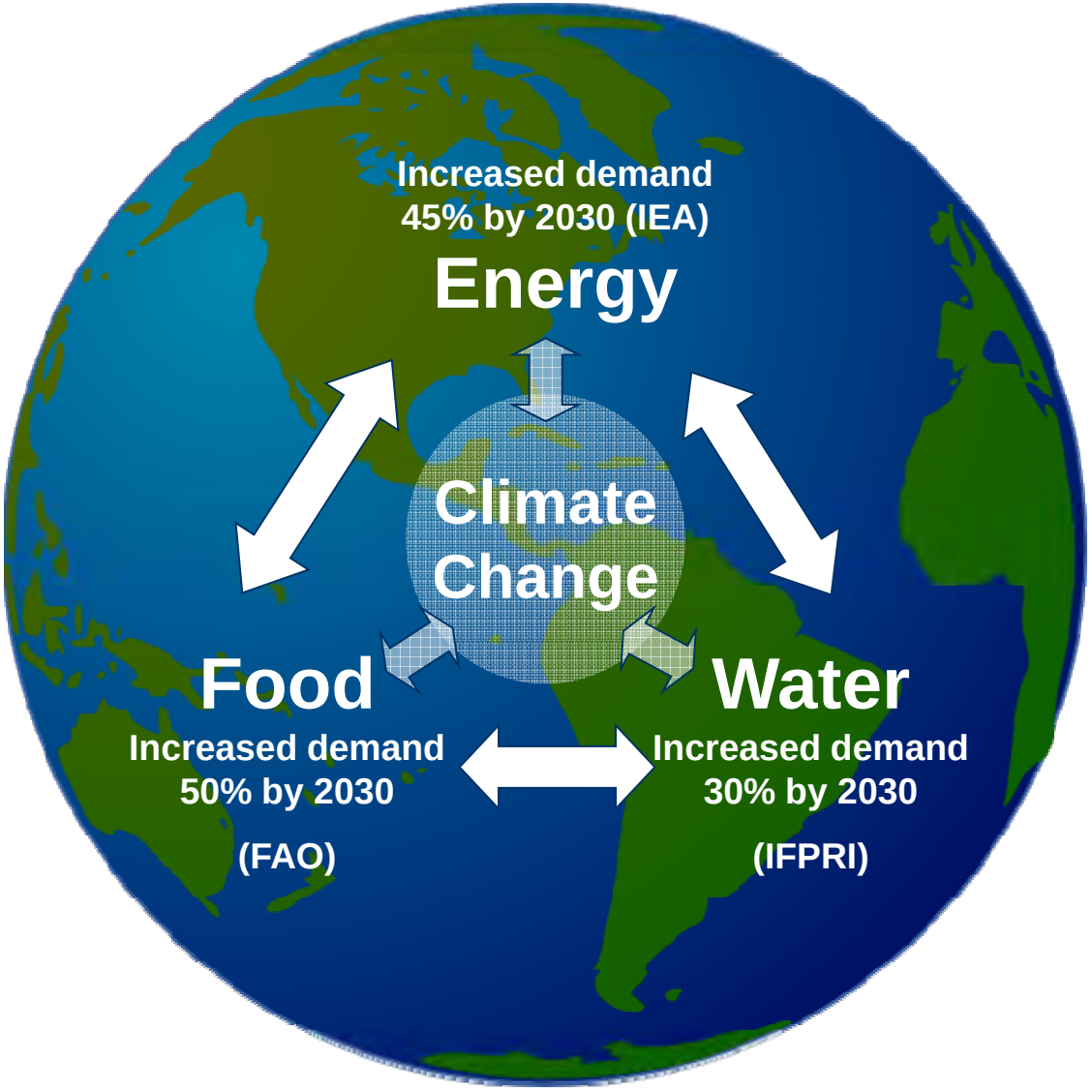
Climate change is only part of a *Perfect Storm* of global events

1. Increasing population
2. Increasing levels of urbanisation
3. The rightful goal to alleviate poverty
4. Climate Change



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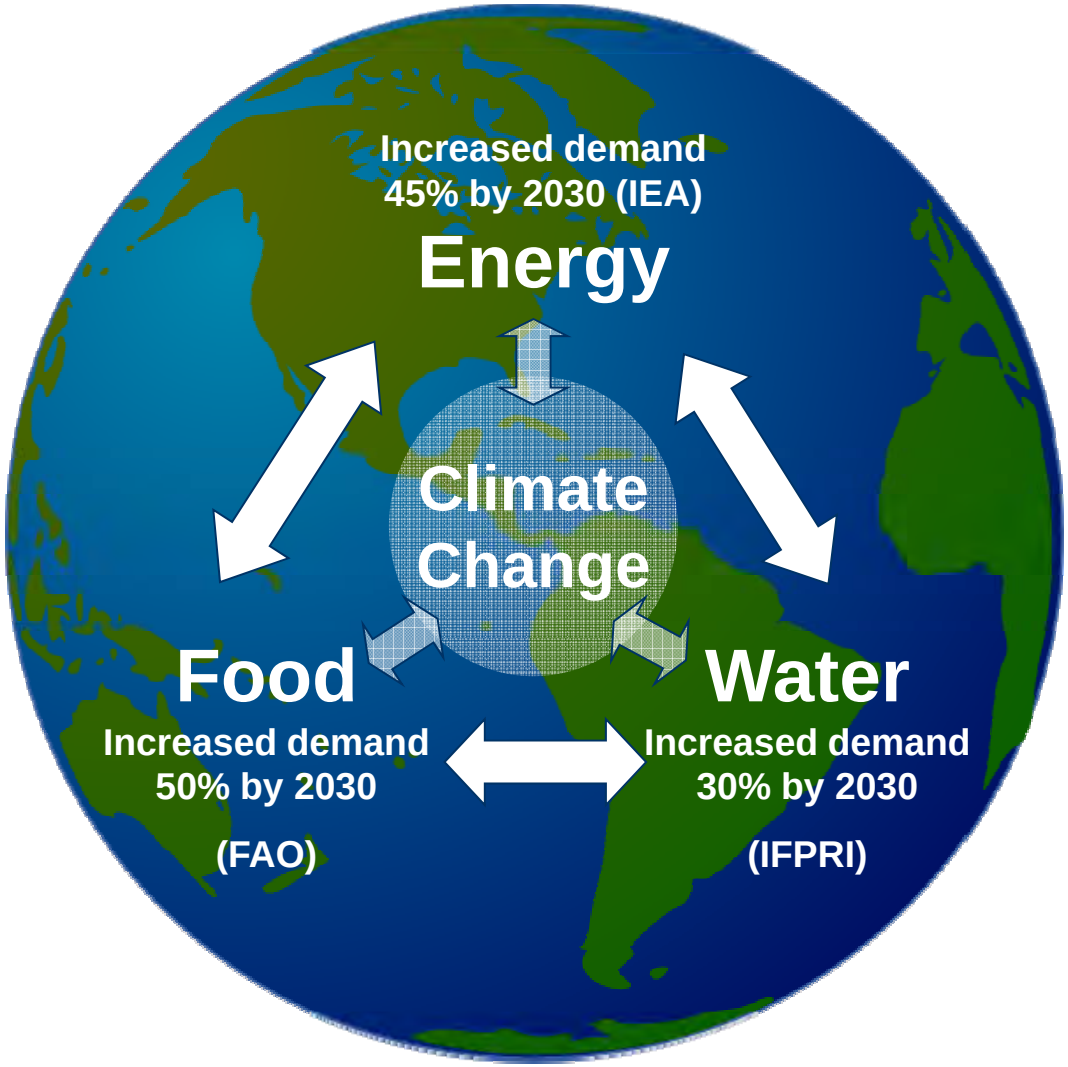
Key questions



1. Can 9 billion people be fed equitably, healthily and sustainably?
2. Can we cope with the future demands on water?
3. Can we provide enough energy to supply the growing population coming out of poverty?
4. Can we do this whilst mitigating and adapting to climate change?
5. How does engineering and science help in preventing and adapting to this **perfect storm** scenario?

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Impacts of global temperature rise

+2°

PROBLEMATIC

- 1 - 2 billion additional people with water stress
- Impacts on cereal productivity at low latitudes
- Increased coastal flooding and storms
- Greater depth of seasonal permafrost thaw

+4°

DISASTROUS

- A 16 °C increase in the Arctic
- 1.1 - 3.2 billion additional people with water stress
- Widespread coral mortality; risk of major extinctions around the globe
- Substantial global impact on major crops
- Long-term prospect of sea level rise

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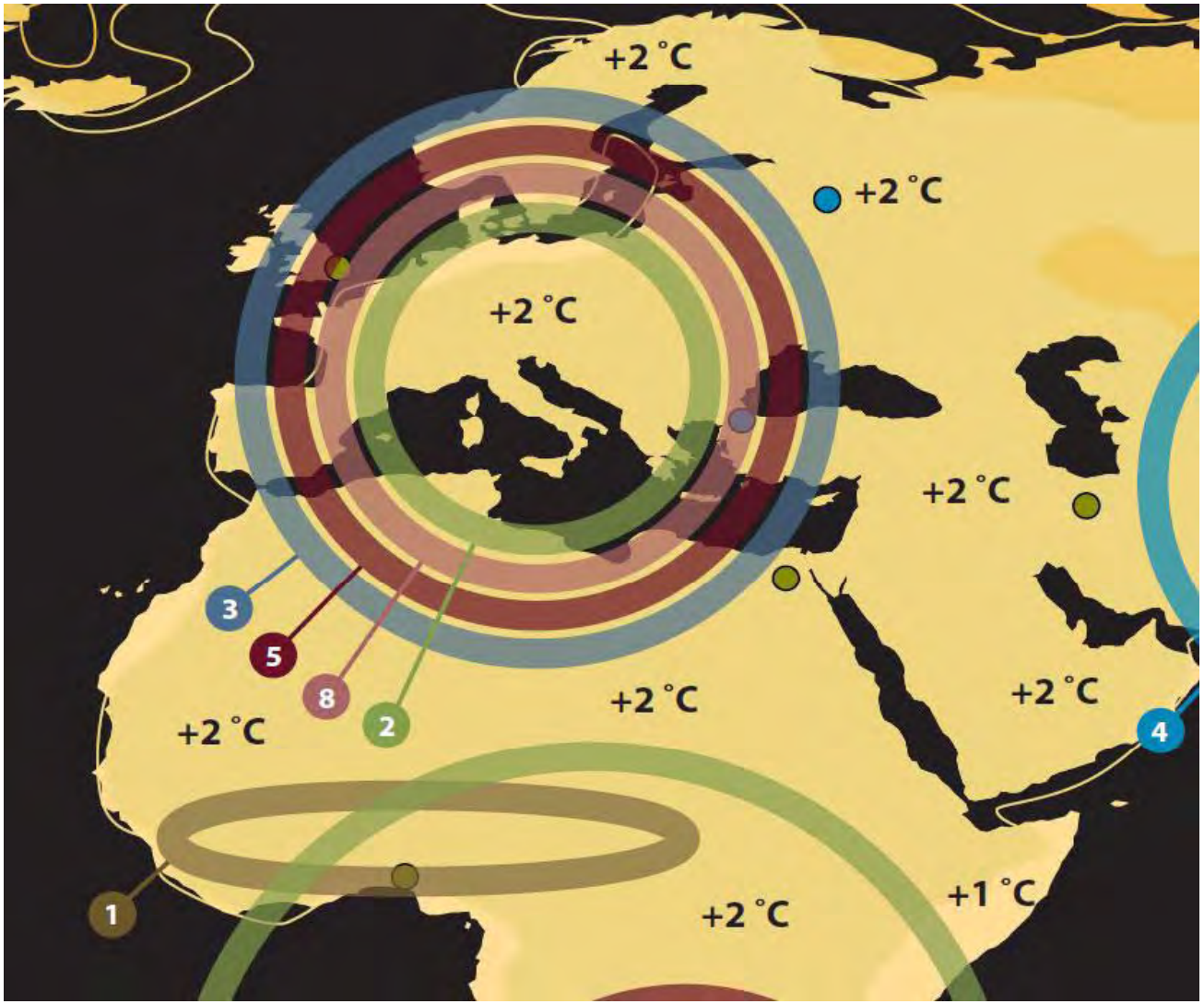
Europe + 2°C



2. Production of some cereal crops may increase (*green ring*)

3. Changes in rainfall patterns (*blue ring*)

5. Drought events one and a half times as frequent (*red ring*)

8. Hottest days across Europe could be as much as 6°C warmer (*pink ring*)

Source: Met Office

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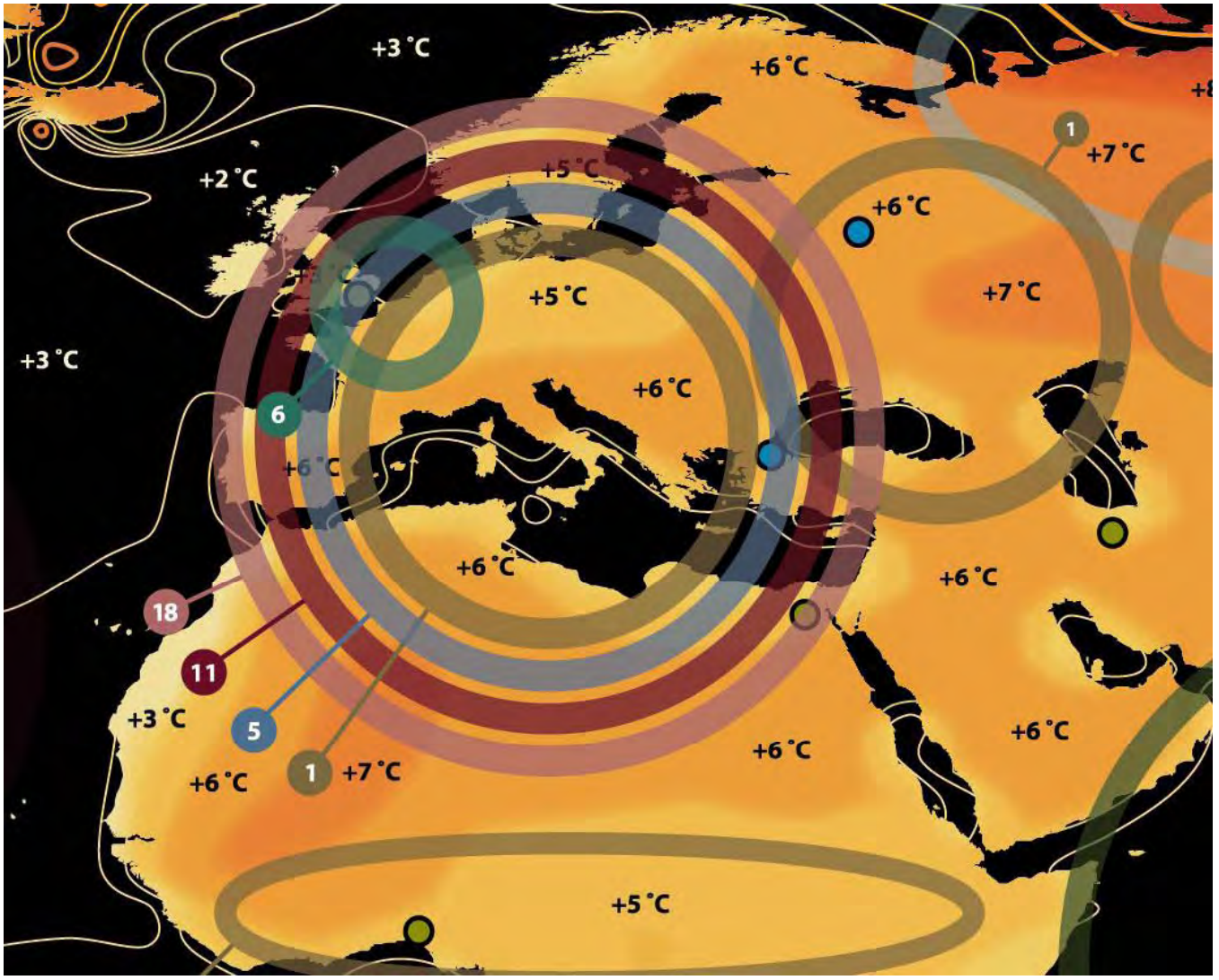
Europe + 4°C



1. High forest-fire danger *(grey ring)*

5. 70% reduction in river and stream flow *(blue ring)*

6. Sea-level rises and storm surges *(green ring)*

11. Drought in Mediterranean basin *(red ring)*

18. Hottest days of the year across Europe up to 8 °C warmer (*pink ring)*

Source: Met Office

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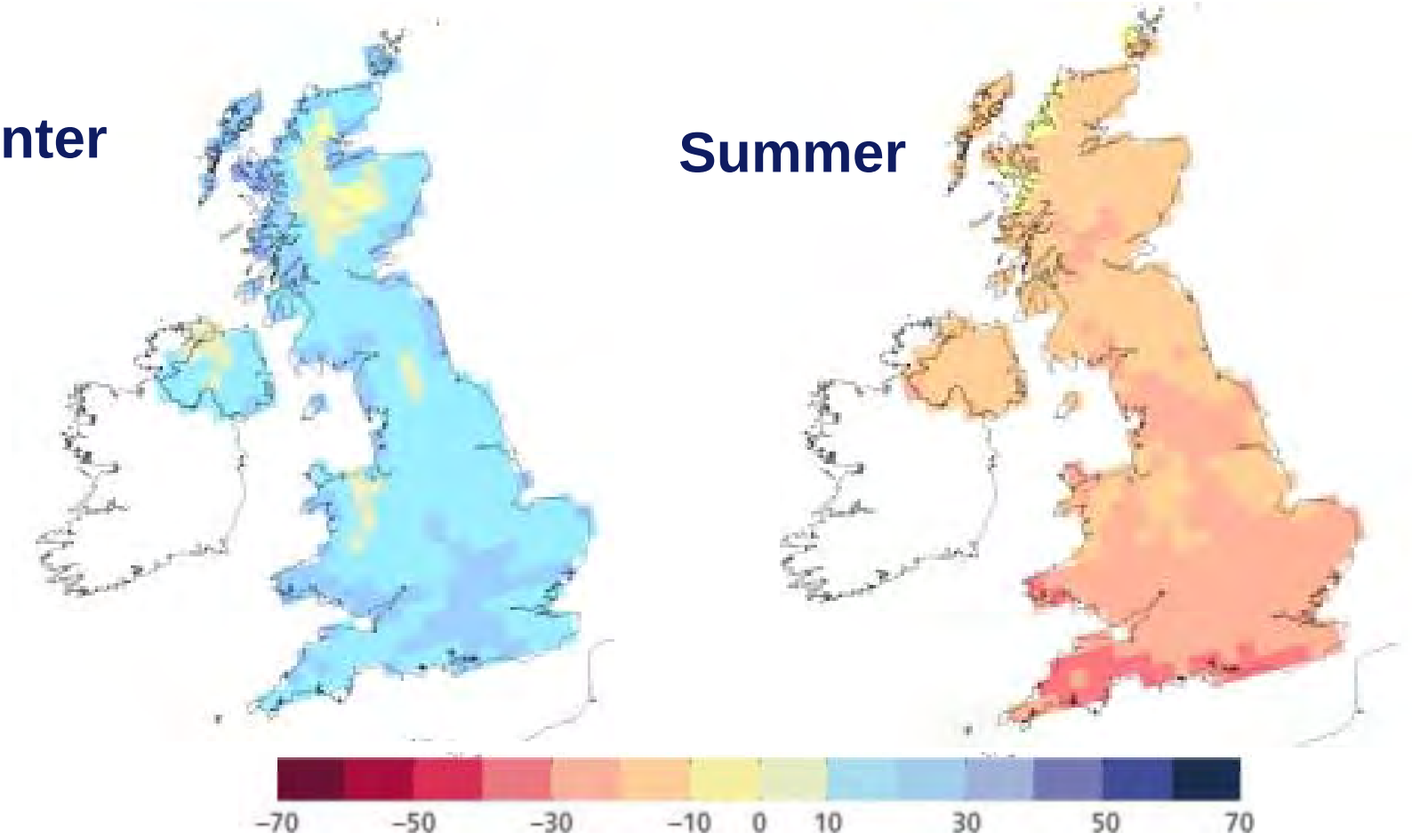
Climate change effects on the UK

Changes in mean precipitation to 2080, 50% probability estimate

Winter

Summer



Source: UKCP09

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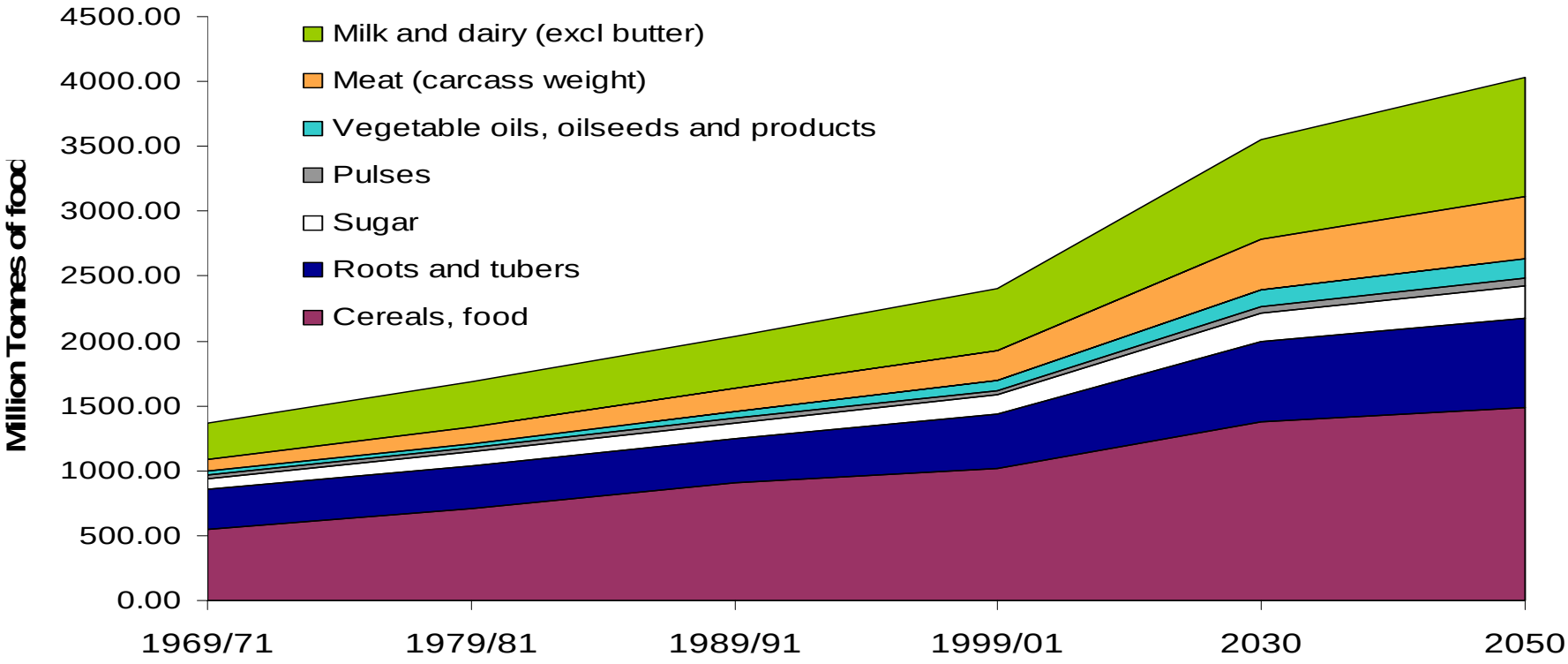
Increased demand for food

World food requirements



World food production must rise by **50 % by 2030** to meet increasing demand (*Source*: *UN 2008)*

Source: FAO / UN

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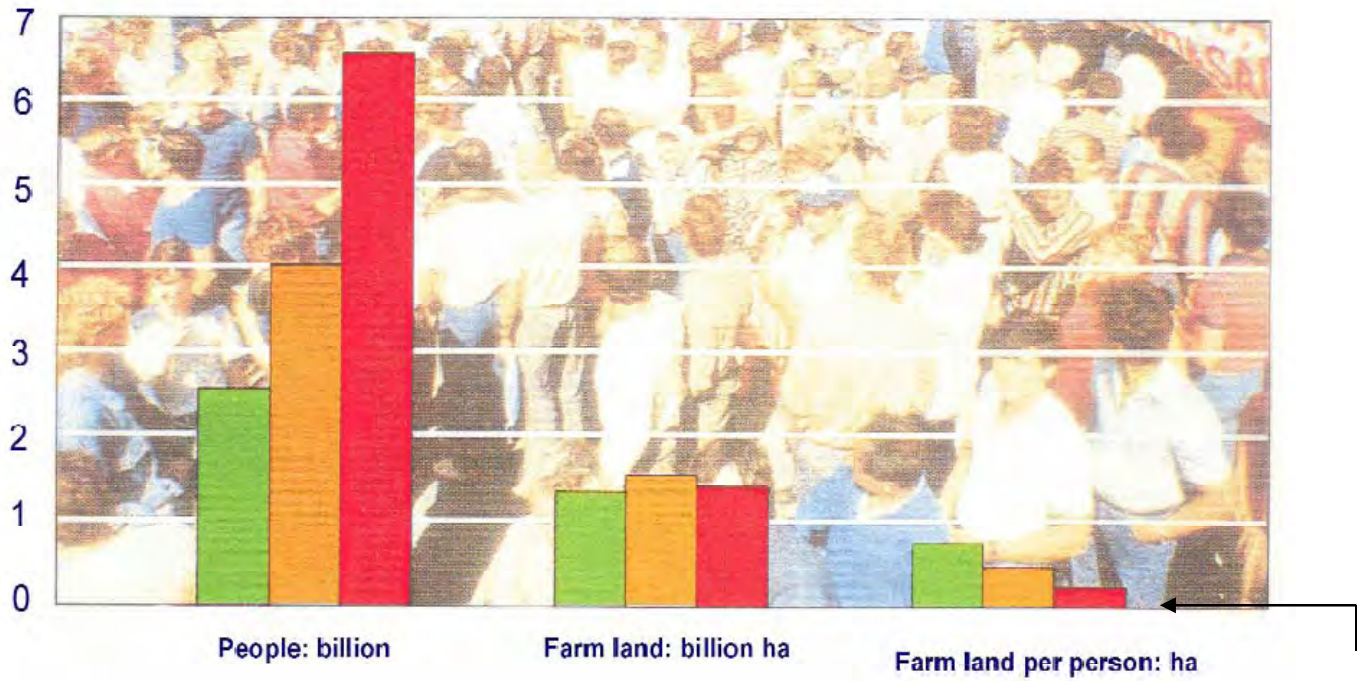
The problem of land availability

More people means less cultivated land per person for food, feed, (agro)-fuel and fibre production

2030 – 8.3 bn people



2030 – even less farmland per person

IAASTD
International Assessment of Agricultural Science and Technology for Development

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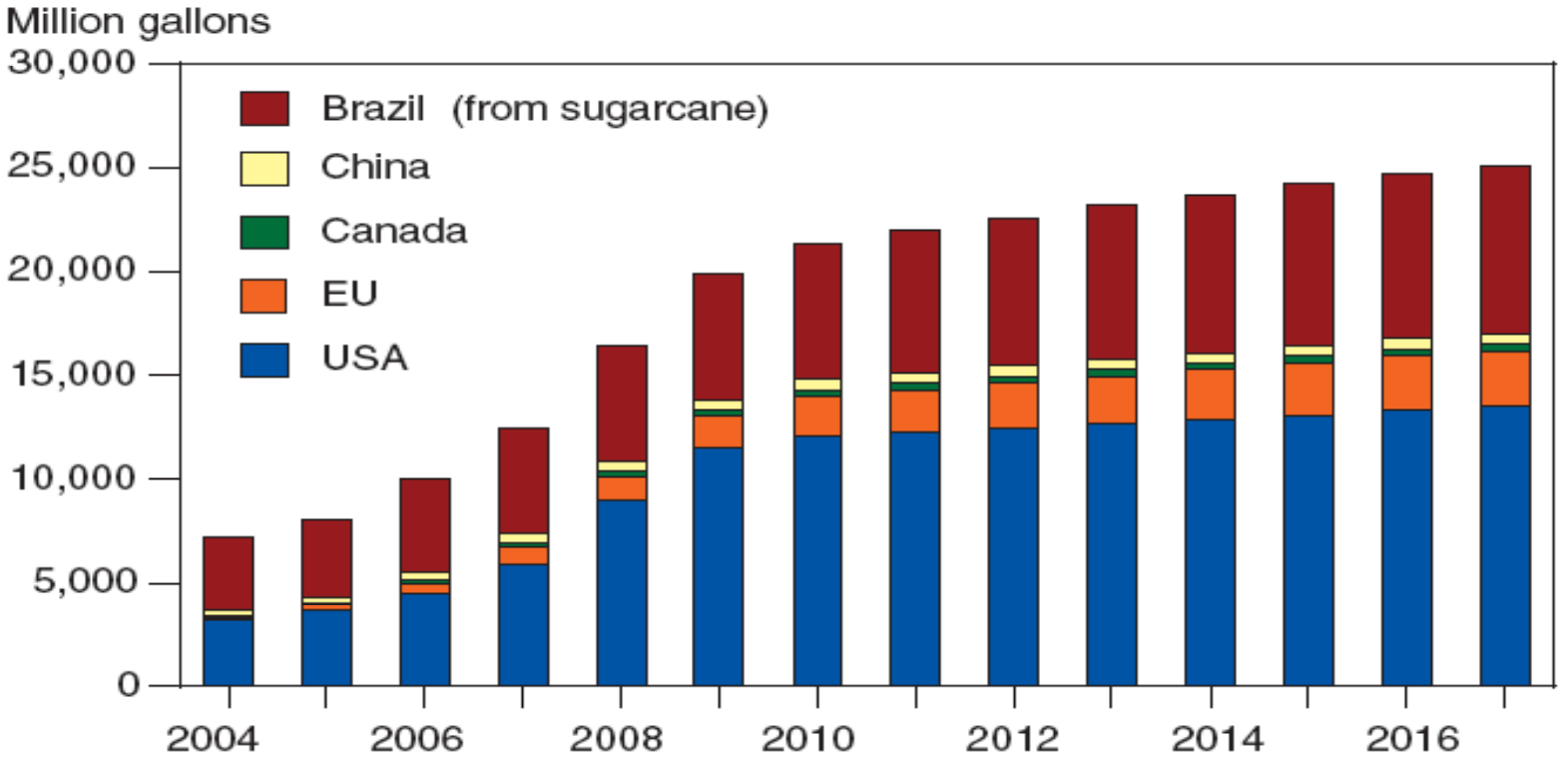
Demand for biofuels: potential competition with food?

Ethanol production

mostly from grain feedstocks except for Brazil



Source: USDA Agricultural Projections to 2017

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The challenge for agriculture

Need:

50% more production on less ***land***, with less ***water***, using less ***energy***, ***fertiliser*** and ***pesticide*** …

…by 2030

… whilst not increasing ***GHG emissions***

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Challenges and opportunities

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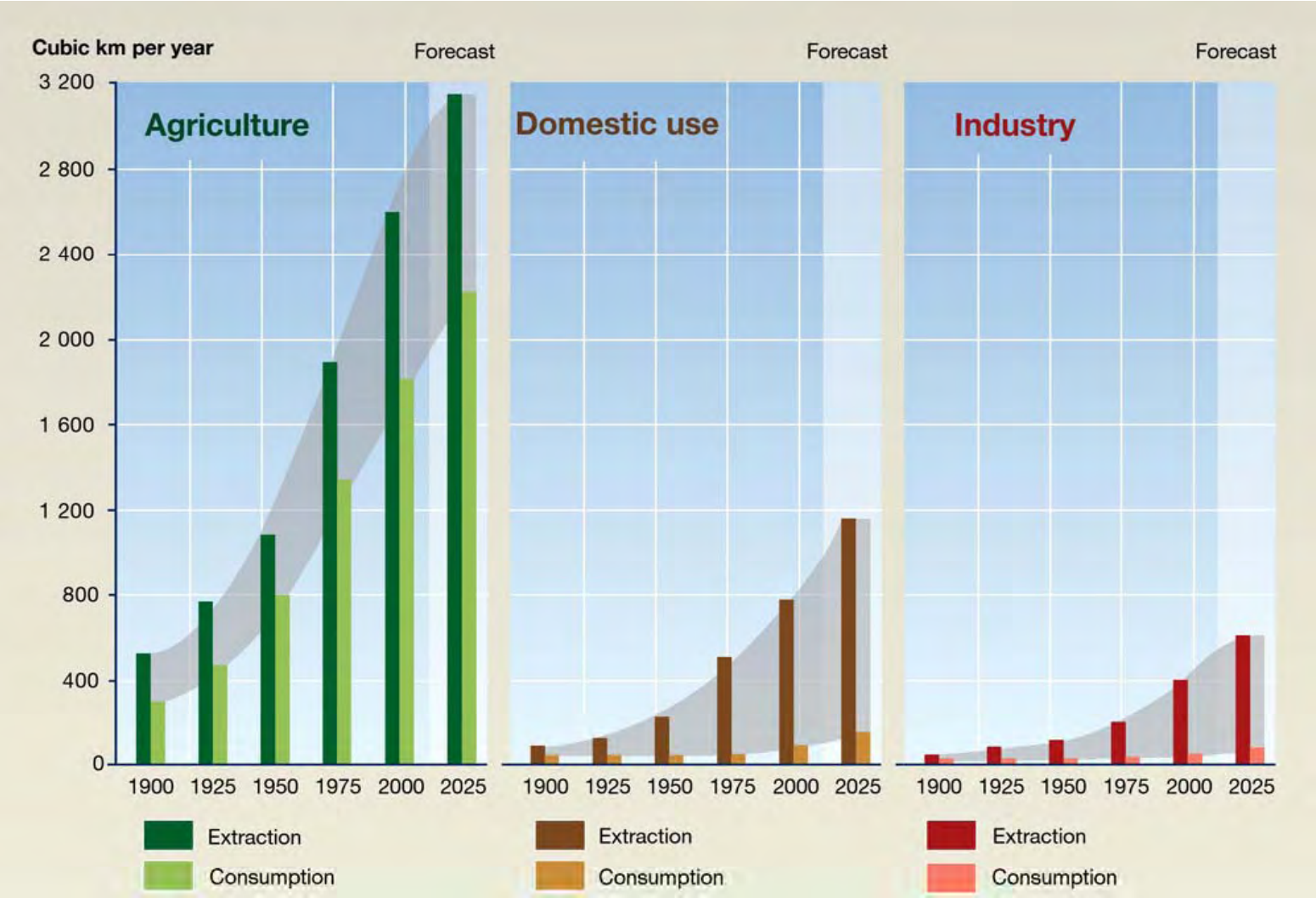
The Challenge: Increasing fresh water use



Source: United Nations Environment Programme 2008

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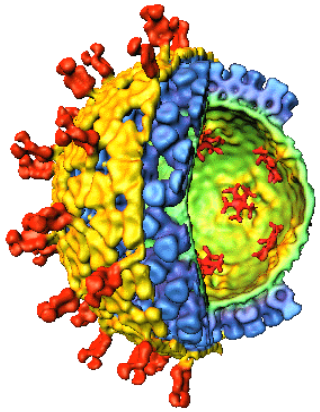
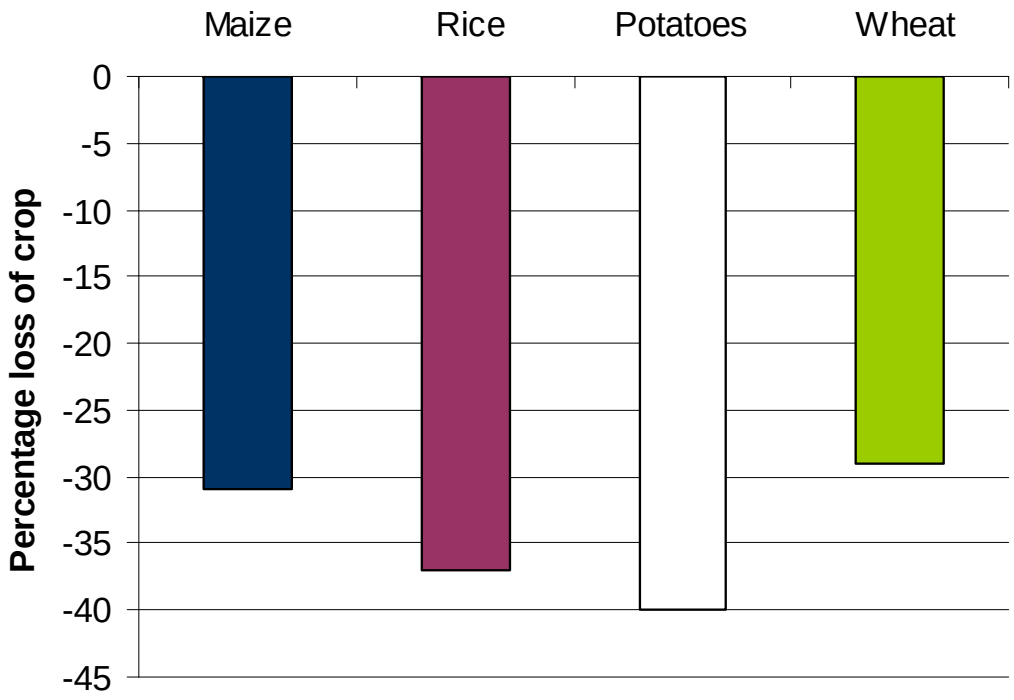
The Challenge: Diseases in crops and livestock

Major livestock diseases:

- Avian Influenza
- BSE
- FMD
- Bluetongue
- Bovine TB
- Rabies
- Scrapie



Current losses due to pests and diseases worldwide



(Oerke, 2006)

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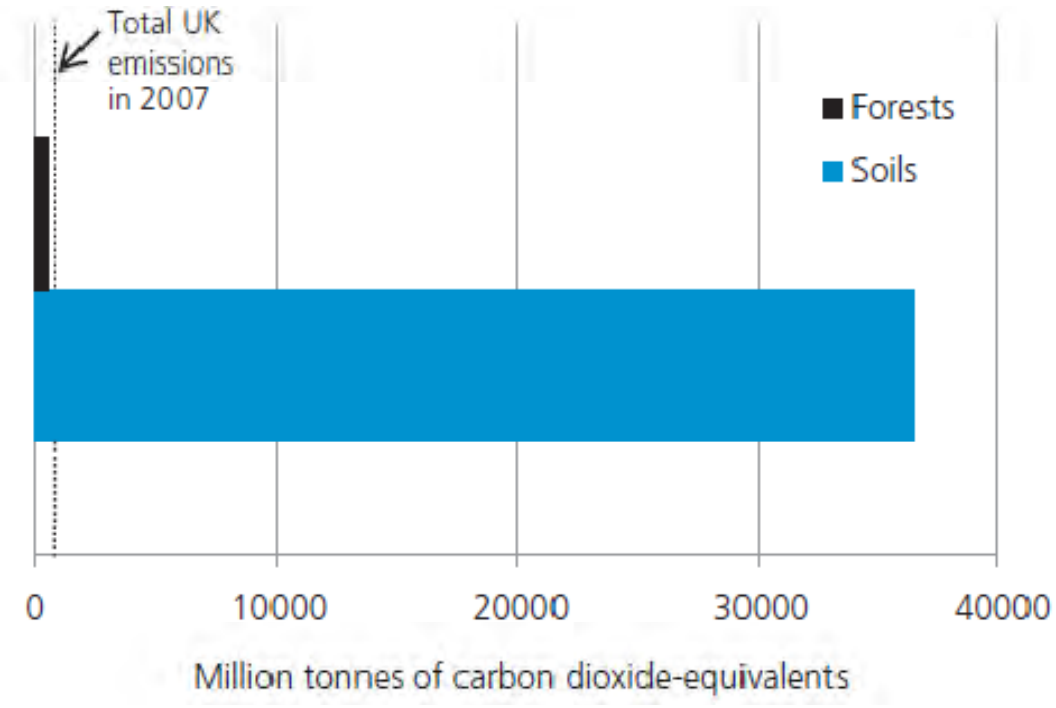
The Challenge: Soil management

Carbon Dioxide equivalents stored in UK forests and soils



Source: Defra

Areas potentially at risk from soil erosion

Source: Boardman, J. and Evans, R. (2004). Soil Erosion in Europe.

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Opportunities for science and engineering

- **Improved crop varieties** to increase yields through drought tolerance and pest resistance
- **Smarter and reduced use of fertilisers and pesticides**
- **Non-chemical approaches** to crop protection in the field and to store crops safely
- **Novel methods** to conserve and manage soil
- **Royal Society Report,** *Reaping the Benefits* examines the contribution of biological sciences to food crop production

Plants grow in an oasis next to the desert in Dunhuang, Gansu province

Techniques and technologies from many disciplines, ranging from **biotechnology** (including plant genomics and genetic modification) and **engineering** to **nanotechnology** will be needed

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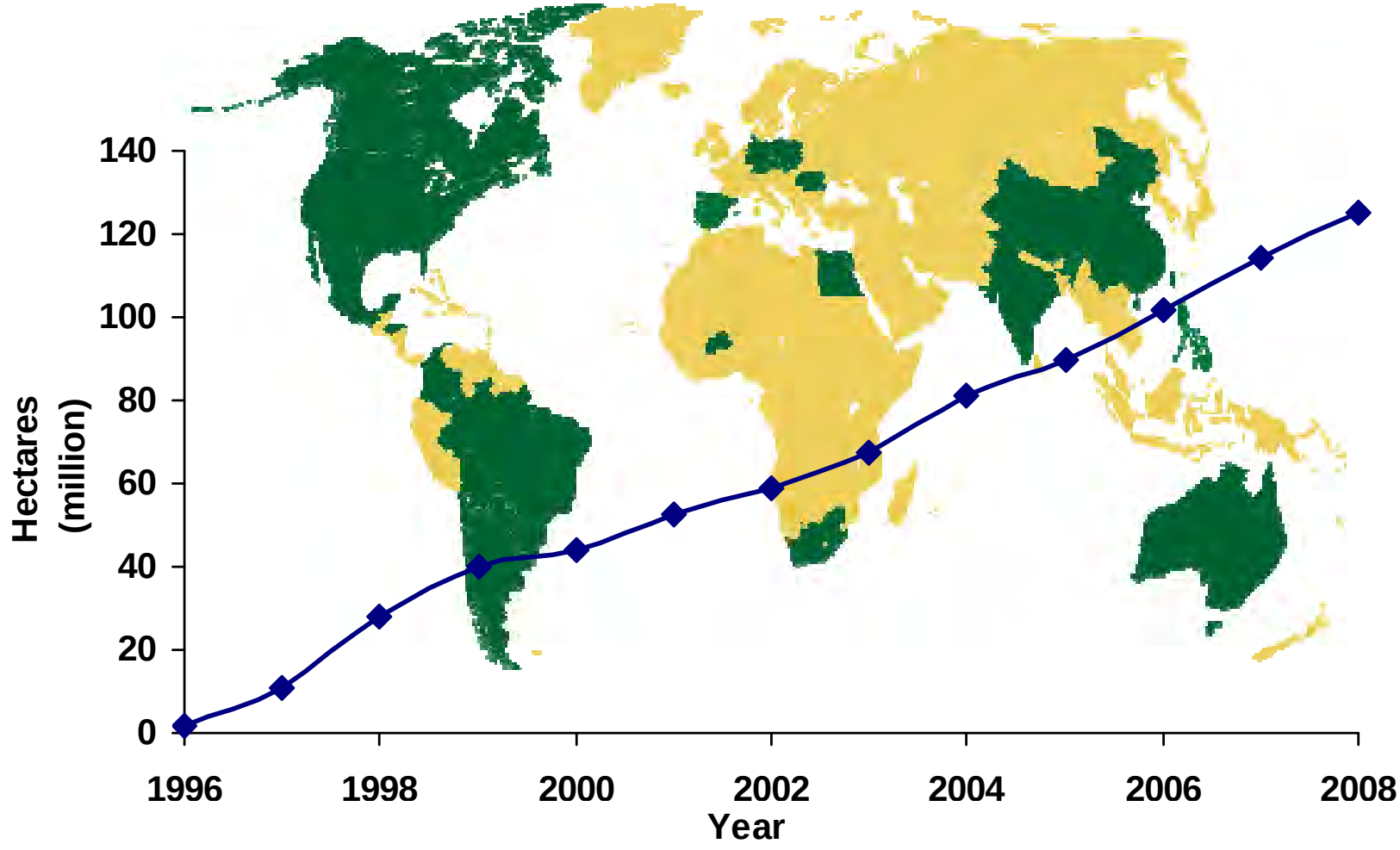
The Challenge: Regulation on biotechnology and GM

Global area of biotech crops 1996-2008 (million hectares)



25 countries that have adopted biotech crops

Source: ISAAA, 2008

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Regulation should be proportionate and evidence based

"All substances are poisons, there is none which is not a poison. The right dose differentiates a poison from a remedy."

Paracelsus, 1493-1531

Risk = Hazard x Exposure

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UK Agricultural Research

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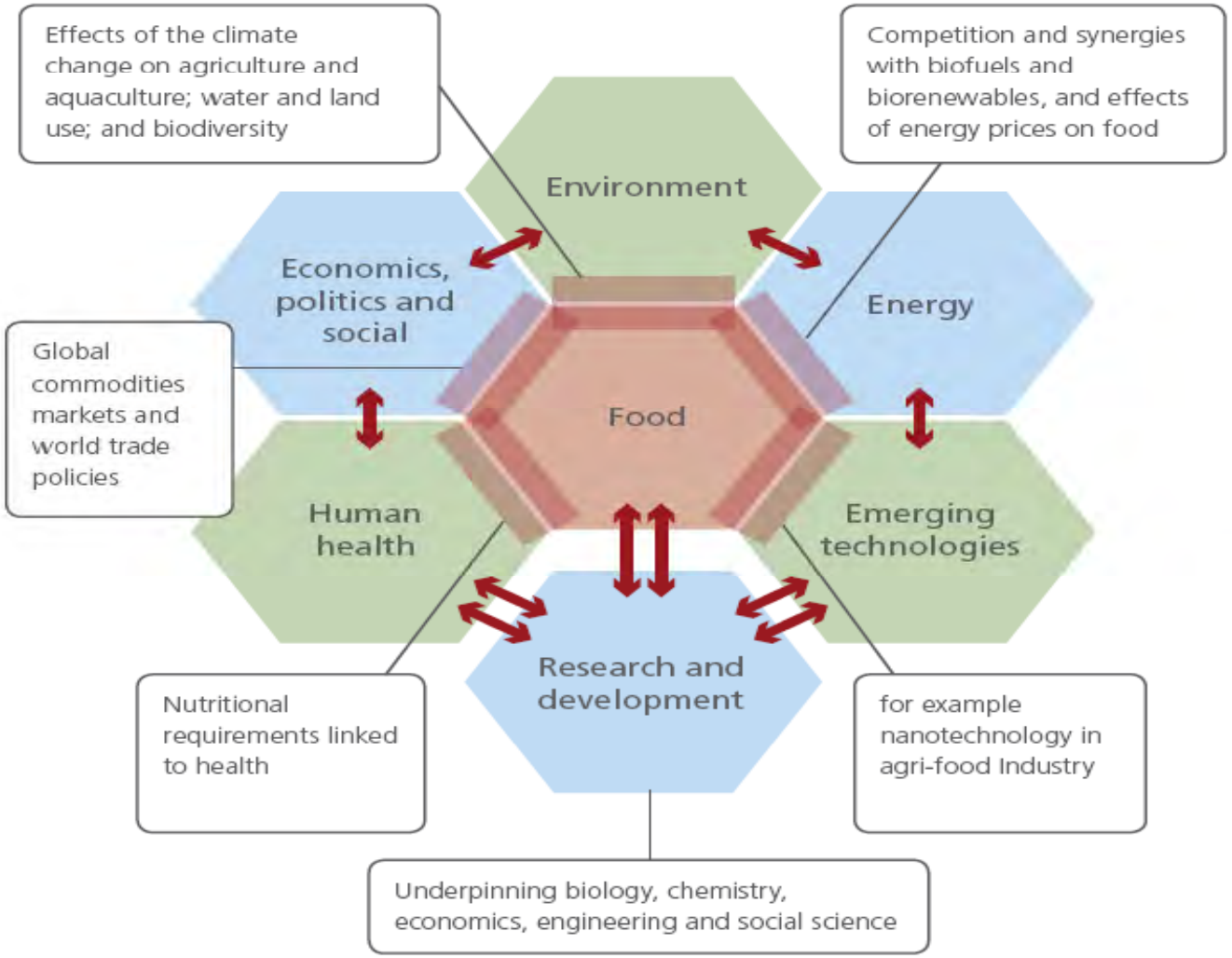
Food research is complex and multi-disciplinary



Source: Food 2030, Defra, Jan 2010

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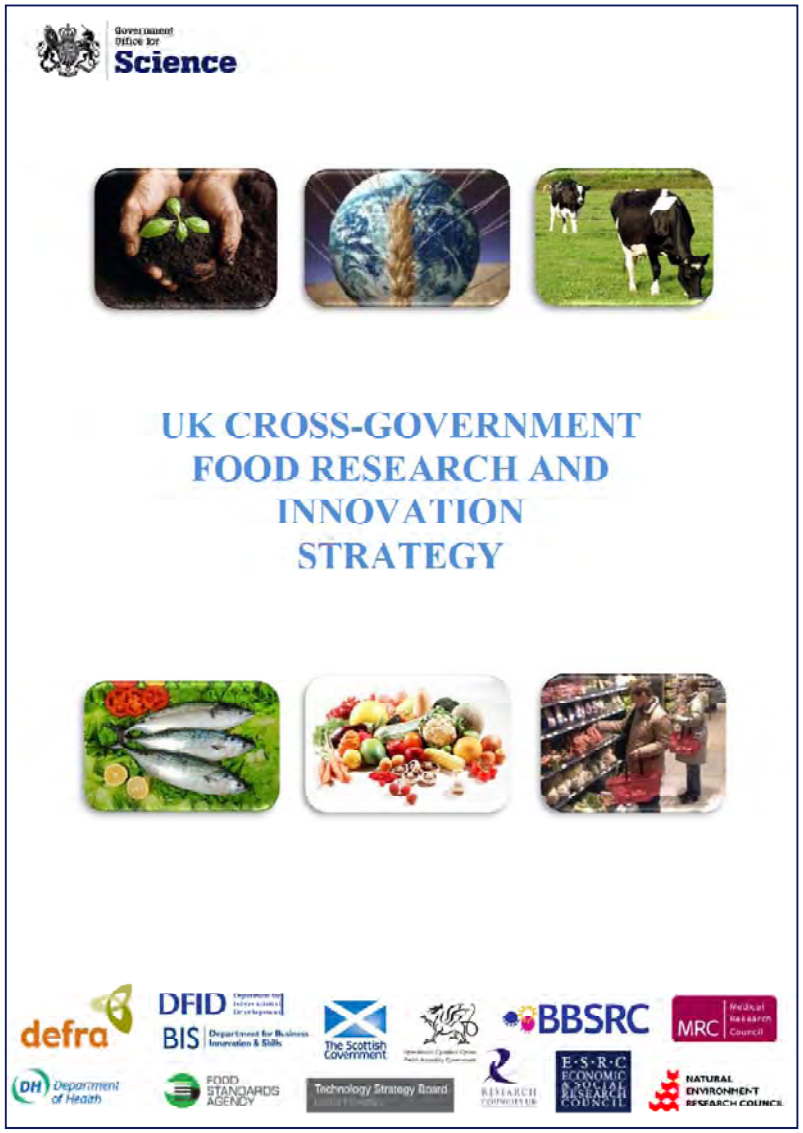
UK food research needs a co-ordinated strategy



Areas of Focus:

- Presenting a coherent approach
- Promoting co-ordination and collaboration
- Addressing cross-cutting issues (e.g. skills, translation)

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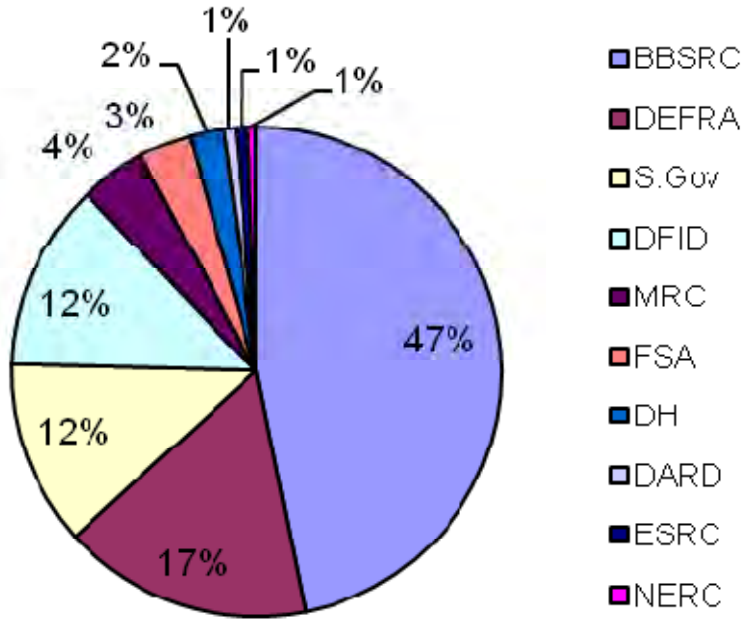
UK food research

Government food research spend 2008 / 09

UK is recognised internationally for its research on:

- Agriculture
- Animal health and welfare
- Aquaculture and fisheries
- Climate change
- Economic and social modelling
- Food safety
- International development



Estimated total spend = **£415m**
(from £408m in FY07/08)

Source: UK Government Food Research and Innovation Strategy, Jan 2010

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Research Skills

Perceived supply gaps in niche skills base:

- **Crop production** - agronomy, forage crops, plant physiology, pathology and general botany, plant-soil interactions, weed science, entomology/pest biology, chemicals and pesticides, agricultural engineering, post-harvest storage, soil science and conservation, agricultural economics**;**
- **Livestock production** - ruminant and veterinary microbiologists/pathologists/ parasitologists, animal genetics, animal physiology and nutrition;
- **Fish production** – freshwater taxonomists/ecologists; and
- **Environmental science** – soil and water management, wildlife conservation.

Source: Food Research Partnership Working Group

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Mitigating GHG emissions

Areas of Focus:

- *GHG* – new technologies, management systems and evaluation tools to reduce emissions;
- *Waste* – prevention, re-use and disposal of agricultural waste; and post-harvest technology;
- *Energy* – off-farm generation of electricity from renewable agricultural sources; harnessing renewable energy and reduce overall energy consumption on farm;
- *Water* – sustainable water management strategies; reduction in water usage; evaluation of water footprint on farm; and
- *Nutrients* – use of fertiliser (organic and inorganic) and other chemical inputs.

For example, % change in emissions per tonne product through genetic improvement (1988-07)

	CH_4	NH_3	N_20	GWP_{100}
Layers	-30	-36	-29	-25
Broilers	-20	10	-23	-23
Pigs	-17	-18	-14	-15
Dairy	-25	-17	-30	-16
Beef	0	0	0	0
Sheep	-1	0	0	-1

Route of Livestock Emissions	% contribution
Enteric fermentation	39
Manure CH_4	4
Manure N_2O	3
Indirect eg Energy for feed	53

Sources: Project for Defra by Genesis Faraday and Cranfield University (AC0204), 2008; Gill, 2009

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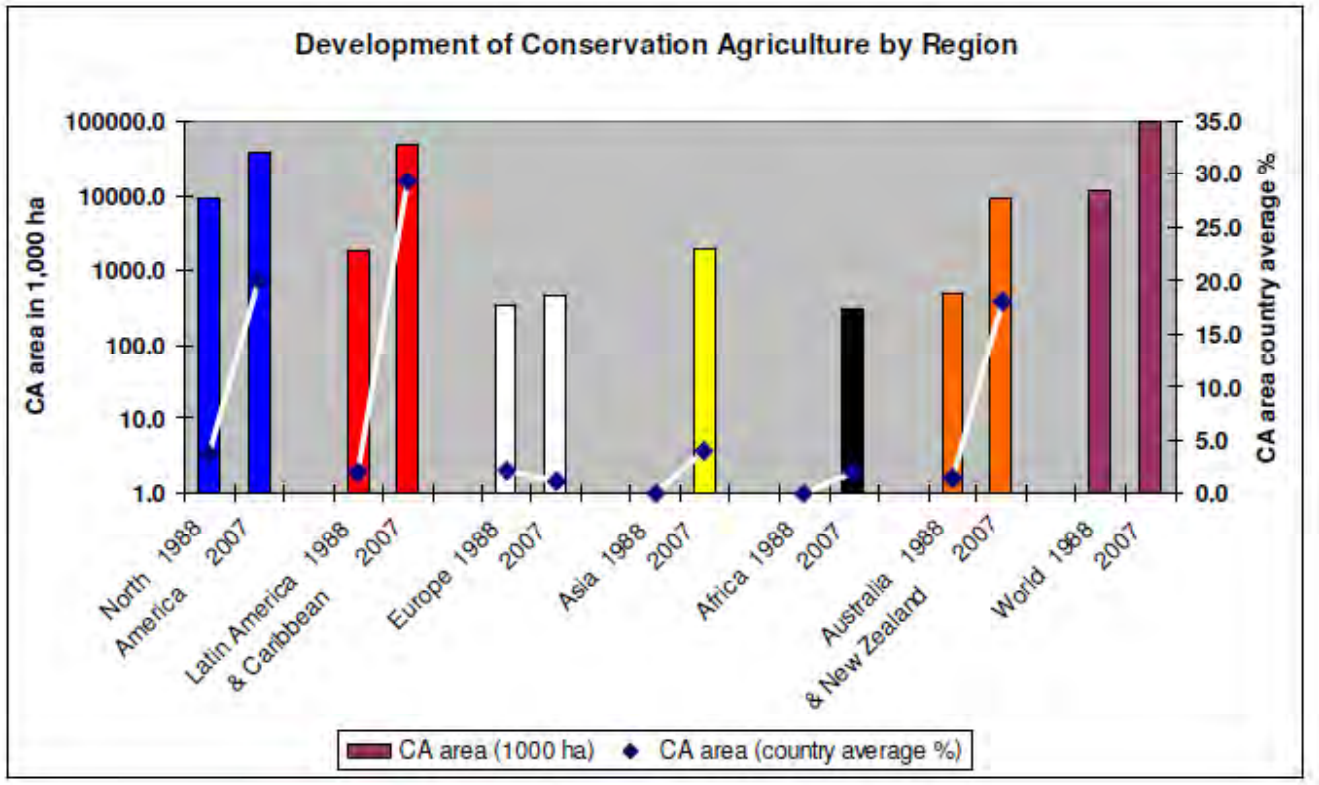
Sustainable Ecosystems

Changing world agricultural practice

Areas of Focus:

- Whole systems approaches to land management practices;
- Maintenance of natural resources;
- Management of competition for farm land;
- Maintenance of ecosystems services;



- Management of agricultural waste;
- Reduction in crop losses (field and post-harvest); and
- Socio-economic understanding of farmer practices and the supply chain.

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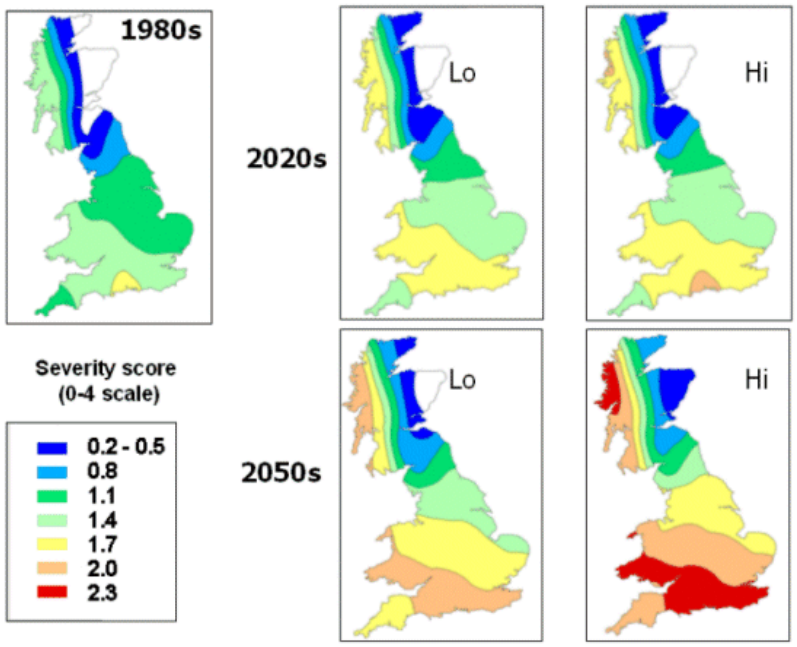
Sustainable food production and supply – Crop Production

Areas of Focus:

- Optimised efficiency of resource use;
- Enhanced nutritional composition;
- Better protection against losses to pests, disease and weeds;
- Enhancing tolerance to abiotic stresses;
- Effective use of advanced crop breeding programmes;
- Monitoring and surveillance of crop diseases and insect pests;
- Exploring nitrogen fixation by non-legume crops; and
- Improved efficiency of photosynthesis.

<u>Production threatened by climate change</u>

For example, range and severity of phoma stem canker increased by global warming



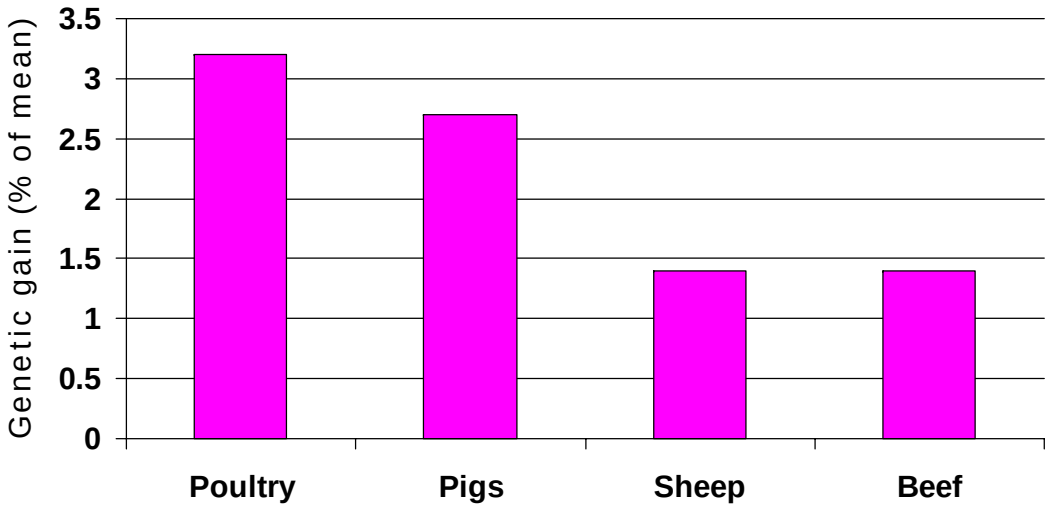
Source: Rothamsted Research 2007

Sustainable food production and supply - Livestock Production

Areas of Focus:

- Animal breeding for improved yield, quality, and welfare;
- Genetic diversity and use of rare breeds;
- Vaccine development for endemic and exotic diseases;
- Improved diets and associated management systems;
- Reduced impact of GHG emissions; and
- Improved monitoring and surveillance of animal diseases.

Rates of genetic change expected in farm livestock



Expected response to selection for growth rate

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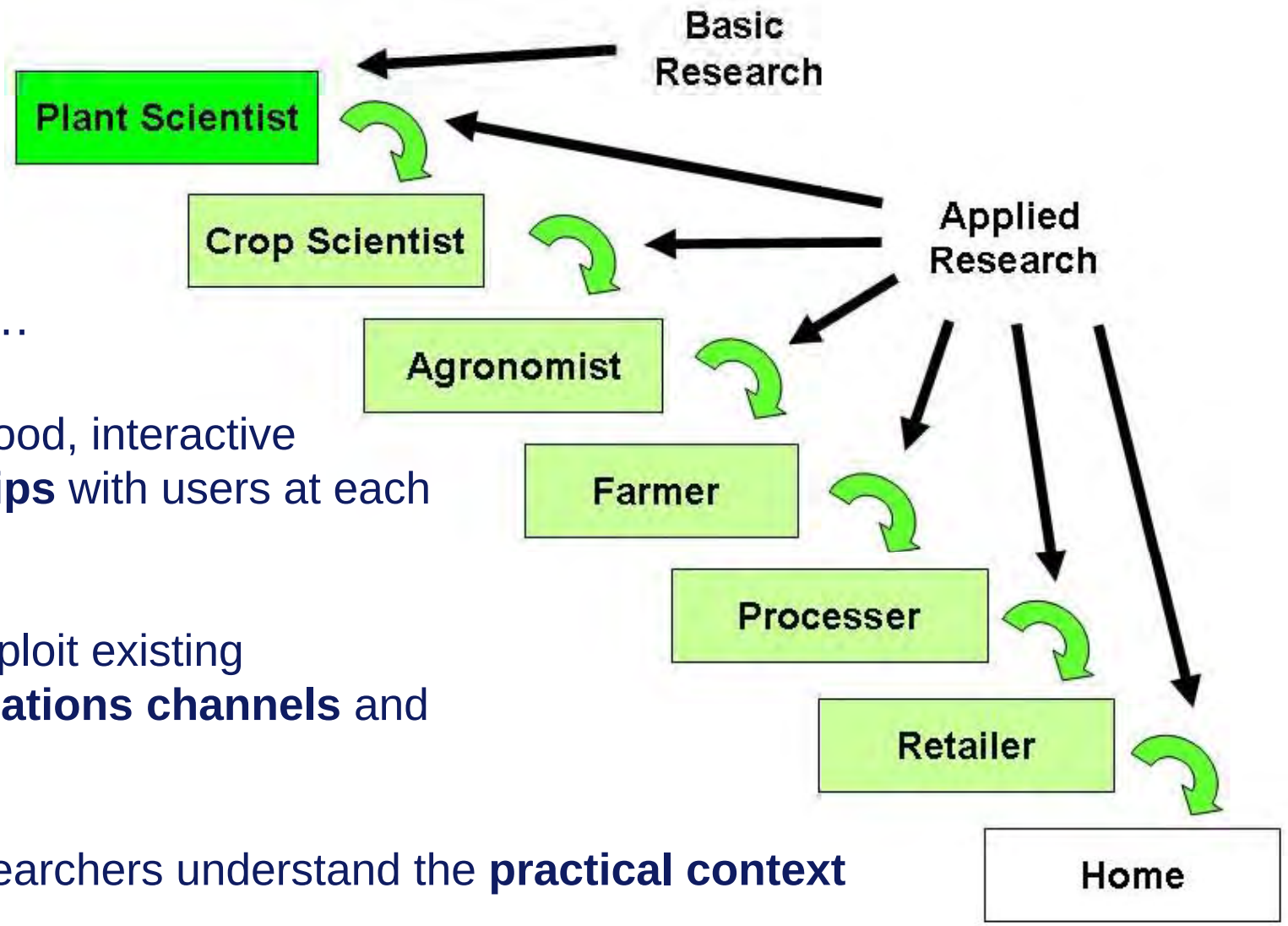
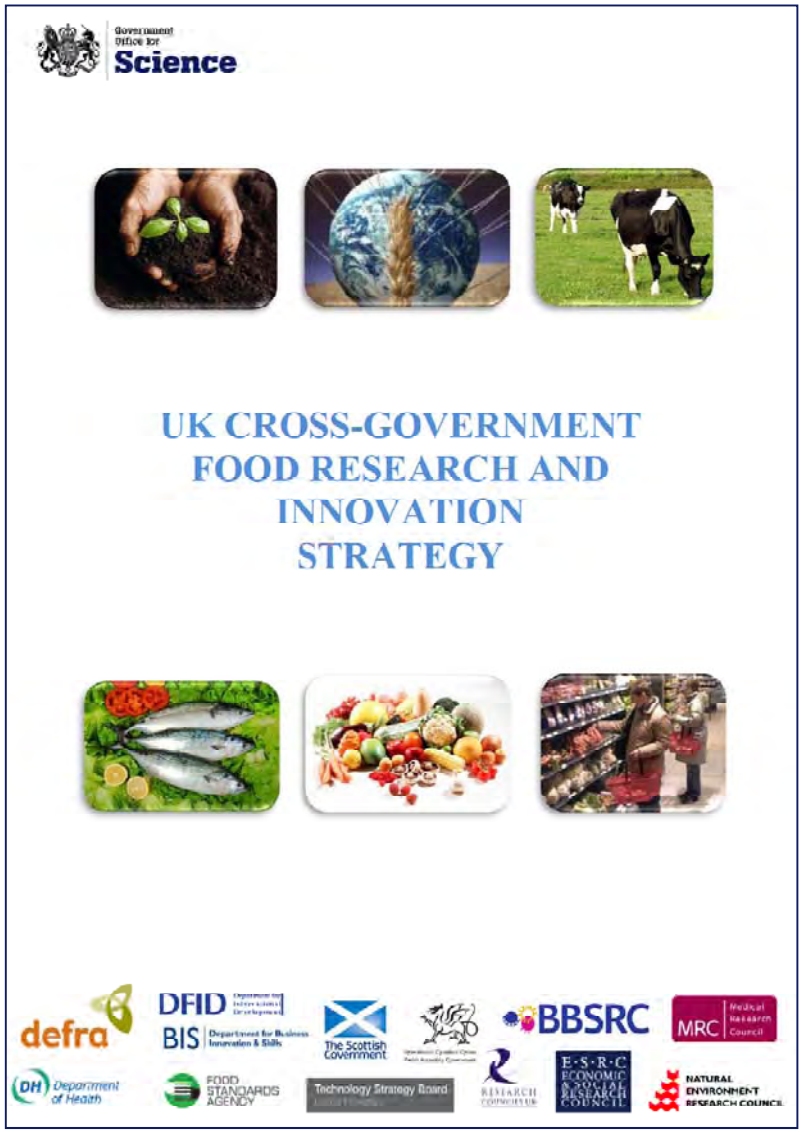
Innovation Chain



We need to…

- establish good, interactive **relationships** with users at each stage
- use and exploit existing **communications channels** and networks
- ensure researchers understand the **practical context** for farmers

A co-ordinated UK food research and innovation strategy



Highlights:

- New multi-partner food security research programme
- New Sustainable Agriculture and Food Innovation Platform
- A new Advanced Training Partnership scheme
- Foresight Project on Global Food and Farming Futures - looking out to 2050 and will take a global view of the food system. Due to be launched in October 2010