

# Science in the BRIDGE project: System complexity and policy integration challenges: the Brazilian Energy-Water-Food Nexus

**Dr Jean-Francois Mercure**

Assistant Professor in Energy, Climate and Innovation

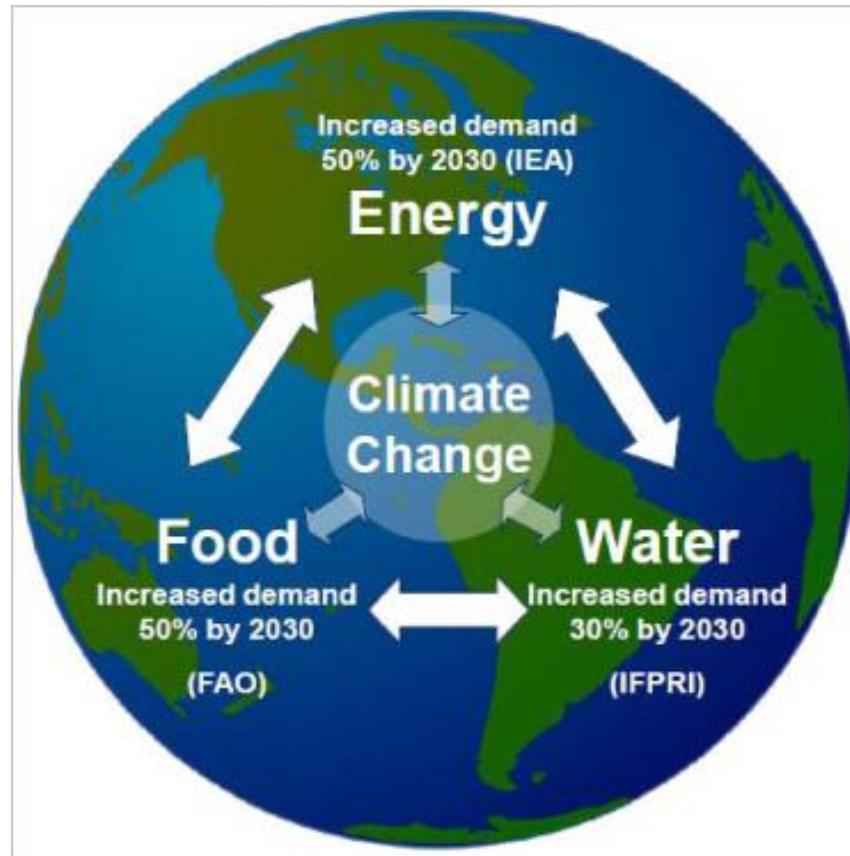
Department of Environmental Sciences, Radboud University, Netherlands

C-EENRG, Department of Land Economy, University of Cambridge, UK

[www.bridgeproject.net](http://www.bridgeproject.net)

# What is the Food-Water-Energy Nexus?

Sir John Beddington's 'Perfect Storm':



# Brazil IS the Food-Water-Energy Nexus

Nexus drivers are both domestic and international:

- International trade transfers problems across borders
- The planet is a global common



Brazil is representative of the World's Nexus

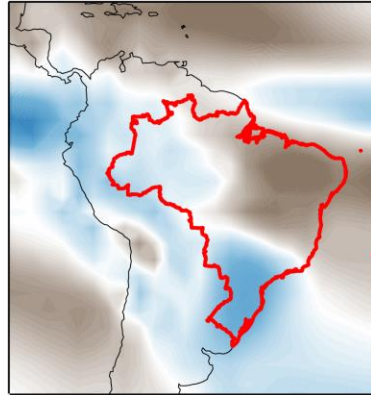
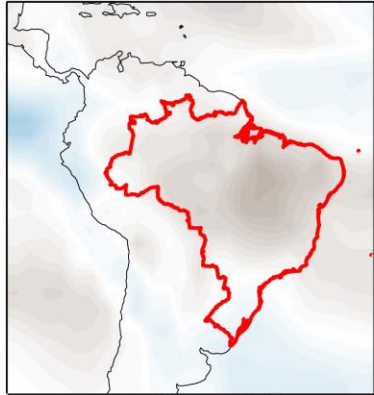
- Brazil will show first symptoms of global Nexus disturbance
- Huge governance and stewardship challenges to address

# Future climate change in Brazil

2071–2100 percentage change in precipitation relative to 1961–1990 (%)

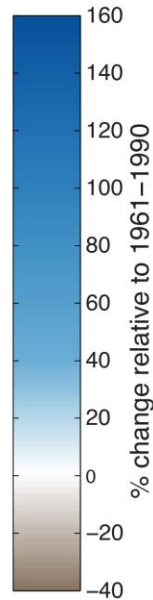
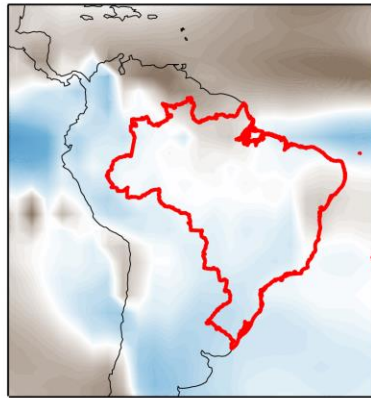
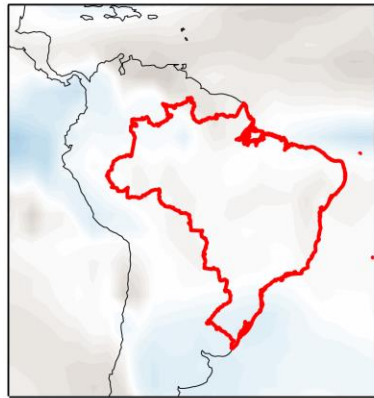
JJA RCP2.6

JJA RCP8.5



DJF RCP2.6

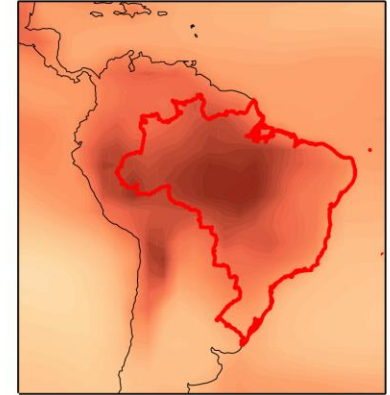
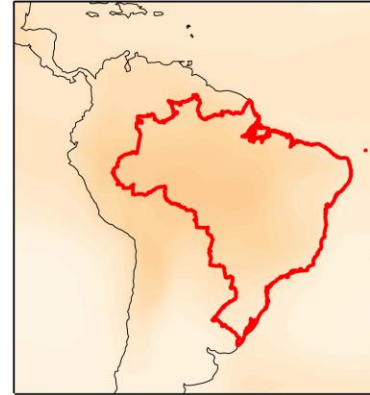
DJF RCP8.5



2071–2100 temperature anomaly relative to 1961–1990 (°C)

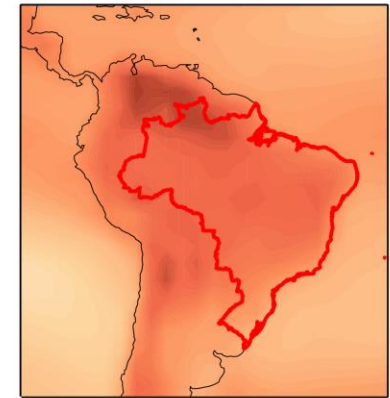
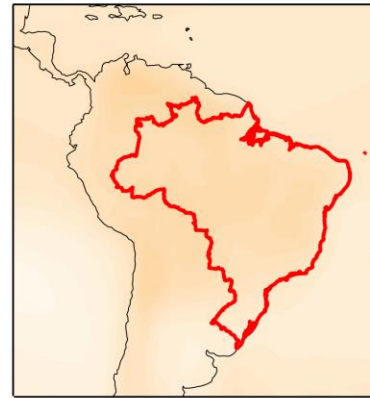
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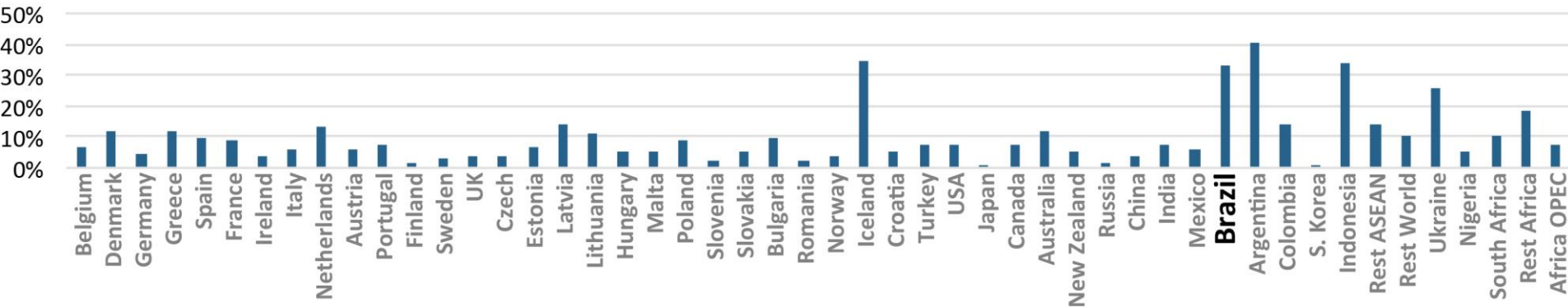
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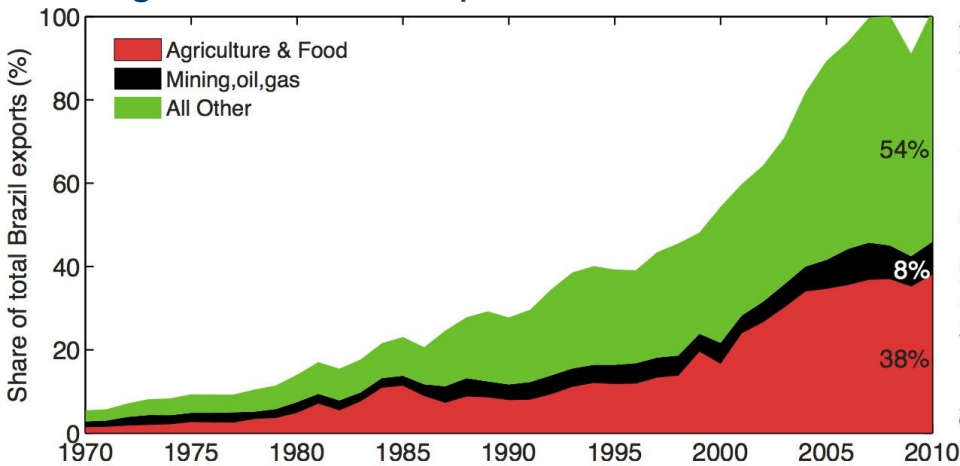


# Agriculture and food in the Brazilian economy

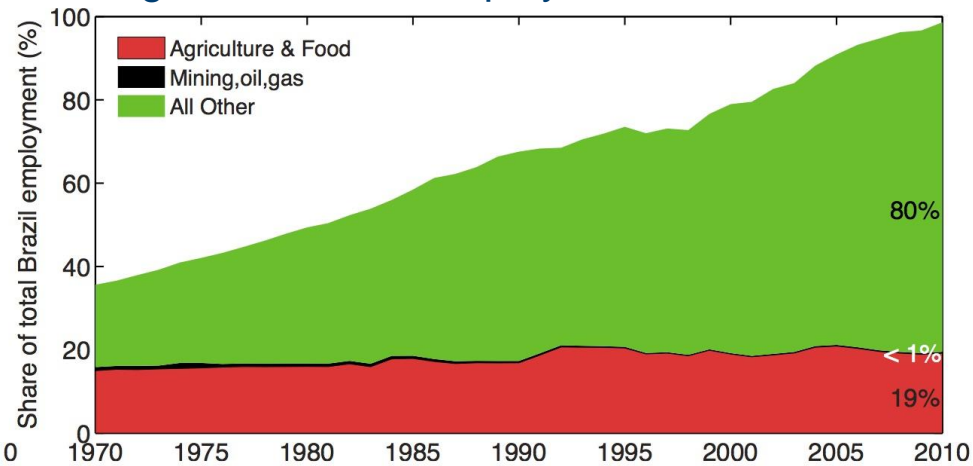
## Shares of national export for agriculture and food



## Agriculture-food exports for Brazil



## Agriculture-food employment for Brazil



# Energy-Water-Food nexus in Brazil: 4 primary issues

## 1. Water-Energy: The Hydro crisis

- ✧ System hydro-dominated, climate change,
- ✧ Water scarcity related to deforestation.

## 2. Energy-Food: Biofuels policy and competition with food

- ✧ International demand → biofuels replacing food production,
- ✧ Promotes indirect land-use change

## 3. Food-Water: Climate change, water scarcity and agriculture

- ✧ North-East suffers desertification, South becomes flooded.
- ✧ Agriculture displaced, total production reduced

## 4. Energy-Water-Food: Indirect land-use change and deforestation

- ✧ International demand for soybeans/maize for animal feed and biofuels feedstocks
- ✧ Indirect land-use change → Amazon/Cerrado deforestation



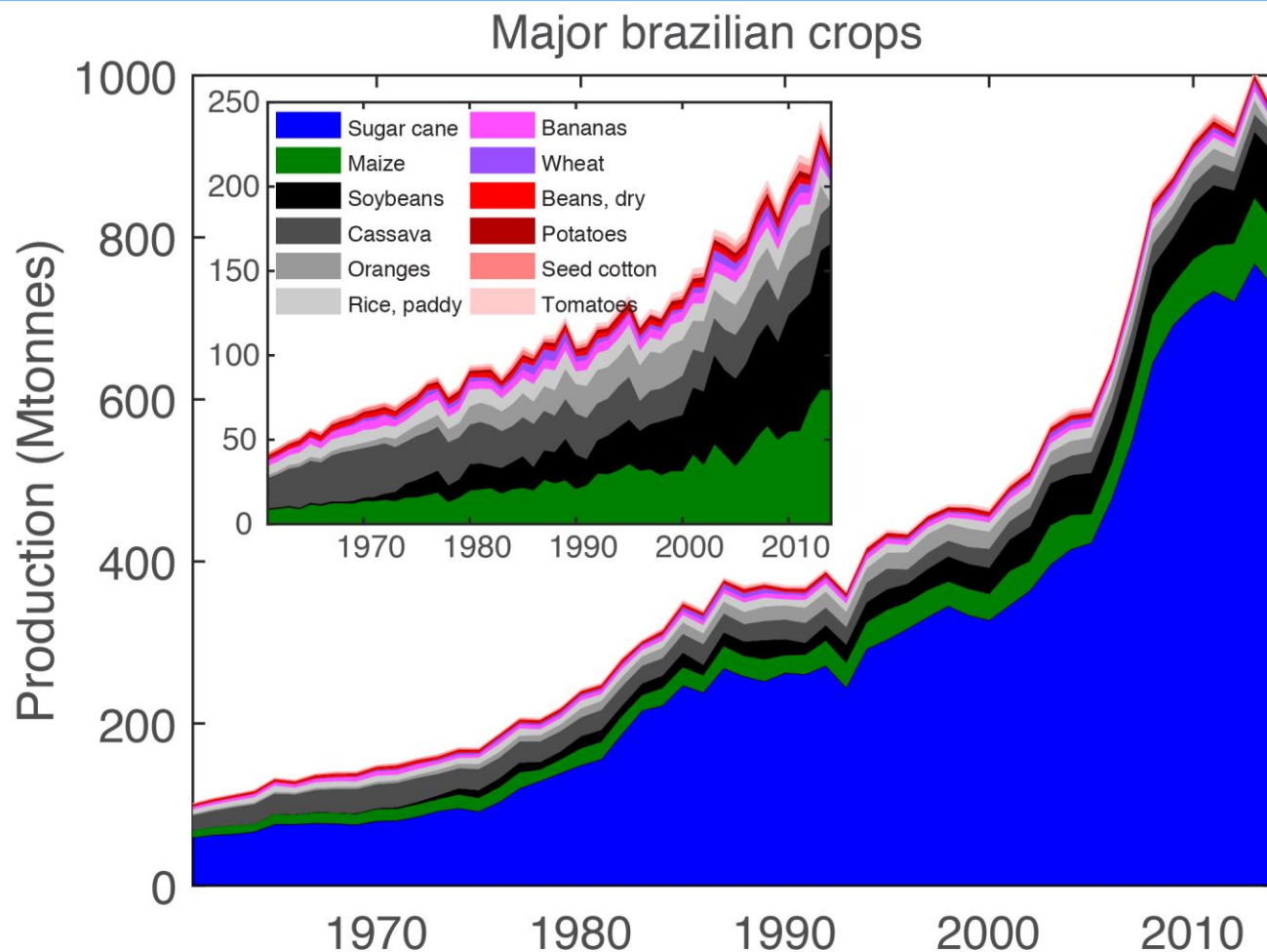
# Energy-Water-Food nexus in Brazil: 4 primary issues

## System Complexity and Policy Integration Challenges: the Brazilian Energy-Water-Food Nexus

J.-F. **Mercure**, M. A. **Paim**, P. **Bocquillon**, S. **Lindner**, P. **Salas**, P. **Martinelli**, I.I. **Berchin**,  
J.B.S.O.A. **Guerra**, C. **Derani**, C. L. **de Albuquerque Junior**, J.M.P. **Ribeiro**, F. **Knobloch**,  
H. **Pollitt**, N. R. **Edwards**, P. B. **Holden**, A. **Foley**, S. **Schaphoff**, R.A. **Faraco**, J. E. **Viñuales**

*C-EENRG Working Papers, 2017-6*

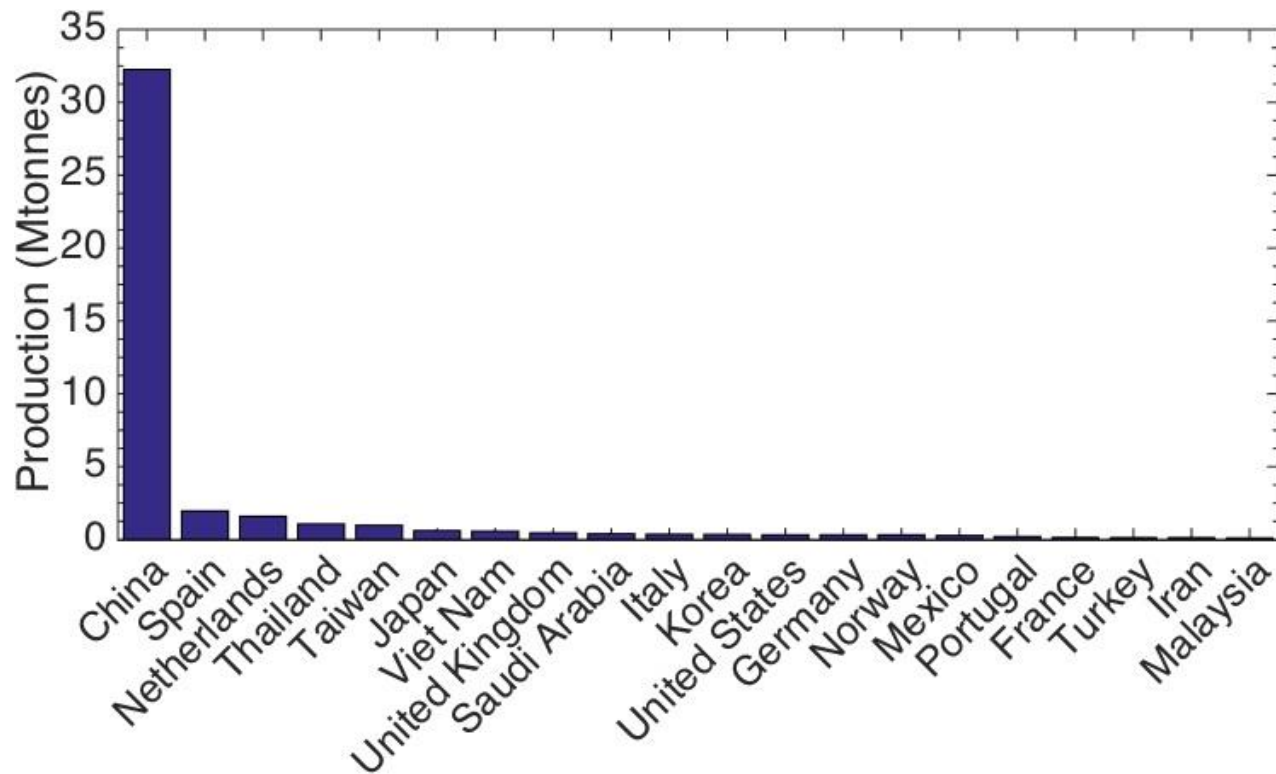
## 4- Energy-Water-Food: Indirect land-use change and deforestation





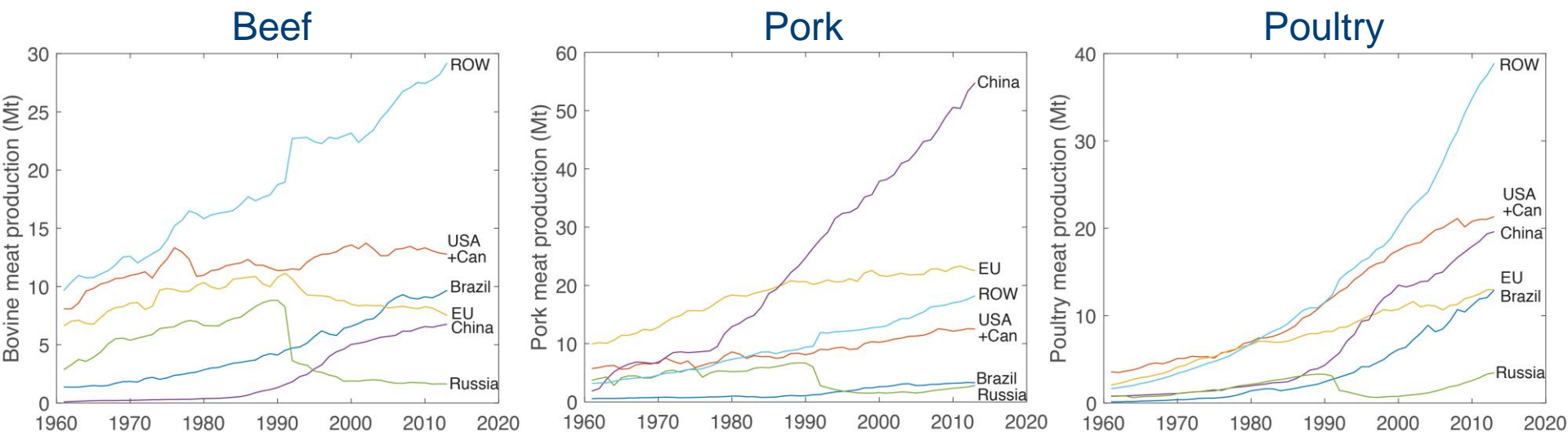
## 4- Energy-Water-Food: Indirect land-use change and deforestation

Soybean exports from Brazil by destination



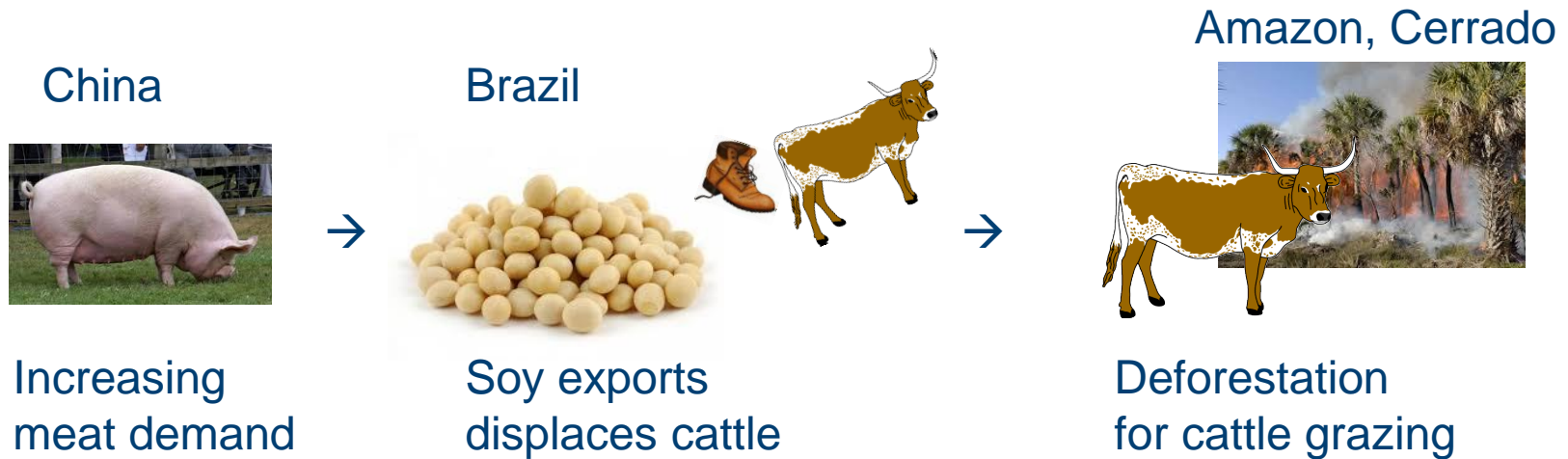
# 4- Energy-Water-Food: Indirect land-use change and deforestation

Soybeans and maize from Brazil feeds animals Worldwide



The global meat industry is changing globally, rising fast in emerging economies

## 4- Complex issue: indirect land-use change



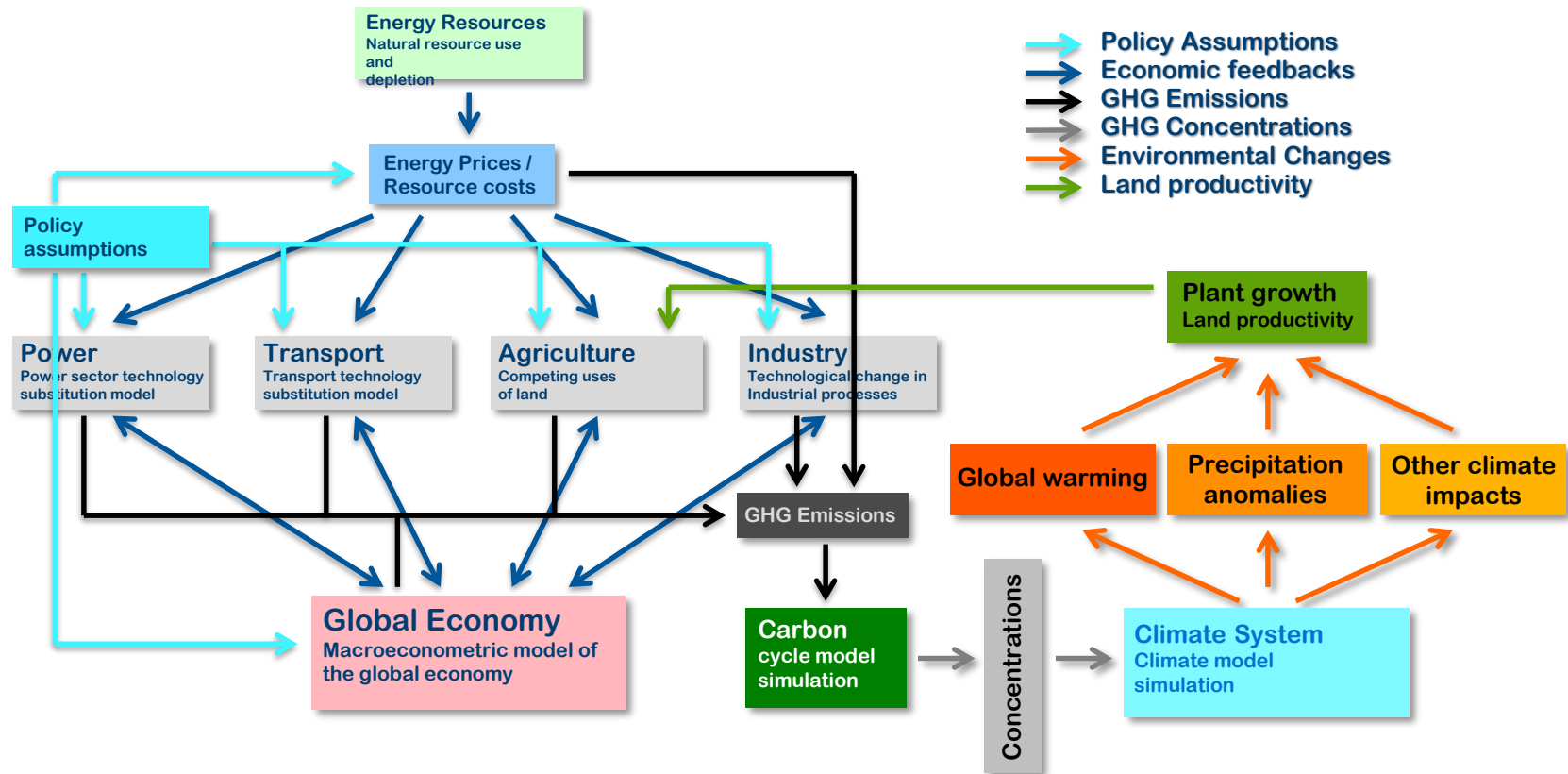
- Demand for meat (e.g. pork) increases in China with increasing income
- Soy is used as animal feed
- Brazil produces and exports soy
- Soy displaces cattle farming
- Cattle farmers deforest the Amazon and the Cerrado
- Deforestation intensifies climate change and water scarcity

## 4- Complex issue: indirect land-use change



- Europe adopts biofuel mandate as part of energy and climate policy
- Demand for ethanol and biodiesel
- Brazilian sugar cane production increases and expands
- Displaces cattle (or other) farming
- Cattle farmers deforest the Amazon and the Cerrado
- Deforestation intensifies climate change and water scarcity

# Our Integrated economy-environment model

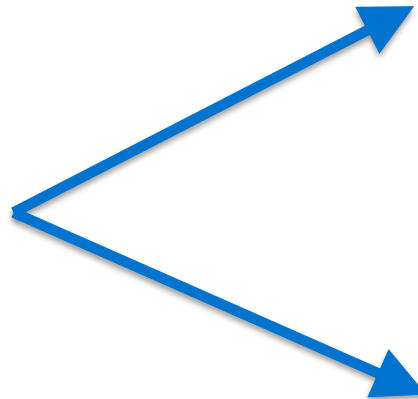


# Diffusion: technology choices

The uptake of new technology:  
Innovation – Selection – Diffusion



$t$



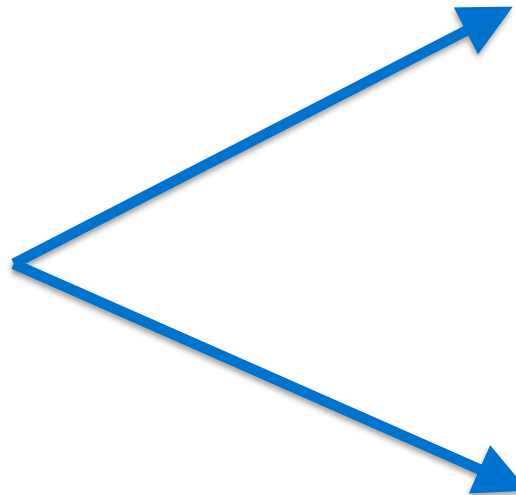
$t + \Delta t$

J.-F. Mercure, *Energy Policy* 48, 799-811 (2012)



# Diffusion: technology choices

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$t$



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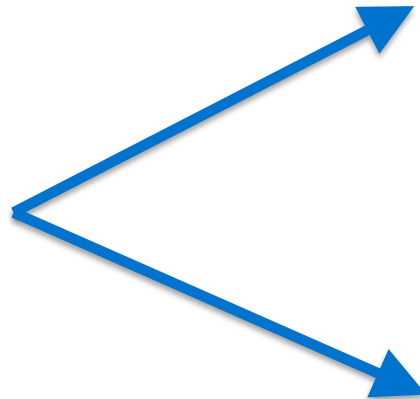
J.-F. Mercure, *Energy Policy* 48, 799-811 (2012)

# Diffusion: technology choices

Changes in crop choices over time:



$t$



$t + \Delta t$

J.-F. Mercure, *Energy Policy* 48, 799-811 (2012)

# Model premises and information

## 1. E3ME Food commodity demand worldwide

- ✧ E3ME estimated using econometrics, driven by income
- ✧ Bilateral trade worldwide estimated
- ✧ FAO food balances respected

## 2. FTT food commodity supply

- ✧ Commodity prices drive crop choices
- ✧ Responds to food demand but sets price with marginal cost
- ✧ Climate change alters land productivity

## 3. Challenges:

- ✧ Biophysical modelling does not match FAO statistics
- ✧ Primary to end-use not fully defined in FAO
- ✧ Land-use/land area is sometimes ambiguous

# Recent model results

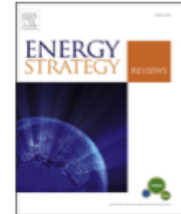
Energy Strategy Reviews 20 (2018) 195–208



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Energy Strategy Reviews

journal homepage: [www.ees.elsevier.com/esr](http://www.ees.elsevier.com/esr)



## Environmental impact assessment for climate change policy with the simulation-based integrated assessment model E3ME-FTT-GENIE

Jean-Francois Mercure <sup>a, b, c, \*</sup>, Hector Pollitt <sup>b, c</sup>, Neil R. Edwards <sup>c, d</sup>, Philip B. Holden <sup>d</sup>,  
Unnada Chewpreecha <sup>b</sup>, Pablo Salas <sup>c</sup>, Aileen Lam <sup>c, e</sup>, Florian Knobloch <sup>a, c</sup>,  
Jorge E. Vinuales <sup>c</sup>

- Full integrated assessment model built
- Explores the global economy, energy system and environment
- Land-use model to be tested soon...








# Recent model results

nature  
climate change

LETTERS

<https://doi.org/10.1038/s41558-018-0197-7>

## Climate-carbon cycle uncertainties and the Paris Agreement

P. B. Holden <sup>1\*</sup>, N. R. Edwards <sup>1,2</sup>, A. Ridgwell <sup>3</sup>, R. D. Wilkinson<sup>4</sup>, K. Fraedrich<sup>5</sup>, F. Lunkeit<sup>6</sup>, H. E. Pollitt <sup>2,7</sup>, J.-F. Mercure <sup>2,7,8</sup>, P. Salas <sup>2</sup>, A. Lam<sup>2,9</sup>, F. Knobloch <sup>2,8</sup>, U. Chewpreecha<sup>7</sup> and J. E. Viñuales<sup>2</sup>

- Climate forcing uses our own Paris Agreement scenarios
- Climate outcome remains uncertain even in a 1.5° C world

# Recent model results

nature  
climate change

LETTERS

<https://doi.org/10.1038/s41558-018-0182-1>

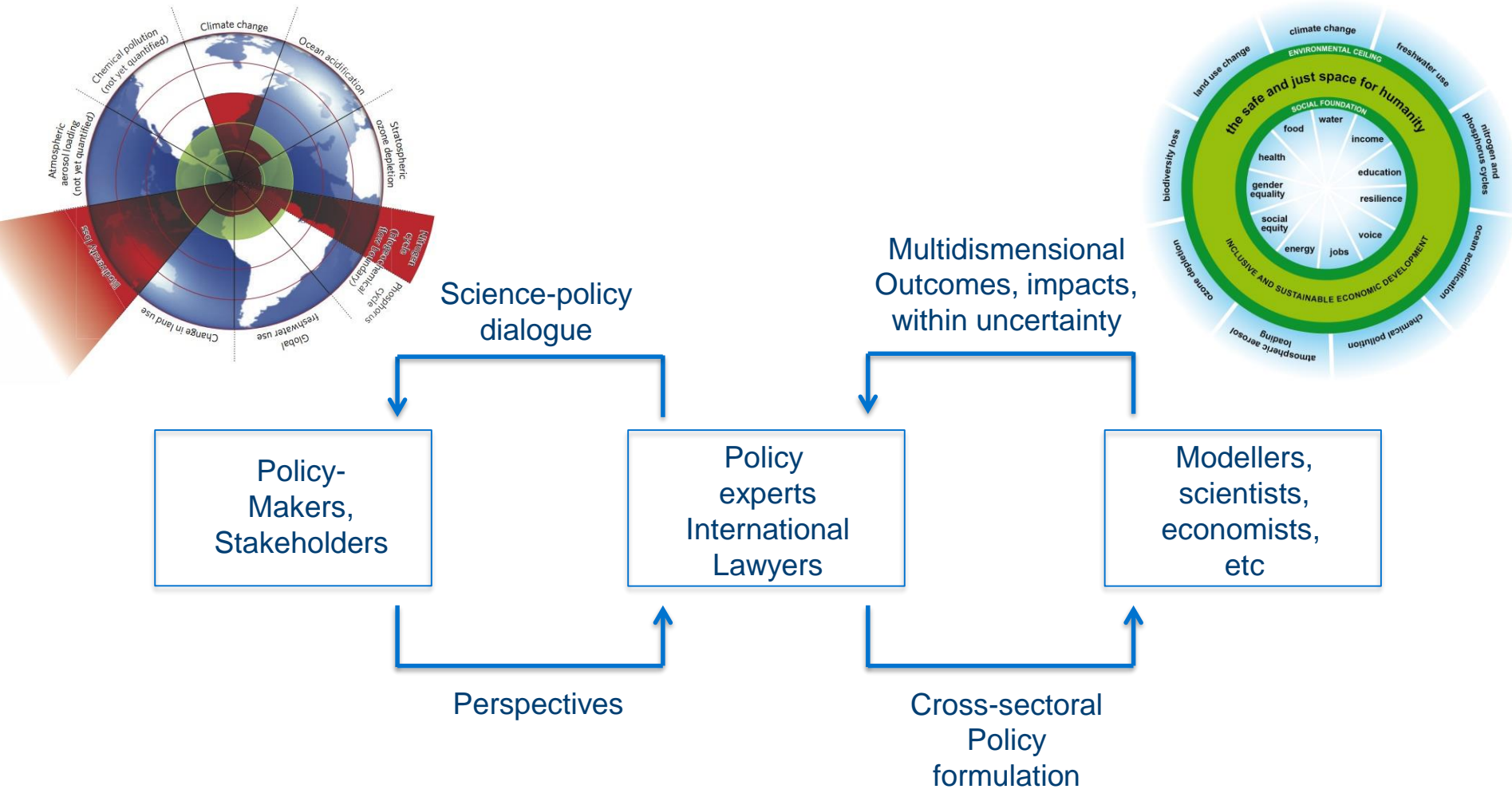
## Macroeconomic impact of stranded fossil fuel assets

J.-F. Mercure <sup>1,2,3\*</sup>, H. Pollitt <sup>3,2</sup>, J. E. Viñuales<sup>2</sup>, N. R. Edwards<sup>2,4</sup>, P. B. Holden <sup>4</sup>, U. Chewpreecha<sup>3</sup>, P. Salas <sup>2</sup>, I. Sognnaes<sup>2</sup>, A. Lam<sup>2,5</sup> and F. Knobloch <sup>1,2</sup>

- A carbon bubble may be forming with overcapacity for fossil fuels
- Economies, including Brazil, could be strongly affected
- The low-carbon transition will leave people behind



# Our integrated Science-Policy BRIDGE



# Research and policy challenges for the Nexus

- Understanding the FWE Nexus
  - Data is scarce and the system highly complex
  - The science is incomplete
  - Interventions create new problems
- Can we identify robust, feasible policies for nexus resilience?
  - We must map out the complex layered regulatory system
  - Policy integration challenges across sectors: working together
- Aim to develop a science-policy dialogue
  - The Nexus is complex, difficult to communicate
  - Science helps support the credibility of policy options

# Many thanks

