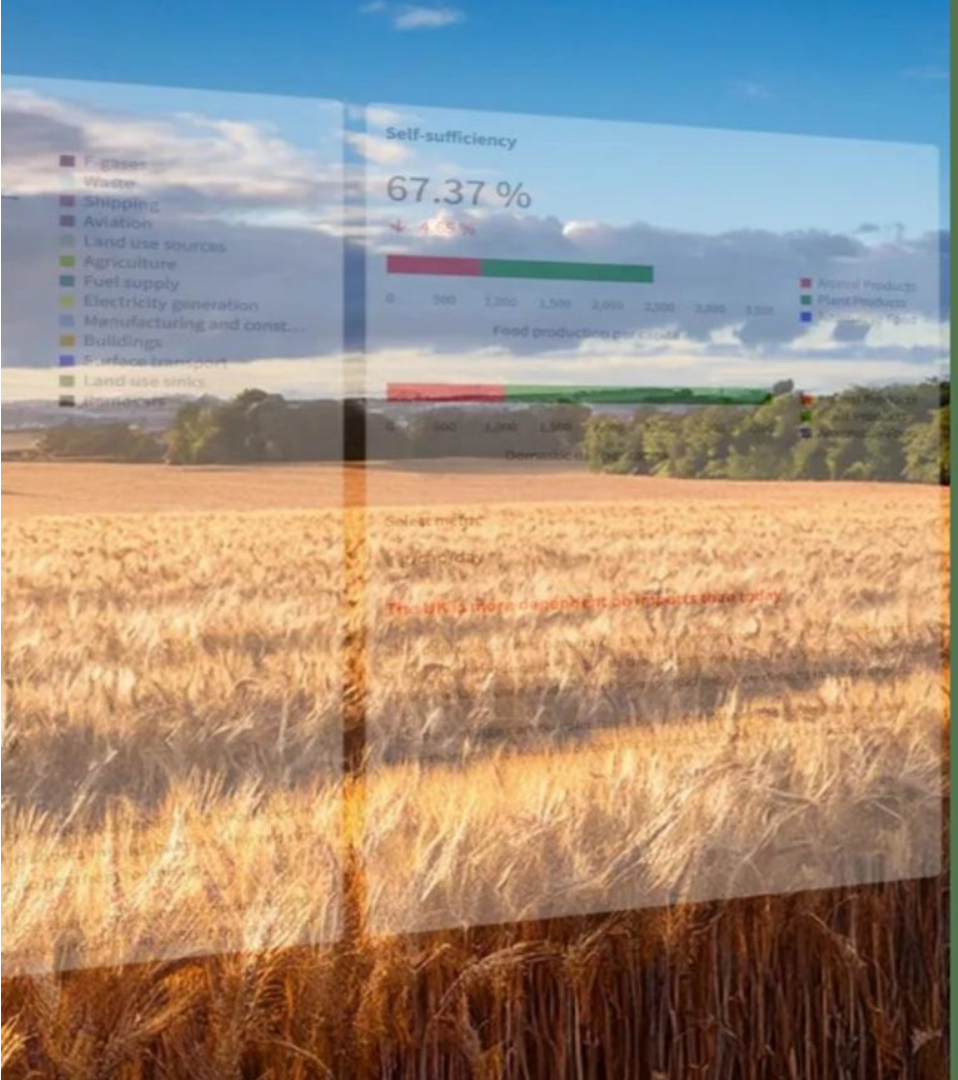


UK Research and Innovation

AFN Network+

How can we trust the data and computer models shaping our food systems?

Professor Sarah Bridle
AFN Network+, University of York
Professor Paul Behrens
University of Oxford
Juan Pablo Cordero
University of York

Modelling the food system: trusting the numbers?

Models can drive major policy decisions… but…

- what are their blind spots?
- when are they reliable?
- should we ask harder questions?

Many types of food model... just a selection:

1. Crop Models (crop yield under climate scenarios)
   - “How much wheat can we grow in 2050 if temperature rises 2°C?”

2. Biophysical models (e.g. IO, LCA etc.)
   - “What is the impact of product X”
   - “Where does food go? What’s the carbon embodied in trade?”
   - Can include projected food demand, population, etc.

3. Systems/Integrated Assessment Models (IAMs)
   - “How do diet changes, land use, climate impacts, and economics interact?”
   - Most uncertain because it’s trying to model human behavior + physics (and many factors are exogenous)

Data dependencies? GIGO?

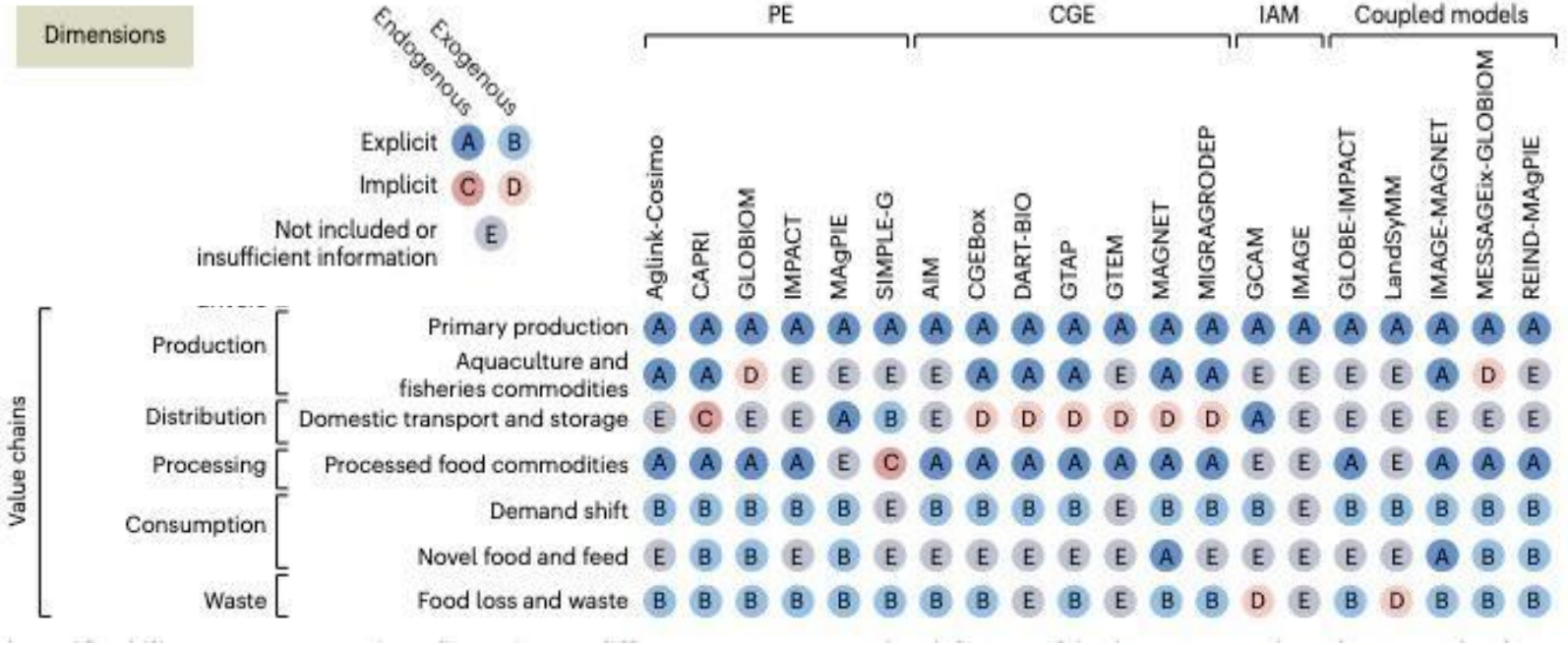
- FAOstat: Self-reported by countries (capacity and quality varies wildly)
  - Note: not enough investment here, people undervalue these data and getting them accurate
- Trade data: customs records
  - Note: exports often undercounted
- LCA emissions factors: mix of measured data and assumptions. Patchy geographical scope
- Surveys: behavioral or farm
  - Note: people often do not recall correctly and farm surveys may have cut-offs for small farms

All downstream models inherit uncertainty.

The uncertainty problem for future scenarios

- Known Unknowns (Measurable Uncertainty):
  - Estimate yield variation under +2°C (range: -15% to -5%) (note: still many factors missing)
  - We can validate these against historical data
- Unknown Unknowns (Ambiguity):
  - “What if consumer preferences shift faster than our models predict?”
  - “What if new crop varieties emerge that we didn’t model?”
  - “What if political collapse creates famine like Syria?”
  - Model cannot quantify these yet are often the most important drivers
- This is trap in a warming and uncertain world: models emphasize precision (what they can measure) over ambiguity (what they can’t). But the big surprises come from the unmeasured unknowns.
- Integrated Assessment Models are notorious for this.

Issues specifically in Integrated Assessment Models



Review article

https://doi.org/10.1038/s43016-025-01257-1

Complexity and uncertainty in future food system transformation modelling

Look at what the model doesn't include

- Crop models: Pests? Extreme weather events? Infrastructure damage on yields?
- Input-output and other models: elasticities in demand and supply
- Integrated assessment models (many, many things!)
- What are the input assumptions? Can you even find them? Are they justified when you can?
- Can the model really capture what it implies it is delivering?
- [redacted] have shocks?
- [redacted] n and do they agree? If

- Can the model be 'proved wrong'?

Transparency

Bad

- Code often closed and when it’s open needs expensive solvers
- Data provenance undocumented
- Assumptions buried in 500-page technical reports
- Models updated without publishing what changed

Good

- Open code
- Anyone can run the model
- Anyone can change assumptions and see what happens
- Clear documentation of sources and conversion factors
- Uncertainty ranges for each input
- Assumption registers (List every choice)
  - E.g. “We assumed elasticity = 0.8 based on study X”

Suggestions

- Look for where there is strong consensus across food system models that have a biophysical/mechanistic rationale such as dietary change
- Explore issues from many angles:
  - CMIP modelling
  - Multi breadbasket modeling
  - Modelling on infrastructure damage
  - Etc.
- Keep a broader view of real-world policies and interventions
- Keep an eye on trade embargoes, societal instability, food price inflation
- That is: make sure you’re aware of factors which almost no models include and how they may alter results in the real world.
- Push for open access, reporting standards etc.

All models are wrong, but some are useful.

- They force you to be explicit about assumptions
- They show where leverage points exist
- They integrate multiple sources of information
- They're better than guessing

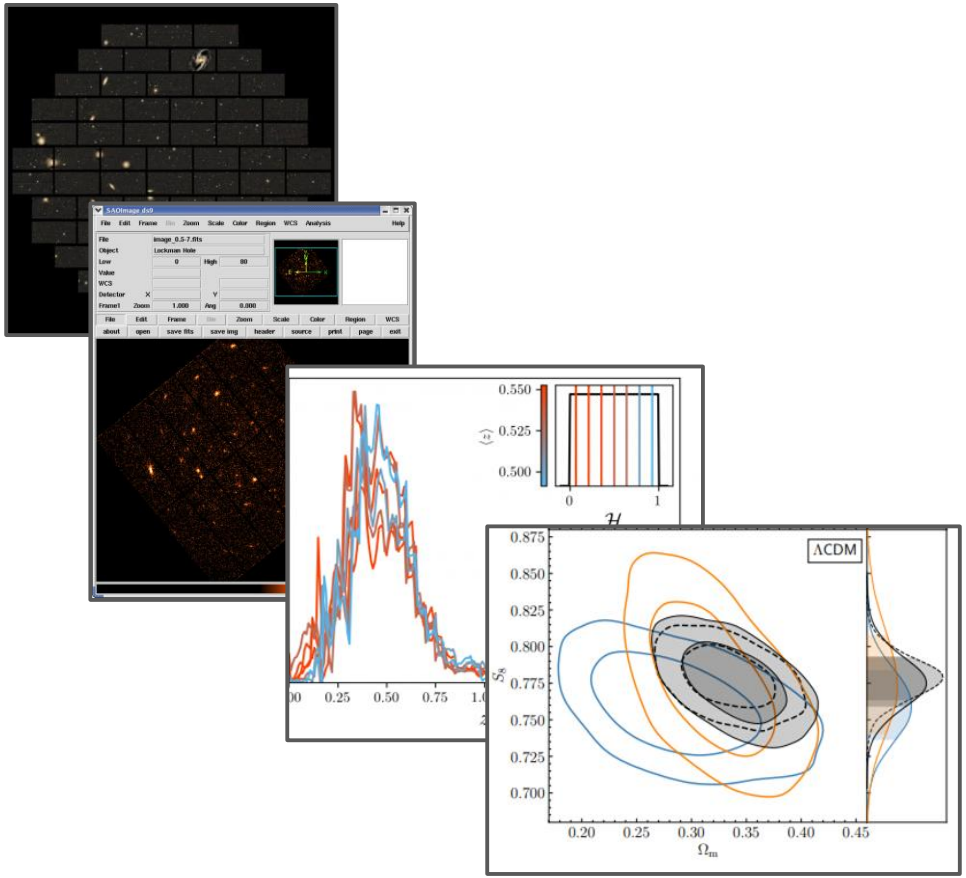
- They're only as good as their data
- They can't predict many real-world events
- Assumptions often matter more than calculations
- They lag real-world complexity

- Models and expert judgment
- Models and diverse perspectives (not just technologists)
- Multiple models testing same question
- Transparent discussion of limitations
- Adaptive management (test assumptions, update constantly)

From astrophysics to agrifood
A vision for an agrifood software ecosystem

Dr. Juan Pablo Cordero

Once upon a time, in astrophysics



cosmosis-developers / **cosmosis-standard-library**

Code | Issues 10 | Pull requests 8 | Actions | Projects

Files | main

cosmosis-standard-library / number_density / nz_multirank / **nz_multirank.py**

joezuntz remove and move old modules — 681ae13 · 3 years ago

260 lines (212 loc) · 9.3 KB

Code | Blame | Raw

```
1   try:
2       from cosmosis.datablock import option_section
3   except:
4       option_section = "options"
5   import numpy as np
6   from scipy.optimize import linear_sum_assignment
7   #import matplotlib.pyplot as plt
8   from nz_gz import nz_to_gchi
9
10  try:
11      import astropy.io.fits as pyfits
12  except ImportError:
13      try:
14          import pyfits
15      except ImportError:
16          raise RuntimeError("You need astropy installed to use the module \
17          nz-multirank; try running: pip install astropy.")
18
19  def load_histogram_form(ext, bin, upsampling):
20      # Load the various z columns.
```

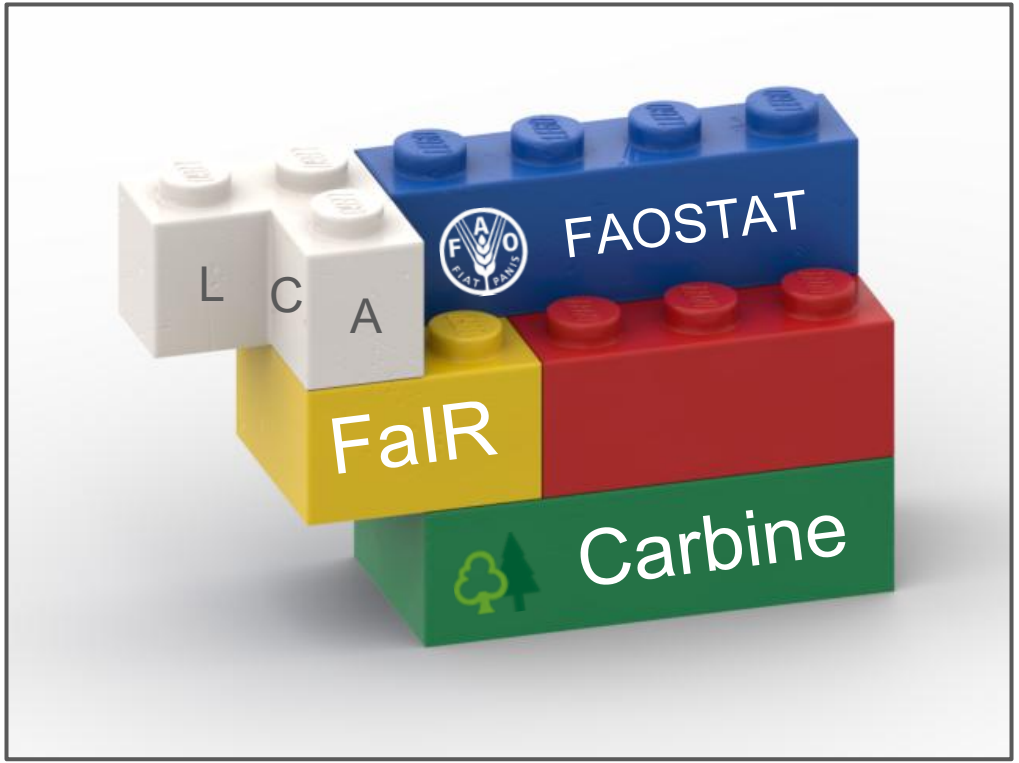
Contributors 31

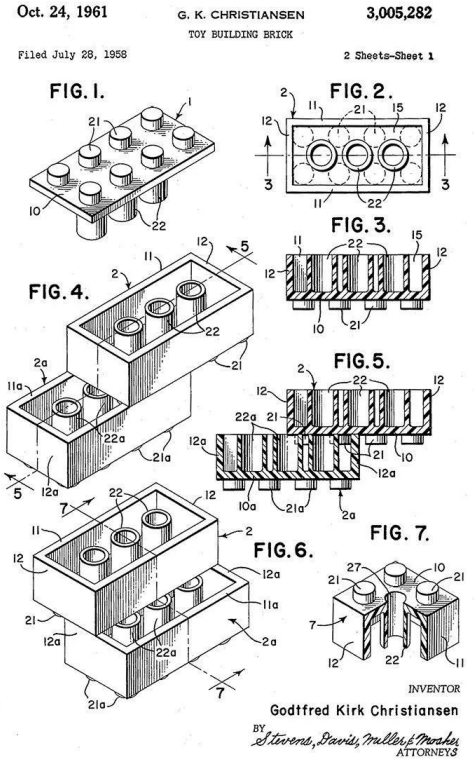
+ 17 contributors

4 years later, in a completely different field!

Astrophysics	Agrifood
Complicated	Complex
Relatively geographically agnostic	Localised challenges and research
Of interest to the public	Affects all lives, and many livelihoods
Irrelevant to most policy	Highly relevant
Accessible and transparent literature - reproducible	Closed, opaque - hard to reproduce
Well-defined field	Overlaps with many fields
Not urgent	Urgent

Our vision for an agrifood software ecosystem




Oct. 24, 1961 G. K. CHRISTIANSEN 3,005,282
TOY BUILDING BRICK
Filed July 28, 1958 2 Sheets-Sheet 1
FIG. 1.
FIG. 2.
FIG. 3.
FIG. 4.
FIG. 5.
FIG. 6.
FIG. 7.
INVENTOR
Godtfred Kirk Christiansen
BY Stevens, Davis, Miller & Mosher
ATTORNEYS

futurefoodcalculator.org/expert-calculator

FUTURE FOOD CALCULATOR

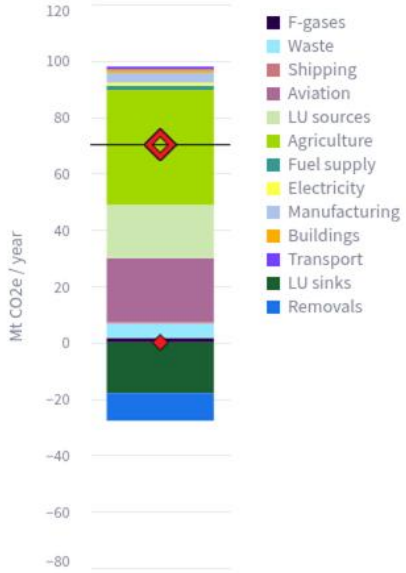
Select a scenario

- Consumption
- Land use
- Livestock
- Arable
- Technology and innovation
- Scenario settings
- Submit slider positions

Reset all sliders | Clear cache

--- Developed with funding from FixOurFood.

UK Emissions balance



Show agriculture and land use only

Total emissions

70.16 Mt CO2e / year

↓ -0.00 Mt CO2e / year

Self-sufficiency

67.37 %

↓ -4.65 %

The UK is more dependent on imports than today

Food production per capita

Domestic use per capita

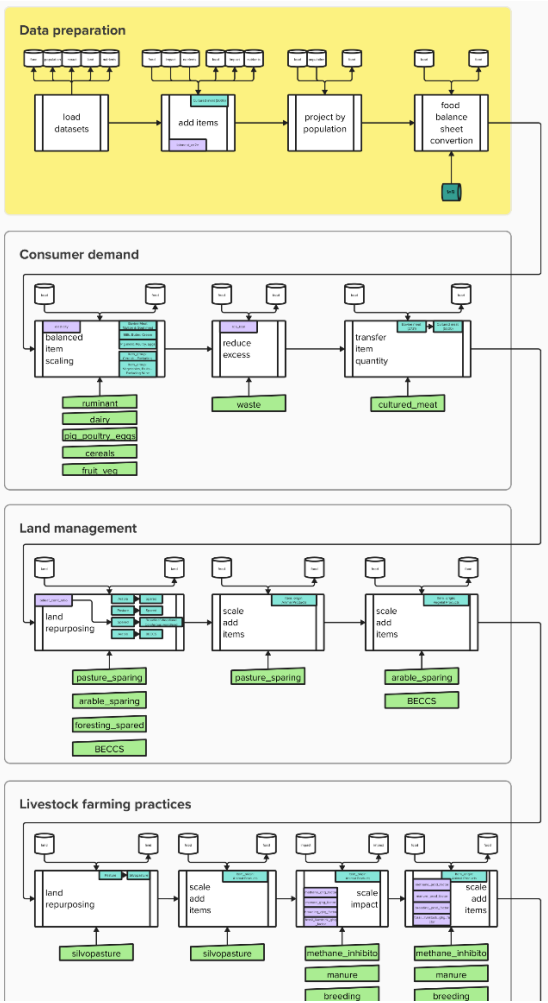
Production and consumption

Herd size	Dairy herd	Beef herd
9.15M	3.48M	5.67M
↓ -867.62	↓ -329.88	↓ -537.74
Poultry heads	**Pig heads**	**Sheep flock**
177…	4.72M	31.…
↓ -16.87k	↓ -447.02	↓ -2.94k

futurefoodcalculator.org

AFN Network+

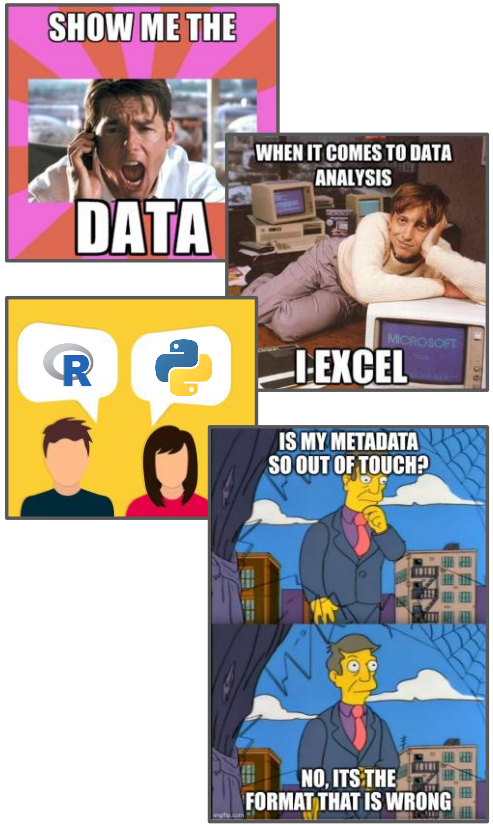
FixOurFood



Scenario	UK Emissions $MtCO_2e$ /yr	Self-sufficiency ratio	Herd Size, Million heads
Baseline	70.16	0.67	9.15
A. BUILD BACK FAST AGAIN	0.68	0.71	6.49
B. CIRCULAR WORLDS	0.06	0.72	4.27
C. SELF-SUFFICIENCY FOR SECURITY	-0.24	1.02	4.49
D. THE RIGHT TO FOOD	0.14	0.60	4.48

A rocky road

Obtaining data



Building networks

Generating trust