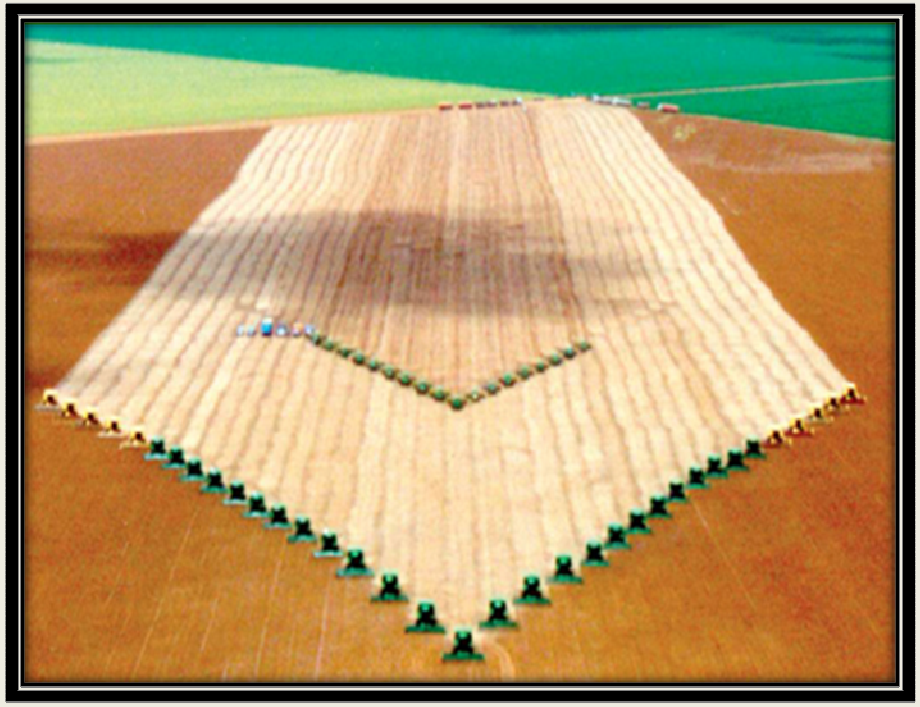
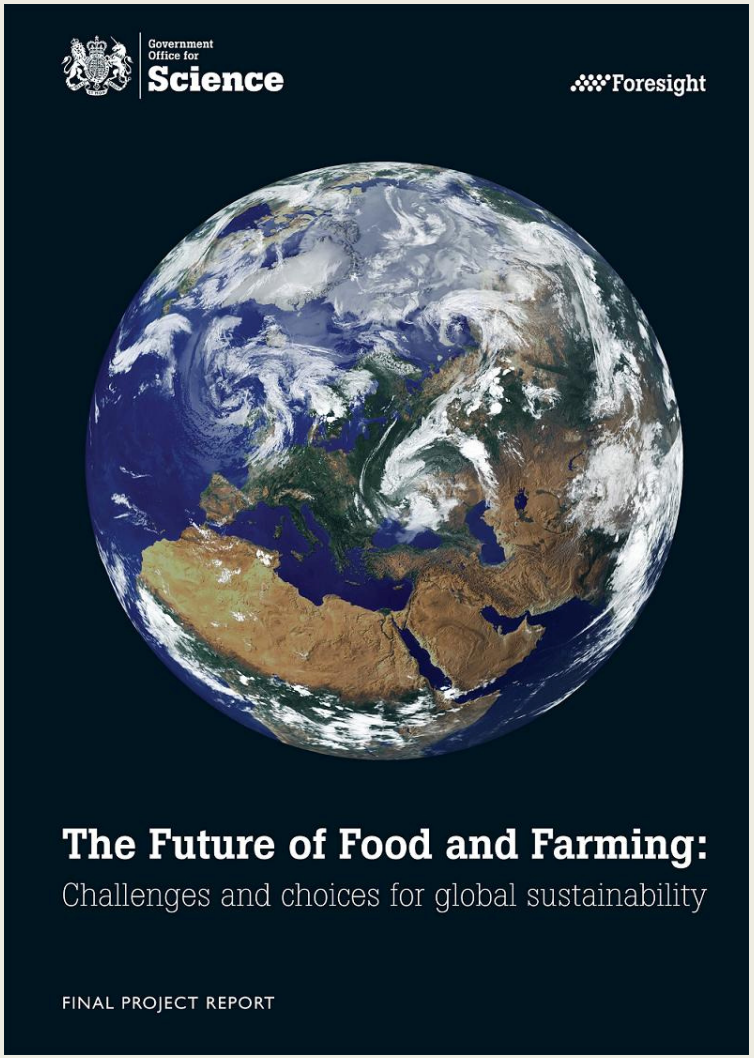
# Session 5
# Food (and Land) Utilisation

*Ian Crute*
*AHDB Chief Scientist*



**FAO/OECD –**
**"Greening the Economy with Agriculture"**
**Paris 5-7 September 2011**




# The Future of Food and Farming: challenges and choices for global sustainability

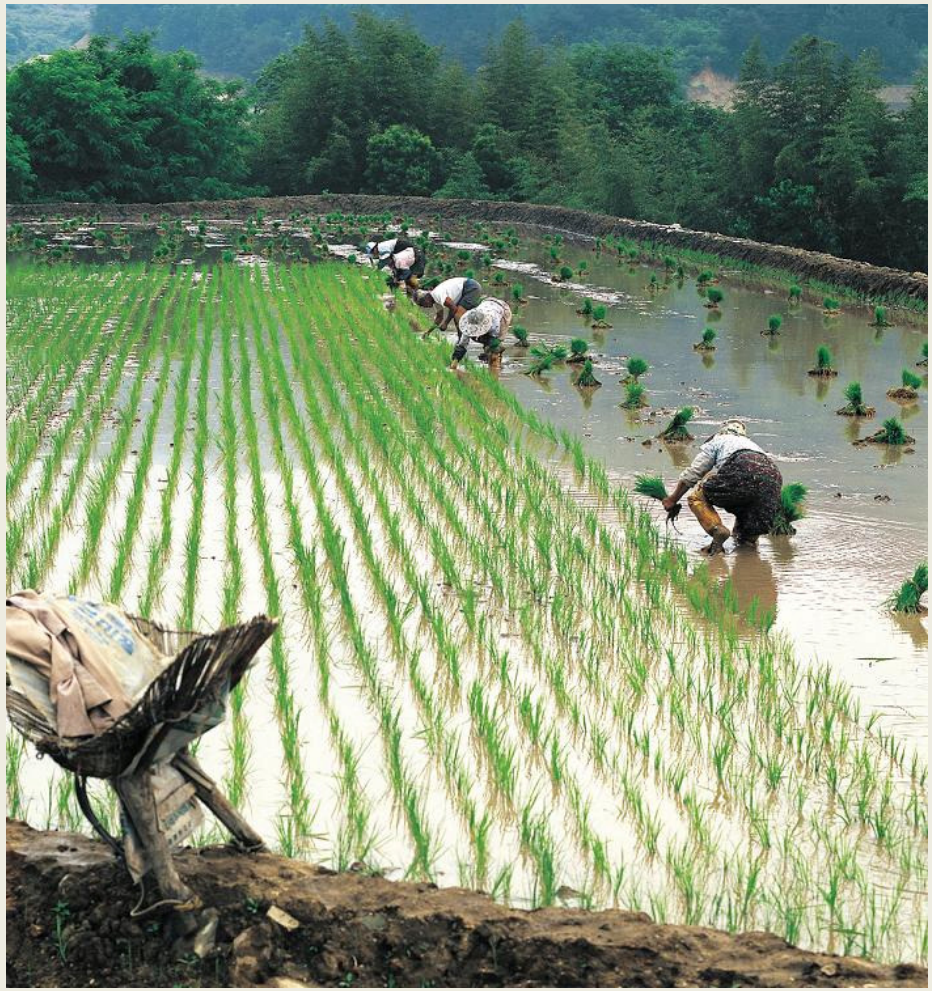
www.bis.gov.uk/foresight

# A key statement from Foresight:

## The food system must not fail on sustainability…

***Sustainability needs to move to centre stage***

- Agriculture currently consumes 70% of total global water withdrawals from rivers and aquifers
- Agriculture directly contributes 10-12% of GHG emissions



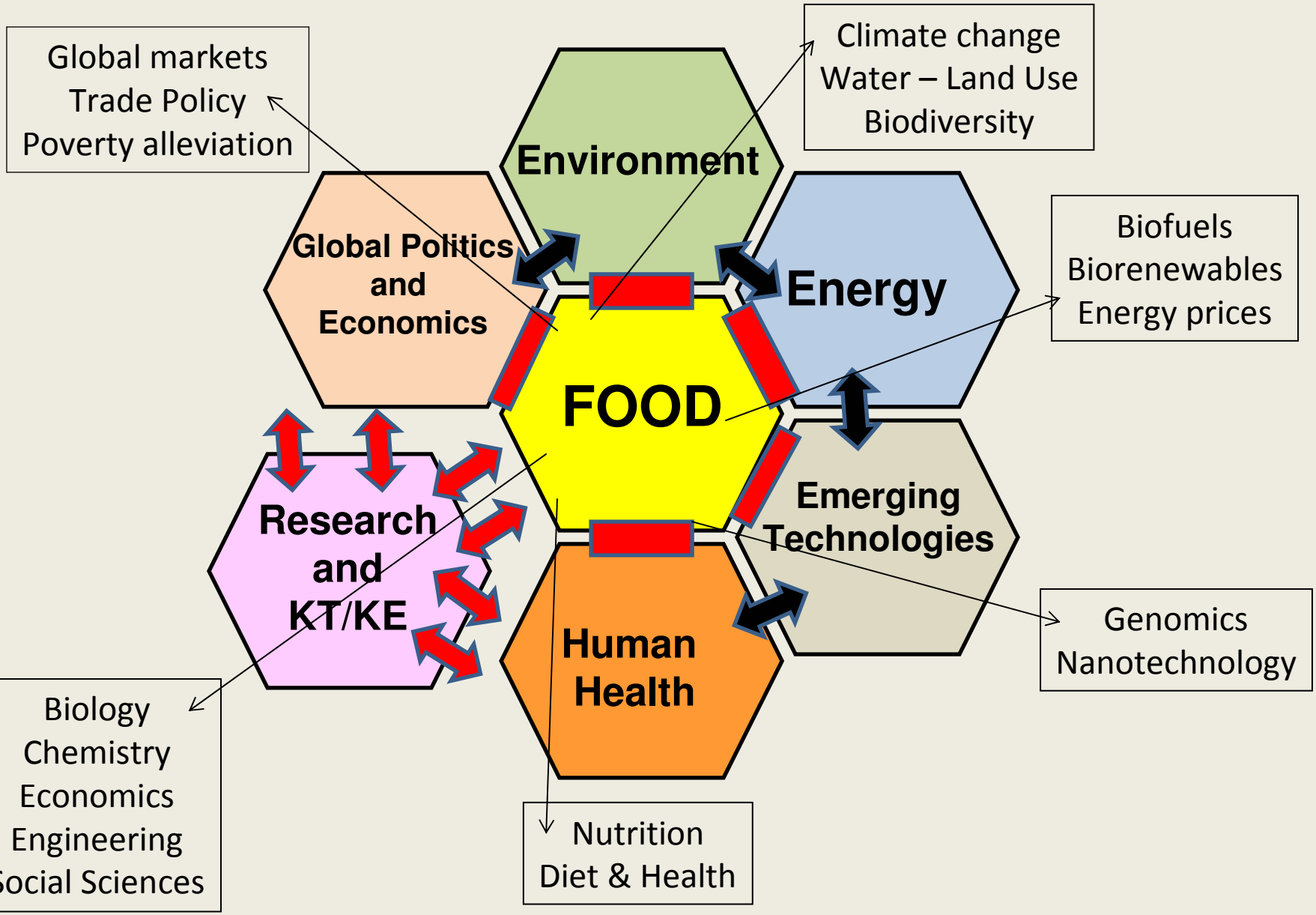
# *Sustainable Intensification*

***"The pursuit of the dual goals of increased productivity with reduced environmental consequences"***

An integrating concept to meet all primary challenges

***Producing as efficiently as possible on the smallest footprint of land capable of delivering (market) requirements is the "greenest" and usually the most profitable way to farm***

# Food (and agriculture) has rapidly become centre-stage



# Next – a few home (inconvenient) truths……

- **Farmers farm to make money (or food for their families – or because they have no alternative) (we need to keep farmers farming – but how?)**
  **- fair rewards and/or subsidies**

- **Most people don't produce food – they buy it and choice (if they have any) is determine by:**
  **- what they can afford;**
  **- what they most like to eat (cultural/regional);**
  **- what they think may be good for them (or their children);**
  **- the "where" and "how" of production (livestock health and welfare; provenance; environmental concerns).**

❑ **Advertising and marketing can influence choice but discriminating consumers (and regulators) demand reliable information (labels):**

- **some facts are easy to verify**

  **(e.g. provenance; nutritional content)**
- **evidence of comparative benefit or harm is hard/impossible to quantify**
- **wealthy consumers *may* want to "do the right thing" (Fair Trade etc….) but validation requires sound evidence *not* advocacy/marketing/hype**
- **confusing, contentious or misinformation breeds consumer cynicism and scepticism (and rejection?)**

❑ Evidence that comparative sustainability criteria for food can add market value is growing but possibly faster than the necessary evidence base on which claims are founded

# The UK Climate Change Act 2008 - GHG Emissions and the Agri-Food Sector

- 80% reduction by 2050 (on 1990 baseline of 748 Mt $CO_2$eq.– excl LUC)

- UK primary production (2009) (DECC, 2011)
  49.5 of 566.3 Mt $CO_2$eq. p.a. = 8.7%
  $N_20$ (55%) @ 289x$CO_2$; $CH_4$ (36%) @ 72x$CO_2$ and $CO_2$(8%).

- Actions captured in UK Low Carbon Transition Plan 2009 (Ch7)
  ⇒***18% reductions on 2008 levels by 2020 (= 34% on 1990 levels) = 3Mt $CO_2$eq. for England by the third Carbon Budget period (2018-2022)***

- Agriculture industry consortium presented Voluntary Action Plan to Defra (2010)

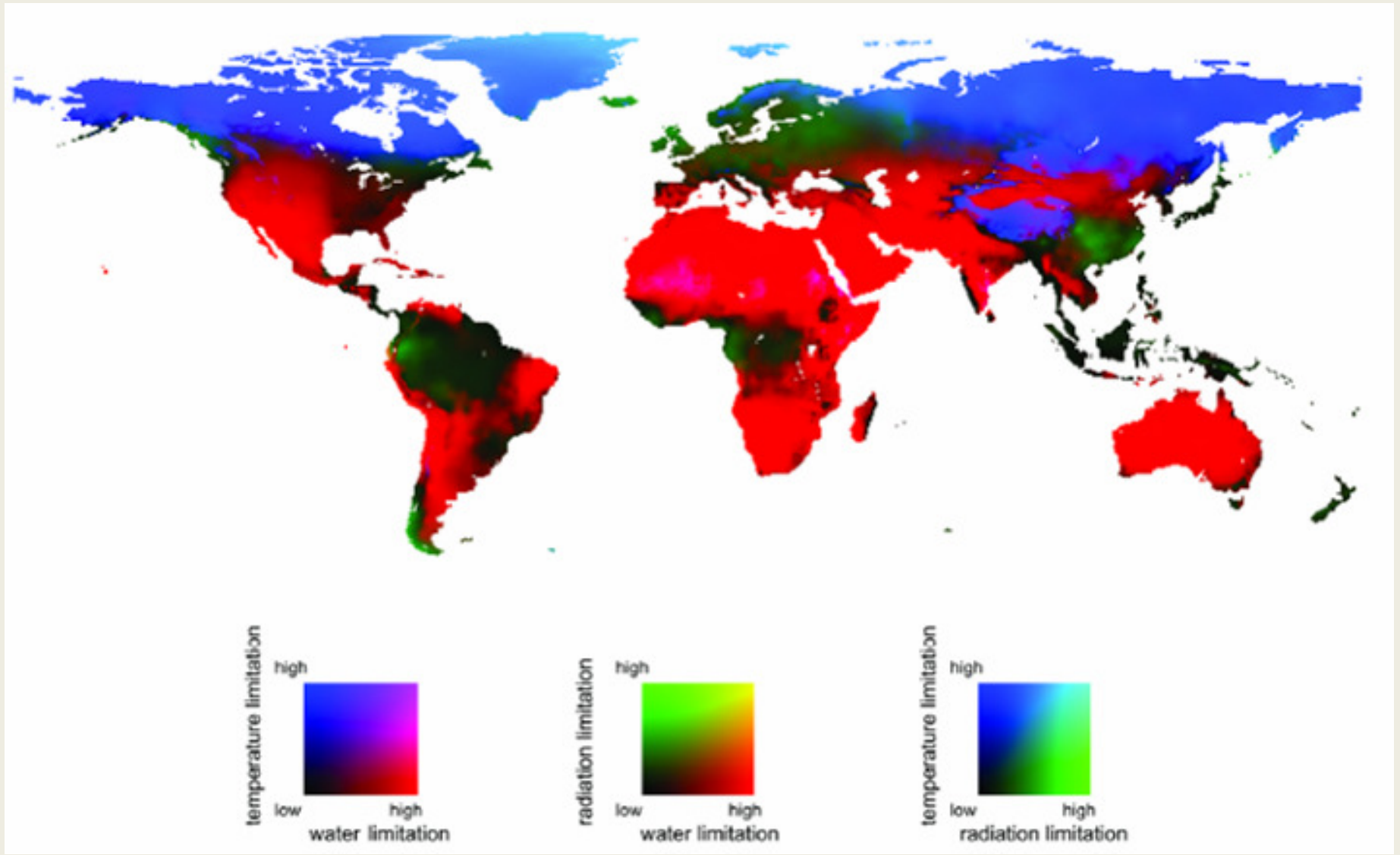
- Committee on Climate Change sceptical about voluntary approach

- Committee delivered advice for the 4th UK carbon budget period (2023-27) in June 2010 - **indicates annual reduction of *5Mt $CO_2$eq.***

- 2050 annual emissions target is ca. 14 Mt $CO_2$eq.– is this possible with a population of ca. 70 million to feed?

***Are emissions reduction targets for primary production the best way to motivate sustainable increases in productivity?***

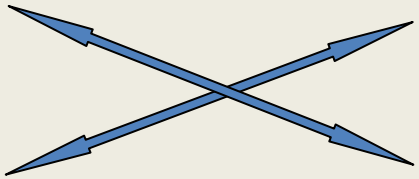
# Limiting factors for global plant productivity




Baldocchi et al. 2004 SCOPE 62

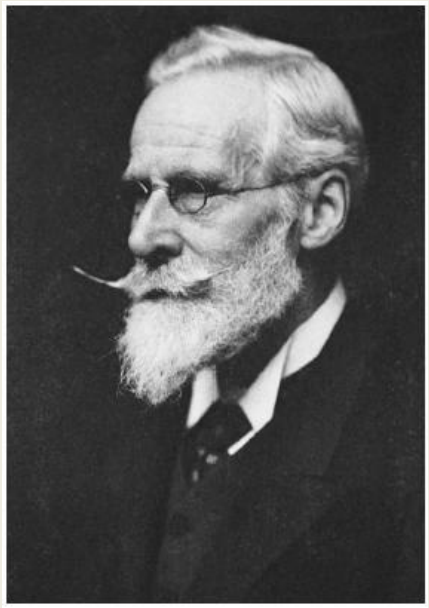
# Available arable land and population density are unevenly distributed

| | Arable Land | % Global Population |
|---|---|---|
| S&E Asia + Pacific | 29% | 53% |
| OECD/Europe/ Central Asia | 46% | 22% |
| Africa | 11% | 11% |
| Middle East/ N. Africa | 4% | 5% |
| Latin America/ Caribbean | 10% | 9% |



# “England and all the civilised nations stand in deadly peril of not having enough to eat”

Sir William Crookes,
President of the BA, Bristol, 1898



***His solution:***
Application of 12 million tons of nitrate of soda applied to the global wheat crop produced by “oxidating free nitrogen of the air by means of electricity” – using Niagra Falls.

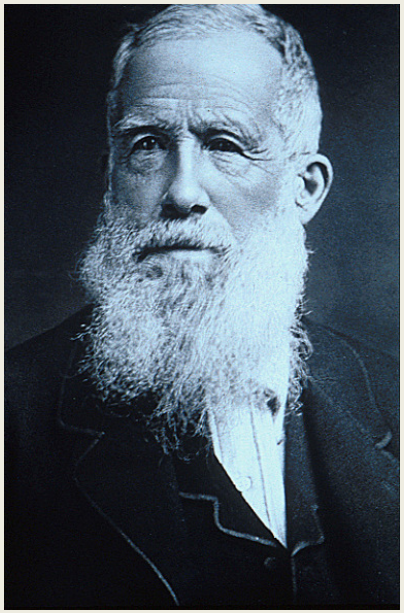
10 years later (1908) the Haber-Bosch process was discovered

100 years later (2008) – 55% of nitrogen in the N cycle is “synthetic”

- without this invention the global population would be at least 25% less than today (1.7bn in 1908; 6.5bn in 2008)

- Crookes’ prediction would have been true

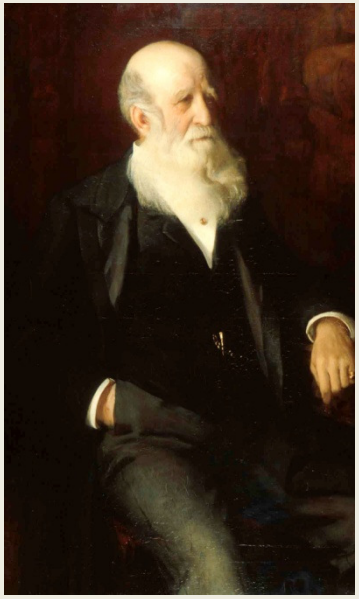

ROTHAMSTED
RESEARCH
The Broadbalk experiment at Rothamsted, Hertfordshire:
since 1843 - 167 years of continuous data



Sir John Bennet Lawes

ROTHAMSTED RESEARCH

**The Times 1898**



Sir Henry Gilbert

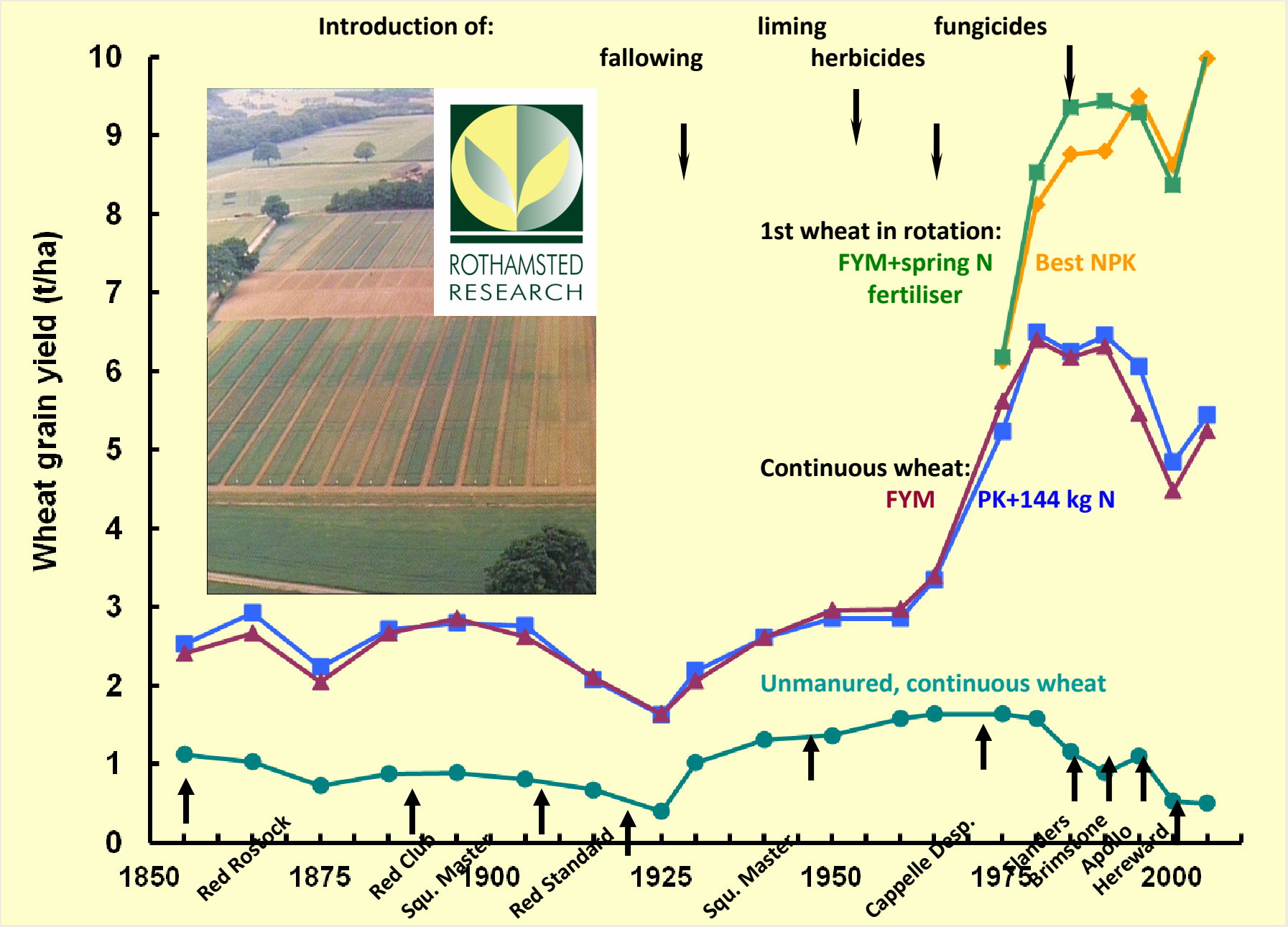
" we believe there will always be sufficient supply (of wheat) forthcoming for those who will find the money to purchase it at a remunerative price"

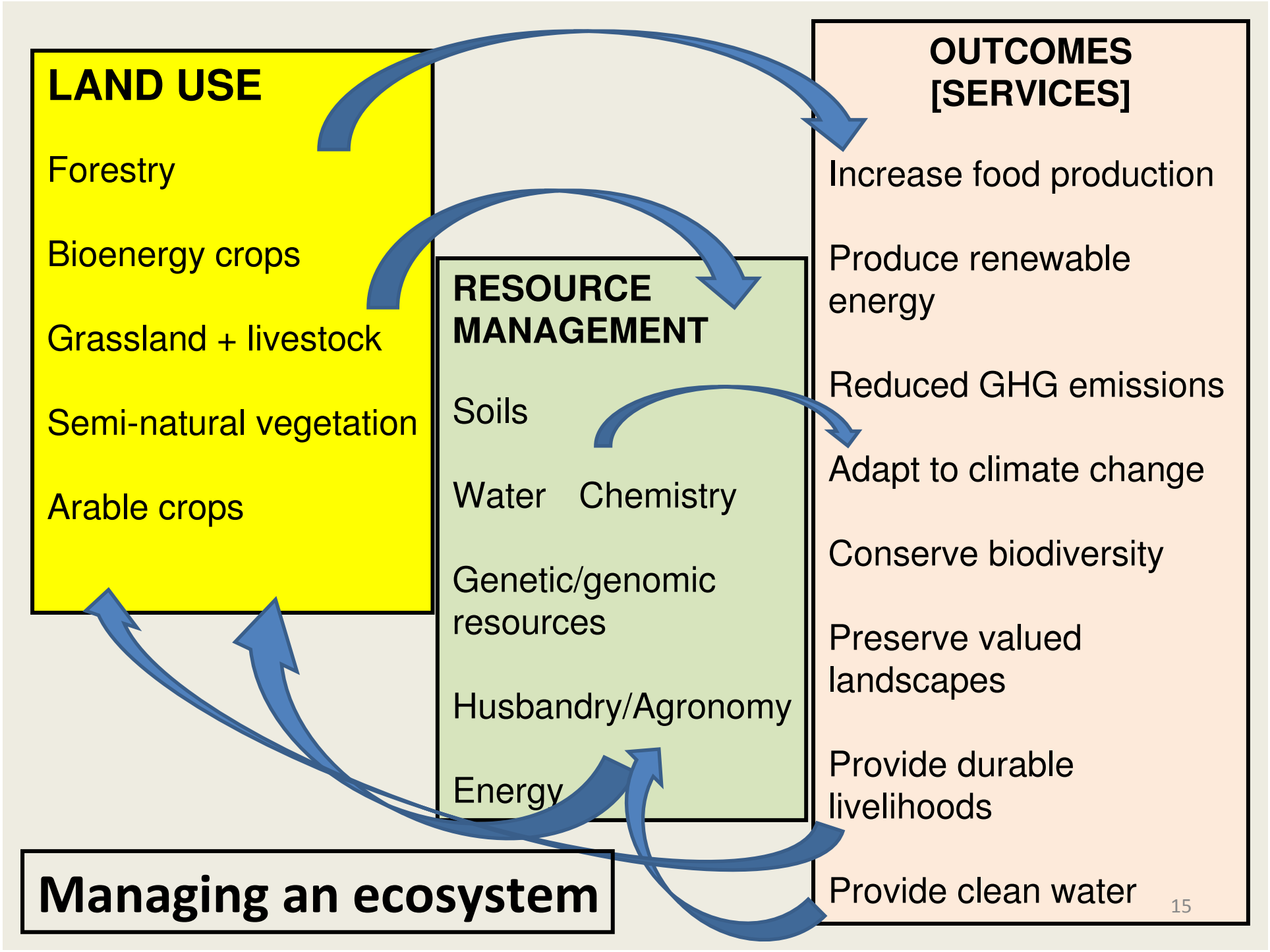
**and (of England)**

"it is simply impossible to provide the food required without very large importation"

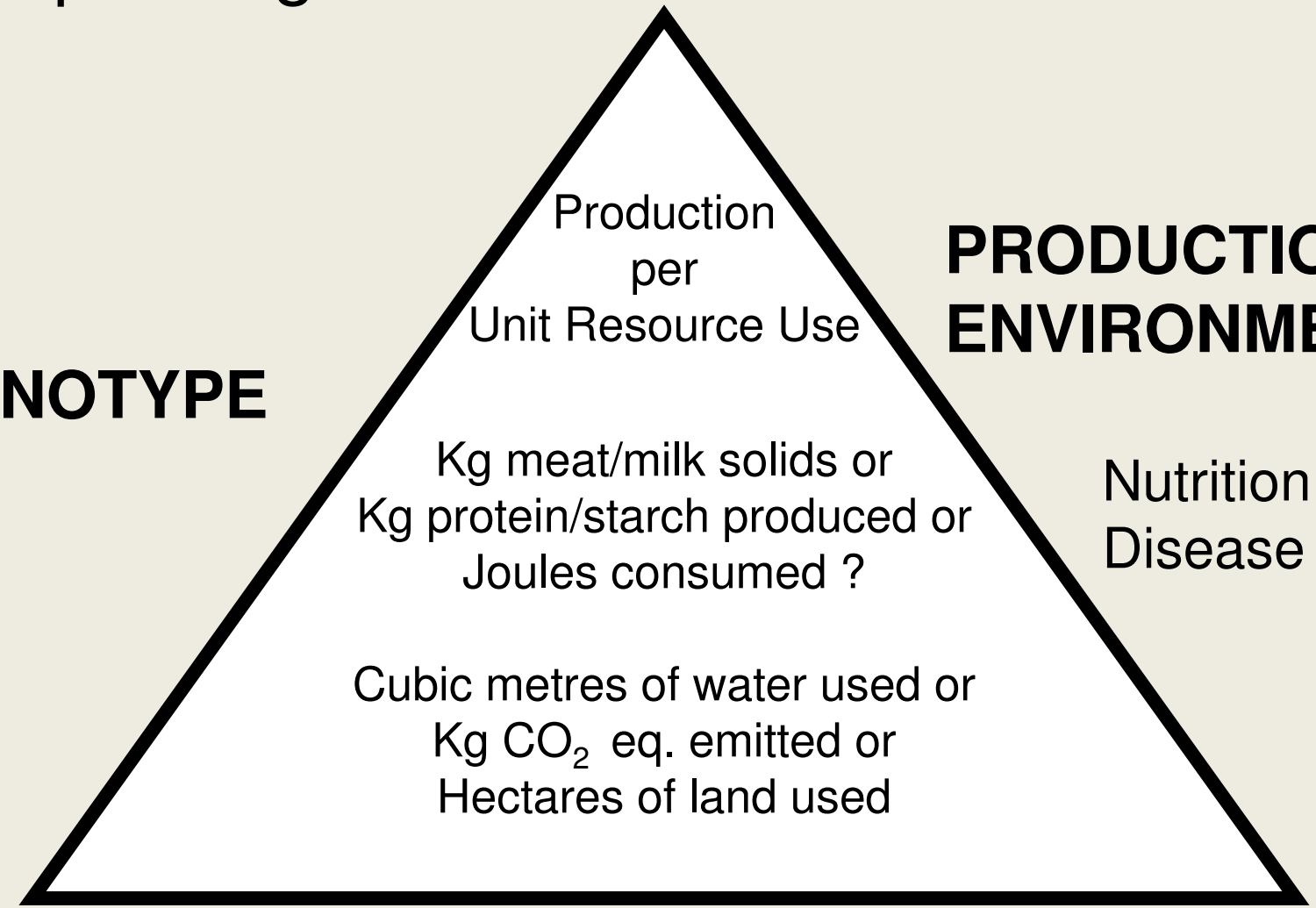
[L & G thought there was no shortage of land to grow wheat for import]

# Broadbalk yields, varieties and major changes



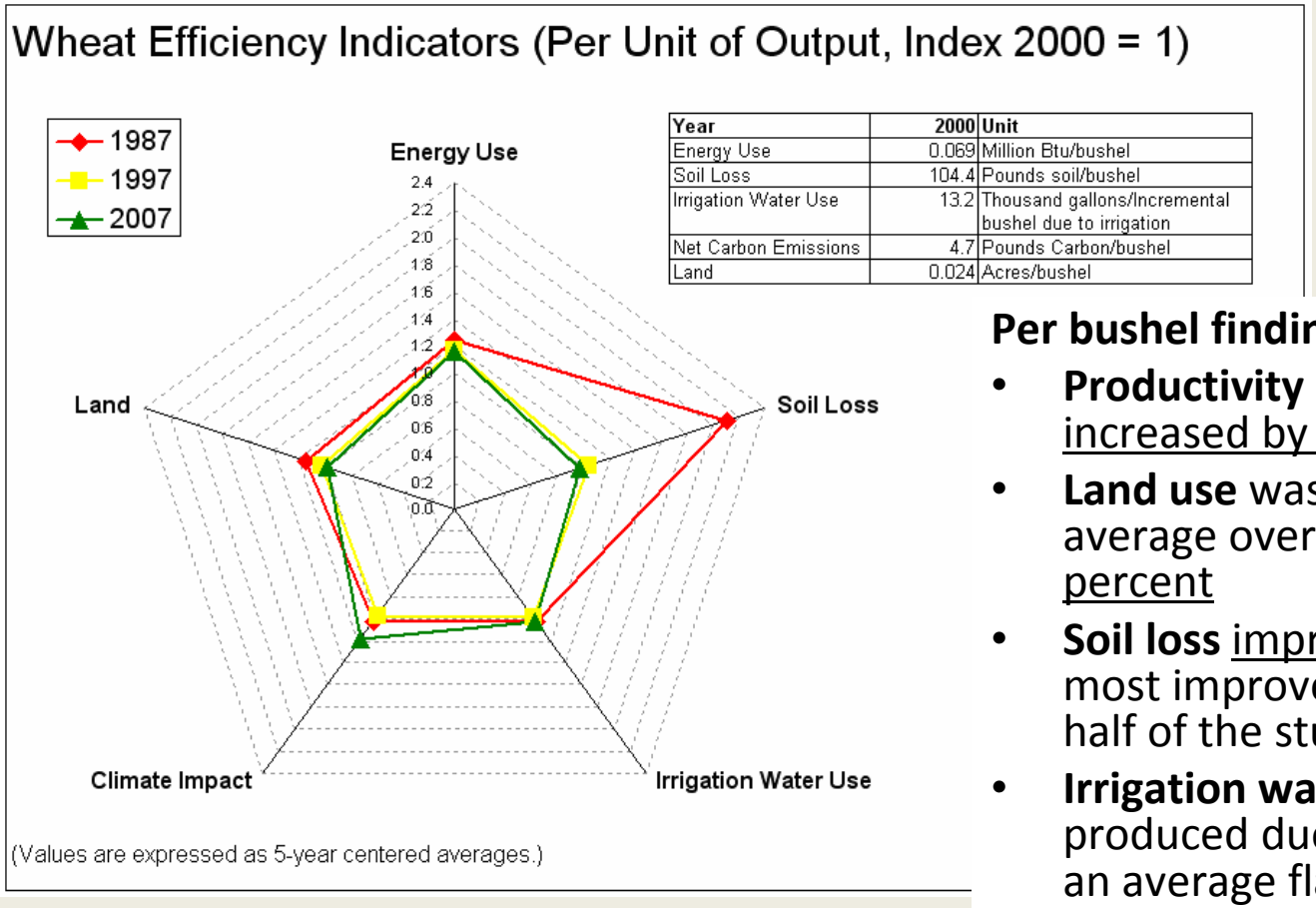

LAND USE
Forestry
Bioenergy crops
Grassland + livestock
Semi-natural vegetation
Arable crops
RESOURCE MANAGEMENT
Soils
Water Chemistry
Genetic/genomic resources
Husbandry/Agronomy
Energy
OUTCOMES [SERVICES]
Increase food production
Produce renewable energy
Reduced GHG emissions
Adapt to climate change
Conserve biodiversity
Preserve valued landscapes
Provide durable livelihoods
Provide clean water
Managing an ecosystem

# Measuring, understanding, managing and manipulating interactions



# Field to Market: The Keystone Alliance for Sustainable Agriculture

May 2010




| Year | 2000 | Unit |
|---|---|---|
| Energy Use | 0.069 | Million Btu/bushel |
| Soil Loss | 104.4 | Pounds soil/bushel |
| Irrigation Water Use | 13.2 | Thousand gallons/Incremental bushel due to irrigation |
| Net Carbon Emissions | 4.7 | Pounds Carbon/bushel |
| Land | 0.024 | Acres/bushel |

**Per bushel findings:**

- **Productivity** (yield per acre) increased by 19 percent
- **Land use** was variable, with an average overall decrease of 17 percent
- **Soil loss** improved 50 percent with most improvements over the first half of the study period
- **Irrigation water use** per bushel produced due to irrigation showed an average flat trend
- **Energy use** decreased nine percent
- **Greenhouse gas emissions** increased 15 percent, with a larger increase in the latter half of the study period

*Field to Market* Website (includes Fieldprint Calculator and background information)

http://www.fieldtomarket.org

# Crop (and livestock) health is fundamental to GHG emissions reduction

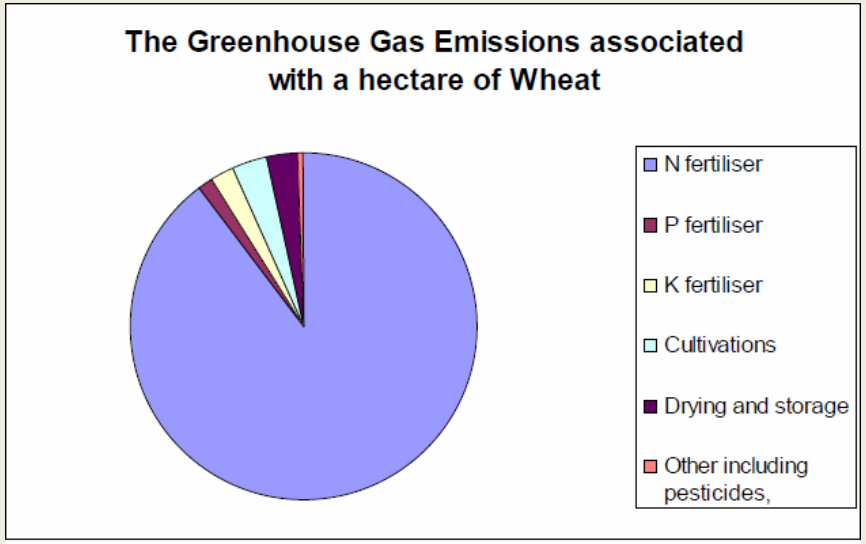


GHG emissions to grow a crop of wheat
– ca. 4000 - 5000 Kg$CO_2$eq./ha

(N, other ag-chem, machinery, cultivations, spraying, harvesting)

Waste = lost yield + wasted inputs (economic) and > emissions/tonne

# Nitrogen inputs, cultivated areas, yield and N use efficiency are key determinants of GHG emissions from cropped land

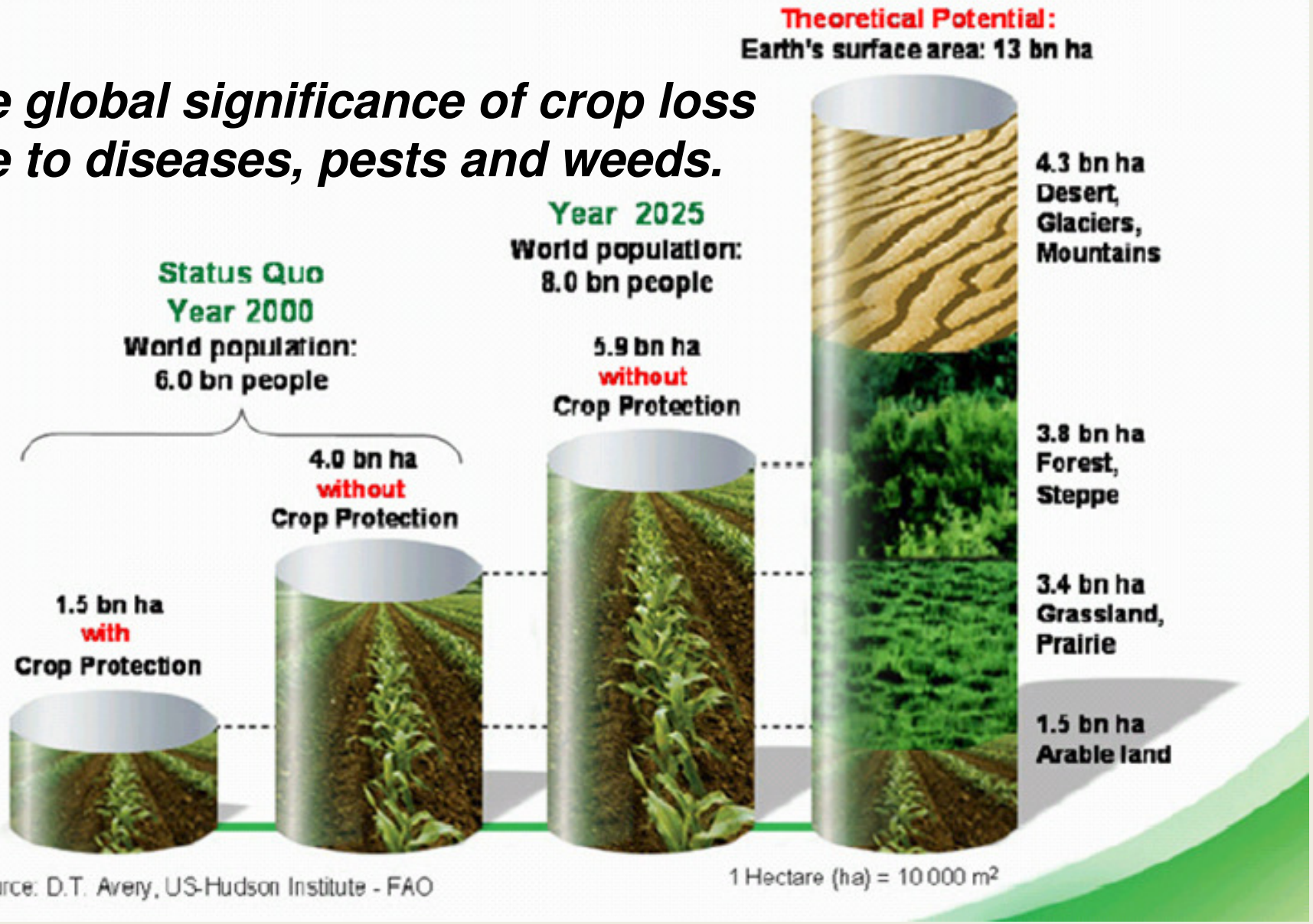



Mortimer (2003)

| Nine UK & Danish wheat crops | | | |
|---|---|---|---|
| | Fungicide | No fungicide | SEM |
| Opt. N (kg/ha) | 158 | 106 | 11.5 ** |
| Yield (t/ha) | 8.9 | 6.7 | 0.55 ** |
| GHG emissions – Kg $CO_2$ eq. per tonne | | | |
| Fungicide/treated optimum | 417 | | |
| No fungicide/untreated optimum | 430 | | 12 (NS) |
| No fungicide/treated optimum | 546 | | 31** |
| No fungicide/untreated opt. + LUC | 740 | | 70** |

Berry et al (2010)

***The global significance of crop loss due to diseases, pests and weeds.***



Two examples of disease resistance in action:

- often due to single genes
- genomics should enable efficient identification and selection of gene combinations

***Yellow rust***


***Soil-borne mosaic virus***

# Comparative "sustainability" – UK Crops

| | Potatoes | Wheat |
|---|---|---|
| Yield (tonne/Ha) | 45 | 8 |
| % starch | 15 | 70 |
| Starch (tonne/Ha) | 6.8 | 5.6 |
| Energy (GJ/Ha) [A] | 116 (15%>) | 95 |
| Man-days of carb. /Ha[B] | *ca.*17,000 | *ca.*14,000 |
| N-use Kg/Ha | 150 | 200 |
| KgStarch/KgN | 45 | 28 |
| $KgCO_2$ equ./GJ [C] | 3.9 | 6.3 |
| Area (KHa) | 130 | 1900 |
| Irrigation $m^3$/Ha | 615 | 3 |
| $MJ/m^3$ irrigation (UK crop) | 190 | 32,000 |

A – starch delivers 17kJ/g; B – 6.8MJ/day from carb.; C – I Kg N yields ca. 3 Kg $CO_2$ equ.
(? Relative proportion of GJ "consumed" – i.e. relative waste?)

# Key summary points

- **Marketable Yield – Land Sparing – Soil Management - Water and Non-renewable Resource-use Efficiency – Crop and Livestock Health – and Waste Reduction are the key sustainability issues for agriculture whether in developed or developing countries**

- **Productivity, profitability and sustainability are correlated; measuring sustainability is complicated – we need more reliable data and better metrics**

- **There is need to recognise and value soil as a "non-renewable" resource**

- **There are of "trade-offs" between different sustainability attributes – e.g. water use or biodiversity may "trump" GHG emissions (and *vice versa*)**

- **For most food products the sustainability of efficient production systems in developed country agriculture is greater than production of equivalent products in less developed countries**

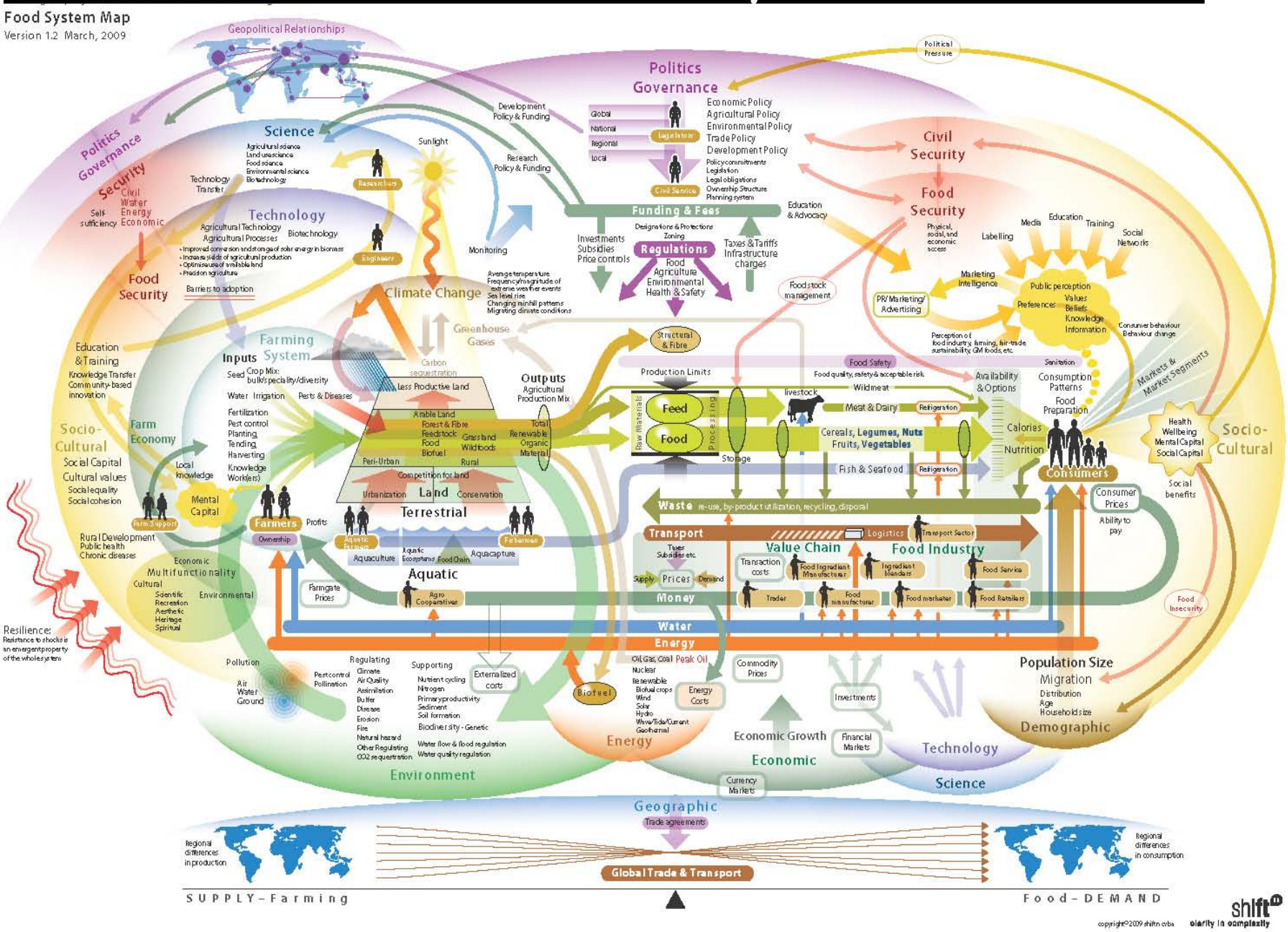
- **Producing as efficiently as possible on the smallest footprint of land capable of delivering (market) requirements is the "greenest" way to deliver food**

- **Genetic/genomic technologies (including GM) are making a significant contribution to sustainable crop and livestock production**

Thank – you

And lest you thought solutions were simple……

# The Global Food System



## *Sustainable Intensification*

- Primary objective of land use for agriculture is efficient conversion of solar energy into varied forms of chemical energy for utilisation by mankind
- Some land is best used to produce forage/feed for ruminant livestock as intermediates – and non-ruminants are good converters of "waste" into food for us.
- Energy conversion involves manipulation and management of the interaction between genotype and the environment to improve efficiency
- There are physical and biological constraints – but maintaining ecosystem functional biodiversity is key to sustainability
- Maximising land-use efficiency provides options to achieve "other" objectives (carbon sinks, maintenance of biodiversity etc).
- "Other" objectives should not be confounded with the requirement to produce food and other agricultural products as efficiently as possible (while sustaining ecosystem functions)
- ***Not*** Either - Or ***but*** Both - And