

Global Food Security

Sustainable, healthy food for all

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Engineering landscapes for food and other services

Tim Benton

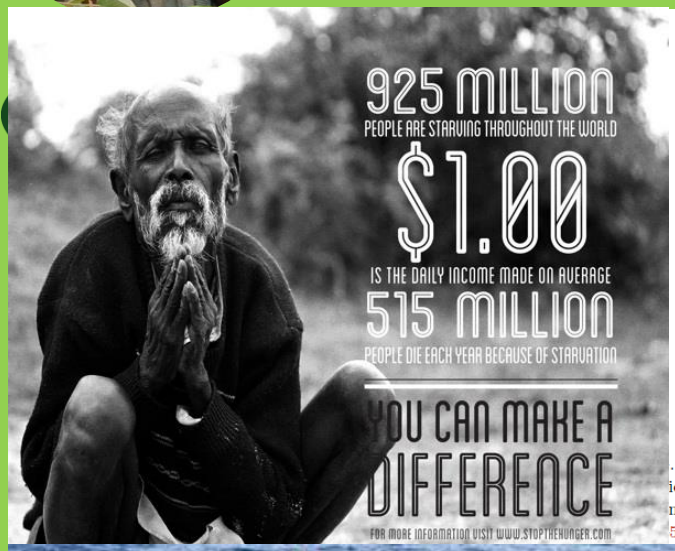
UK Champion for Global Food Security & Professor of Ecology, University of Leeds

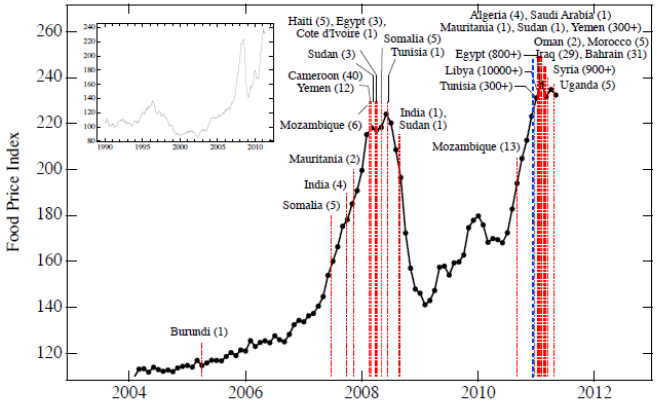
tim.benton@foodsecurity.ac.uk

@timgbenton



Food security is important in many ways





. 1: Time dependence of FAO Food Price Index from January 2004 to May 2011. Red dashed
ical lines correspond to beginning dates of "food riots" and protests associated with the major
nt unrest in North Africa and the Middle East. The overall death toll is reported in parentheses
55]. Blue vertical line indicates the date, December 13, 2010, on which we submitted a report to









…and the food system is the world biggest land user, employer and, arguably, polluter



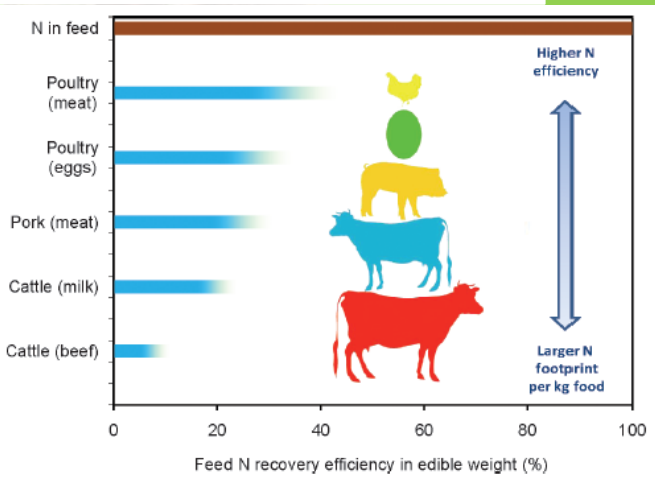
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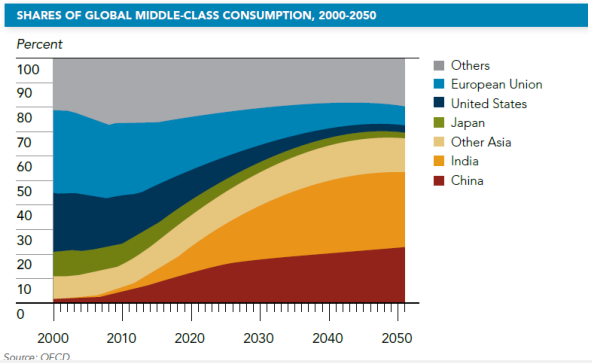
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DRIVERS OF CHANGE

Animal protein expensive in resources to produce (ENA)





2000: 60% middle class "western" vs 20% "eastern"
2050: 12% vs 68%

Growth in global food demand

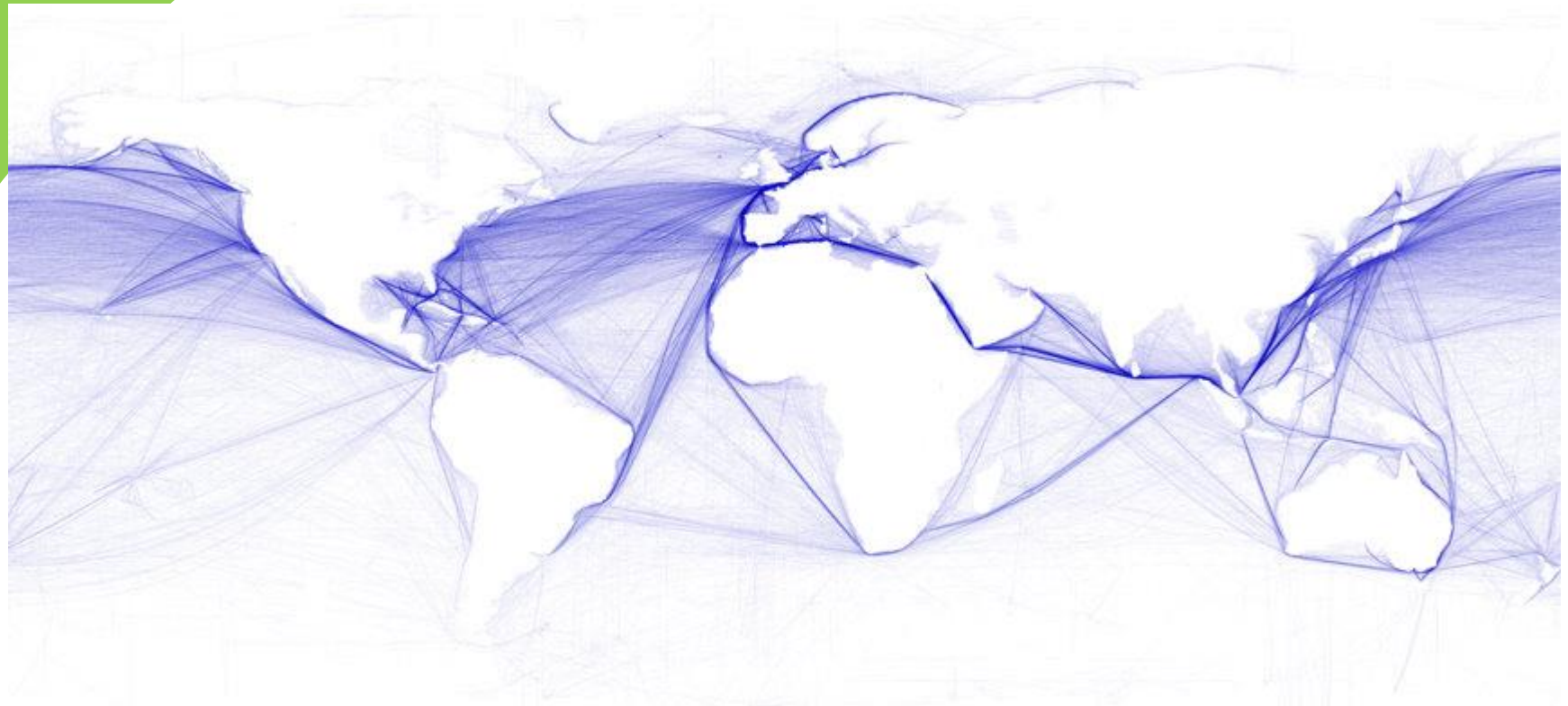


- 35% more mouths by 2050
  - Mainly in Asia, Africa and S. Am
- Richer people eat more and differently:
  - Global middle class will increase 3bn by 2050
- 70% urbanised
  - Understanding of food systems

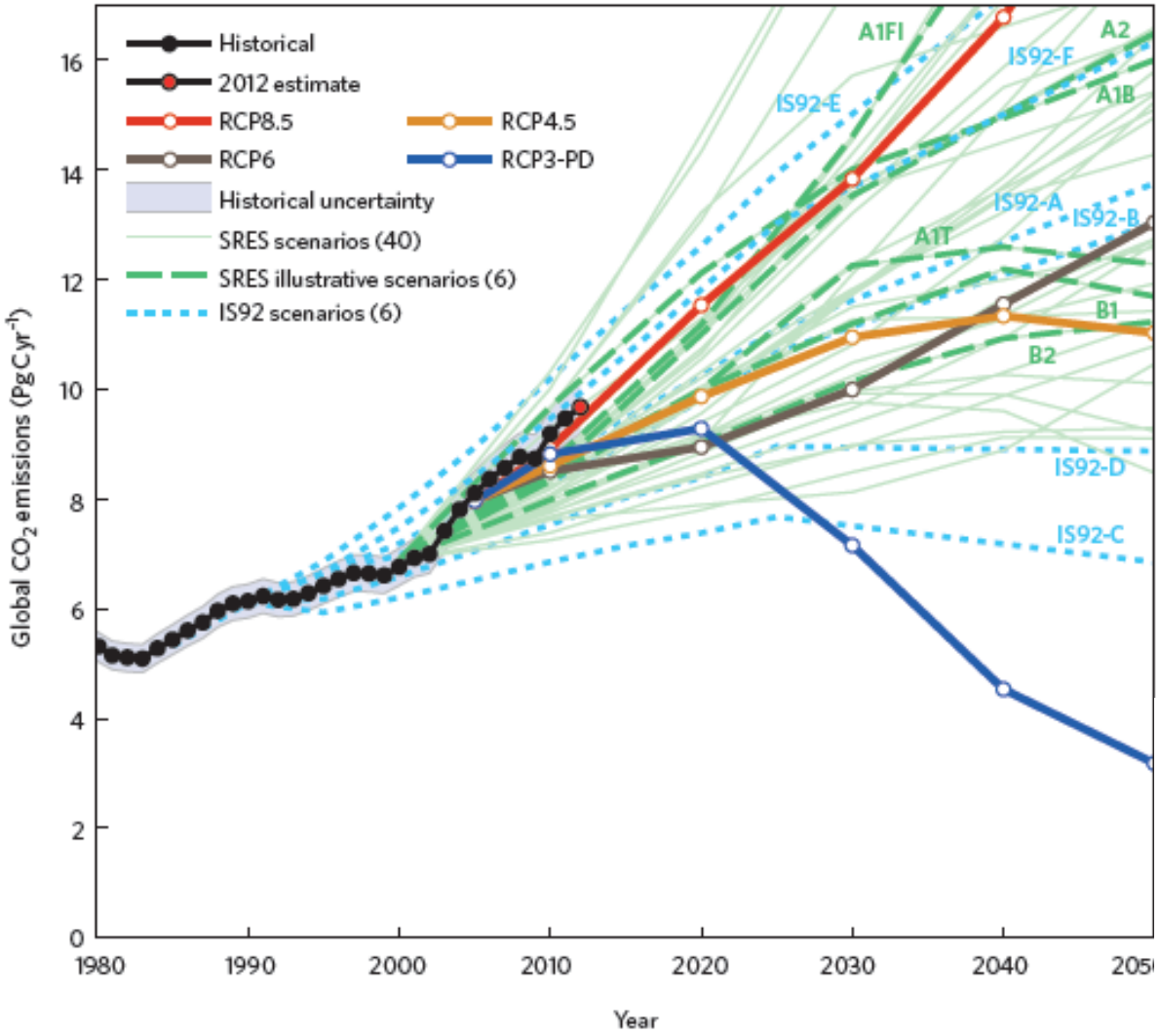
- All add up to projected increased global food demand (FAO estimate 60% more)

Supply chain logistics



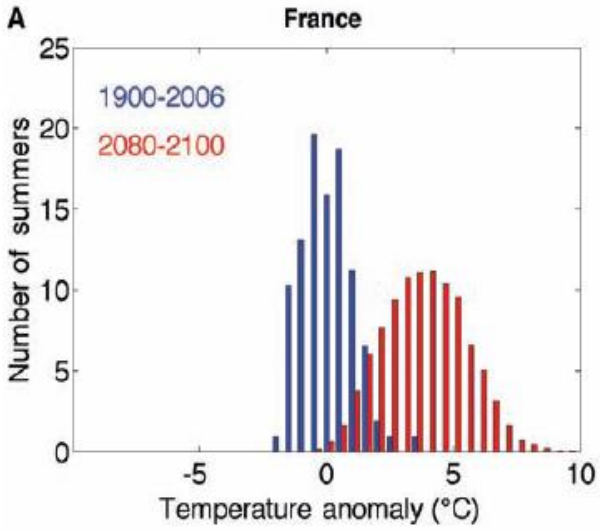


courtesy of http://rsif.royalsocietypublishing.org/content/early/2010/01/19/rsif.2009.0495.full



We're on course for a 4 degree world

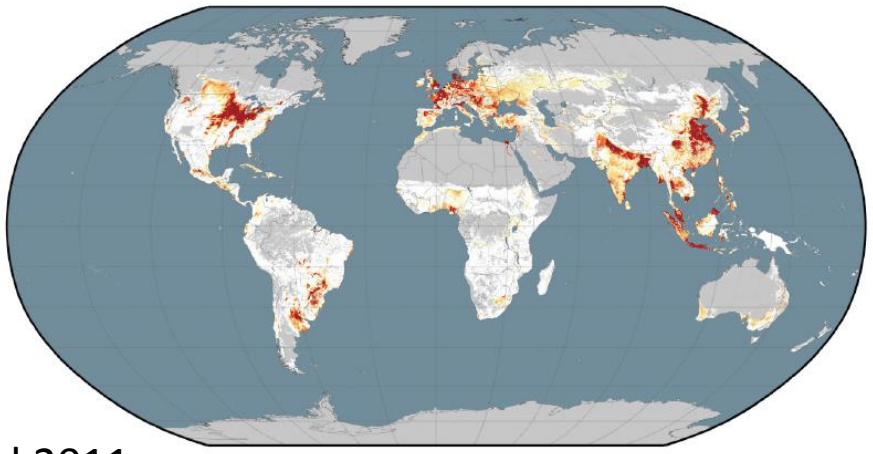




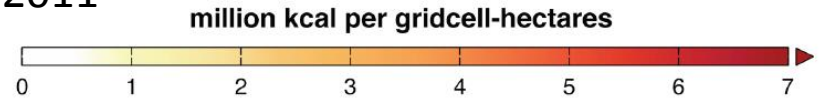
The challenge to keep global warming below 2 °C

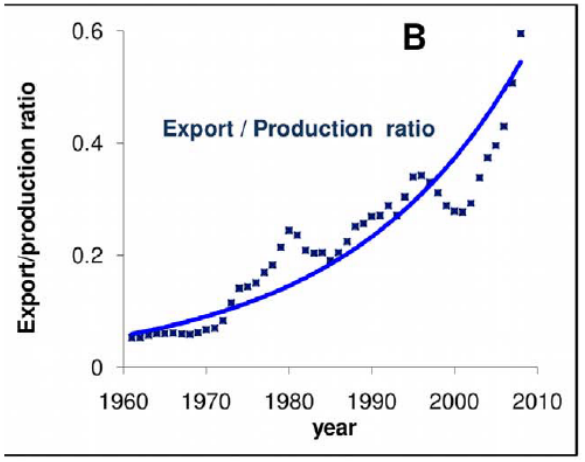
Glen P. Peters, Robbie M. Andrew, Tom Boden, Josep G. Canadell,
Philippe Ciais, Corinne Le Quéré, Gregg Marland, Michael R. Raupach and Charlie Wilson

Fig 37a



Foley et al 2011

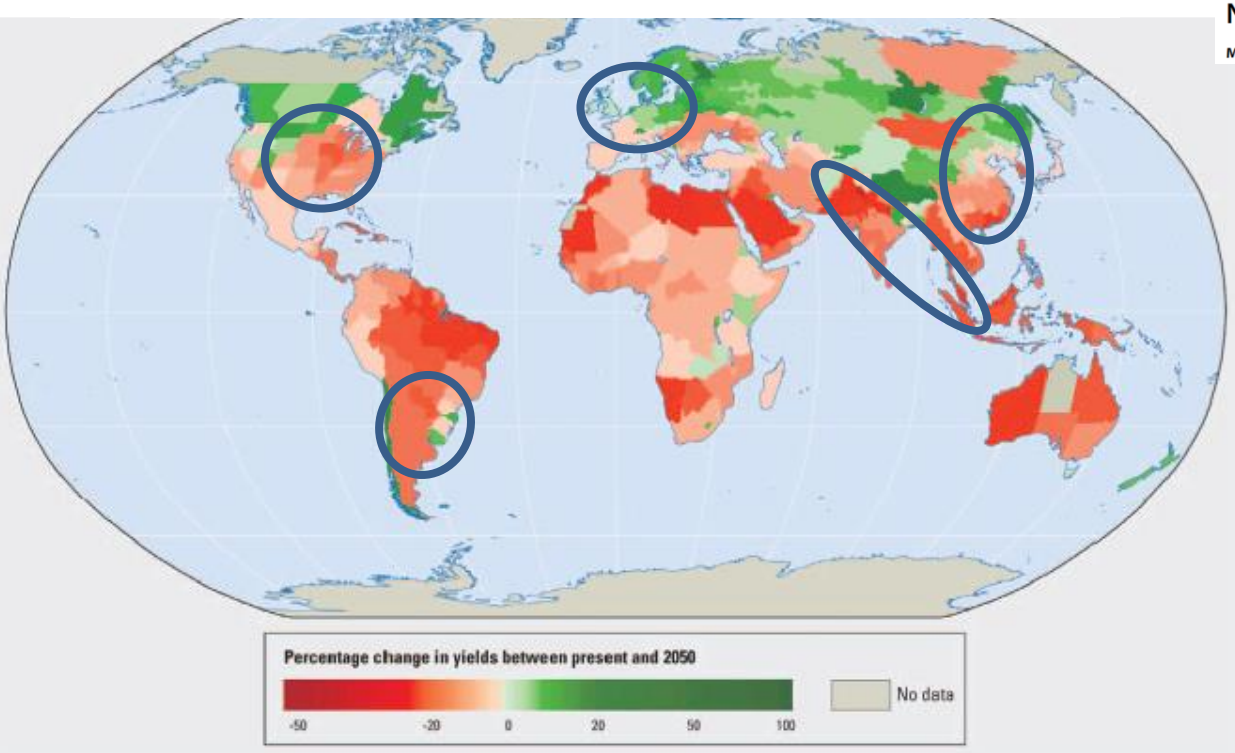




ction. (**A**) (Log-linear scale). The world's food production (thin red line), nt of food transported on the IFTN (linearly fitted small squares, blue) s flow at an increasing rate from countries to countries, as shown by the rom the above data (small squares fitted by an exponential curve). Note JN databases [6,23].

Complexity of the International Agro-Food Trade Network and Its Impact on Food Safety

Mária Ercsey-Ravasz[1,2], Zoltán Toroczkai[1], Zoltán Lakner[3], József Baranyi[4]*



From Wheeler & Von Braun (2013) after World Bank (2010)



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THE CHALLENGES

1. Growing more



…on less land, with fewer inputs, in a changing world

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Robotic weeding:
Weed recognition through machine vision (26 species); applies Glyphosphate only to the leaf of the weed (~1 g per hectare cf 720 g/ha)

Simon Blackmore, Harper Adams

- Manage soils for long-term production better
- Efficiency of resource use, using new and best knowledge to close yield gaps
  - Best practice (perhaps especially) in low yielding systems
  - “Precision” Farming
  - New chemistry/inputs/nutrients
  - ICT/forecasting/sensing etc
- New varieties (crops and livestock) to raise local yield ceilings
- New farming systems: beyond monocultures
- Optimising GxExM



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THE CHALLENGES

2. Reducing environmental impacts

What does land do?





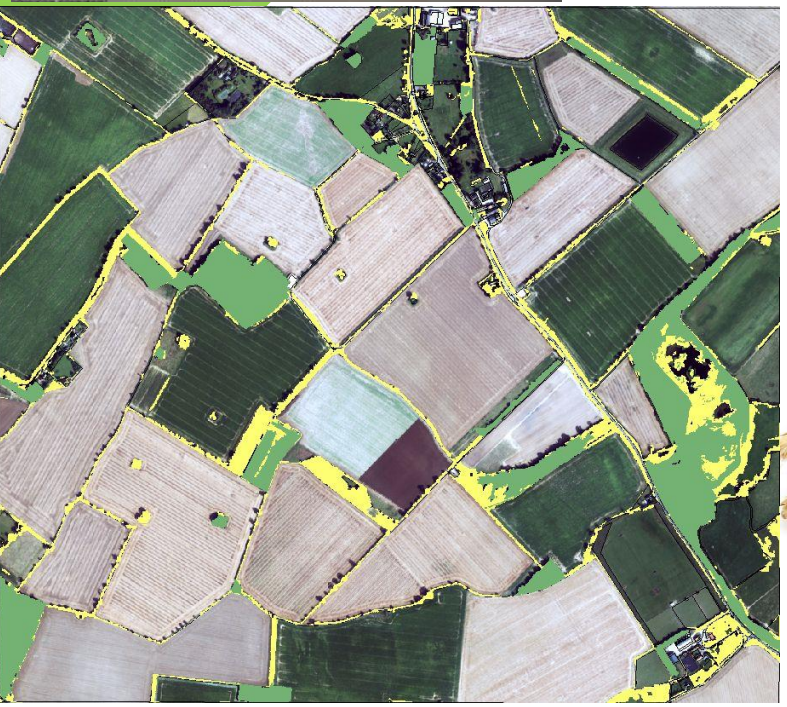


















Sustainable intensification is





- *increasing food production from existing farmland in ways that place **far less** pressure on the environment and which do not undermine our capacity to continue producing food in the future*

- *SI requires equal emphasis on both words*

Garnett et al *Science* 2014



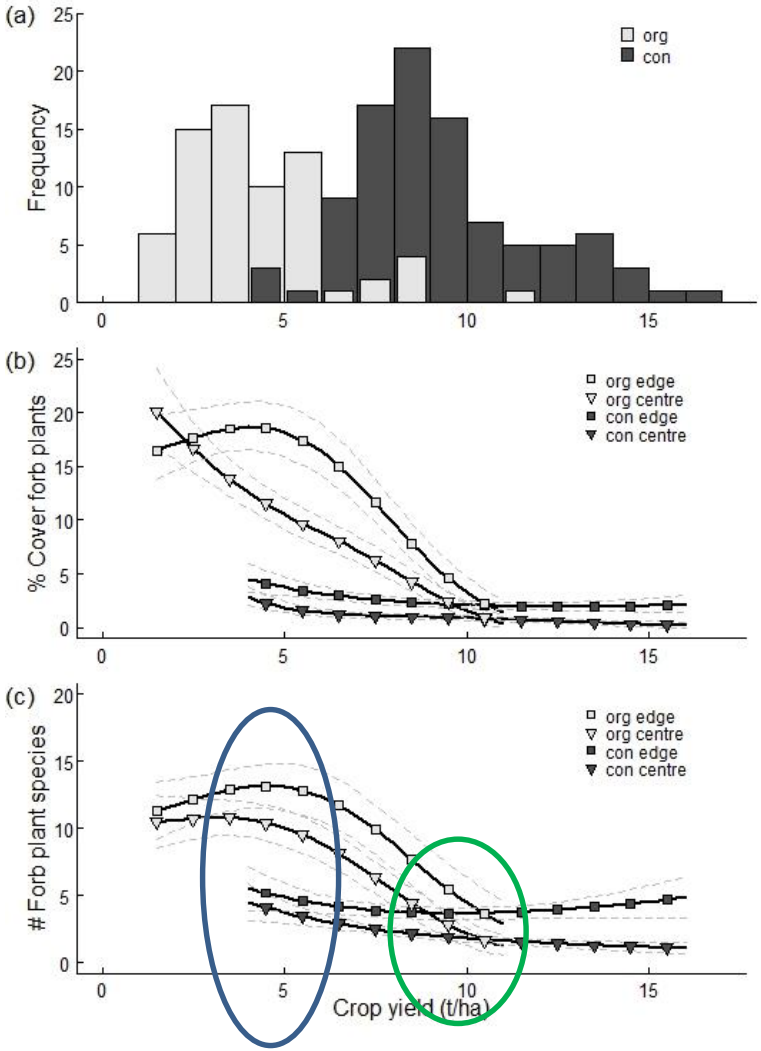
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There is no recipe for "sustainable agriculture"

Low-yielding organic farming has biodiversity benefits but High-yielding organic agriculture can impact on ecology in similar ways to conventional farming





Gabriel et al 2013 J appl ecology

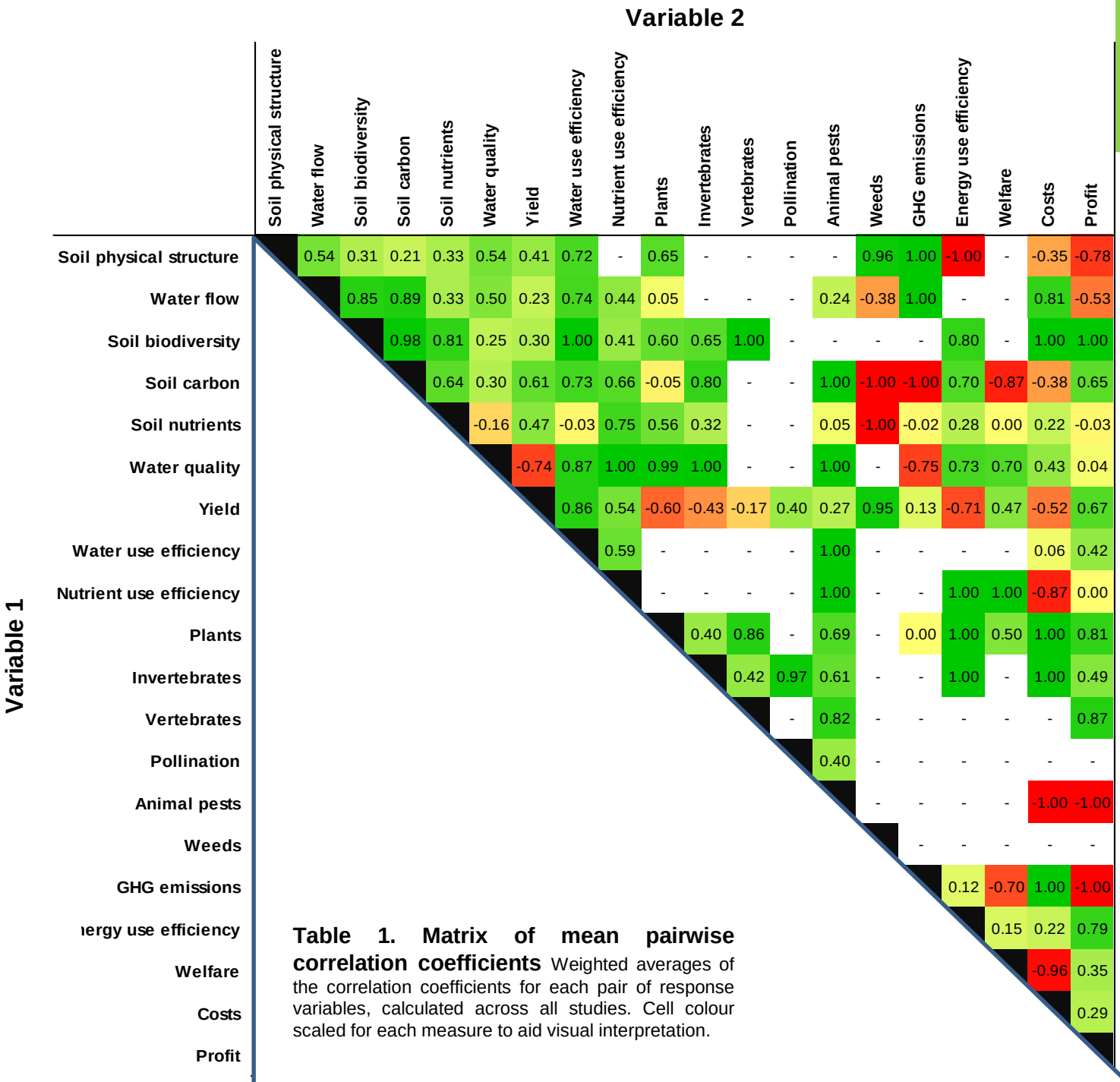


Table 1. Matrix of mean pairwise correlation coefficients Weighted averages of the correlation coefficients for each pair of response variables, calculated across all studies. Cell colour scaled for each measure to aid visual interpretation.

“Sustainable Agriculture” needs…







- Management of farming’s impacts within plots/fields
- management of land to maintain other services

Sustainable agricultural landscapes require landscape planning: many services depend on the amount, quality and configuration of non-cropped habitat



Zero sum game for demand

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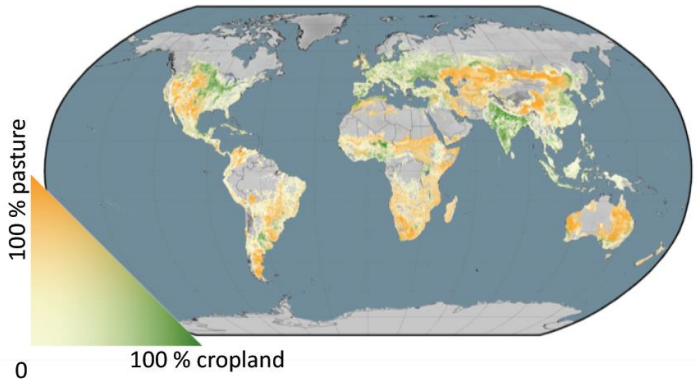


Figure S1. Extent of Global Agricultural Lands. This map illustrates the global extent of croplands (green) and pastures (brown), as estimated from satellite- and census-based data by Ramankutty *et al.*[1]. According to U.N. FAO statistics, croplands currently extend over 1.53 billion



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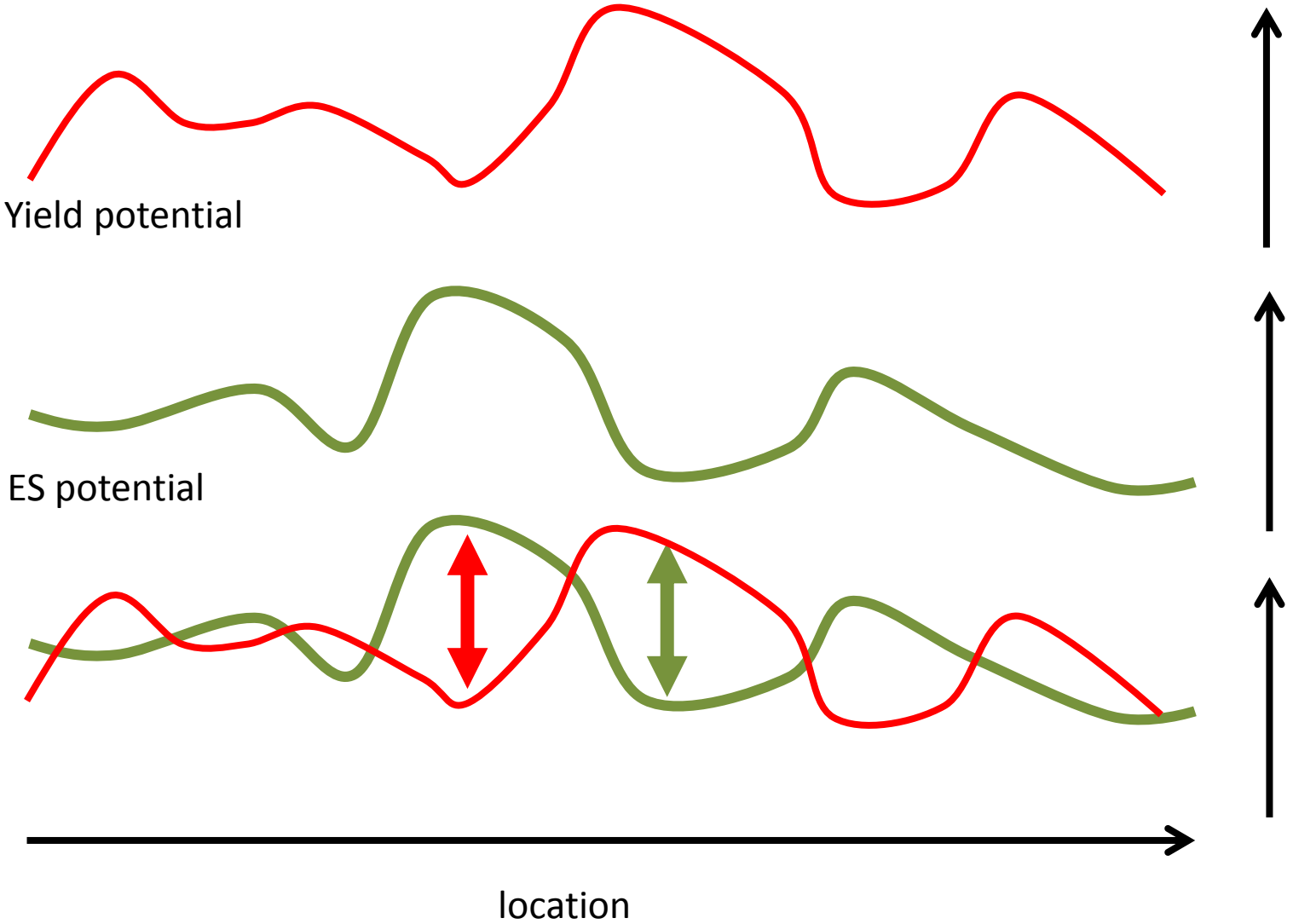
SUSTAINABILITY NEEDS A SPATIAL STRATEGY



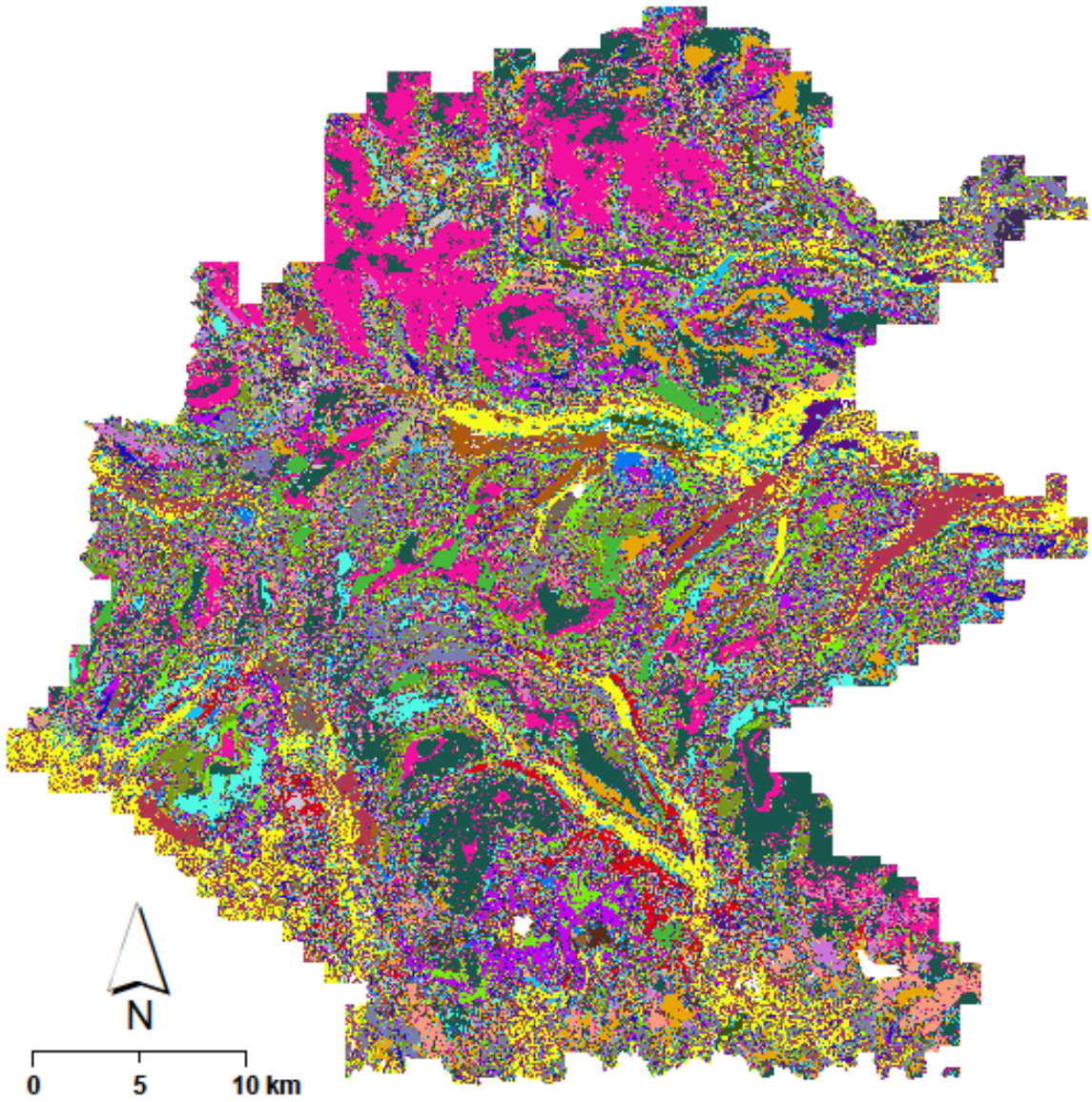
Spatial analysis







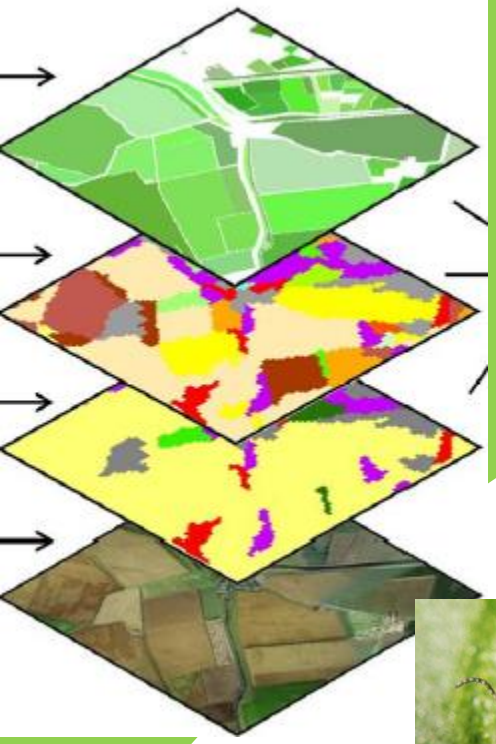
Remote sensing: 5m resolution 1750 km^2



Map derived using aerial images (Copyright GeoPerspectives), Soils data © Cranfield University (NSRI) and for the Controller of HMSO 2009, Land-Form PANORAMA and PROFILE data downloaded from the EDINA Digimap OS service. © Crown Copyright/database right 1993 and 2003. An Ordnance Survey/EDINA supplied service, slope data (Intermap Technologies/Natural England), OS MasterMap (Reproduced from the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution and civil proceedings. Yorkshire Dales National Park Authority, OS Licence Number 100023740 2007).

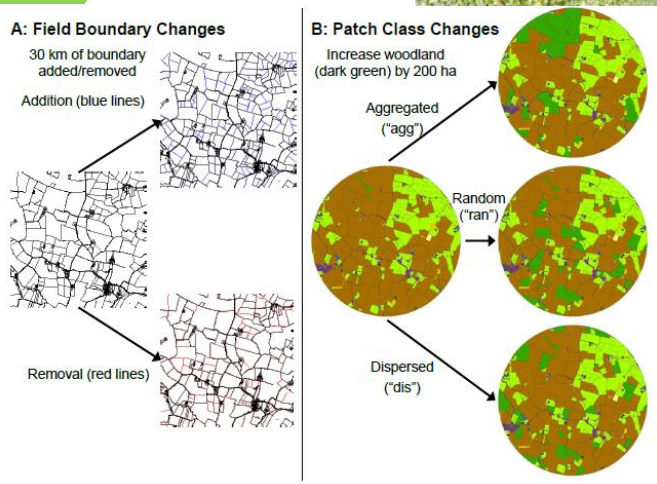
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Can we do this?





- Using remote sensing to map habitats/ vegetation and estimate yields
- Overlaying a range of ecosystem services
- Numerical modelling to find “optimal” layout of landscape based on known habitat-service relationships



Richard German thesis 2012



Modelling







Land cover change			Aphid abundance								
			dis			ran			agg		
Arable	Ag_grass	Non-crop	+	nc	-	+	nc	-	+	nc	-
↓	↑	↑									
↓	↑	0									
↓	0	↑									
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0	↓	↑									
0	↑	↓									
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- If you know:
  - Habitat association of floral rich and grass-rich areas and pollinators and natural enemies, and yields
  - Can simulate spatially explicit landscape and look for layouts that maximise yields whilst maintaining services



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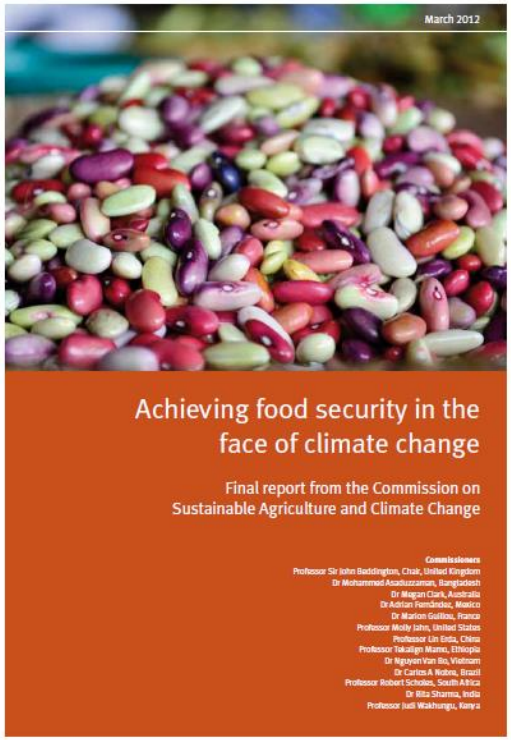
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And if you can do it in one place

- …you can do it everywhere
- Connecting yield, with prices, with land use decisions





Need to use new technologies better

- Integrated "Knowledge systems for sustainability" (KSS)
- Integrated engineering solutions for landscape-scale sustainability

FINAL REPORT: ACHIEVING FOOD SECURITY IN THE FACE OF CLIMATE CHANGE

Recommendation 7: Create comprehensive, shared, integrated information systems that encompass human and ecological dimensions

Too often, policy, investment and management decisions are inadequately supported by appropriate evidence and analysis. There is generally a weak understanding among national policy makers of current and future agricultural constraints (i.e. the challenges of both climate and food security) and among global donors of the business case for better-directed investments. Underdevelopment of decision support tools that can evaluate the return on investment in resource allocation decisions fosters inaction or unintended outcomes.

Navigating towards a 'safe operating space' requires a place-specific understanding of potential benefits, trade-offs socioeconomic data. At the same time, sensor information and communication technologies are rapidly making the creation of such systems technically achievable. What is needed is a renewed commitment to this goal and sufficient resourcing to make it a worldwide reality.

Sustain and increase investment in regular monitoring, on the ground and by public domain remote sensing networks, to track changes in land use, food production, climate, the environment, human health and well-being worldwide.



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Engineering is an enabler

- "the application of scientific, economic, social, and practical knowledge in order to design, build, and maintain structures, machines, devices, systems, materials and processes".

WIKIPEDIA
The Free Encyclopedia

Increasing sustainability as big a challenge as growing or maintaining yields – it is not just about "resource use efficiency"



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Thank you!

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