Anglia Ruskin University

Global Sustainability Institute

# Global Resource Observatory: the road to Dr Apocalypse

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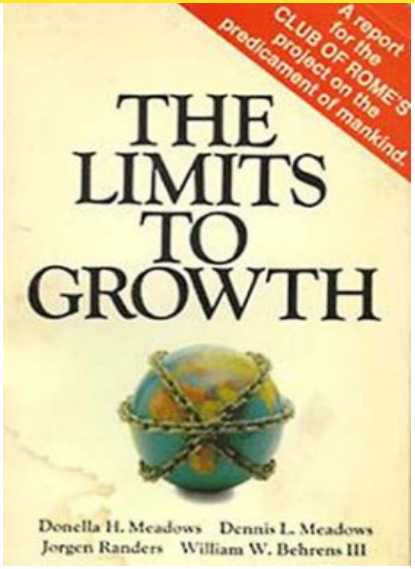
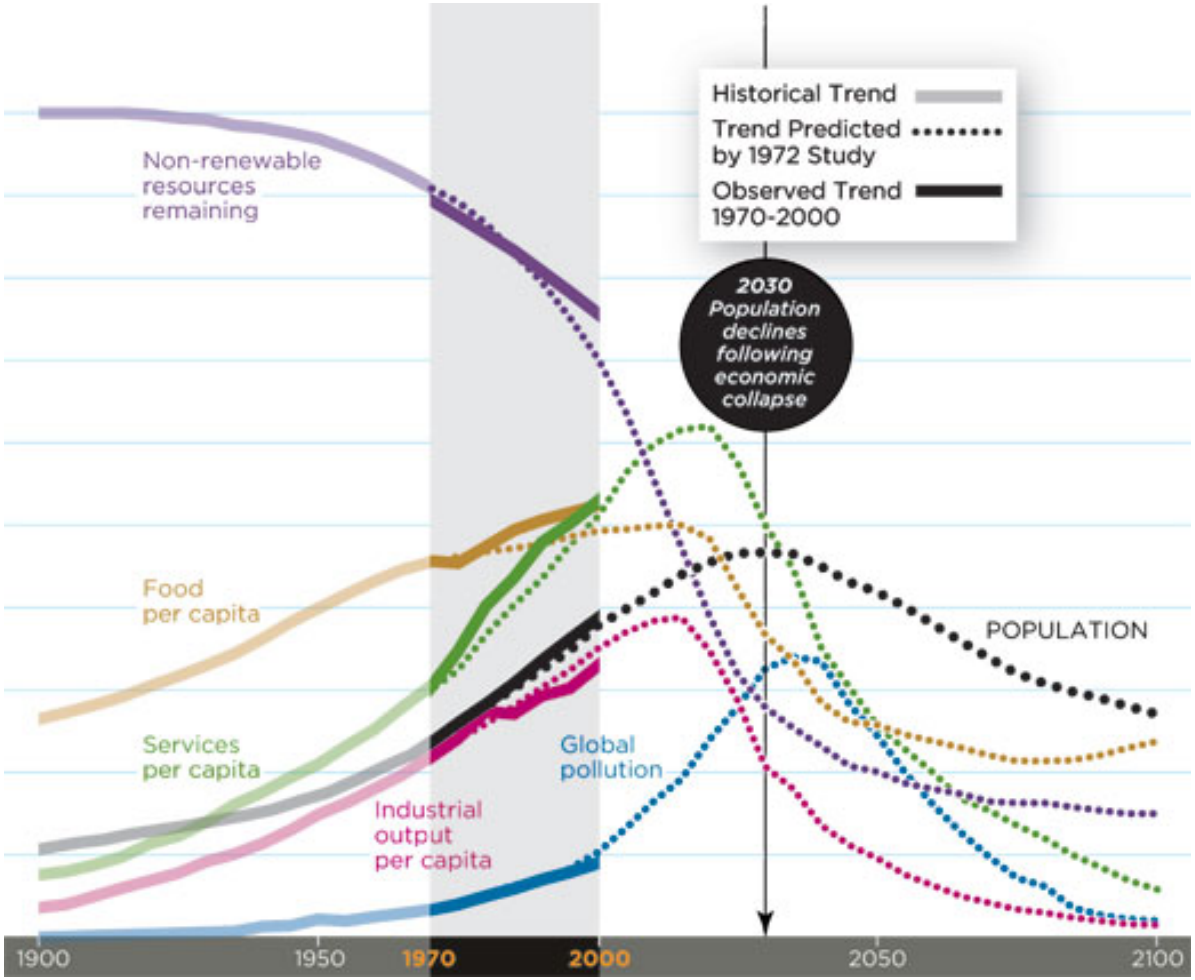
# Resource constraints

Taking a systems view of the natural and social (human) capitals what do scarce resources potentially mean for the system flows in a global economy and in particular to financial capital?

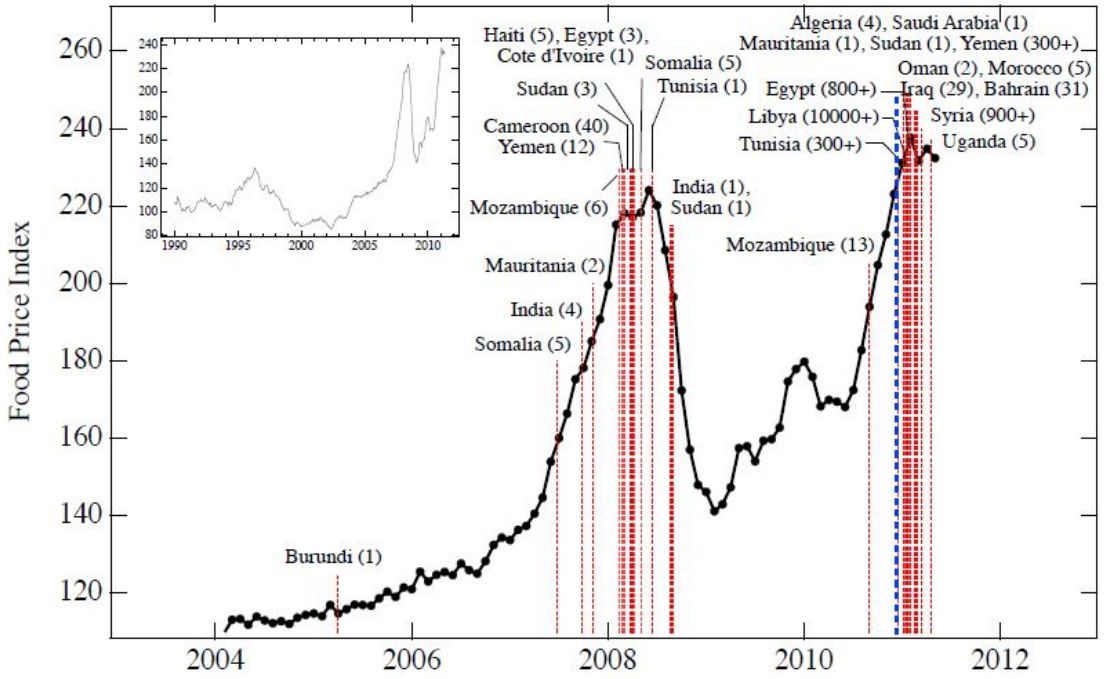
- Energy availability
- Food availability
- Water availability
- Land availability
- Metals availability
- Social mobility and health
- Capital availability
- Environmental loading

# So What?


A report for the CLUB OF ROME'S project on the predicament of mankind
THE LIMITS TO GROWTH
Donella H. Meadows Dennis L. Meadows
Jorgen Randers William W. Behrens III


Historical Trend
Trend Predicted by 1972 Study
Observed Trend 1970-2000
Non-renewable resources remaining
2030 Population declines following economic collapse
Food per capita
POPULATION
Services per capita
Global pollution
Industrial output per capita
1900
1950
1970
2000
2050
2100

# Will we get to 2053?




- Grantham (2012): we are experiencing a paradigm shift: after 200 years characterized by declining commodity prices, since 2002 prices started to rise
- In the next 10 years the overall trend will be higher costs of resources caused by more expensive extraction, supply-demand imbalances, and costs of environmental damage caused by the use of these resources (e.g., climate change and biodiversity loss).

# A resource view

1. We live in a planet with finite resources
2. Resources getting more scarce/expensive/politically divisive as environmental depletion, population, urbanisation increase
3. Resource scarcity causes price spikes, access inequality and poverty
4. Commodity price spikes cause political instability

# GRO history

- **In the beginning:** First approached by Peter Dawe to do something about this risk with a research agenda that appeared to many as potentially impossible/crazy.
- **The context:** The financial and political systems are plagued by short termism, vested interests, unvalued externalities and herd behaviour.
- **The problem:** The financial and economic system is a complex interconnected system which is far simpler to approach in silos that it is to tackle as a whole.
- **The challenge:** To model the short term dynamics of the system has been described by some as simply ‘modelling the noise.’

# Global Resource Observatory

- The GRO pilot model consists of the following elements both of which exist in pilot forms:
  - A **Systems Dynamic** (SD) model to evaluate the systemic risk generated by food and energy supply shocks and their interactions with the material, financial and knowledge economies under the constraint of finite planet at the global level;
  - An **Agent Based Model** (ABM) simulating the behaviour of country-to-country trade of natural resources, heterogeneously modelled, based on empirical data in order to better evaluate political and social risk.
- A **database of key indicators** (resources and social measures) that can be used to inform the models and scenario development
- An **advisory group** of experts from finance, government, academia, media and think tanks

# The Dawe Global Security Model

*An Agent Based Model (ABM) simulating the behaviour of country-to-country trade of natural resources, heterogeneously modelled, based on empirical data in order to better evaluate political and social risk.*

# The Dawe Global Security Model

Natural resources are scarce

Resources are getting more scarce as our consumption increases

Resource scarcity causes price spikes

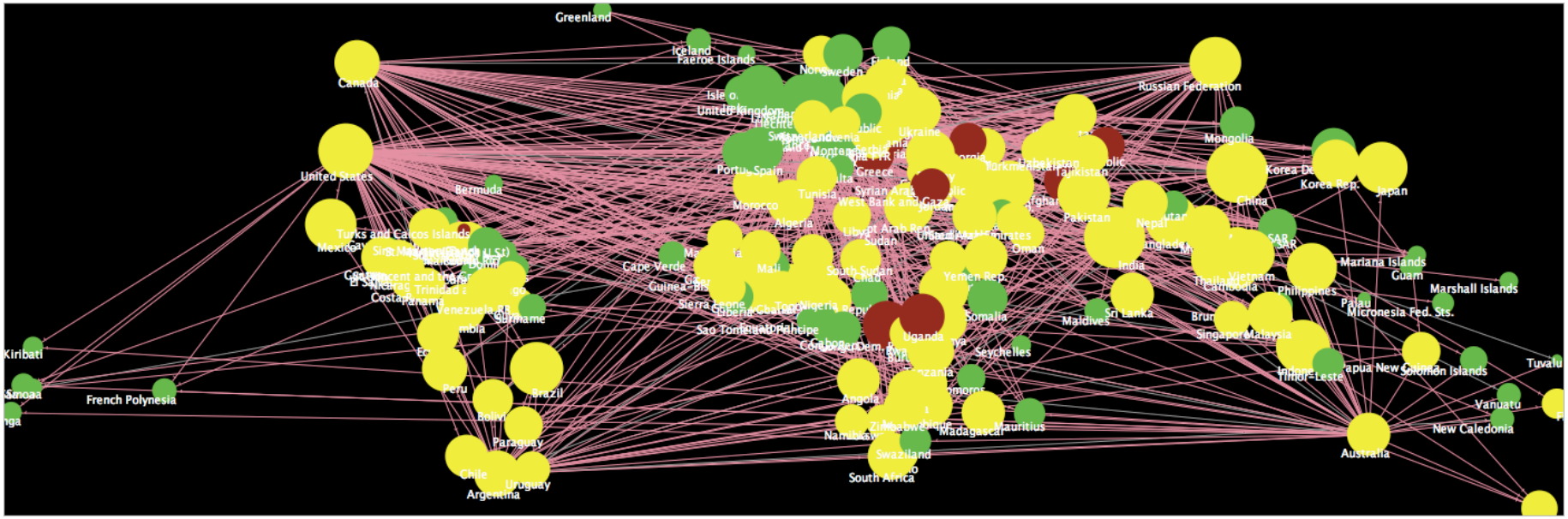
Price spikes cause political fragility

Political fragility can spread via international trade of natural resources

# Key components

- **Extraction/consumption of key natural resources**:
  - Coal production/consumption (Energy Information Administration data)
  - Oil production/consumption (EIA data)
  - Natural gas production/consumption (EIA data)
  - Food production/consumption (FAO data)
- **Trade network(s) for international trade of natural resources** - based on UN Comtrade database
- **International prices of natural resources**
- **National Political fragility (WGI) –** calibrated on Arab Spring – Natalini et al. (2015)

# 2008 Scenario




Yellow = did not meet their need to restock

Orange = did not meet their consumption in the normal trade

Pink = did not meet either consumption or need to restock

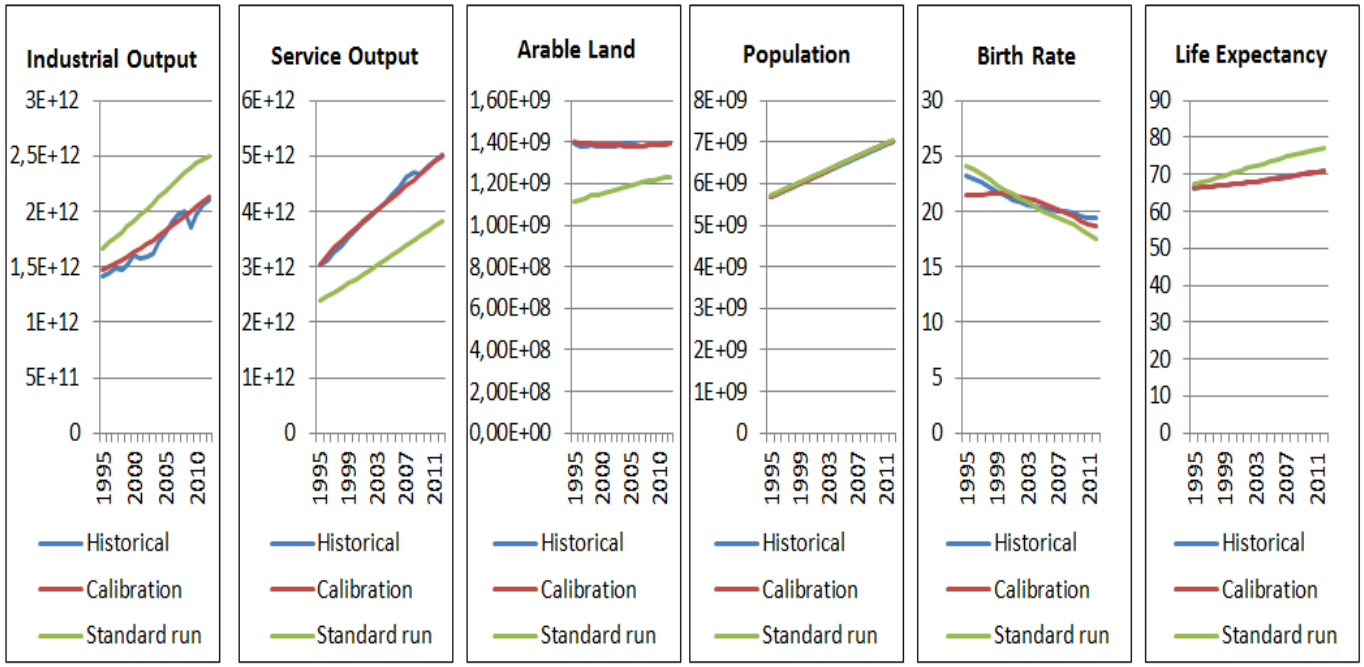
Dark red = food riot

# Financial risk model

*A Systems Dynamic (SD) model to evaluate the systemic risk generated by food and energy supply trends and shocks and their interactions with the material, financial and knowledge economies under the constraint of finite planet at the global level*

# The Limits To Growth World3-03 model (Meadows et al. 2004)

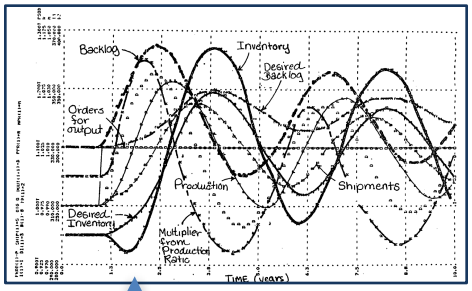
- A model to capture the dynamics of **real** capital growth in a finite world.
- Calibration of World3 (Pasqualino et al., 2015)

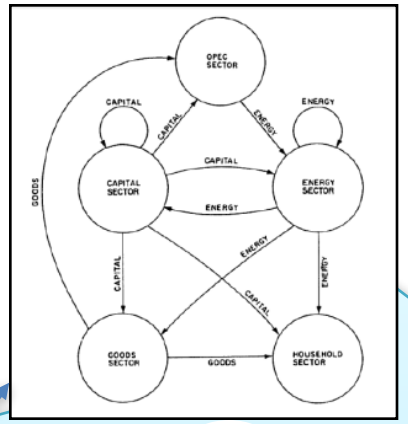


# Gap in the literature

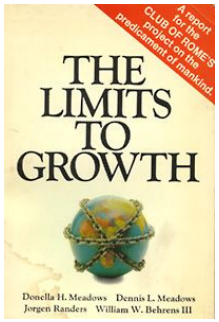
**SDNM –** Pioneer in hybrid system dynamics-agent based modelling. (never published the model). Includes:

- production sectors
- labor and professional mobility
- demographic sector and consumption sectors
- commercial banking to make short-term loans
- a monetary authority with its controls over money and credit
- government services
- foreign sector




***(1971, 1972) Forrester, Meadows et al. World dynamics and Limits to Growth***




***(1976) Forrester's System dynamics national model (SDNM)***

***Senge - 1978 comparison of investment function of SDNM with economic theory***

***Sterman - 1981 application of SDNM framework to Energy transition (conventional to unconventional) and the economy in the US 1980s***

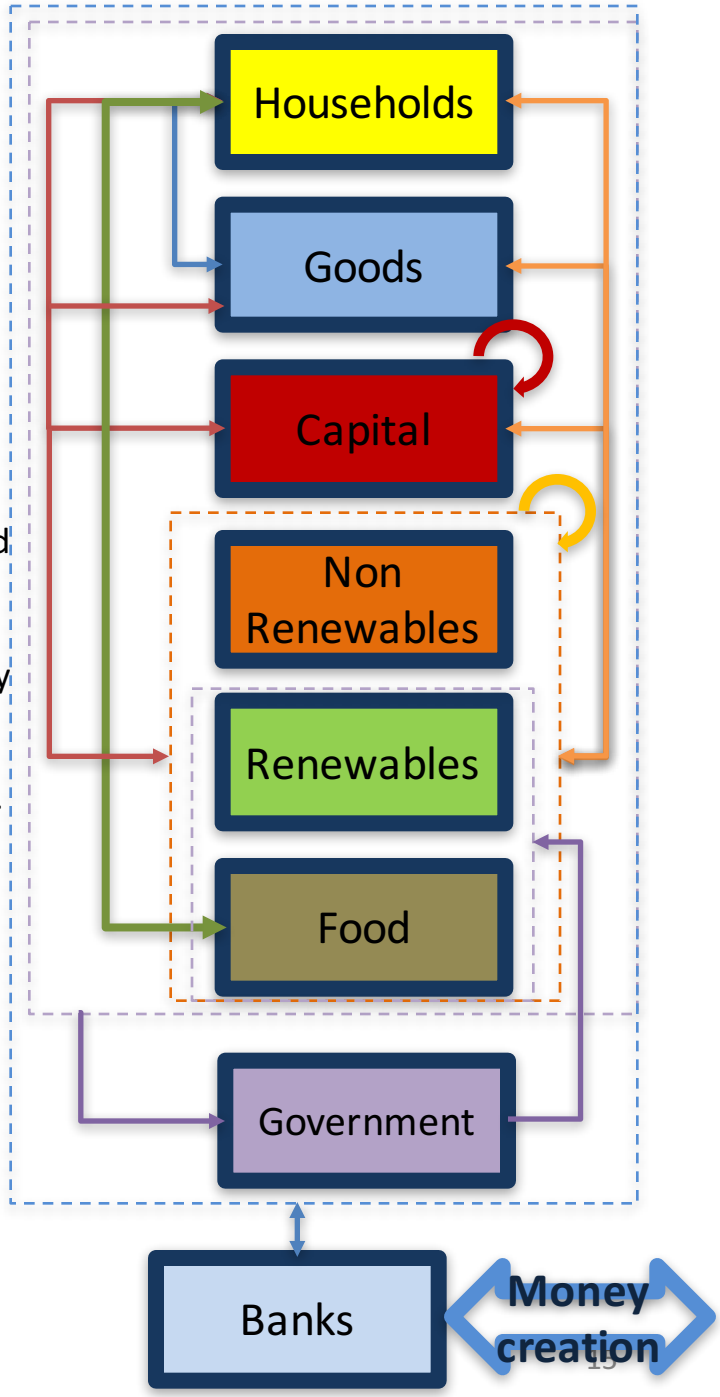
***(2014-2016) Pasqualino update and application of such a framework to food and energy system modelling***

**Key steps in the research**

- Use Sterman (1981) as ground
- Update financial system (in particular banks and government)
- Include food system on the basis of Limits to growth (2003)
- Inclusion of feedback loops between energy transitions and biofuel production
- Integration of short term structures such as Inventory-Labour force to capture dynamics of short-term (4-7 years) business cycle
- Use the object for testing climate shock and implication for finance
- Pasqualino & Jones (TBP (2017)) - Resources, financial risk and dynamics of growth, Routledge

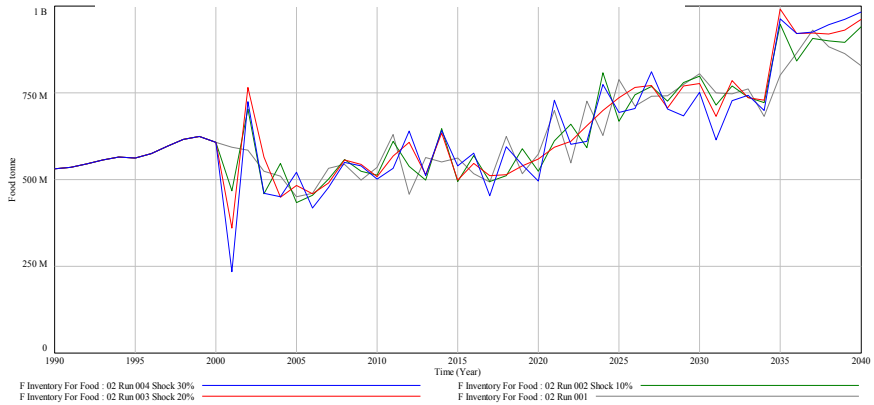
# Model foundations and boundaries

- Out of equilibrium **Post-keynesian economy** driven by the utility function (2 layer Cobb-Douglas acconting for technology and available energy) from **(1) Households** (Sato 1967)
- **Supply chain** among productive sectors (**(2) Capital, (3) Goods, (4) Food, (5) Nonrenewable** and **(6) Renewable energy**) using Inventories and Backlog management between Supply and demand (Sterman, 2000)
- **Labour market** to move people from sector to sector, and voluntary enemployed
- **(7) Banks** are assumed to provide loans and print money whenever required and set **interest rates** (i) real – exogenous, (ii) nominal – based on inflation, (iii) prime rate – based on defaults per sector.
- **Prices, wages** are endogenously modelled to translate physical in financial flows
- **Balance sheet** approach with double entry rule is used to manage financial flows
- **(8) Government** collects taxes and can provide **subsidies** to food and energy systems to mitigate risk

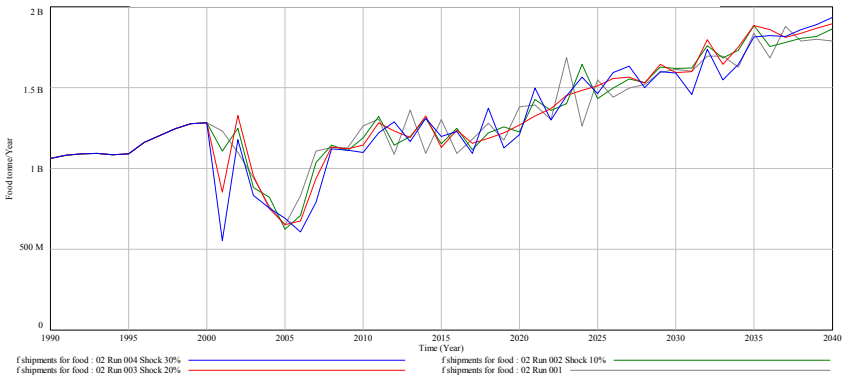


# Climate shock in food production 0%, 10%, 20%, 30% in the year 2000

**Food inventory**

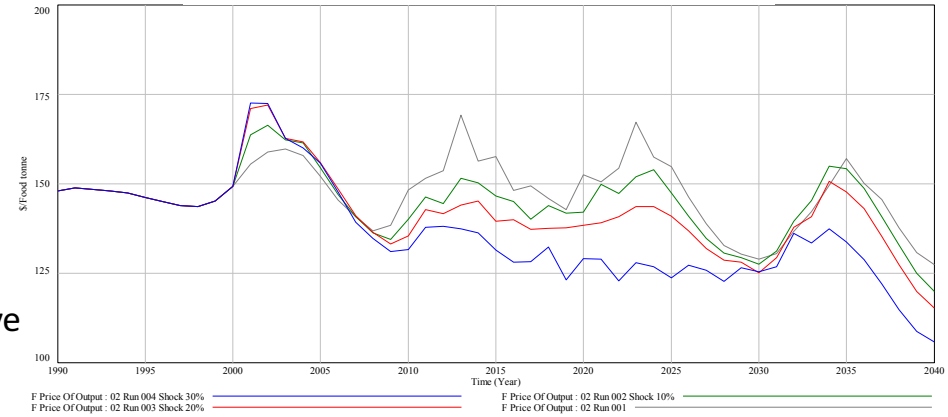



**Food consumption**




- A production shock in the year 2000 generates:
  - A sudden decrease in Inventory
  - A conservative behaviour from producers in mantaining desired level of stock constrining sold
  - Food price rise
  - Decrease of food consumption because of expensive food
  - Increase in the supply with a delay
  - Supply excess demand (takes time for capital to dicard) resulting in decreasing price in the long term

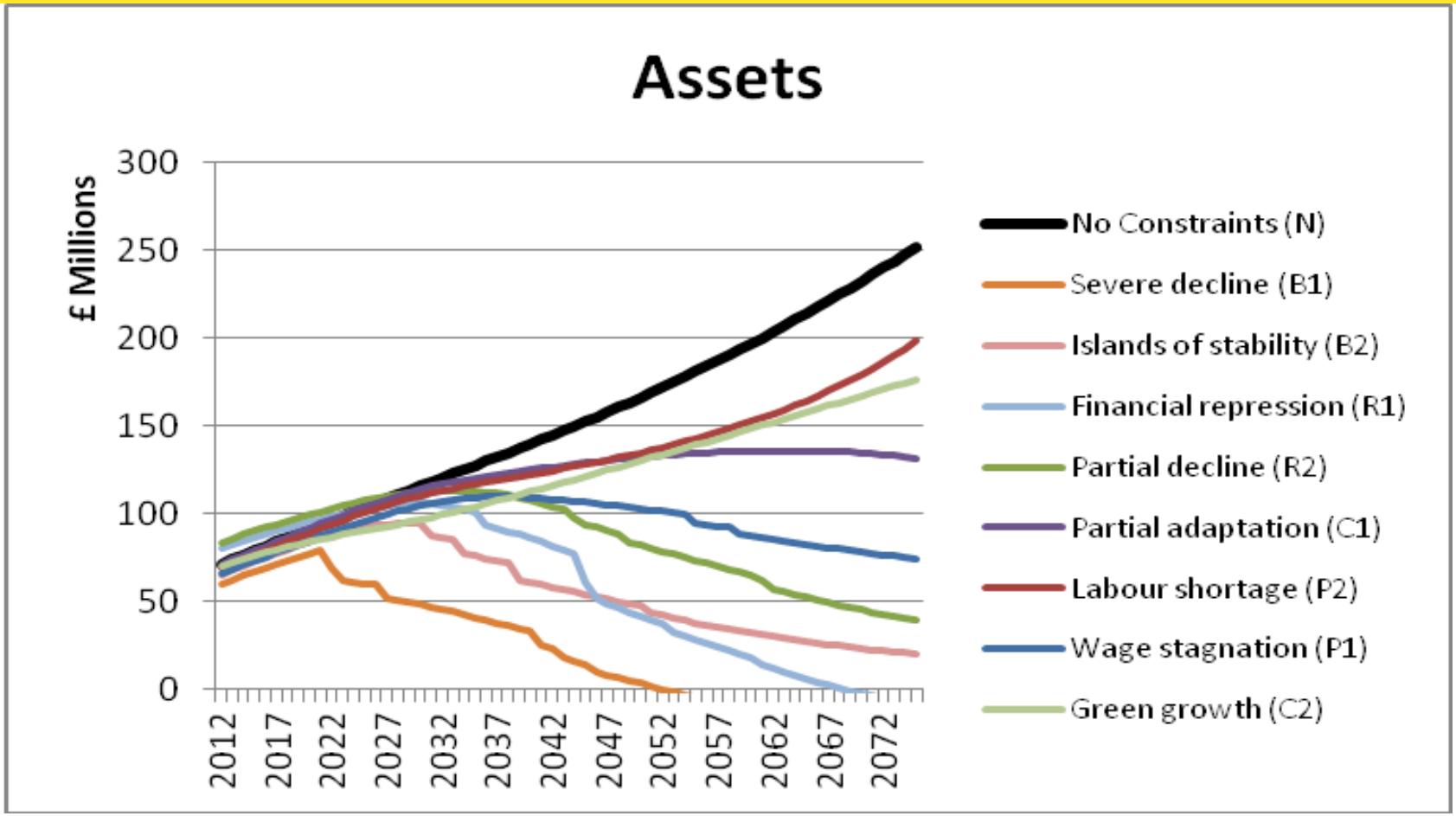
**Food price**



# Case studies: scenarios and models

- Resource constraints
  - Investment
- Food constraints
  - Insurance
  - Government

# Institute of Actuaries: resource constraints

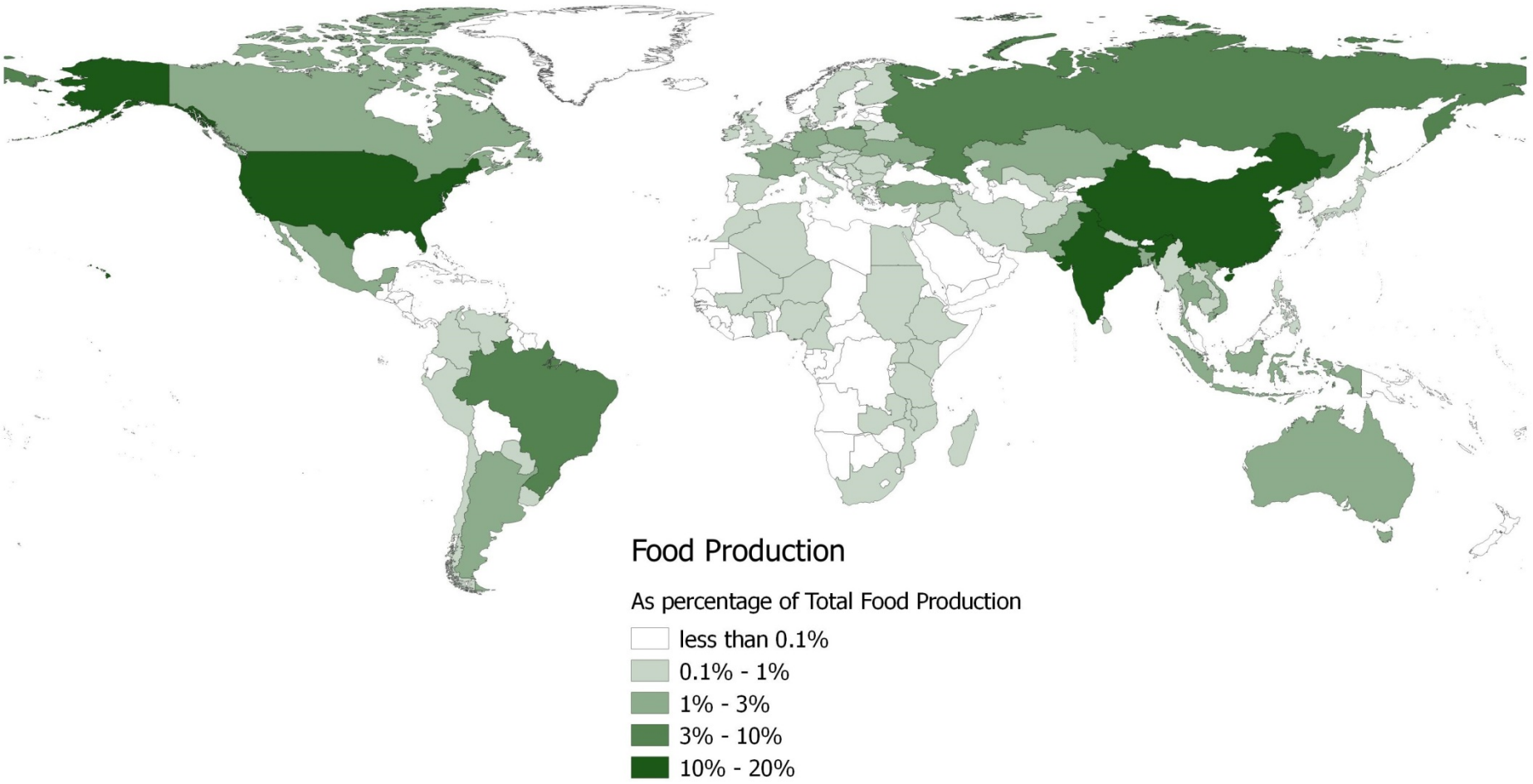


# Insurance & security: Food Prices

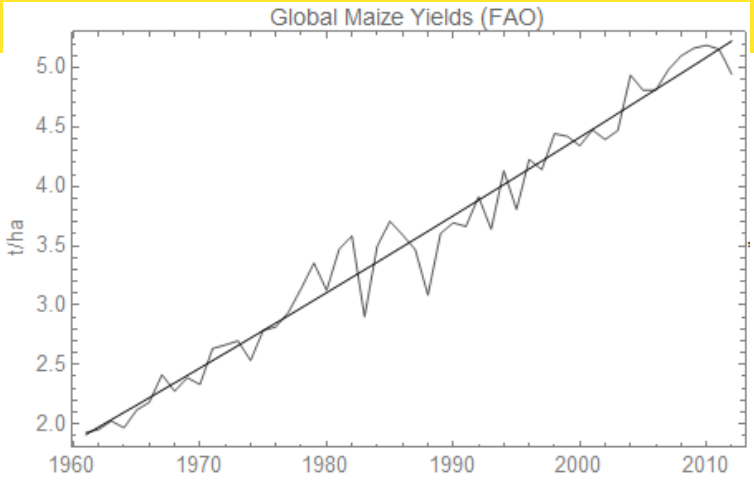
Food prices have in the past been a trigger for major social and political unrest and were a factor in the Arab Spring.

- Food production & consumption
- Land
- Weather
- Governance & political processes
- Trade volumes, partners & policies
- Demography
- Social statistics
- Energy (renewable & non-renewable)
- Water
- Capital & finance
- Investment flows, money creation and banking systems
- Infrastructure
- Global, country & regional

# Food production globally



# Historic production

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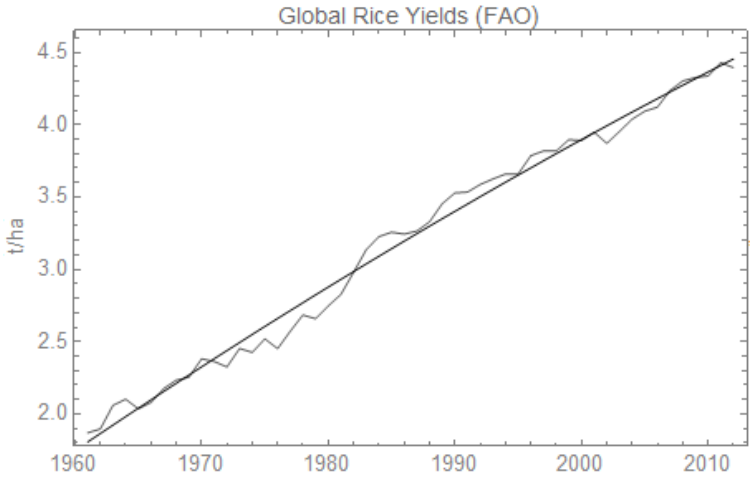
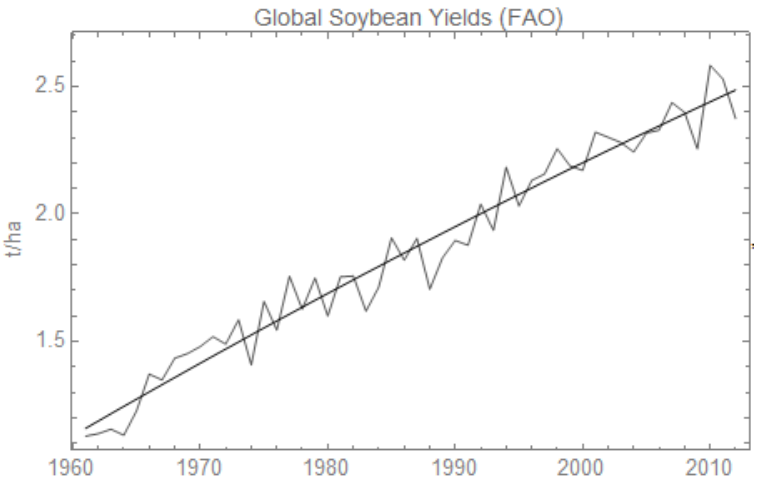
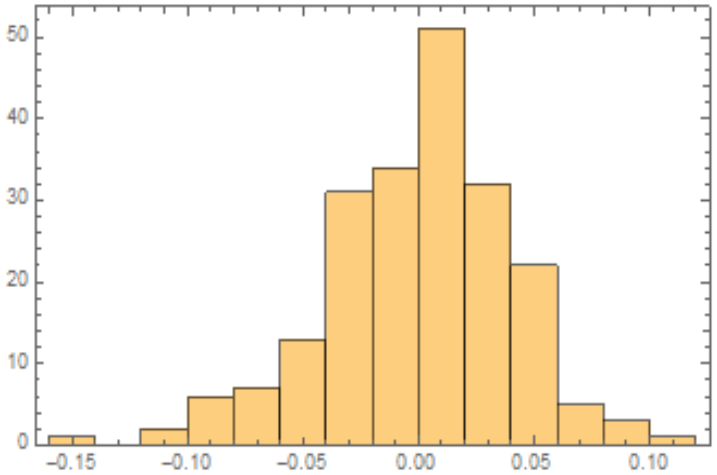
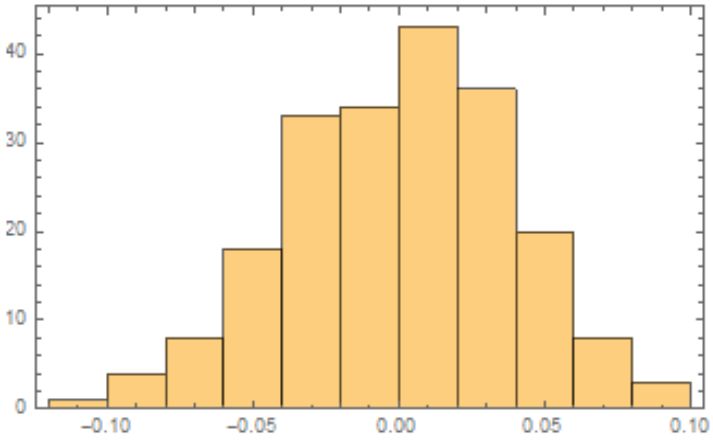


# Shock distribution




Maize: max global production loss is 15% (1988)




Wheat: max global production Loss is 10% (1975)

# Responses: methodology

- Qualitative stakeholder interviews with 40 experts from governments (Nation States, Supra-National organisations) and businesses (retailers, manufactures, farming, traders) – funded by FCO
- Quantitative analysis using historic data and Thomson Reuters Eikon platform
- Preliminary results used to inform scenarios

# Lloyds scenario

- *Food production shock (developed by Molly Jahn, University of Wisconsin)*
  - *Maize: 10% production shock*
  - *Soy: 11% production shock*
  - *Wheat: 7% production shock*
  - *Rice: 7% production shock*


From left to right: Sophie Abraham (Willis), Lucy Stanbrough (Lloyd's), Dr John Alarcon (Willis), Oliver Bettis (Munich Re), Nigel Ralph (Lloyd's), Tom Hoad (Tokio Marine Kiln), Trevor Maynard (Lloyd's), Mike Maran (Catlin), Will Steeds (Catlin), Kenneth Donaldson (Munich Re), Dr Aled Jones (Anglia Ruskin University), Prof Molly Jahn (University of Wisconsin-Madison)

Attendees not pictured: Nick Beecroft (Lloyd's), Andrew Hitchcox (Tokio Marine Kiln), Falk Niehörster (RMS)

# Insurance impacts

- Political risk insurance
  - Contract frustration (e.g. China-Brazil)
  - Cargo/marine hull (e.g. Liberia)
  - Trade credit
- Political violence and terrorism
  - Strikes, riots & civil commotion (e.g. Egypt)
  - Contingent business interruption
  - Terrorism
  - War on land
- Crop insurance
- Liability insurance (directors & officers, errors & omissions)

# Case study:
# Nigeria civil war and terrorism in India

- Food riots break out in urban areas across the Middle East, North Africa and Latin America.
- Nigeria civil war following major offensive by Boko Haram. Onshore and shallow offshore oil rigs attacked.
- Pakistan terrorist group targets major cricket tournament. India cricket cancellations.
- Europe has an increasingly militarized border with Russia as political tensions continue.
- The Euro weakens and the main European stock markets lose 10%; US stock markets follow and lose 5% of their value.
- Public agriculture commodity stocks increase 100% in share value, agriculture chemical stocks rise 500% and agriculture engineering supply chain rise 150%

# UK-US Taskforce

## 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… | …by 2026 ? |
|---|---|---|
| | • Escalating demand for food<br>• Trade volume and interdependencies amplify shocks<br>• Crop production concentrated in global regions, increasing exposure to extreme weather risks<br>• Reduced self sufficiency in China for cereals<br>• Increasingly inelastic demand | • Key Food import states, economically and politically unstable<br>• Greater interdependencies<br>• Production struggles to keep pace with demand<br>• Underinvestment in exporting region infrastructure<br>• 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 stock to use ratio raises concerns of availability

**PRICE volatility**
**EXPORT bans**
**Import Restrictions**

### POLITICAL

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

**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.

### 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

### 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<br>• Better understand the risks by improving climate, economic and crop modelling tools<br>• Better coordinate risk management<br>• Do not impose export restrictions | • Better understand how responses can amplify shocks<br>• Improve function of international markets<br>• Bolster national resilience to market shocks<br>• Make biofuel mandates more flexible<br>• 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.

# Users of the GRO outputs

- ***Government****: risk modellers, policy developers, development agencies (including the World Bank) – those interested in the risk from future political instability caused by food or energy crisis, e.g. learning from the Arab Spring. Departments would include defence, diplomatic and development.*

- ***Finance sector:*** *risk modellers (including actuaries), insurance companies and pension funds. Interested in economic risk and systemic risk in finance sector caused by general trends in food and energy prices from changing climate and resource availability.*

# Future of the Global Resource Observatory

- Ongoing development of GRO toolkit of resources in dialogue with end users.
- Internal market intelligence/co-production resource needed to firmly establish:
  - **Who** needs this toolkit?
  - **How** would they use the tools developed?
  - What **specifically** do they need?
  - Who should we be working with as a **priority**?
  - How do we maximise the **impact** of our outputs for these people?
- Thus building demand

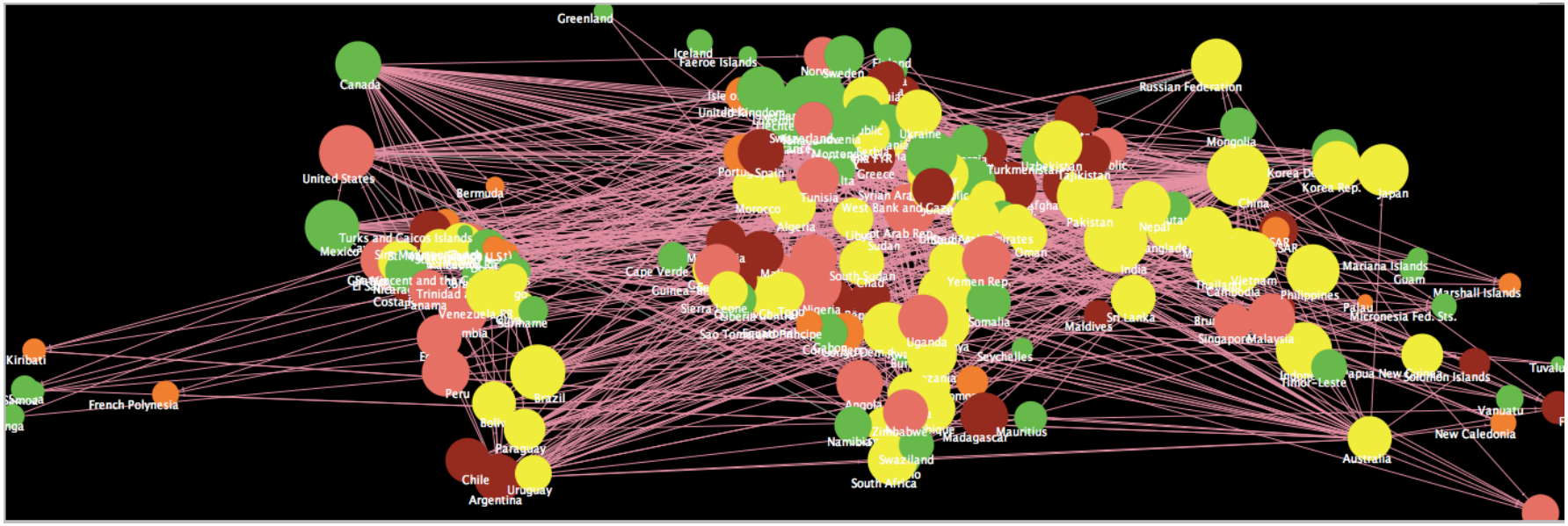
# Mapping

- **Who** needs this toolkit?
- **How** would they use the tools developed?
- What **specifically** do they need?
- Who should we be working with as a **priority**?
- How do we maximise the **impact** of our outputs for users?

# General conclusions

- There is a systemic risk from resources
- Some countries are particularly vulnerable to food & energy shocks
- Resource production & extraction is very concentrated in a small number of countries
- Market and government responses are unpredictable as they depend on external factors including general sentiment at the time
- Price shocks have coincided with production shocks but there is no strong correlation (require event analysis)

# The road to Dr Apocalypse




- 2040 scenario run
- Model is not designed to run this long – assumptions no longer valid
- Demonstrates need for technological change before this

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THE INDEPENDENT

# Society will collapse by 2040 due to catastrophic food shortages, says study


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