CALLUND CONSULTING

FOOD SECURITY

A case study in scenario development

Louise Pryor | Kenneth Donaldson | December 2015

AGENDA

- Why does food security matter?
- Why use scenarios?
- A food security scenario

http://www.worldometers.info/world-population/

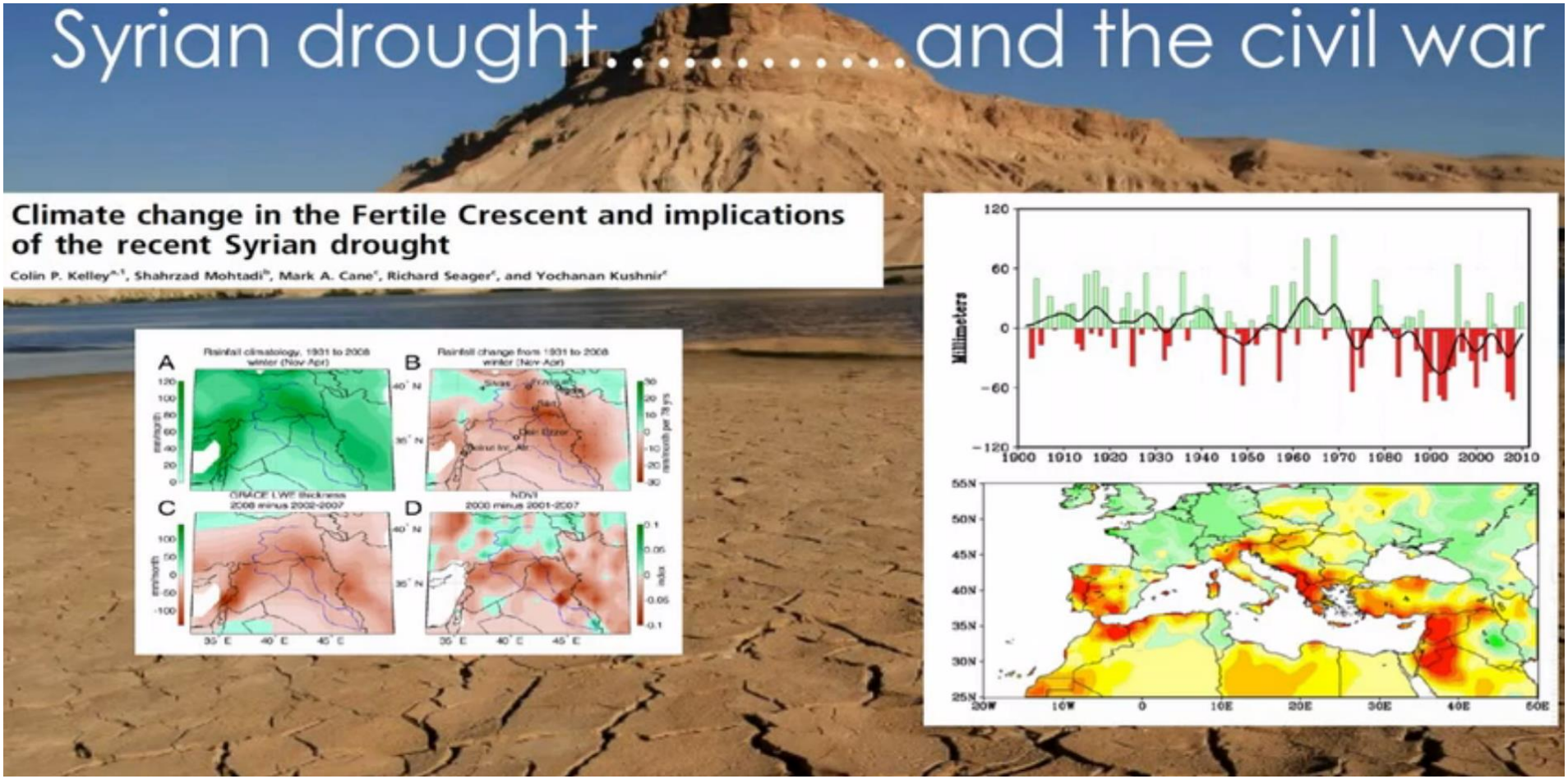
FOOD SECURITY – DOES IT MATTER TO YOU?

Arab Spring

"… Middle East and north Africa depend more on imported food than anywhere else. Most Arab countries buy half of what they eat from abroad and between 2007 and 2010, cereal imports to the region rose 13%, to 66m tonnes. Because they import so much, Arab countries suck in food inflation when world prices rise. In 2007-08, they spiked, with some staple crops doubling in price. In Egypt local food prices rose 37% in 2008-10"

The Economist, 17 March 2012

OR SYRIA?

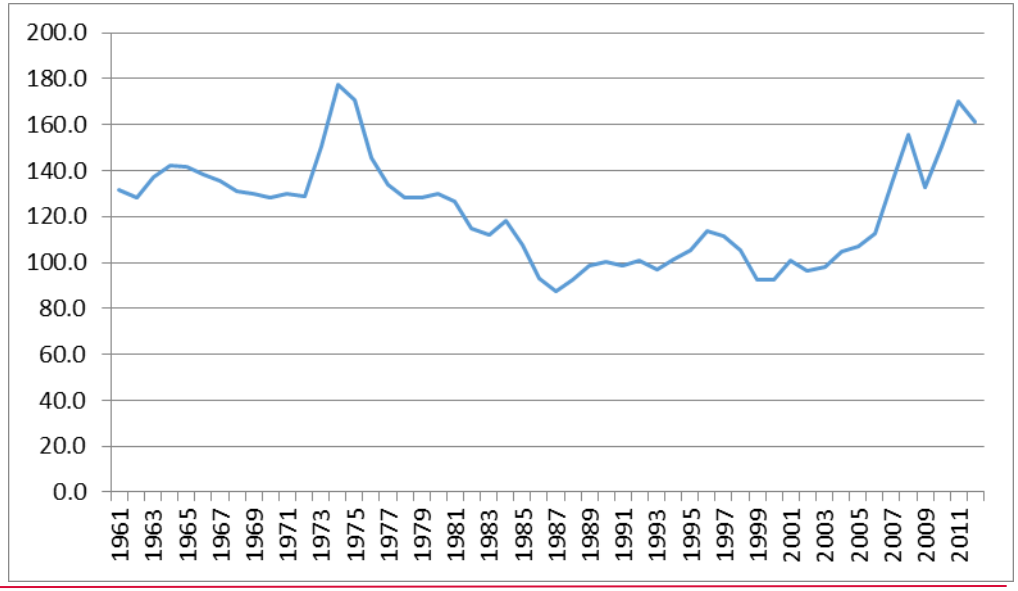


http://www.huffingtonpost.com/entry/2015-humanitys-most-important-year_560d5001e4b0dd85030af63f

WITH KNOCK-ON EFFECTS, FOR EXAMPLE OIL…

- 1973 OPEC oil crisis
  - Demand Shock: Russia's wheat crops failed in '72
  - Russia purchased more than ¼ of US wheat production (the great grain robbery)
  - US soybean export embargo in '73
  - On 16 October 1973, OPEC raised the posted price of oil by 70%

FAO Food Price index (annual deflated - cereals) - shocks in 1973 (40% increase) and post 2006 (50%-60% increase although peak was the same as that in 1973 shock)



OTHER IMPACTS - EQUITIES

In response to the 2007/08 price and food production shocks public equities experienced major volatility. In late 2006, early 2007 the anticipation of a food shock event in 2007 caused stock valuations of commodity traders and agriculture businesses to increase by as much as 800% within a 12 month period. However, as the market began 2008 these stocks were seen to be significantly over-valued and a crash occurred – the crash continued until the financial crisis in September 2008 where the majority of all stocks crashed. However the crash in agriculture had started nine months before the financial crash. Food companies did not experience the same volatility (likely because the input costs from grains are much lower for food companies).

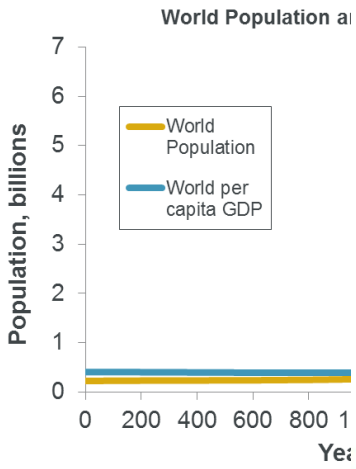
Agriculture commodity stocks: 100% increase
Agriculture chemical stocks: 500% increase
Agriculture engineering supply chain: 150% increase
Food company stocks: 0%

Source: Dr Aled Jones (Director, Global Sustainability Institute, Anglia Ruskin University)

VARIOUS INSURANCE CLASSES

- Agriculture
- Supply chain risk
- Business interruption
- Product liability/ recall
- Environmental liability
- Political Violence / Terrorism
- Political Risk
- Liability
- D&O
- E&O
- Contingency (eg event cancellation)
- Health
- Life
- Marine and Aviation (less trade, less travel)

PRESSURE RISING



Source: http://www.albartlett.org

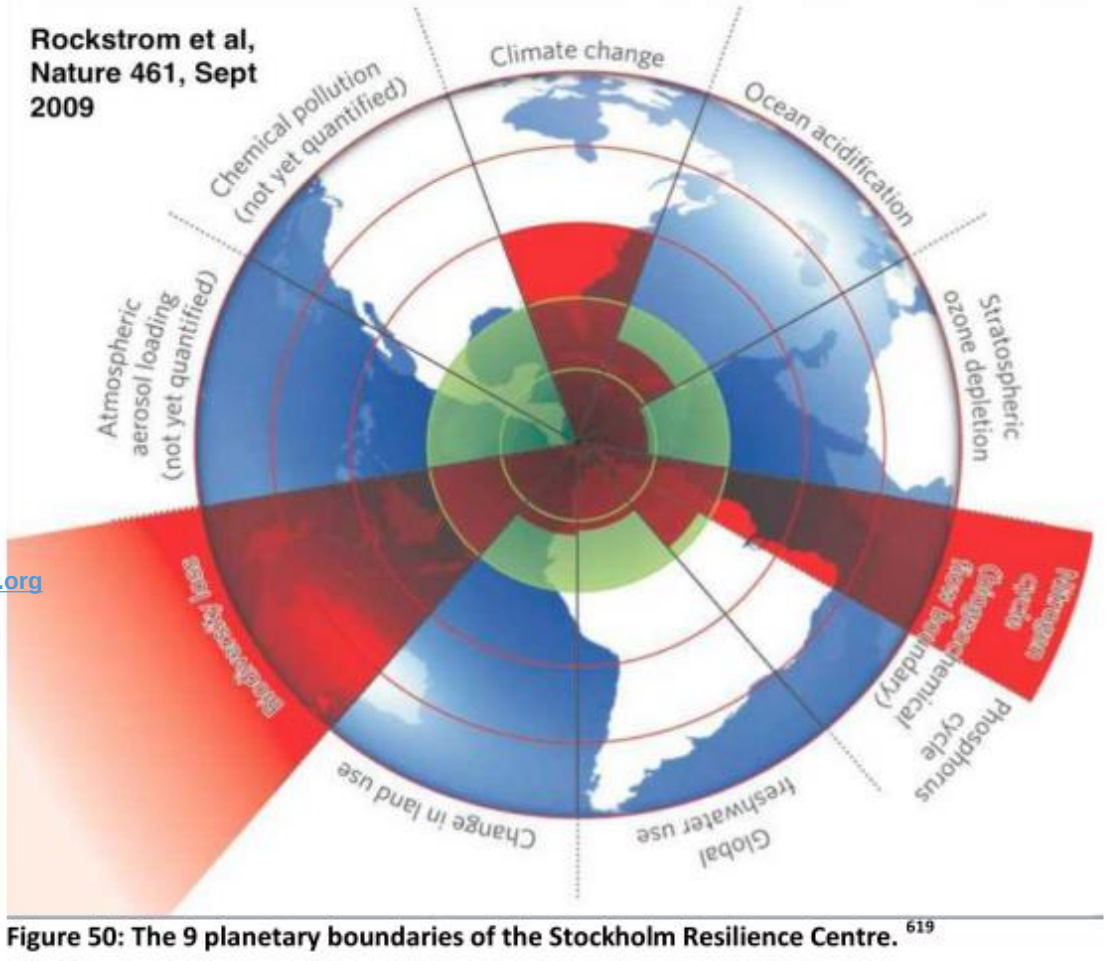


Figure 50: The 9 planetary boundaries of the Stockholm Resilience Centre. [619]

O2 Program
F. Bollenbacher and S. J. Walker

CLIMATE IMPACTS ON FOOD PRODUCTION

Met Office Hadley Centre

Run off

Regions of both increase and decrease

Water demand for irrigation

Global increases in the amount of water needed by crops

Average crop yield

Both increases and decreases in yield of wheat, rice and soybeans; Decreases for maize

Drought

Global increases in number of days in drought

Flood frequency

Increases in flood frequency over large regions, smaller areas seeing decreases

Coastal flooding

Millions of people at risk of coastal flooding due to sea level rise and population increases

Temperature of warm days

Increases globally

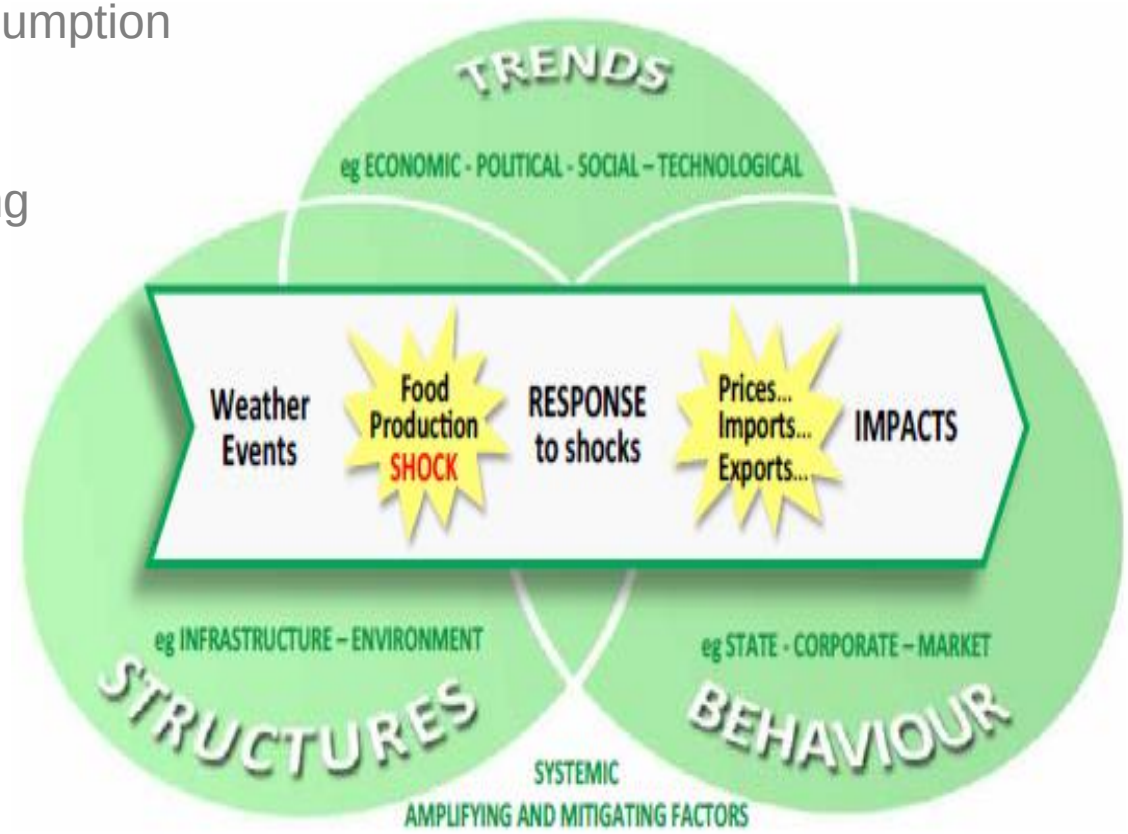
Population

Global population rising.

Source: Kirsty Lewis, Climate Security Team Leader, Met Office

IT'S COMPLEX!

- Climate change – non-stationary risk
- Increasing homogeneity in consumption
- Crop science
- Food policy / strategic stockpiling
- Transport infrastructure
- Pricing mechanisms / subsidies
- Energy (biofuel) policy



WHAT IS A SCENARIO?

- A story
- … worked out in some detail
- … plausible
- … not probable
- … and definitely not a prediction

SCENARIOS HELP TO

- Illustrate the effects of a complex, extreme event
- Understand the potential for disruption
- Quantify the sizes of economic and financial effects

CONSTRUCTING A SCENARIO

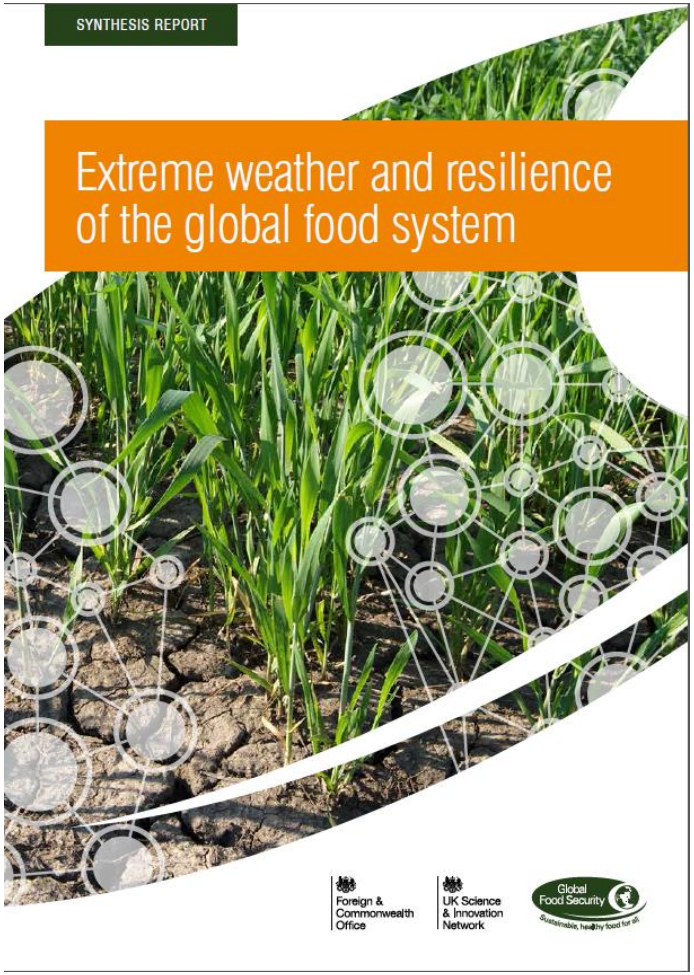
- Often difficult to get it extreme enough
- Need to be pessimistic or at least sceptical
- Think Swiss cheese!

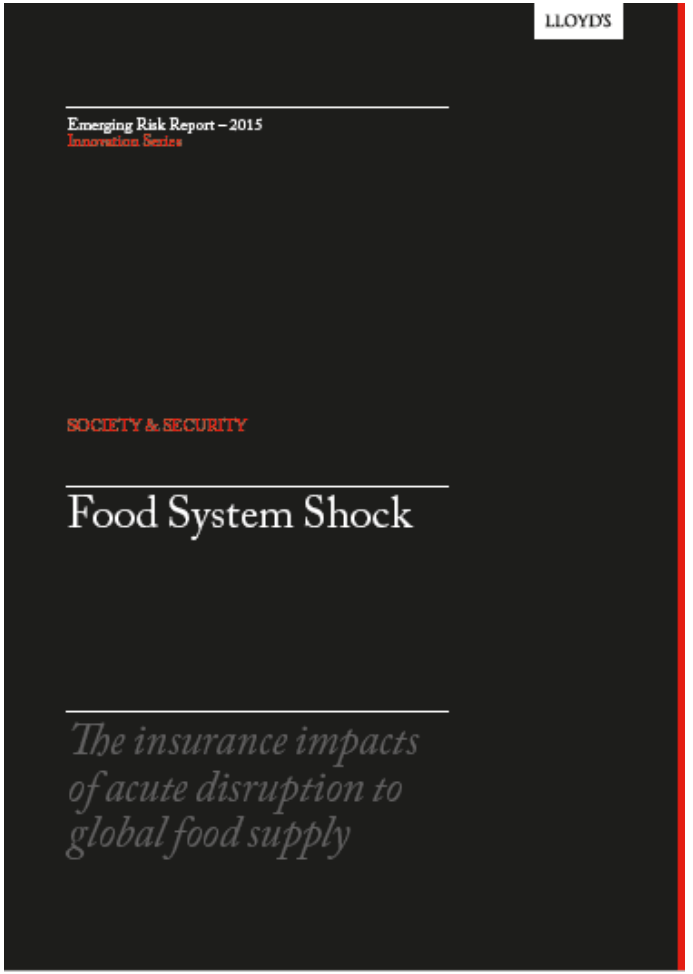
- Expert panel
- Precedents for components

LIMITATIONS OF SCENARIOS

- Deterministic
- Difficult to assign probabilities

FCO PROJECT… AND THE LLOYDS' SCENARIO





HOW THE PROJECT WORKED

Taskforce of academics, industry and policy experts

- Chatham House
- UK Global Food Security Programme
- University of Leeds
- Computation Institute at the University of Chicago, USA
- ILSI Research Foundation, Washington, USA
- Global Sustainability Institute, Anglia Ruskin University
- University of Wisconsin-Madison
- Met Office
- The James Hutton Institute, Aberdeen
- Scottish Government
- Centre for Food Security, University of Reading
- Department of Atmospheric Sciences, University of Illinois

Plus workshops with Lloyds of London, Willis, Munich Re, IFoA, Aviva, F&C, LGIM, Sarasin & Partners, Impax, Climate Change Capital, IIGCC and others.

UK Science & Innovation Network

Global Food Security
Sustainable, healthy food for all

HOW THE PROJECT WORKED

Stages of the modelling framework

1. Define ‘Loss factors’ for target crops, which are reductions to global crop production that could be achieved through one or multiple extreme weather events.
2. Define a set of consequences for global food security that could plausibly be caused by the reductions set out by the Loss factors (part 1). These will be defined as impacts on Food Import capability, Prices, Export capability (FIPES), including no impacts
3. Determine the likelihood of such reductions to crop production occurring and produce a set of weather events that could plausibly lead to them, given current and future climate (the Agricultural ‘Bang’).

Team 1

4. Identify the range of policy and market Responses to the crop production reductions set out in part 1 that could lead to the food security consequences set out in part 2.
5. Assess the Impacts on markets, people, geopolitics, that could occur as a result of part 2.

Team 2

6. Iterate the process

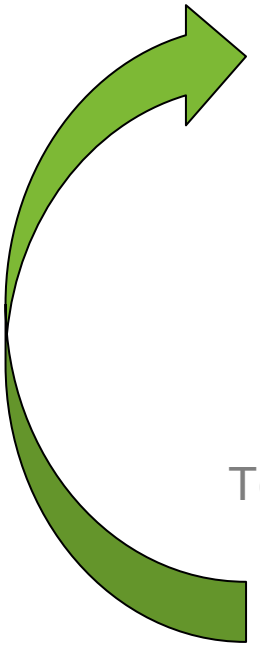
HOW THE PROJECT WORKED

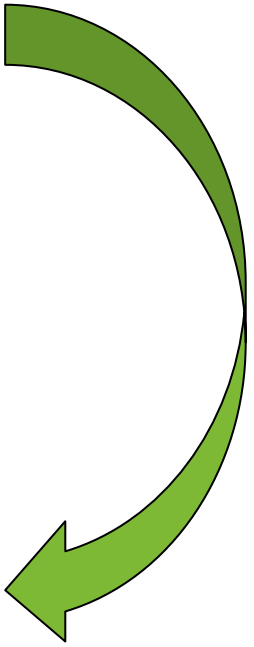
Team 1

- First draft scenarios produced by Team 1, based on wheat, maize and rice shocks of 50% greater severity** than “de-trended* historical anomaly data”. So a 12.5% reduction in maize becomes an 18.75% hit in the scenario.
- So for example, for wheat:
  - Rust pathogen takes out 40% of East Africa, 50% of Middle East and 60% Central Asia
  - A combination of drought followed by deluge and storm causes 50% loss to US spring harvest

Team 2

- Lots of work on price / yield reduction correlations
  - FAO Food Price Index
  - Yield data





* **Detrended to take account of shifting technology, yield, area under production etc.**

** **50% a first educated guess at plausible worst case, then subject to further expert consultation and review**

NON-STATIONARY RISK

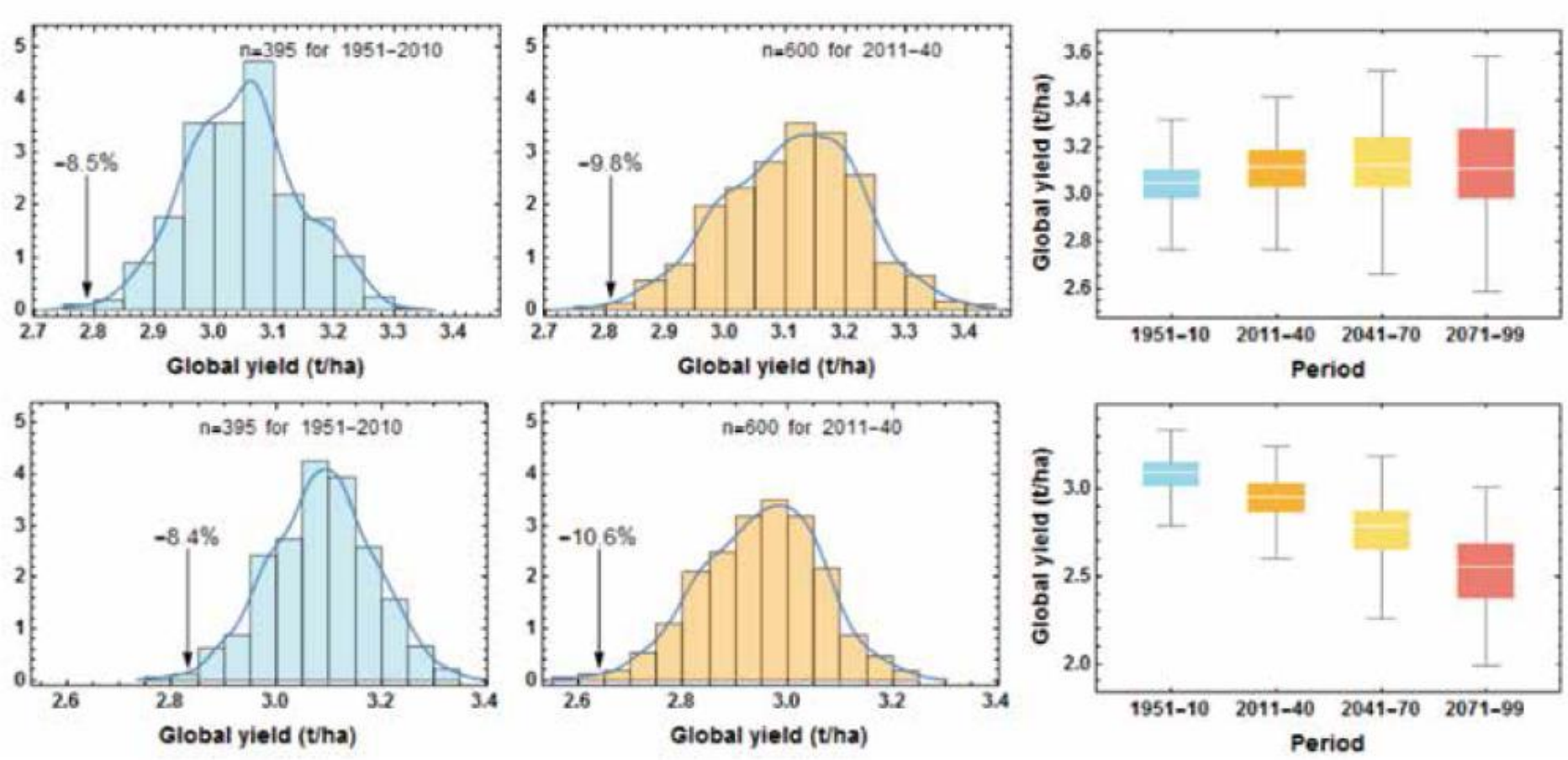


Figure 3: Model-based distributions of global calorie-weighted yield of maize, soy, wheat, and rice for the historical (1951-2010) and near-future (2011-2040) period with (top row) and without (bottom row) the effects of fertilization from increasing atmospheric CO2 included. The estimated magnitude of a 1-in-200 year event in each period is indicated by arrows on the histograms. The box plots summarise the distributions and show the likely increasing variability continuing throughout the century.

Extreme weather and resilience of the global food system (2015). Final Project Report from the UK-US Taskforce on Extreme Weather and Global Food System Resilience, The Global Food Security programme, UK.

ROUNDTABLES

- The above work was then exposed in roundtable discussions:
  1. Insurance
  2. Investment
  3. Insurance revisited

- With expert market opinion on how the scenario might impact (or not!)

EXTREME WEATHER AND RESILIENCE OF THE GLOBAL FOOD SYSTEM

- Isolated crises have occurred before: for example, in 1988/89 there was a significant drought related impact on the yields of maize and soybean, and in 2002/03 drought impacted wheat in Europe, Russia, India, and China; rice in India.
- The level of risk is growing: evidence suggests that the risk of a 1-in-100 year production shock event from extreme weather, could increase to 1-in-30 year or more in the next few decades.
- Extremes are where the greatest impacts from climate change will be felt, but predicting the frequency and intensity of extreme events is extremely challenging.

OPERATING CONTEXT

2016…
- Escalating demand for food
- Trade volume and interdependencies amplify shocks
- Crop production concentrated in global regions, increasing exposure to extreme weather risks
- Reduced self sufficiency in China for cereals
- Increasingly inelastic demand

…by 2026 ?
- Key Food import states, economically and politically unstable
- Greater interdependencies
- Production struggles to keep pace with demand
- Underinvestment in exporting region infrastructure
- Recovery of oil prices

MULTIPLE BREADBASKET FAILURE

EXTREME WEATHER disrupts production

- Poor Indian monsoon, reduces wheat crop in India and China
- Early Spring thaw-freeze in Black sea area affects wheat crop
- Summer drought in N. America affects maize and wheat forecasts
- Heat wave and drought in Europe affects wheat crop
- Indian monsoon second failure, causes rice harvest concerns

ESCALATING PANIC exacerbates crisis

- As cereal prices climb, export bans are imposed
- Countries impose tariff reductions or consumption subsidies
- China and Argentina raise export taxes on Soybean and Maize
- The US does not waive the ethanol mandate
- Hoarding and further export restrictions in SE Asia
- Further export bans are imposed
- Low stocks to use ratio raises concerns of availability

PRICE volatility
EXPORT bans
Import Restrictions

POLITICAL
- Social unrest experienced; Middle East and North Africa particularly vulnerable.

ECONOMIC
- FAO food prices hit 250 and prices of affected grains go up 3x.
- Country level budgetary pressures experienced
- Poverty rates increase
- Inflation and deterioration in the balance of payments

IMPACTS: the hardest economic, social and political impacts are likely to be felt by import dependent countries, particularly in Sub-Saharan Africa. Major economy impacts would likely be muted.

SOCIAL
- Deterioration in nutritional security
- Government intervention (e.g. in China) may protect some poor food consumers

Reduced Resilience
- Intensification and extensification of agriculture
- Degradation of biodiversity, soil and water resources
- Increase in GHG emissions and degradation of landscape carbon
- Destabilisation of governments
- Increase in regional migration (internal and external)
- Reduction in global stocks

Increased Vulnerability

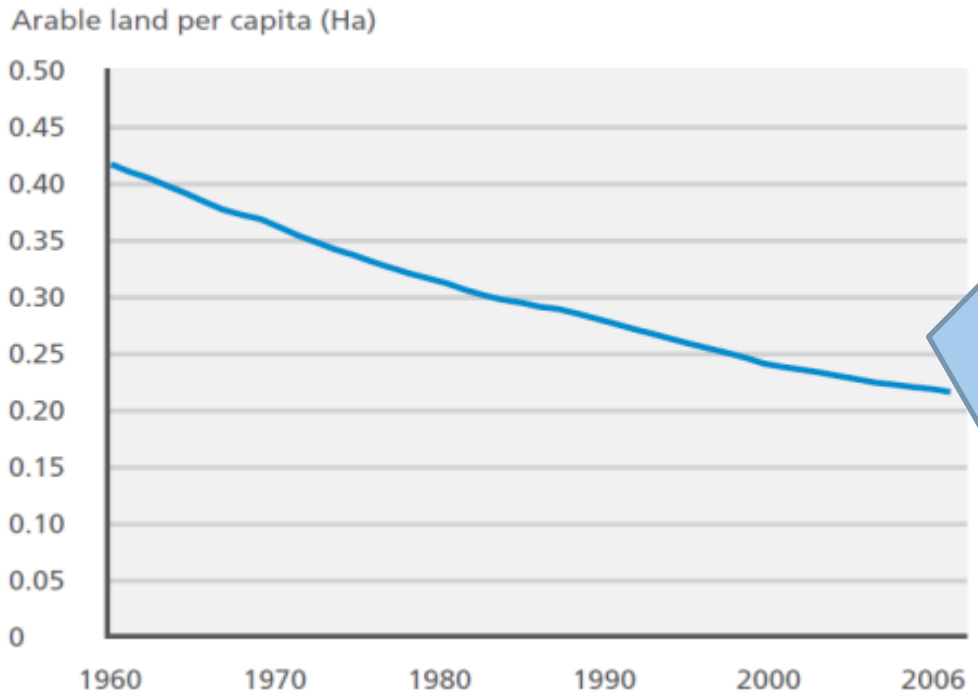
KEY RECOMMENDATIONS
- Adapt agriculture to account for climate extremes
- Better understand the risks by improving climate, economic and crop modelling tools
- Better coordinate risk management
- Do not impose export restrictions
- Better understand how responses can amplify shocks
- Improve function of international markets
- Bolster national resilience to market shocks
- Make biofuel mandates more flexible
- Implement mechanisms to protect low income, fragile countries

- The above visualisation represents a fictional, but plausible 2016 scenario outlined in the Resilience Taskforce summary report.
- Text in red indicates how the scenario could develop further in a 2026 situation.
- The scenario originated from the isolated crises outlined above in 1988/89 and 2002/03, occurring simultaneously.

APPPENDIX

- The following slides are extracts from a presentation on Limits to Growth given by Elliot Varnell at the IFoA Life Convention 2013
- They do not form part of the presentation but are included as additional background for anyone who is interested

LAND, SOIL, FOOD



Arable Land (Where Cereals Can Be Grown)

- **Arable land per capita has halved over the last 50 years.**
- **The area of land growth was much less of a factor in the production increases – productivity increases have kept agriculture apace.**
- **To increase production just from land use would have resulted in 3x as much land use being required.**

LAND, SOIL, FOOD

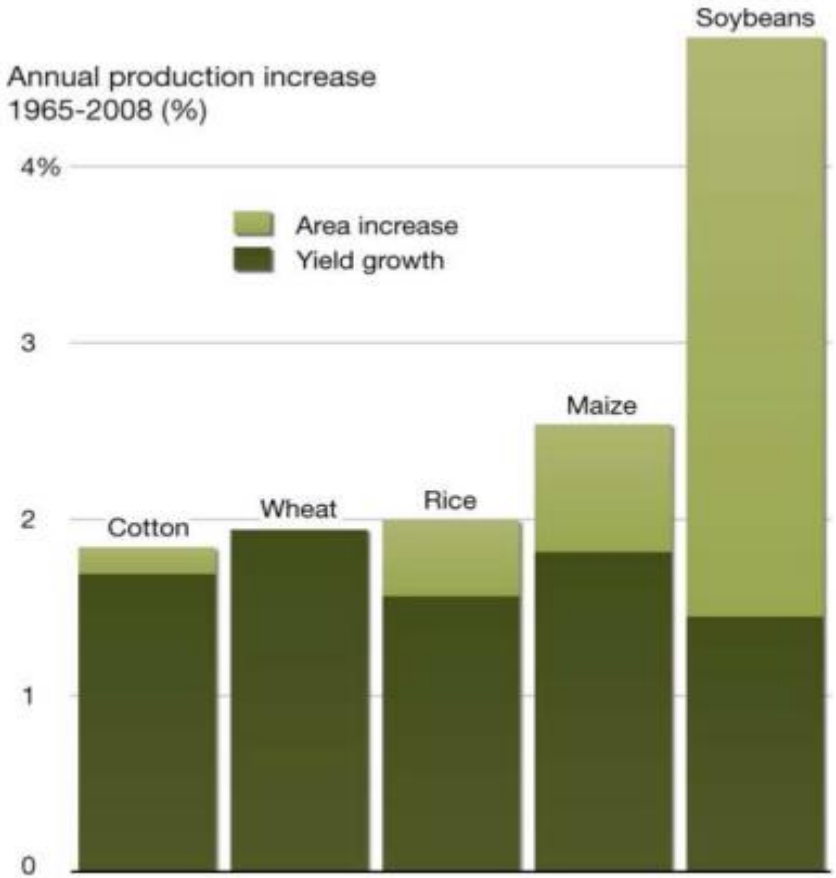


Figure 33: Agricultural production increases, per commodity 1965-2008[422]

Yields Have Increased

Since 1960s the increase in yields has been:

- **270% - Cereals**
- **160% - Tubers / Roots**
- **400% - Meat**

Increased yields can be attributed to:

- **50% from fertiliser**
- **20% from irrigation**

Fertilisers from phosphorous – demand expected to grow by 50%-100% by 2050 with peak phosphorous by around 2030.

75% of phosphorous production concentrated in USA, China, Morocco and Russia.

LAND, SOIL, FOOD

- From the Land Commodities Global Agriculture & Farmland Investment Report 2009
- A story of forests and grasslands giving way to agricultural land to support populations.
- In 2005 University of Wisconsin reported that 40% of the worlds surface is being used for agriculture – vs. 7% in 1700.
- 13.4bn ha on earth – 3bn ha suitable for agriculture – 1.5bn used already – the rest is underneath rain forest!

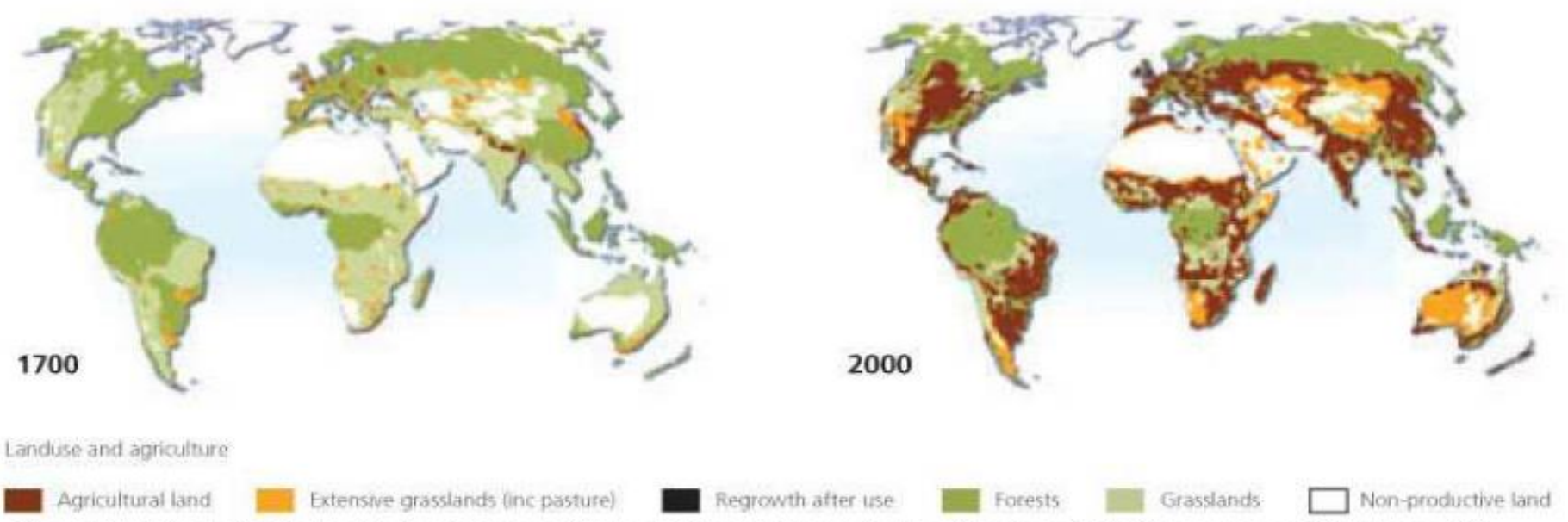


Figure 34: Estimated global agricultural land use 1700 and Actual global agricultural land use in 2000 based on satellite imagery[431]

LAND, SOIL, FOOD

Soil Degradation

- Production time for 6 inches of topsoil is tens of thousands of years.
- Mainly caused by weather (flooding, irrigation, wind).
- 40% of agricultural land is seriously degraded. 80% of global farmland is moderately to seriously degraded.
- Over past 40 years 30% of global arable land has become unproductive.

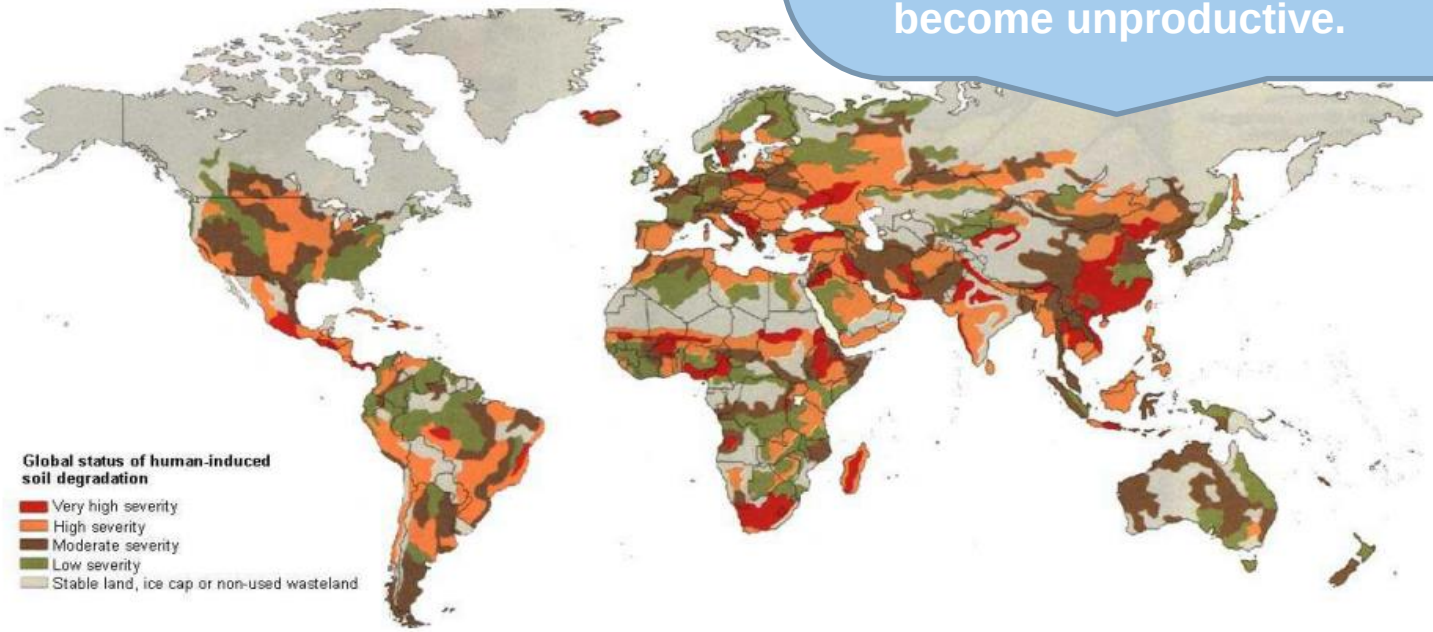


Figure 38: Global status of human induced soil degradation[477]

LAND, SOIL, FOOD

What happens when you have too many people for your land to support?

- **If you are rich you go and buy up land from someone poorer than yourself – its not just land but water resources being secured.**

Source : Guardian

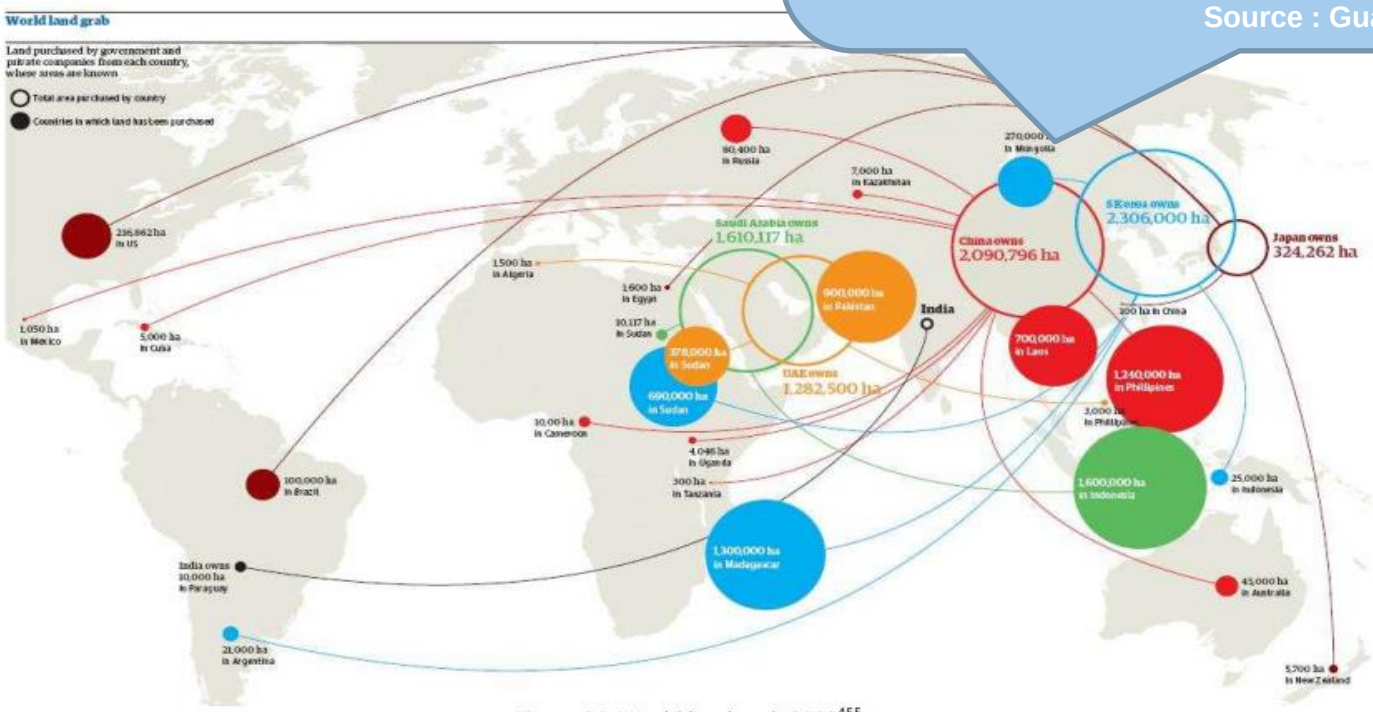


Figure 36: World land grab 2008[455]

LAND, SOIL, FOOD

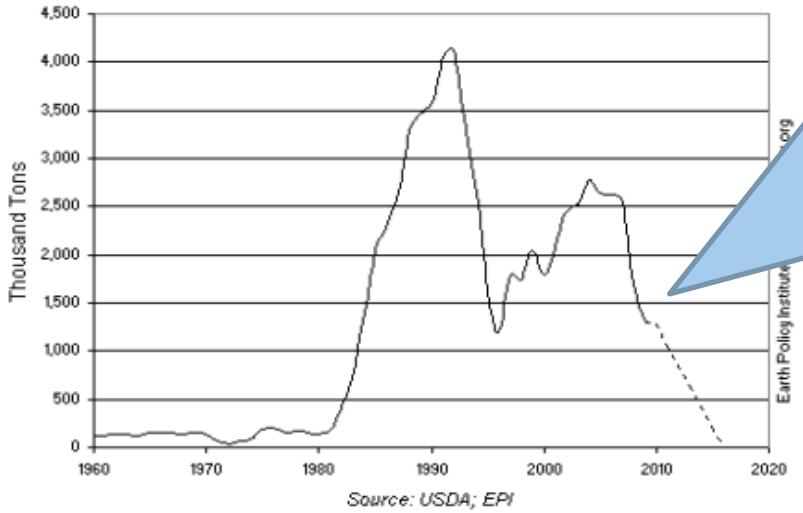


Figure 37: Wheat Production in Saudi Arabia, 1960 - 2009, with Projection to 2016[462]

What happens when you run out of water?

- **Saudi Arabia reports that it has exhausted its principal aquifer through over irrigation of its wheat and will now stop producing wheat by 2016.**
- **In 2008 Saudi government earmarked $5bn for private firms wishing to invest in countries with strong agricultural productivity potential.**

LAND, SOIL, FOOD

Private Investment in Land

- **In 2011 there was $14bn invested in farmland – this figure expected to grow 10 fold according to one source.**
- **US Pension Funds are among the biggest investors – $5-15bn are reported to be invested with expected return rates of 10% - 20% cited.**
- **Increasing common area for pension fund investment here in the UK too.**

Fund	Total assets under management (AUM)	Global farmland investment portion…(% of AUM)	…and its status
AP2 (Second Swedish National Pension Fund)	SEK220 billion [US$34.6 billion]	US$500 million in grain farmlands in US, Australia and Brazil (1.4%)	**Planned** joint venture with TIAA–CREF. **First forays** into farmland investing were in 2010
APG (administering the National Civil Pension Fund), Netherlands	€220 billion [US$314 billion]	**€1 billion** (0.5%) [US$1.4 billion]	A planned increase
Ascension Health, USA	US$15 billion	Up to US$1.1 billion (7.5% target)	**Looking** to invest in farmland for the first time, to help meet a real assets target of 7.5% that is currently underachieved
CalPERS (California Public Employees' Retirement System), USA	US$231.4 billion	About US$50 million (0.2%): majority invested in agribusiness firms with huge int'l farmland holdings	**Current**
Dow Chemical, USA		not revealed	**Farmland added recently.** Aimed annual returns on US holdings: 8–12%
New Zealand Superannuation Fund	NZ$17.43 billion [US$14.2 billion]	NZ$500 million (3%) [US$407 million]	The 3% allocation **has been made** at the Fund's strategy level. First purchases into domestic farmland have started
PGGM (Pension Fund for Care and Well-Being), Netherlands	€90 billion [US$128 billion]	not revealed	**May raise** farmland allocation in 2011
PKA (Pensionskassernes Administration), Denmark	US$25 billion	US$370 million (1.5%)	In June 2011, made a **first placement** of US$50 million in Silver Street Capital's Silverland Fund.
Sonoma County Employees' Retirement System Association, USA			Expected to allocate **3% to UBS Agrivest Farmland Fund**
TIAA–CREF (Teachers Insurance & Annuity Association – College Retirement Equities Fund), USA	US$426 billion	US$2 billion in **400 farms** in North and South America, Australia and Eastern Europe (0.5%)	**Current**. They claim annual returns of 10%

[486] In ibid (Reproduced with permission.)

LAND, SOIL, FOOD

Soil	World Peak Estimate	Source	Date of Prediction
Before 2012	10 millennia ago	David Pimentel, Agricultural Ecologist, Cornell University[487]	?
By 2030	No topsoil left by 2070 (within 60 years)	John Crawford, University of Sydney[488]	2011
	No topsoil left between 40 – 80 years time	John Jeavons, Founder Ecology Action (non-profit)[489]	2010
After 2030	Run out of fertile topsoil or one or two more centuries	David Montgomery, Author 'Dirt: The Erosion of Civilizations'[490]	2008
No peak on horizon			

	World Peak Estimate	Date of Prediction
Palm Oil	Supply of land for palm oil to run out by 2020/2022 in Indonesia and Malaysia	Ken Arieff-Wong, Analyst, KL[491]
Phosphorus	Could peak by 2033	Soil Association[492]
	Enough to last several hundred years	International Fertilizer Development Centre[493]
	2030	Cordell, Drangert, White, Linköping University and University of Technology Sydney, *Global Environmental Change*[494]
	Readily available supplies may start running out at the end of this century	*Scientific American*[495]
	1989	Patrick Déry, The Oil Drum[496]

Issues

- **Phosphorous peak**
- **Energy needed to create fertilizers / irrigation systems / mechanised farming.**
- **Reliance on fresh water irrigation to provide crops.**

When is Peak Soil?

- **Predictions of top soil running out between 40-200 years.**

When is Peak Phosphorous?

- **Peak phosphorous predictions around 2030 – with outliers suggesting 1989 and several hundred years.**

WATER (BRIEFLY!)

Issues With Water

- Very localised – very expensive to move around.
- Water Resources Group cite a 40% increase in fresh water use by 2030 if no efficiency gains.
- Third of global population live in areas where demand exceeds supply by 10% now – expected to rise to 50% by 2030.

Rivers Running Dry

- This table gives evidence of the dry running of some major rivers.
- Examples from China, USA, India, Africa, Aral Sea.

Table: Major Rivers Running Dry[508]

Major Rivers Running Dry	
River	**Condition**
Amu Darya	The Amu Darya, which originates in the mountains of Afghanistan, is one of the two rivers that feed into the Aral Sea. Soaring demands on this river, largely to support irrigated agriculture in Uzbekistan, sometimes drain it dry before it reaches the sea. This, along with a reduced flow of the Syr Darya—the other river feeding into the sea—helps explain why the Aral Sea has shrunk by more than half over the last 40 years.
Colorado	All the water in the Colorado, the major river in the southwestern United States, is allocated. As a result, this river, fed by the rainfall and snowmelt from the mountains of Colorado, now rarely makes it to the Gulf of California.
Fen	This river, which flowed from the northern part of China's Shaanxi province and empties into the Yellow River at the province's southern end, has literally disappeared as water withdrawals upstream in the watershed have dropped the water table, drying up springs that once fed the river.
Ganges	Some 300 million people of India live in the Ganges basin. Flowing through Bangladesh en route to the Bay of Bengal, the Ganges has little water left when it reaches the bay.
Indus	The Indus, originating in the Himalayas and flowing west to the Indian Ocean, feeds Pakistan's irrigated agriculture. It now barely reaches the ocean during much of the year. Pakistan, with a population of 157 million projected to reach 349 million by 2050, is facing trouble.
Nile	In Egypt, a country where it rarely ever rains, the Nile is vitally important. Already reduced to a trickle when it reaches the Mediterranean, it may go dry further upstream in the decades ahead if, as projected, the populations of Sudan and Ethiopia double by 2050.
Yellow	The cradle of Chinese civilization, the Yellow River frequently runs dry before it reaches the sea.

WATER (BRIEFLY!)

Since 1900 half of the worlds wetlands have disappeared. Freshwater species down by 50% since 1970 (faster than species disappearance in sea or on land). Global threats to river biodiversity have been mapped as illustrated in Nature.

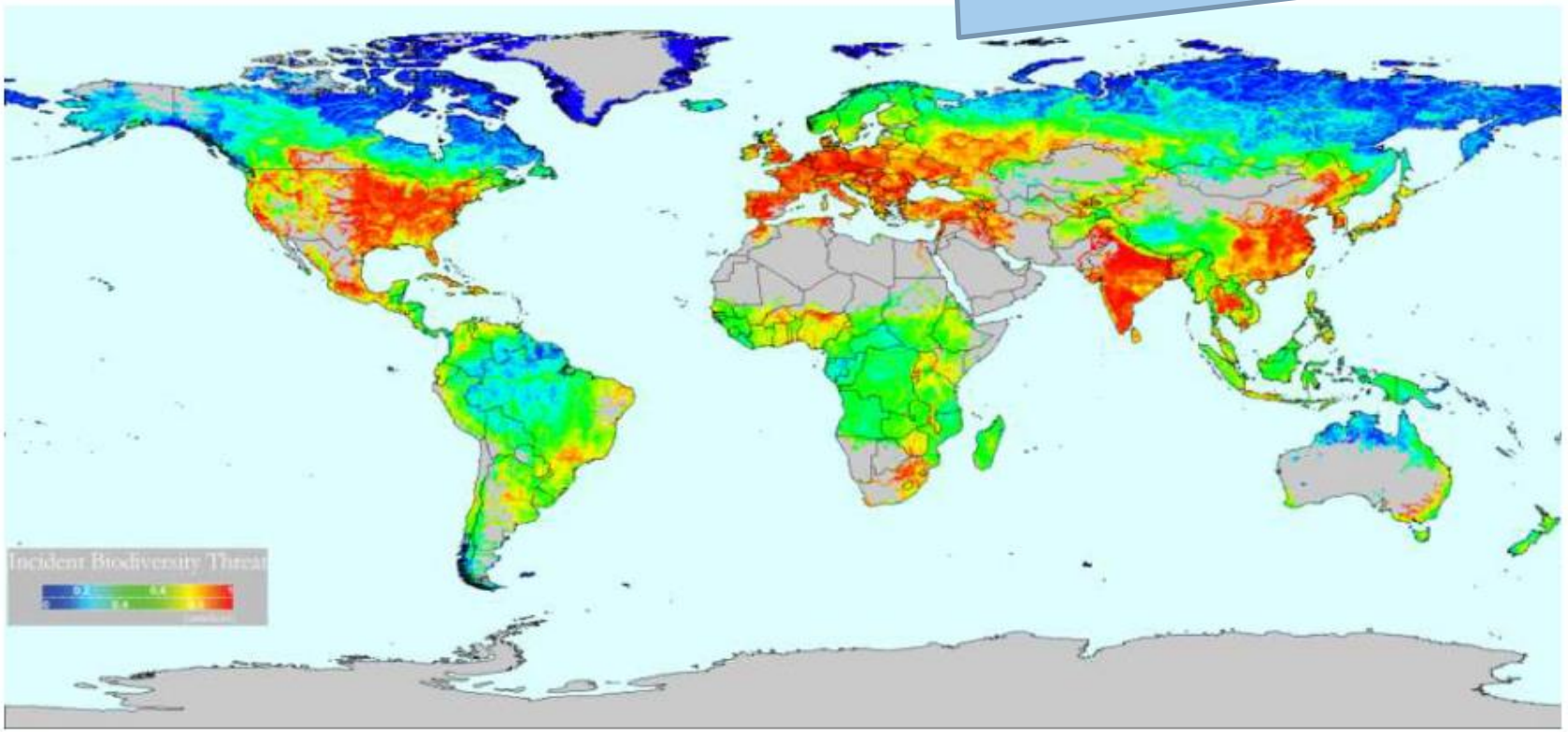


Figure 40: Global geography of incident threat to human water security and biodiversity[518]

WATER (BRIEFLY!)

	World Peak Estimate	Source	Date of Prediction
Before 2012	Saudi Arabia hit peak water 10 years ago	The Oil Drum[528]	2008
	Cyprus has hit peak water; Yemen to run out by 2015; Pakistan under pressure	Alexander Bell, author of 'Peak Water', in *The New Statesman*[529]	2010
	Peak water "come and gone"	*Guardian* news[530]	2011
	In many parts of the world already hit peak water, including USA – which hit peak water in the 1970s	Peter Gleick, Pacific Institute, California[531] [532]	2011
	Peruvian watershed likely passed peak water due to melting glaciers	Michel Baraër, McGill University, Montreal[533]	2011
By 2020	"Dawning era of peak water"	Matthew Power, *Wired* magazine[534]	2008
By 2030	By 2030 the global water demand will be 40% greater than today's "accessible, reliable, environmentally sustainable supply"	McKinsey & Company[535]	2009
After 2030	N/A		
No peak on horizon	N/A		

Peak Water?

It seems to be hard to estimate peak water but localised studies suggest some places have hit peak water already.