The Telecoupled Global Food System

Lessons from Modelling

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These slides at:
cutt.ly/JM-FEAS21

landscapemodelling.net

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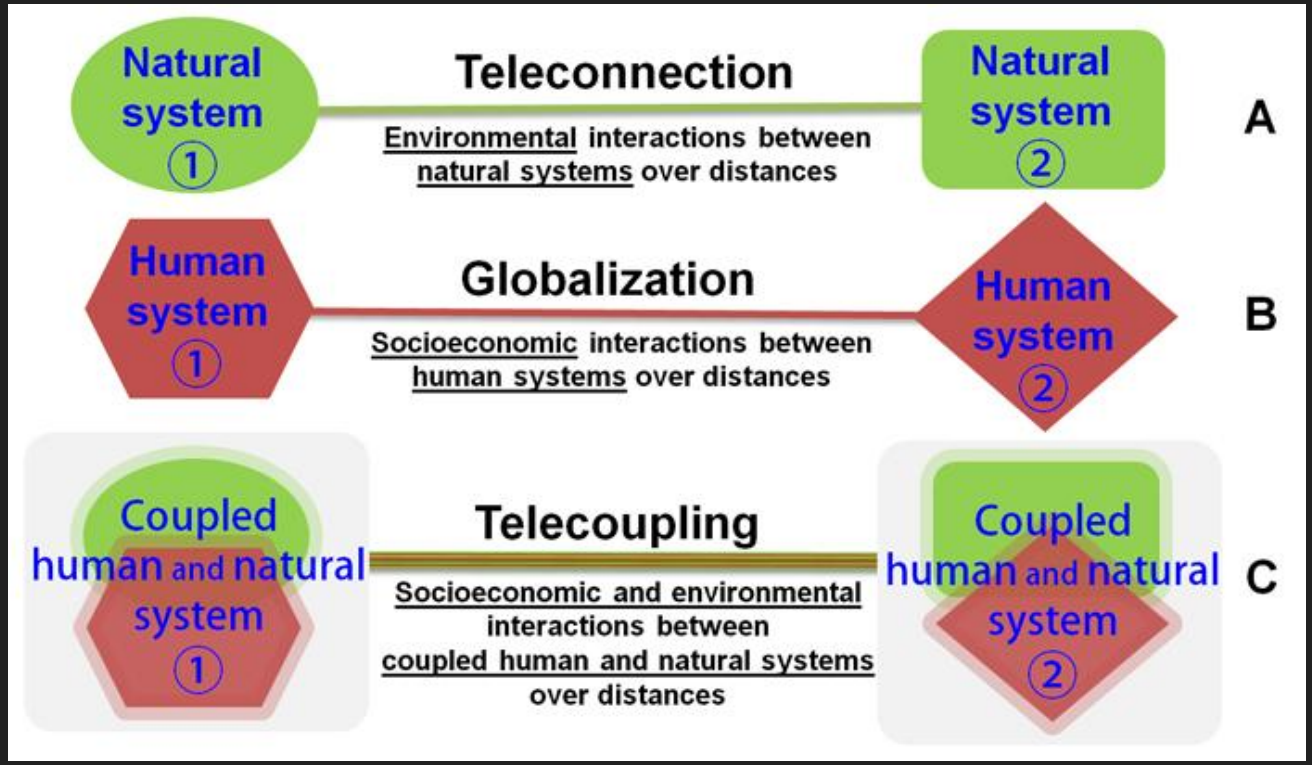
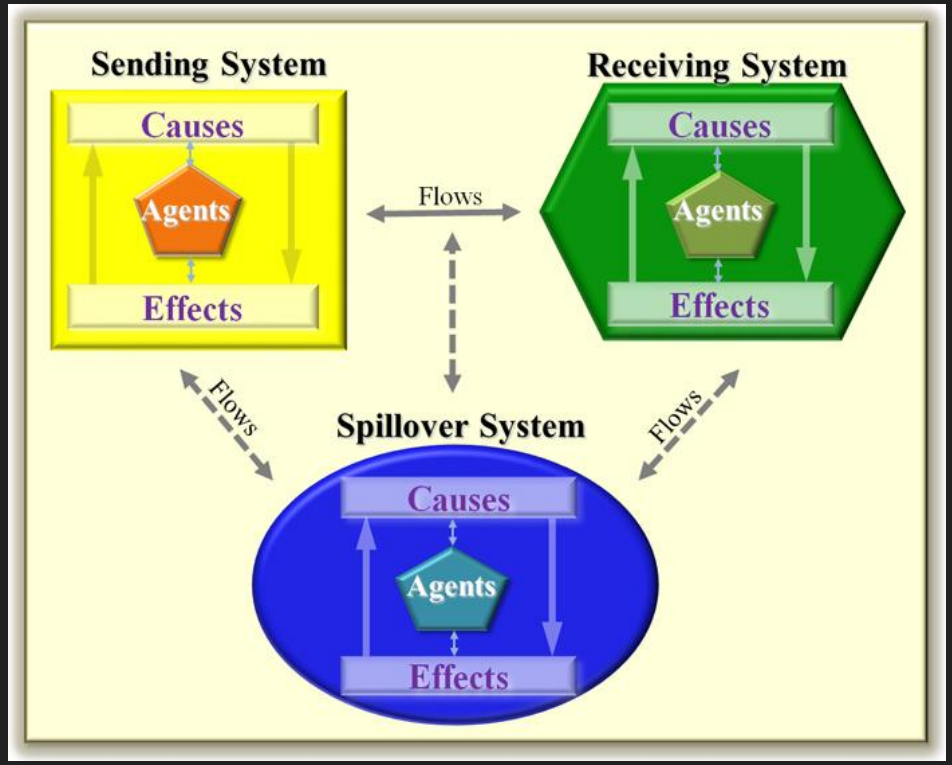
Telecoupling combines previous concepts



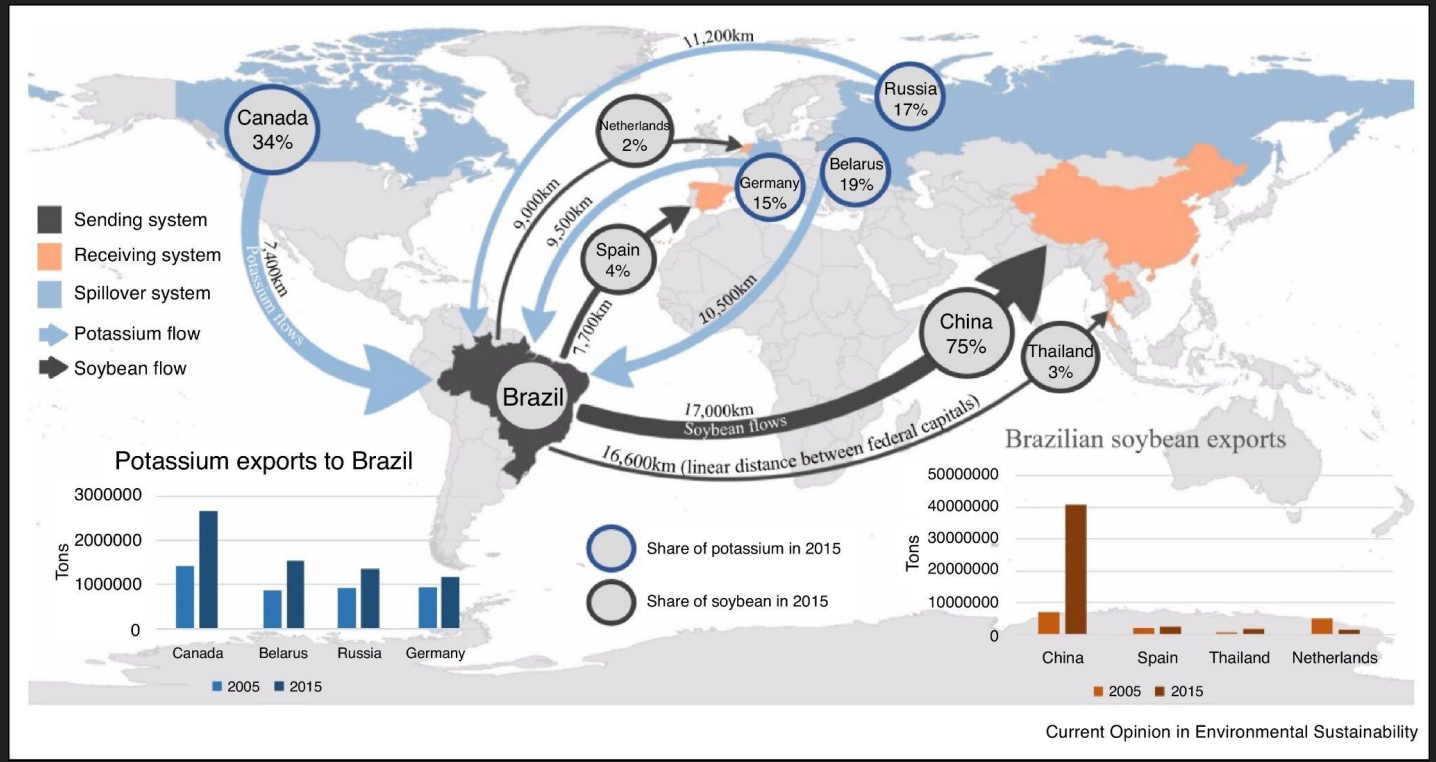
Liu *et al.* (2013)
[Ecology & Society]

Telecoupling is a systems perspective



Liu *et al.* (2013)
[Ecology & Society]

Telecoupling example: soybeans & fertilisers



Liu *et al.* (2018)
[Current Opinion in Environmental Sustainability]

Telecoupling has multiple components

Components	Sub-components	Characteristics
Systems	Sending system	- Agribusiness in Brazil
	Receiving system	- China's soybean demand
	Spillover system	- Agribusiness in Argentina
Flows	Material	- Soybean export
	Information	- Trading information
Agents	Chinese government	- Import policy
	Chinese consumers	- Dietary habits
	Brazilian research institutes	- Development of the tropical agriculture
	Brazilian government	- Farm credit policy, Agricultural development policies
	Brazilian producers	- Decision on grain production
	Brazilian Producer associations	- Lobbying, information flows to producers
	Seed producer companies	- Seed varietal development and management packages
	Traders	- Logistics, credit
Causes	Economic	- Increasing soybean demand in China
	Political	- Shifting in China's import policy: preference to Brazil over U.S. - Brazilian farm credit policy - Brazilian Cerrado development policy
	Technological	- Brazilian agricultural development
Effects	International	- Brazil became the No.1 soybean exporter
	National	- Land use dynamics and maize as a second-crop - Food price and security
	Regional	- Agricultural intensification - Native vegetation fragmentation

Silva *et al.* (2017) *[LAND]*

Telecoupling Modelling Challenges

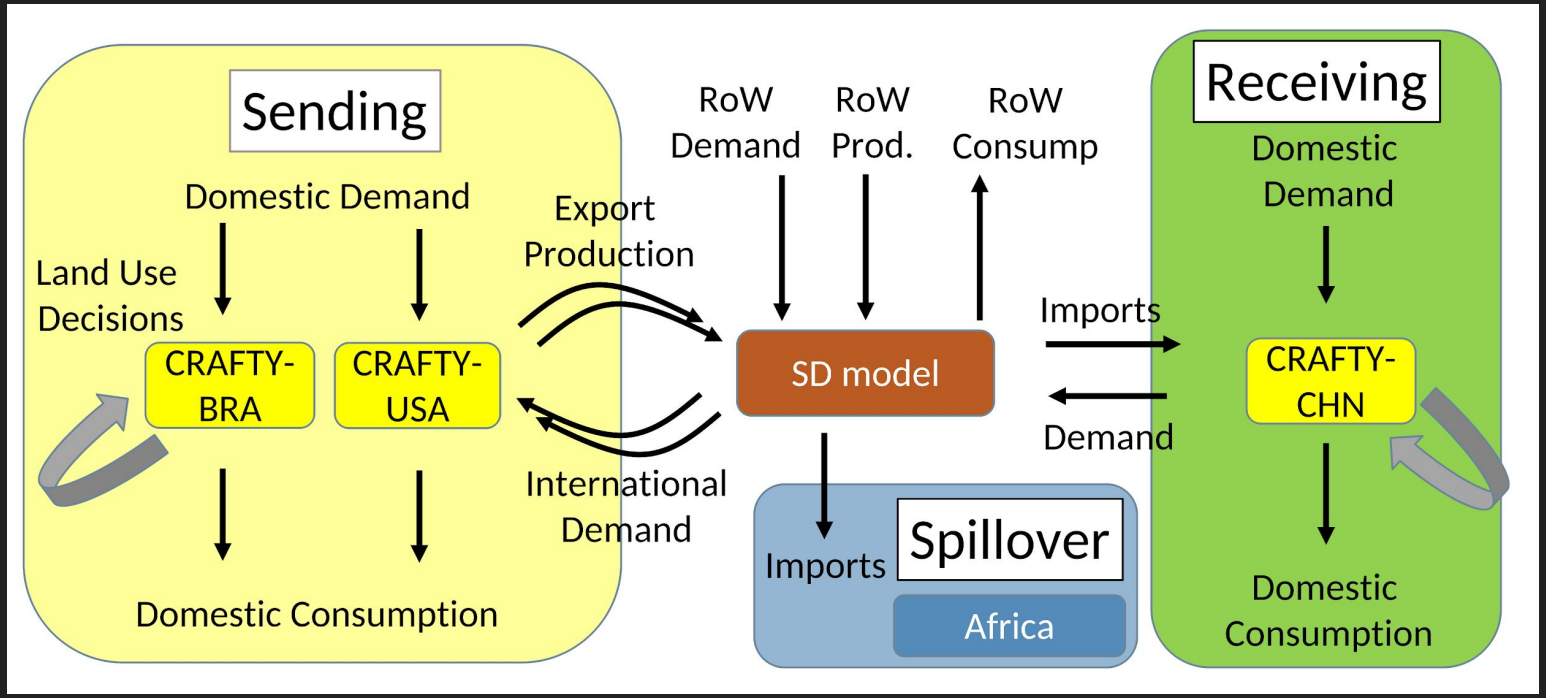
Millington *et al.* (2017) *[LAND]*

- Argued that hybrid computational models would beneficial
- Highlighted challenges of data requirements and uncertainty assessment

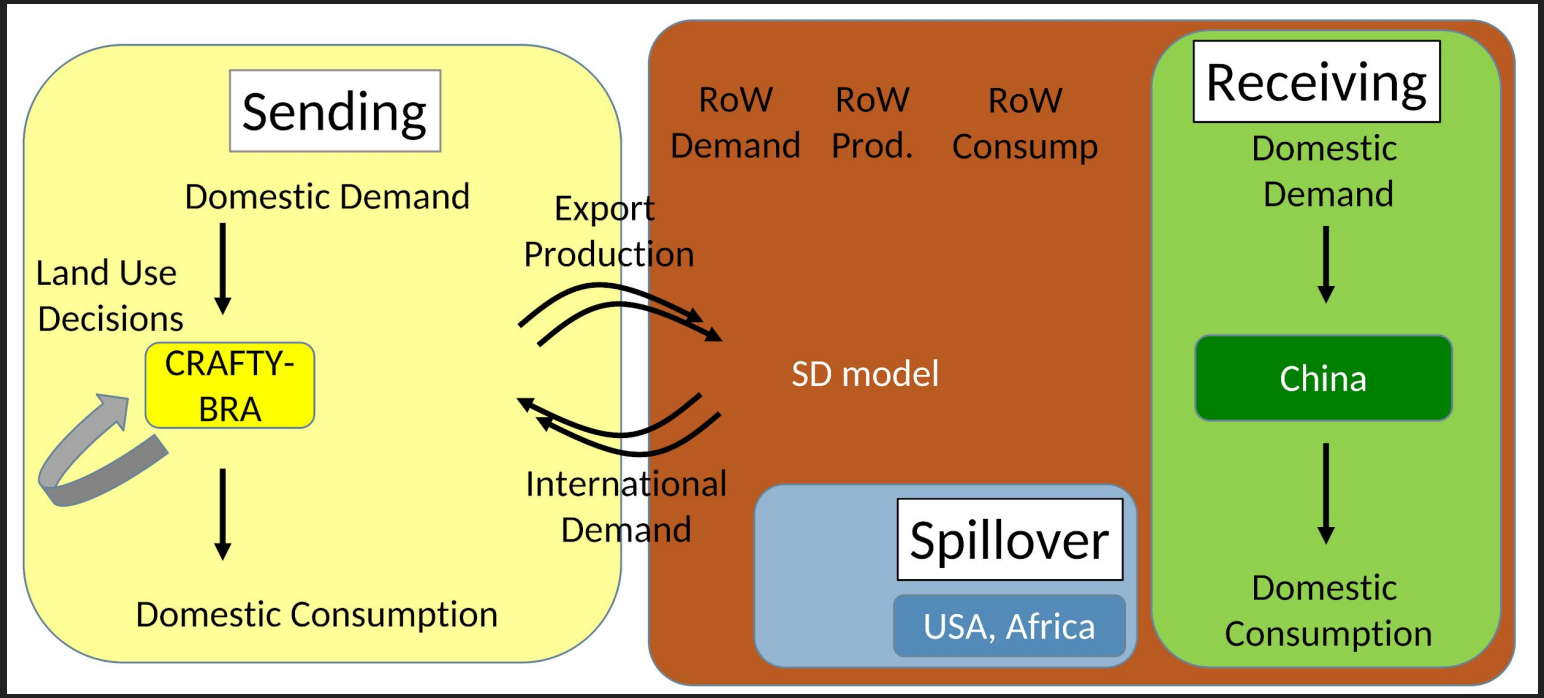
Liu *et al.* (2018, p.64) *[Current Opinion in Environmental Sustainability]*

“Combining and synthesizing quantitative methods to examine scenarios of change will be particularly important for understanding spillover effects and options for future sustainability.”

FLUTE - Aim


Sending
Domestic Demand
Land Use Decisions
CRAFTY-BRA
CRAFTY-USA
Domestic Consumption
Export Production
International Demand
RoW Demand
RoW Prod.
RoW Consump
SD model
Imports
Spillover
Africa
Receiving
Domestic Demand
Imports
Demand
CRAFTY-CHN
Domestic Consumption

FLUTE - Current



CRAFTY-Brazil

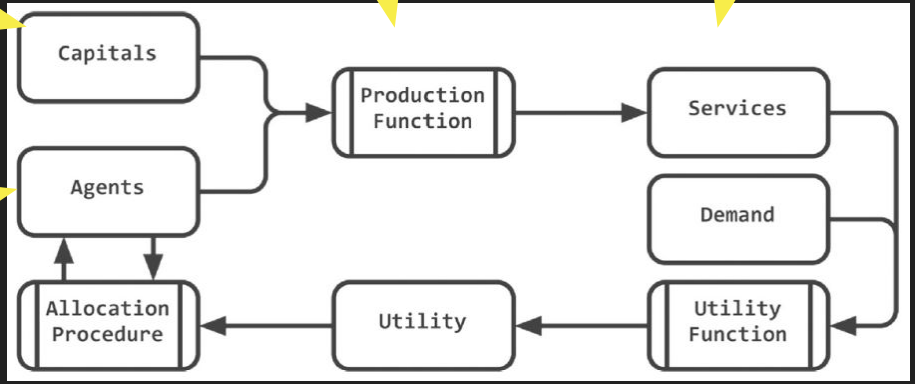
Cobb-Douglas Production Function:

$$p_s = \prod_c c_i^{\lambda_{c,a}}$$

Services
- Soy
- Maize
- Beef

Capitals
- Climate
- Transport Access
- Conservation Value
- Technological Inputs
- Protected Areas

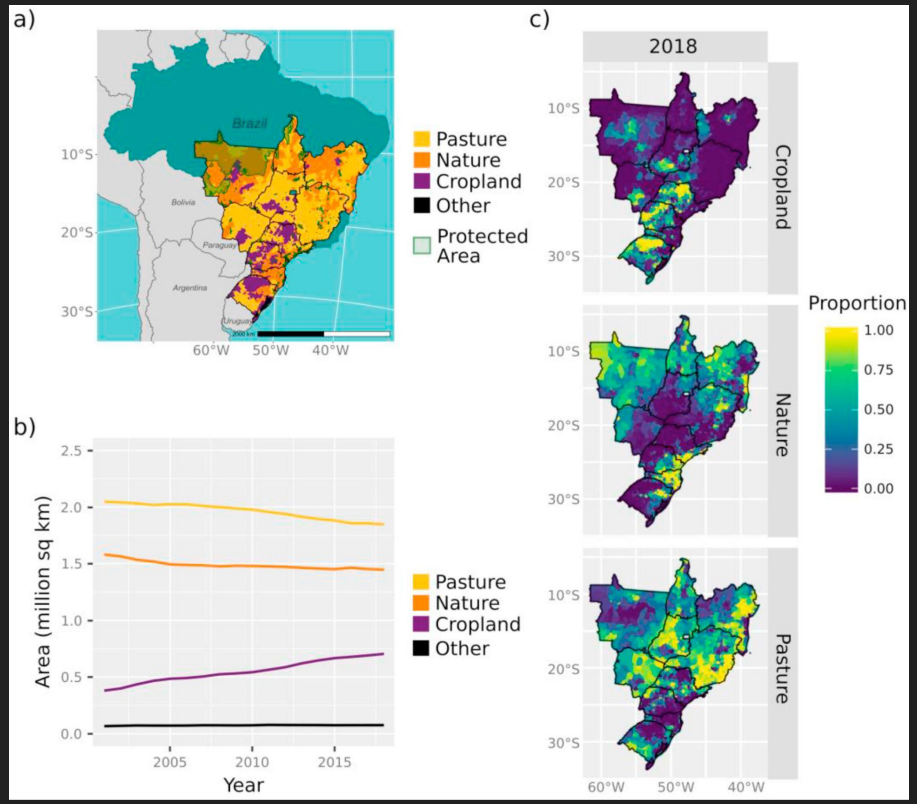
Agents
- Individual Services
- Soy-Maize Double Crop
- Pristine ‘Nature’
- Secondary ‘Nature’



Murray-Rust *et al.* (2014)
[Environmental Modelling & Software]

CRAFTY-Brazil

Simulation of 10 Brazilian States (4 million km^2, annually) based on observed land use and production data



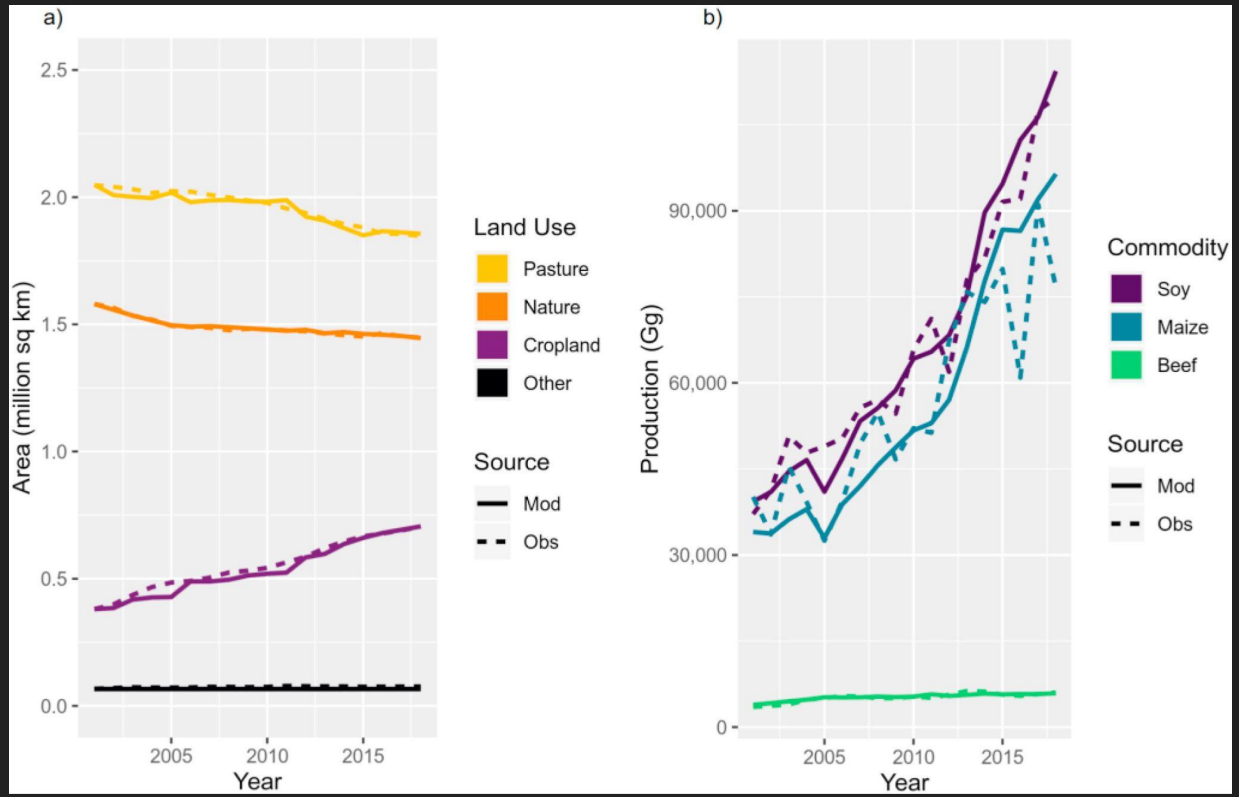
Millington *et al.* (2020)
[Environmental Modelling & Software]

CRAFTY-Brazil Results

Model appropriately reproduces observed time-series of:

(a) land use

(b) production

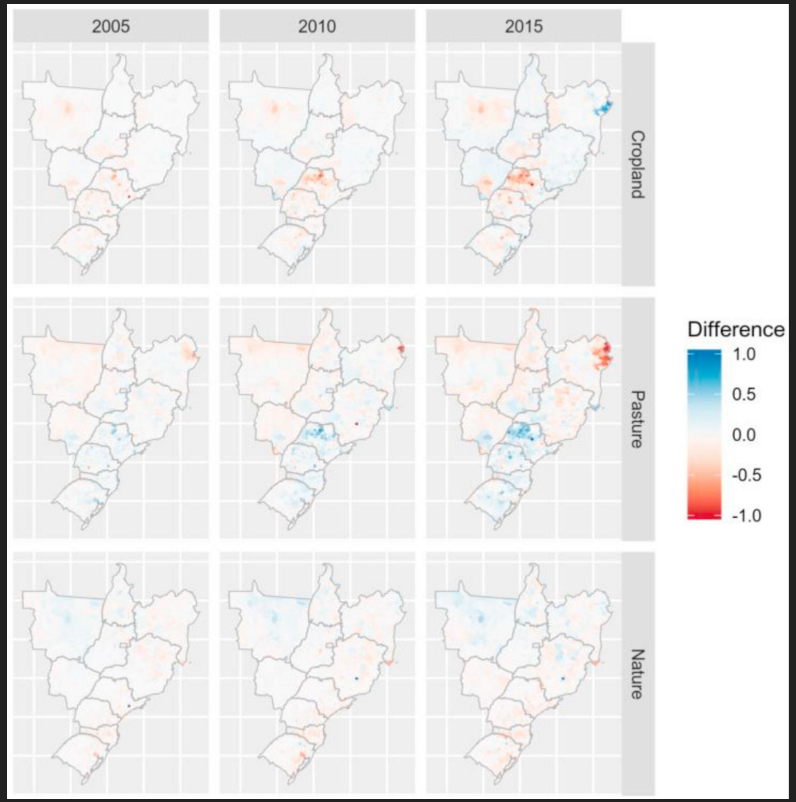


Mod: Modelled
Obs: Observed

Millington *et al.* (2020)
[Environmental Modelling & Software]

CRAFTY-Brazil Results

Model is not as accurate at reproducing spatial distribution of land uses



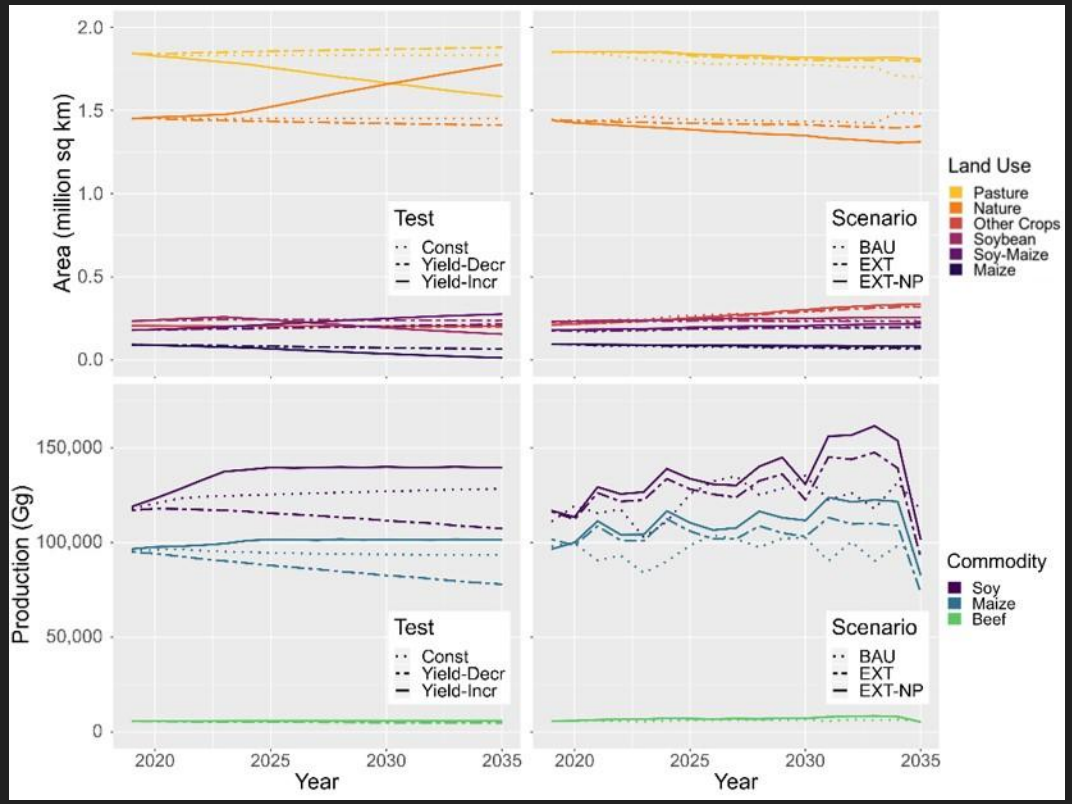
Difference:
Municipality proportional difference from observed

Millington *et al.* (2020)
[Environmental Modelling & Software]

CRAFTY-Brazil Results

Time-series output from counter-factual scenarios (below)

Model is more sensitive to yields than climate (or demand)



Yield-Decr: decreasing yield
Yield-Incr: increasing yield
BAU: business as usual
EXT: future extremes
EXT-NP: +no protected areas

Millington *et al.* (2020)
[Environmental Modelling & Software]

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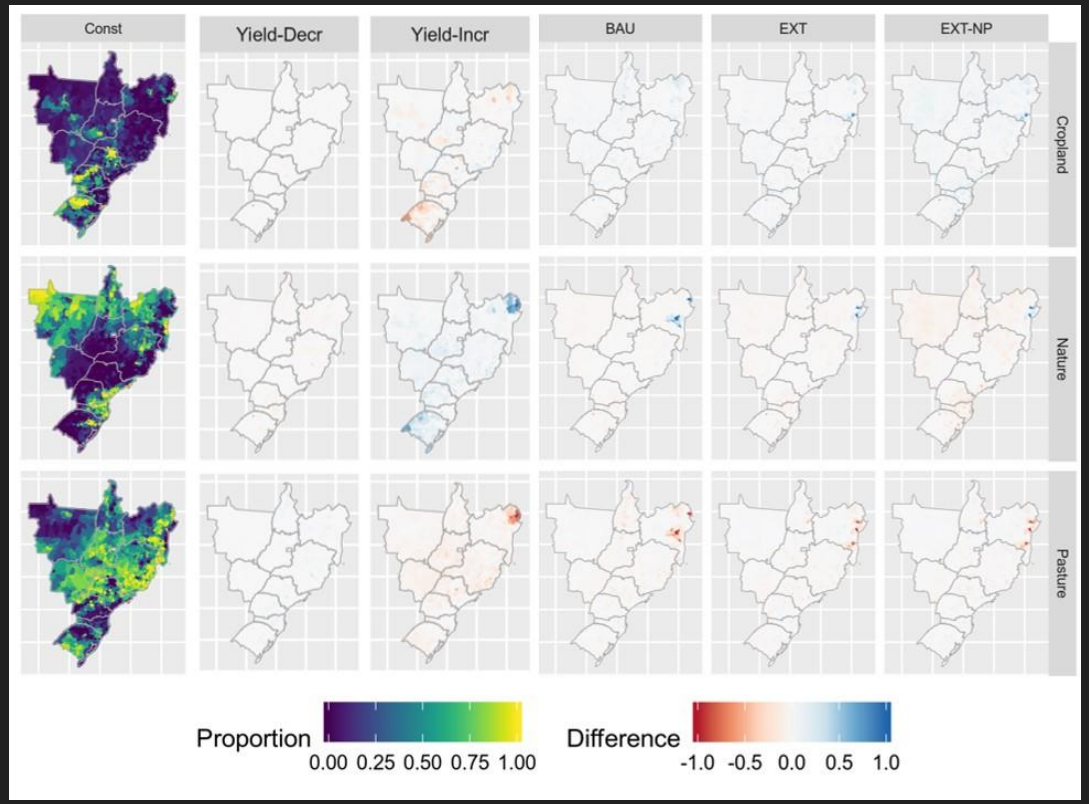
CRAFTY-Brazil Results

Spatial output from counter-factual scenarios (below)

Widespread change for yield scenarios vs localised for climate



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Millington *et al.* (2020)
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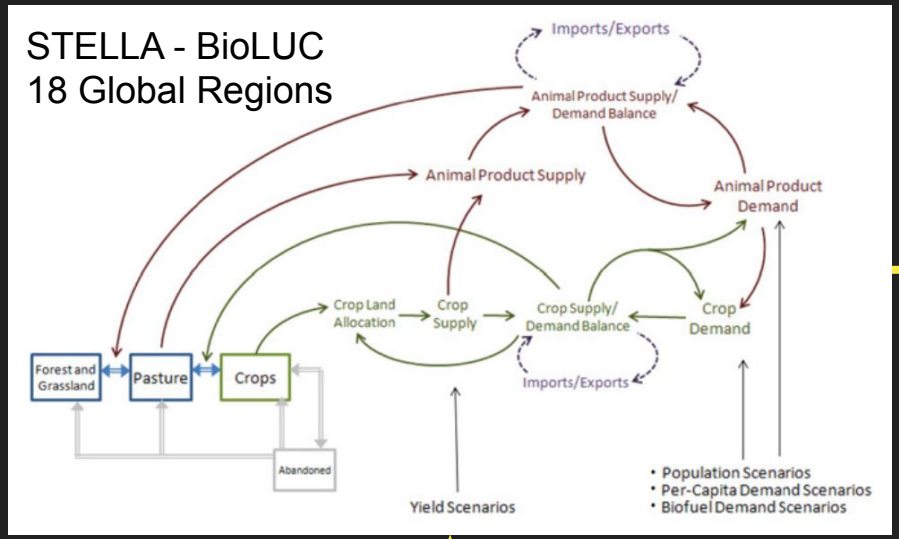
FLUTE

Coupling STELLA (BioLUC) with CRAFTY-Brazil



Warner *et al.* (2013)
[Environmental Research Letters]

Global Annual Commodity Demand

CRAFTY-BRA

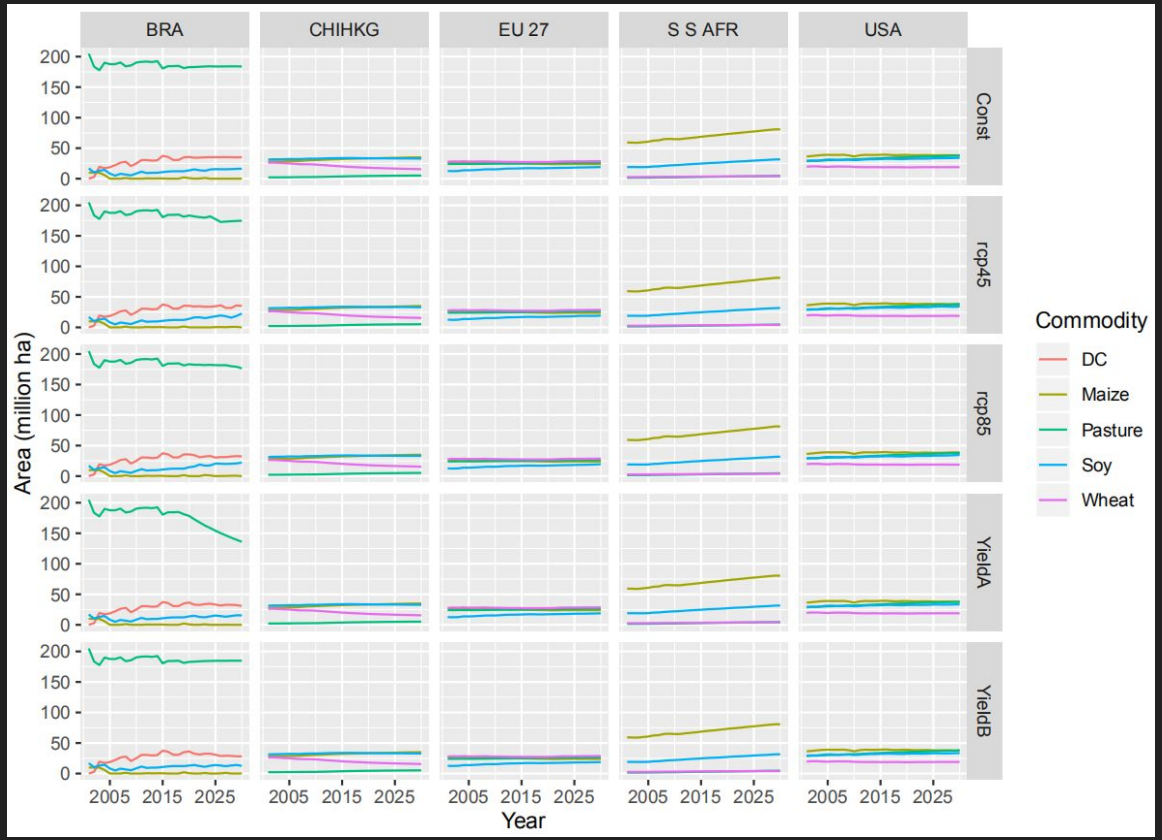
Total Brazil Annual Production

landscapemodelling.net

FLUTE: Testing Results

Time-series output from counter-factual scenarios

Testing model behaviour and comparing global regions for land area

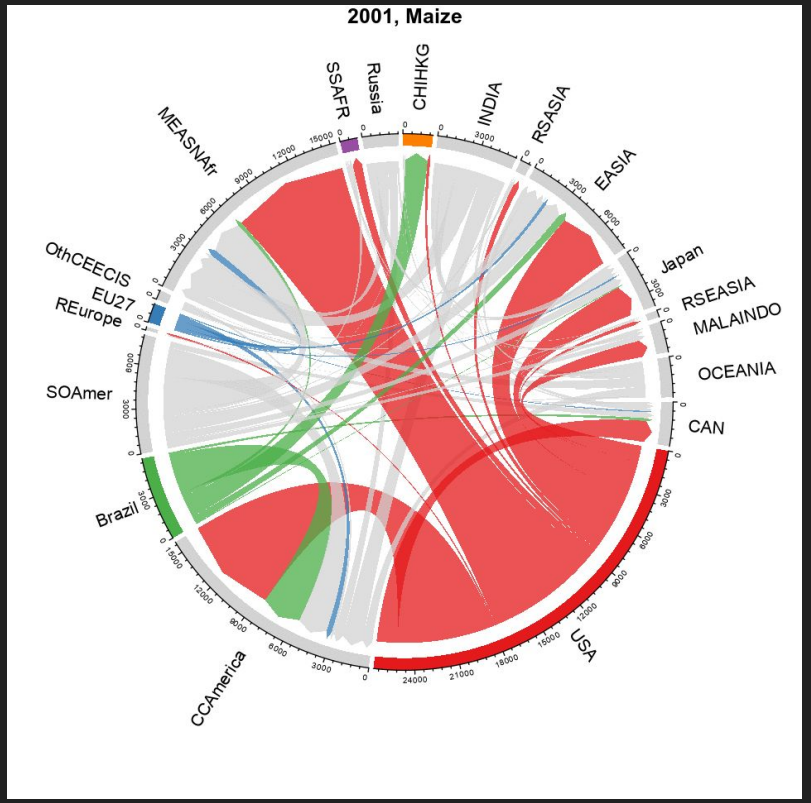


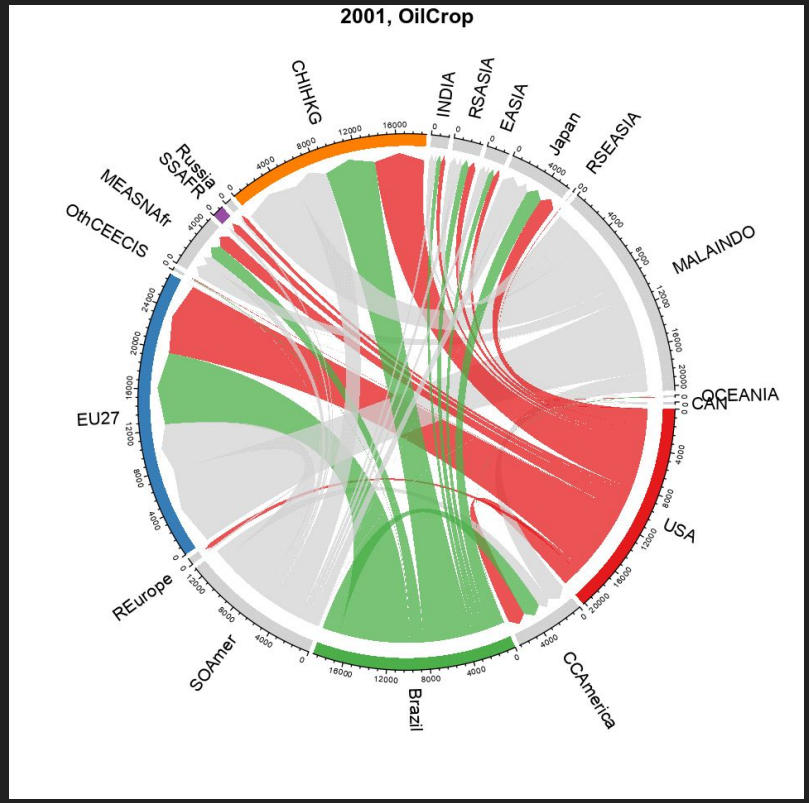
CHIHKG : China, Hong Kong
S S AFR: Sub-Saharan Africa

DC: Soy-Maize double crop

FLUTE: Testing Results

Export Flows (Gigagrams)





FLUTE: Example Application

2019 Swine Flu in China

Marked decrease in soy imports & significant increases in pork and beef imports

Scenarios (next decade)

1. Observed changes are permanent and the new demand levels continue
2. Gradual return to per capita demand levels in China for soy and pork
3. Decline in per capita consumption of pork and beef over next 10 to 20 years

Outputs

- Land and Production impacts for regions around the world (incl. spillovers)
- Brazil: focus on changes at margin for soy production and de/re-forestation

Thanks!

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