

# System dynamics modelling to explore climate, economy, environment and society interactions

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*UK DEFRA Systems Thinking Seminar*

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**Radboud University**



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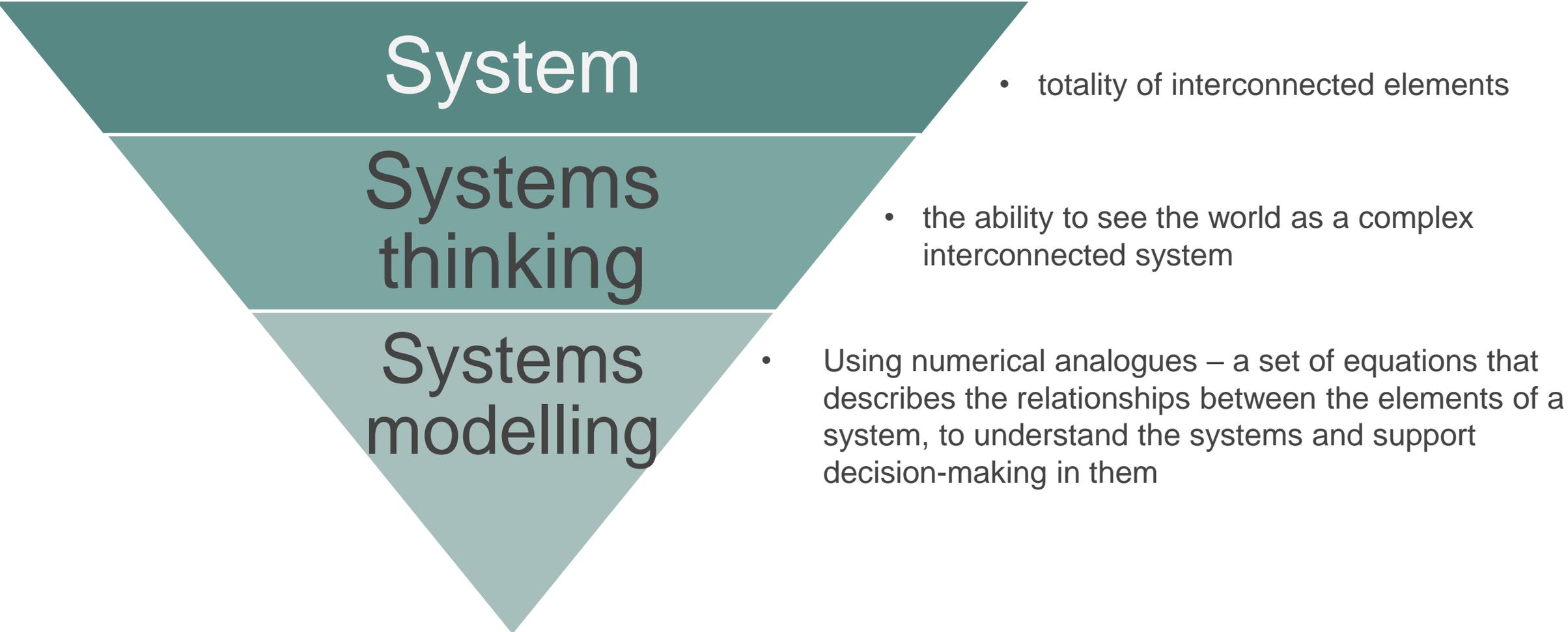


<https://sibeleker.github.io>



[@sibel\\_eker\\_](https://twitter.com/sibel_eker_)

# SYSTEMS...



System

- totality of interconnected elements

Systems  
thinking

- the ability to see the world as a complex interconnected system

Systems  
modelling

- Using numerical analogues – a set of equations that describes the relationships between the elements of a system, to understand the systems and support decision-making in them

# SYSTEMS MODELLING

## Systems modelling methodologies

### Static

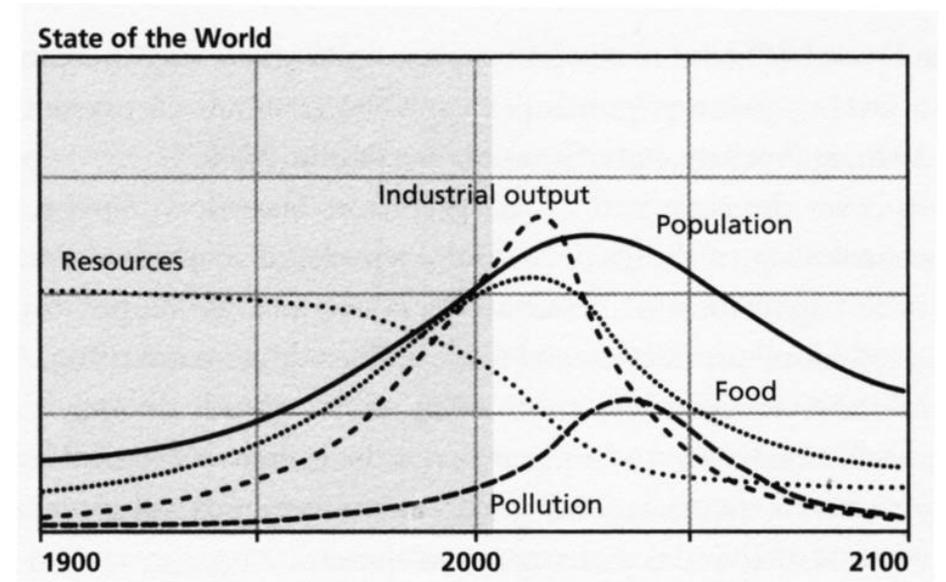
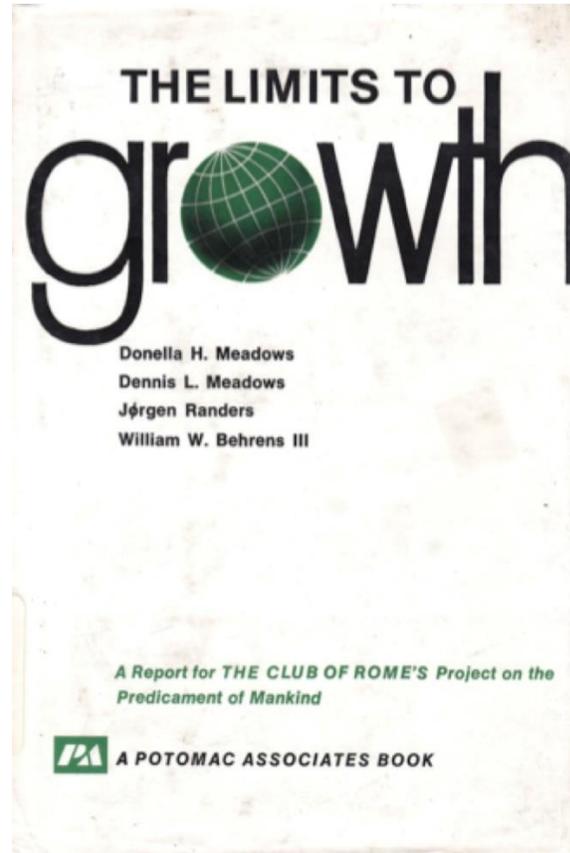
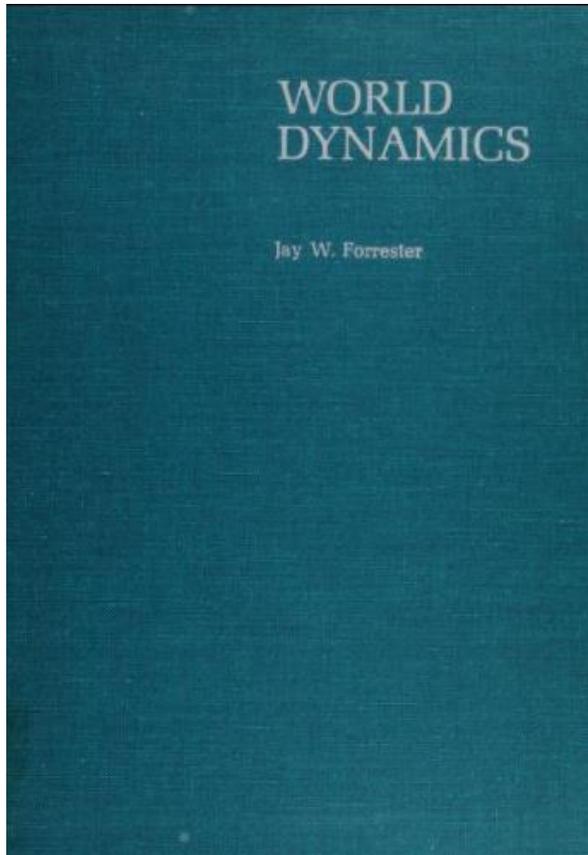
- Spreadsheets
- Linear programming for optimal allocation
- Network models
  - Forecasting
- Decision trees

### Dynamic

- Discrete event simulation
- Agent-based modelling
  - Dynamic optimization
- System dynamics



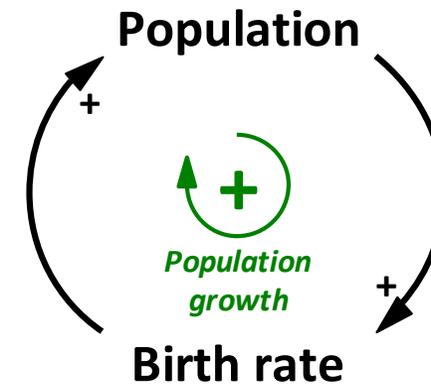
# SYSTEM DYNAMICS





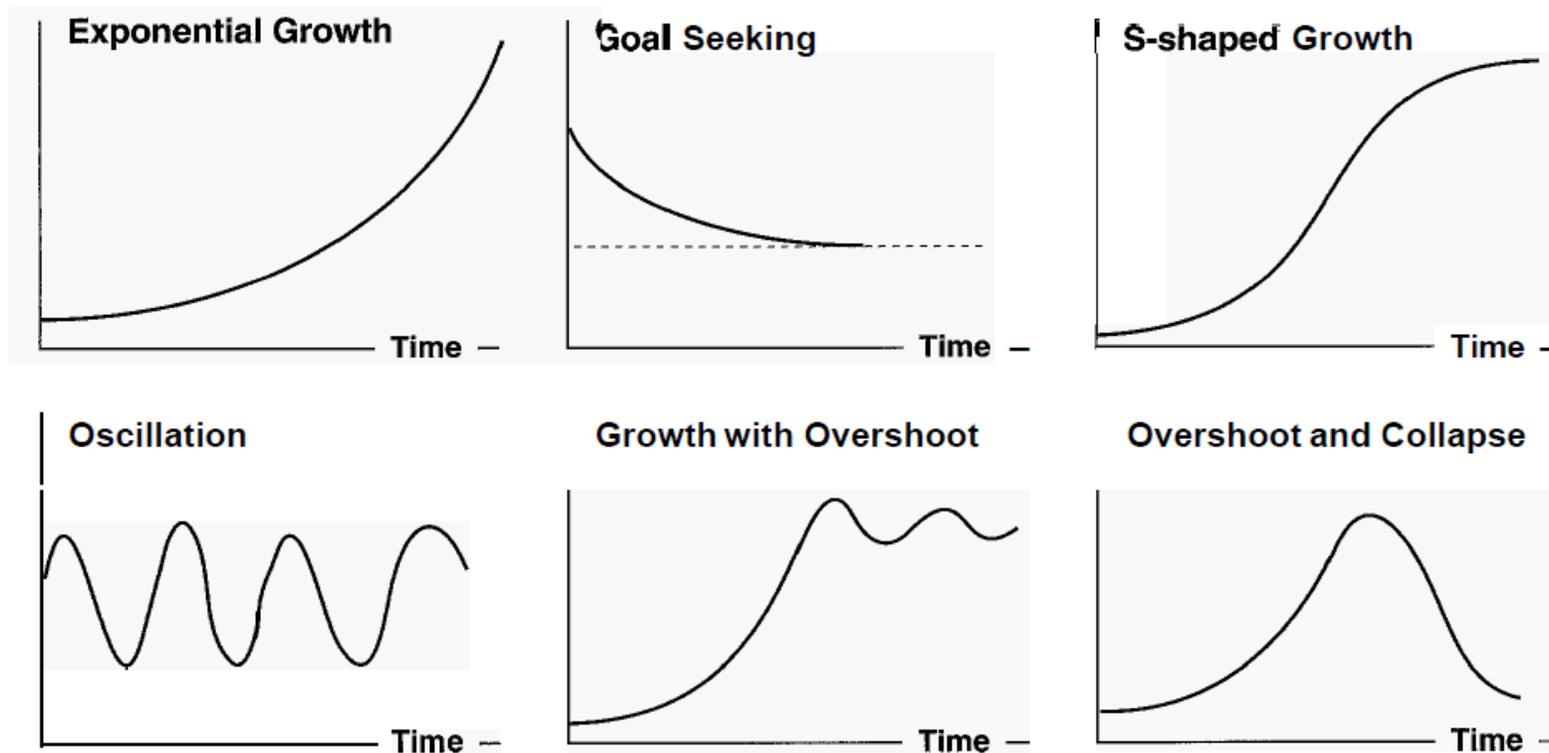
# SYSTEM DYNAMICS

- Based on the core concepts of systems thinking
  - stocks, flows, delays and feedback loops



# SYSTEM DYNAMICS

- Dynamic, time-continuous
  - endogenous dynamic behaviour created by feedbacks



# SYSTEM DYNAMICS

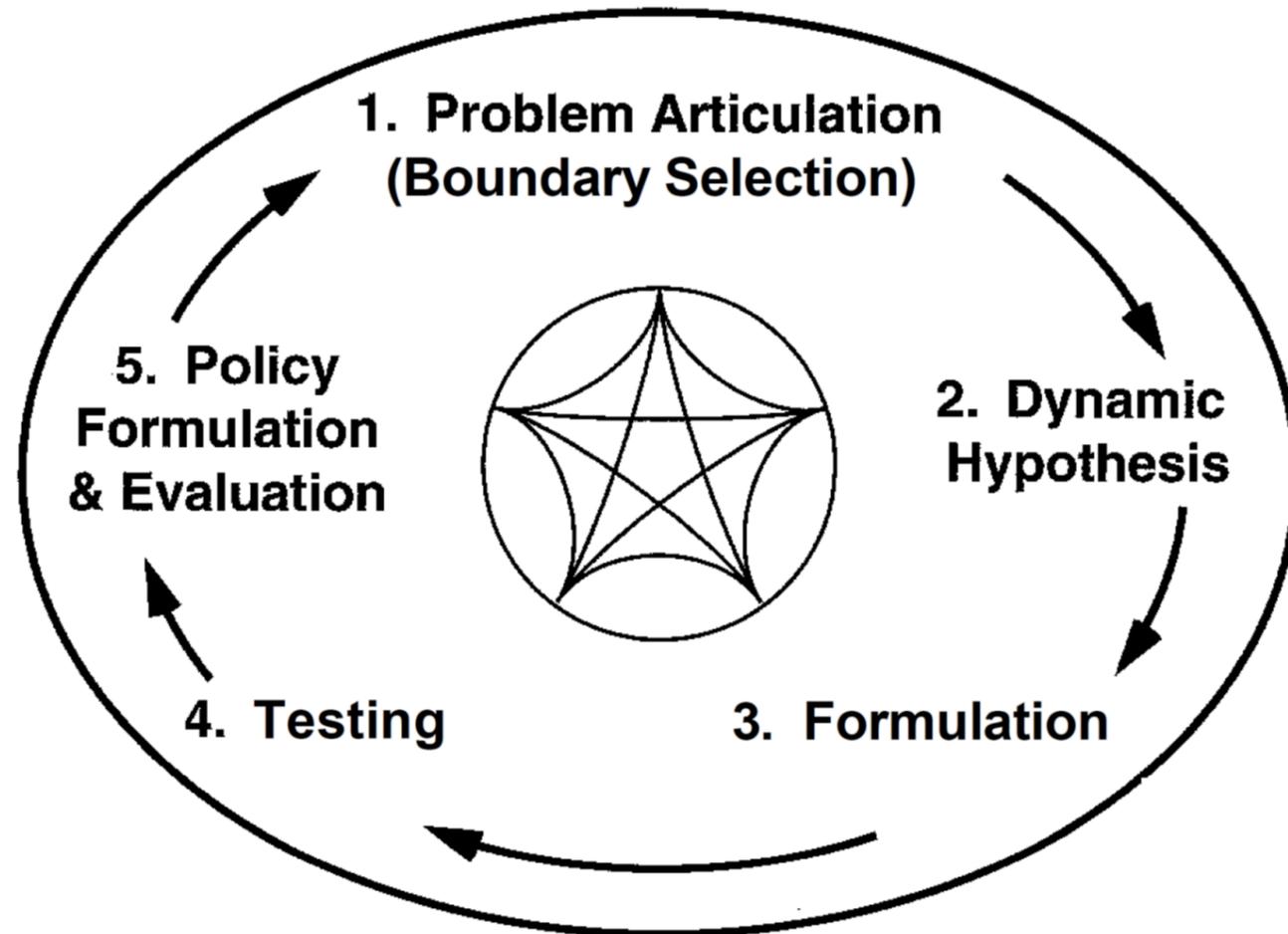
- Ordinary differential equations, integration
  - computationally efficient

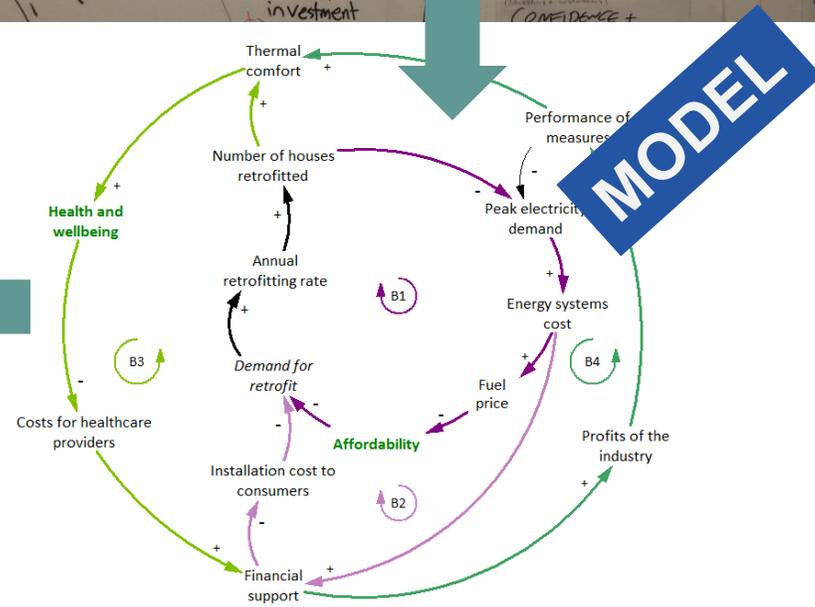
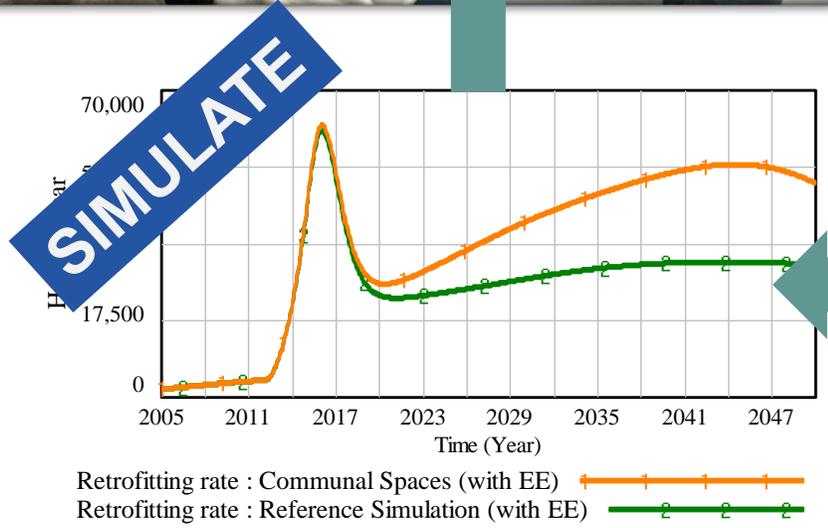
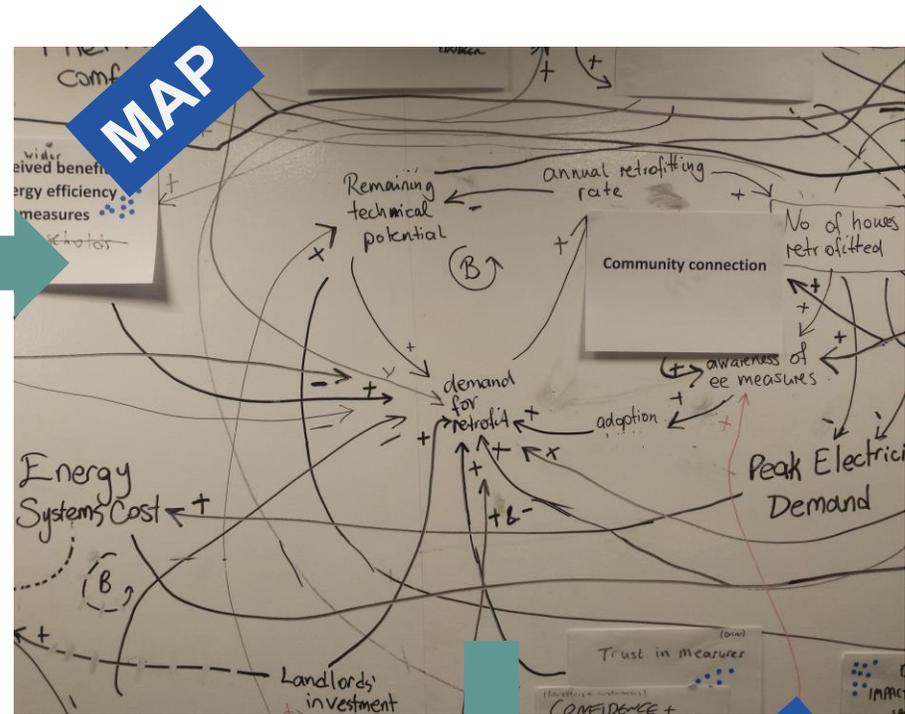


$$\frac{dStock}{dt} = Inflow - Outflow$$

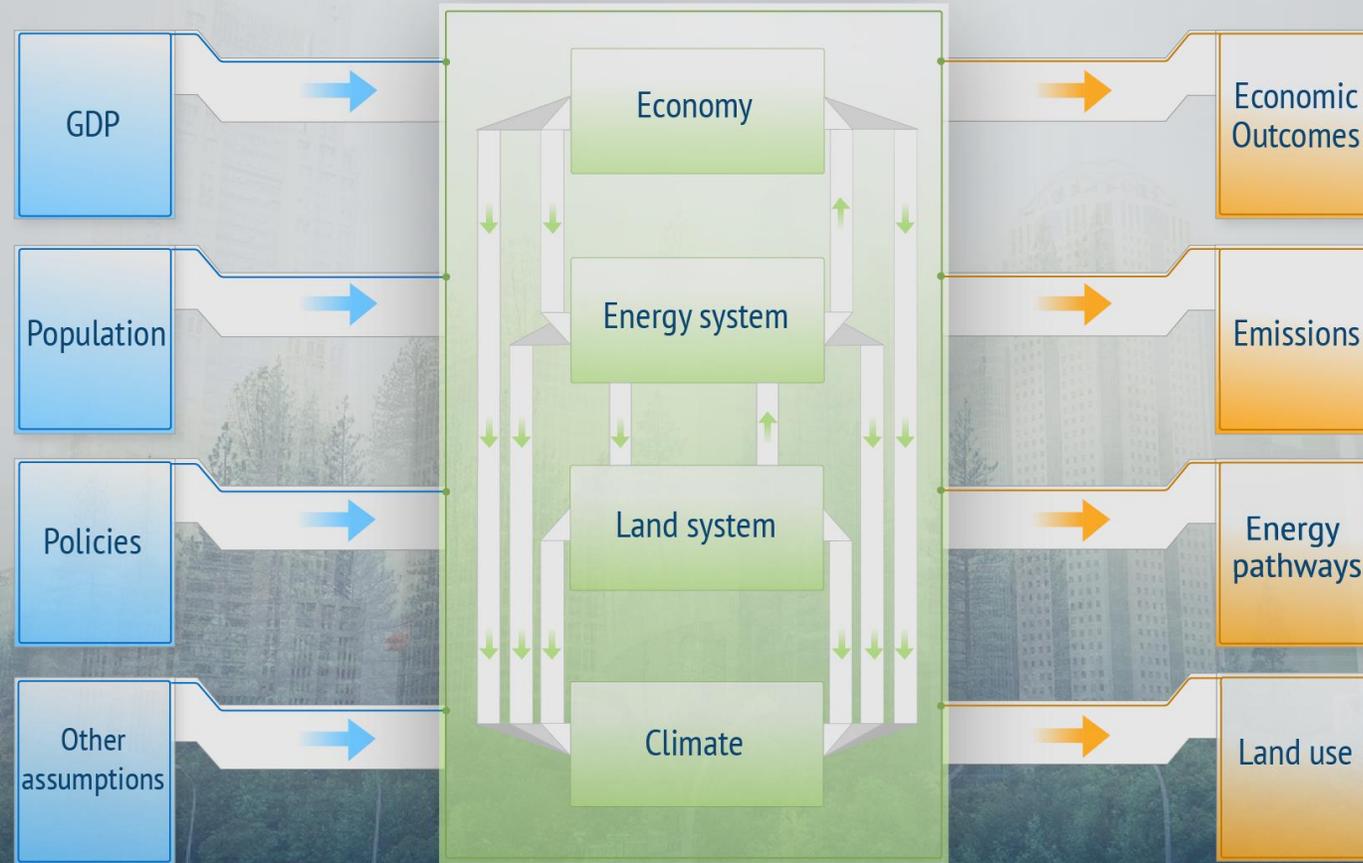
$$Stock(t) = \int_0^t (Inflow - Outflow) * d\tau$$

# SYSTEM DYNAMICS MODELLING CYCLE





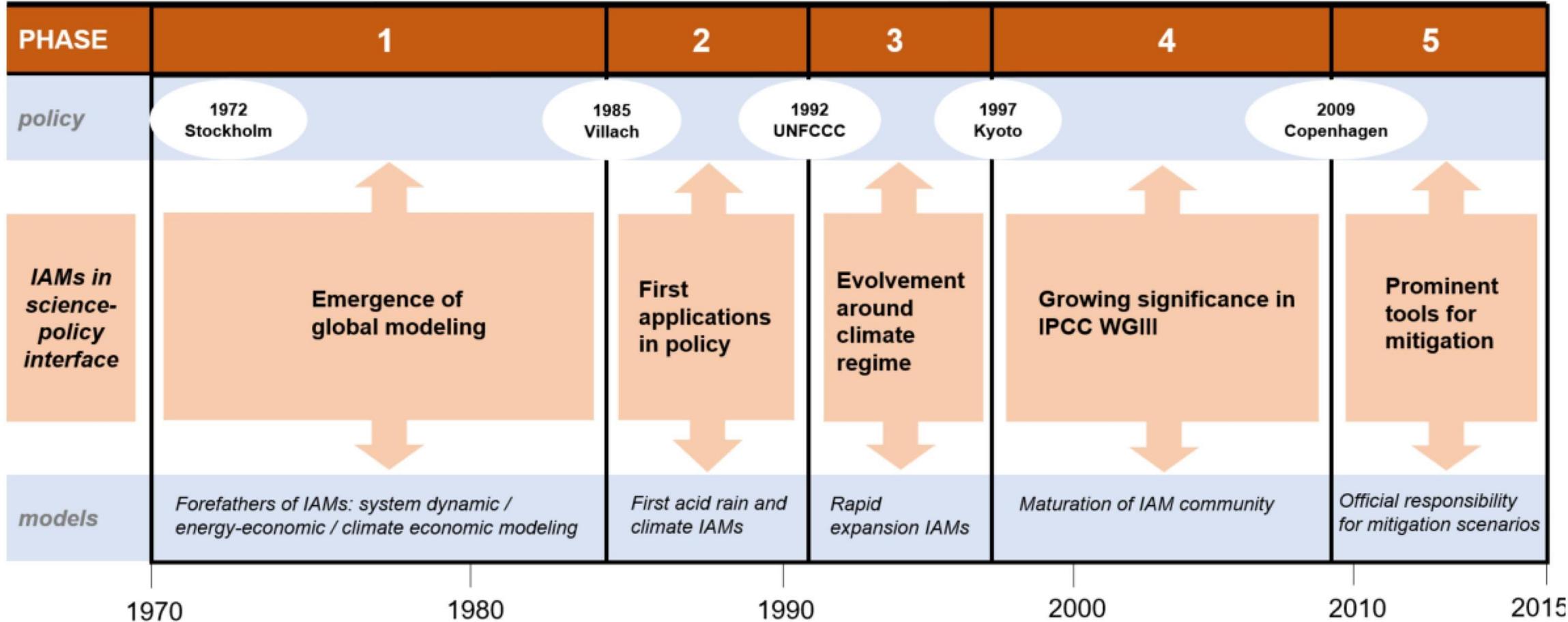
## How do Integrated Assessment Models work?



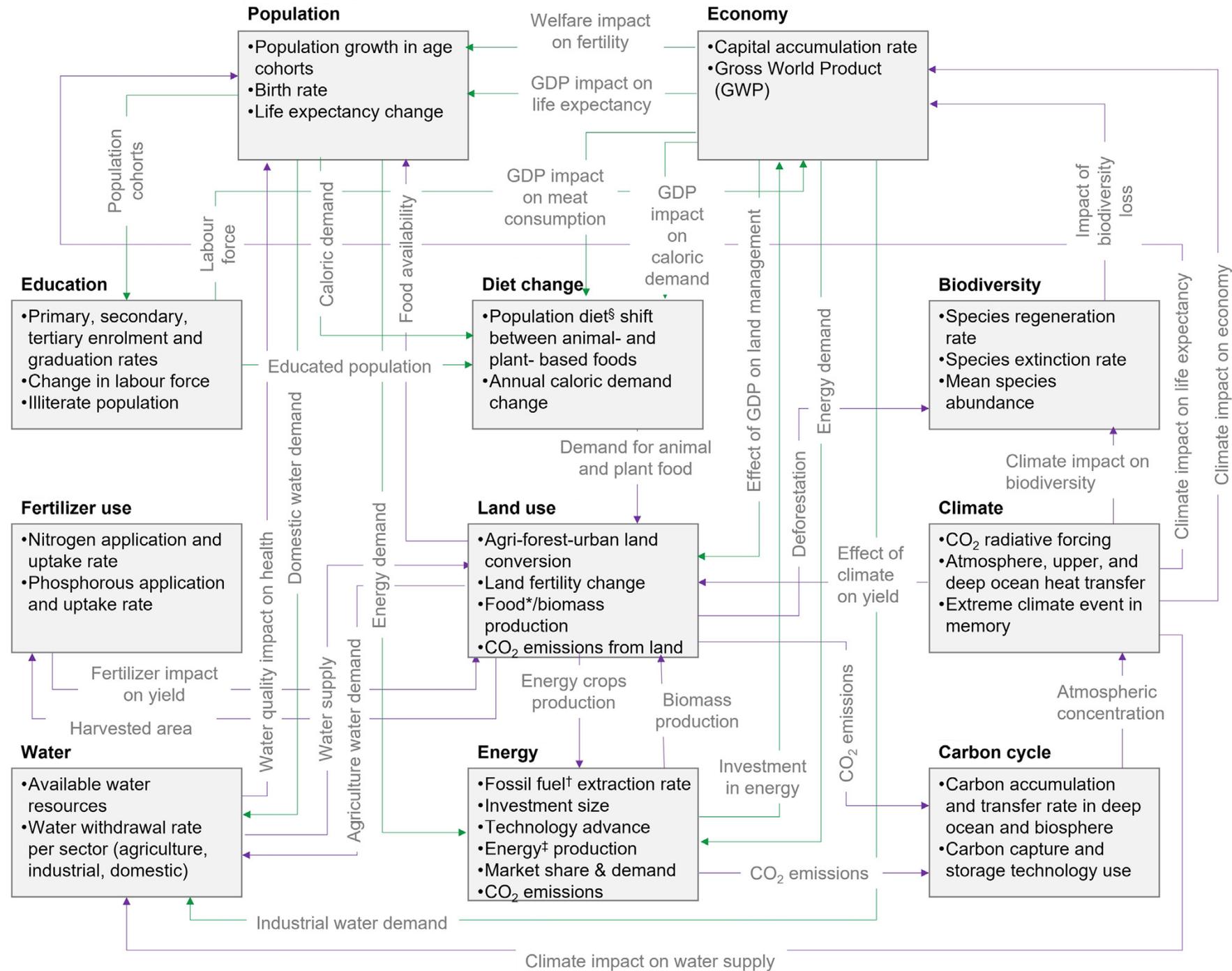
CarbonBrief  
CLEAR ON CLIMATE

“Integrated assessment models (IAMs) are complex models of the energy-land-economy-climate system that use socioeconomic assumptions to produce energy, land use and emissions scenarios.” (*SENSES project*)

# Role of IAMs in the climate science-policy interface

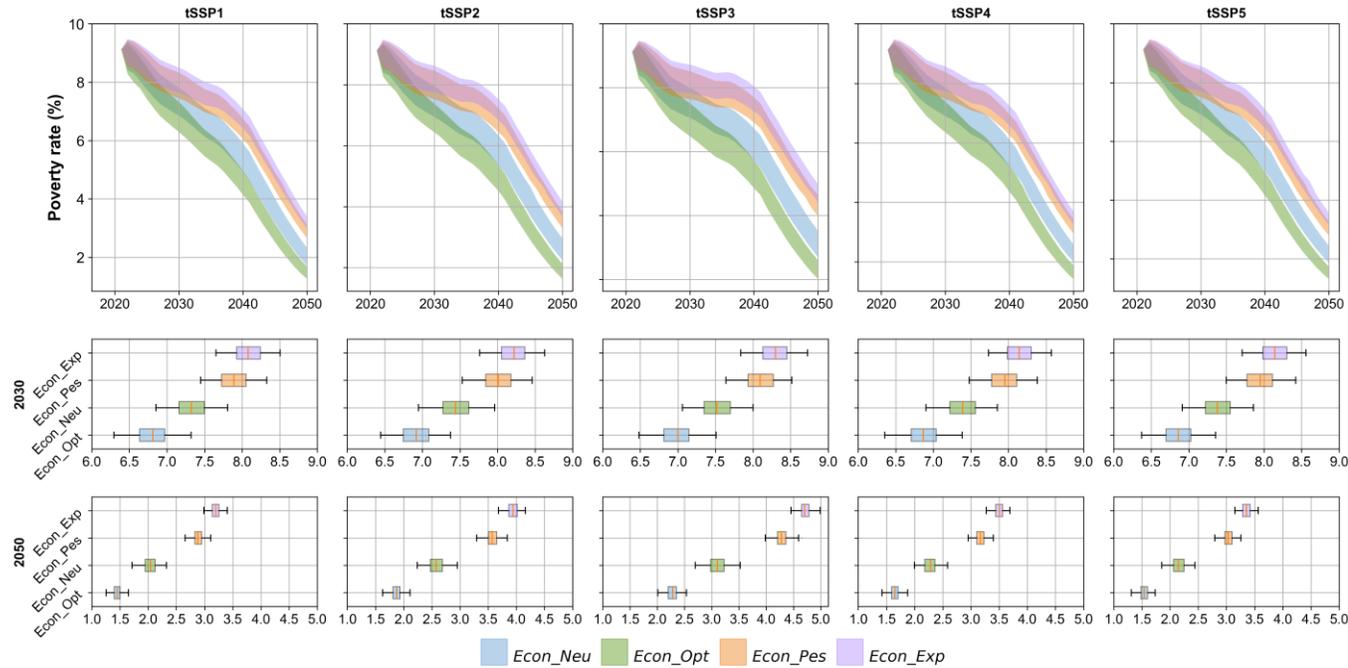
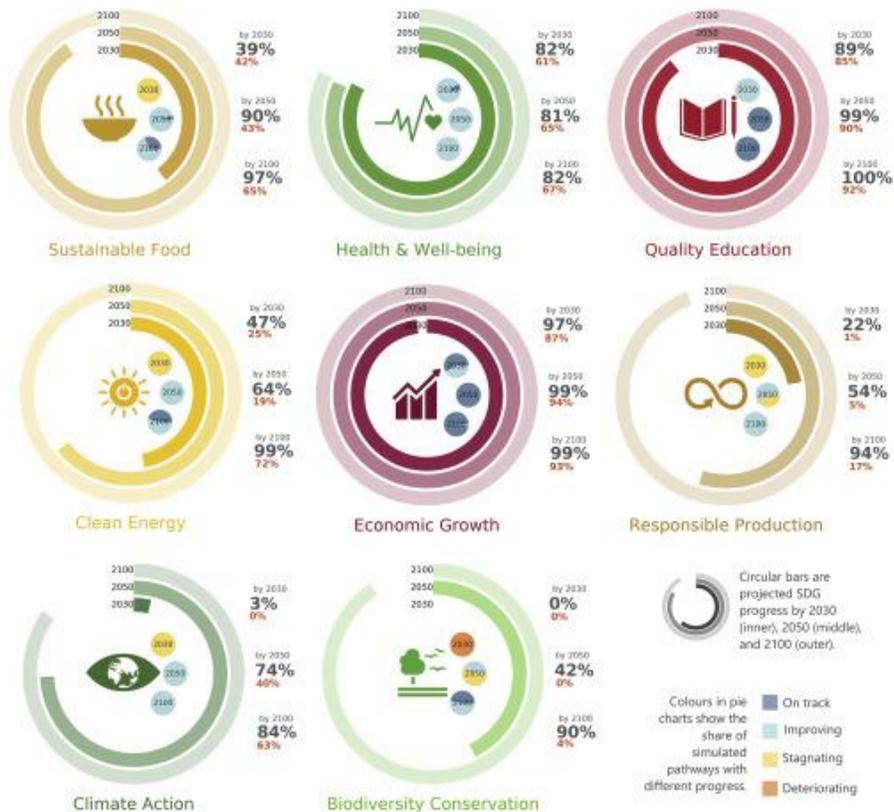


# FELIX MODEL



# FELIX MODEL

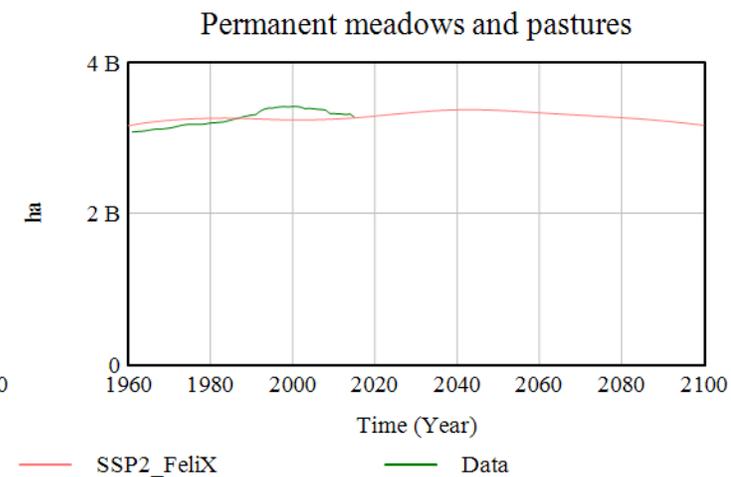
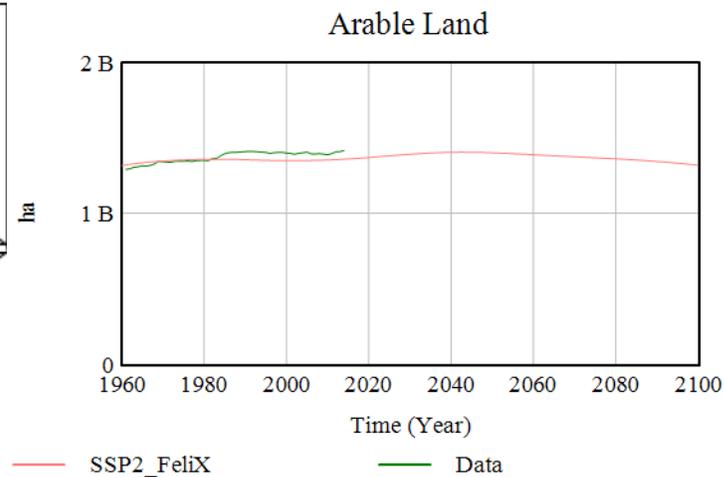
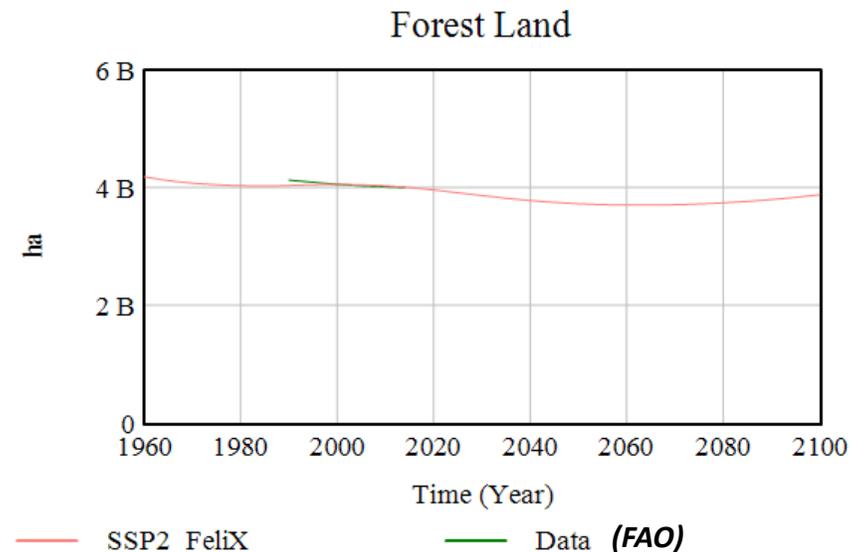
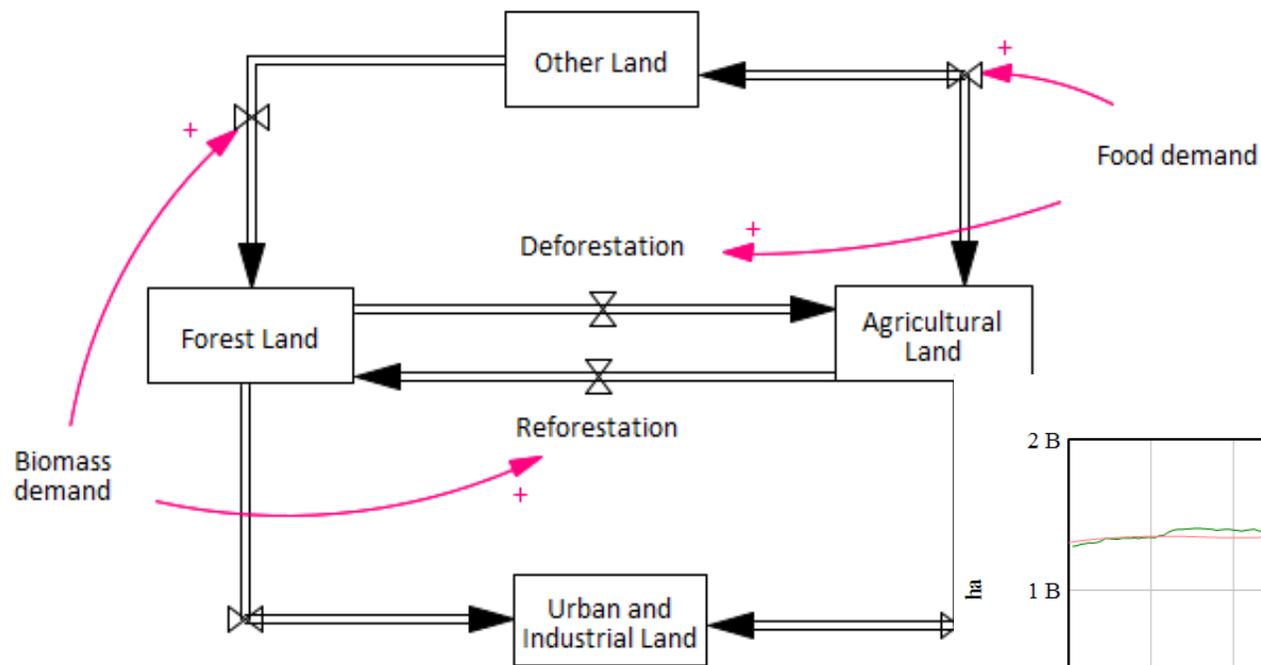
- To explore SDG interactions and tradeoffs, including a focus on poverty
- To improve the representation of social systems in integrated assessment modelling



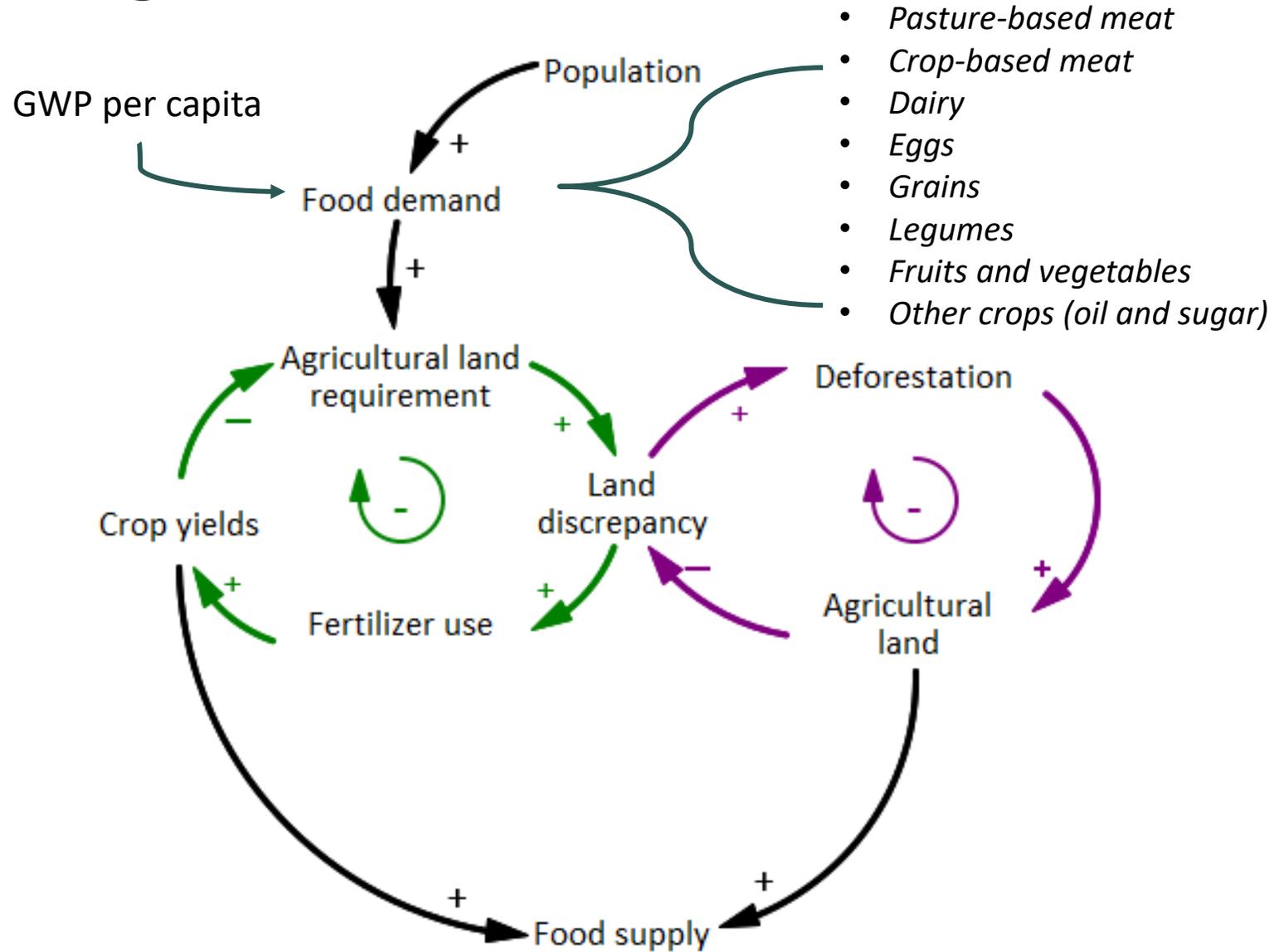
Moallemi et al. (2022) *One Earth*

Liu et al. (2022) *One Earth*

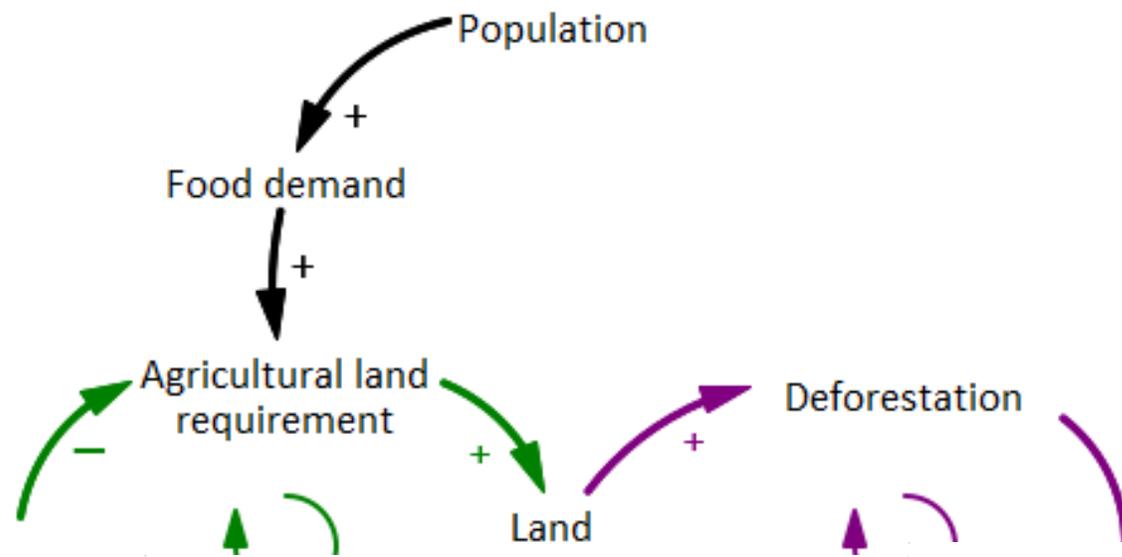
# Land use change in the FeliX model



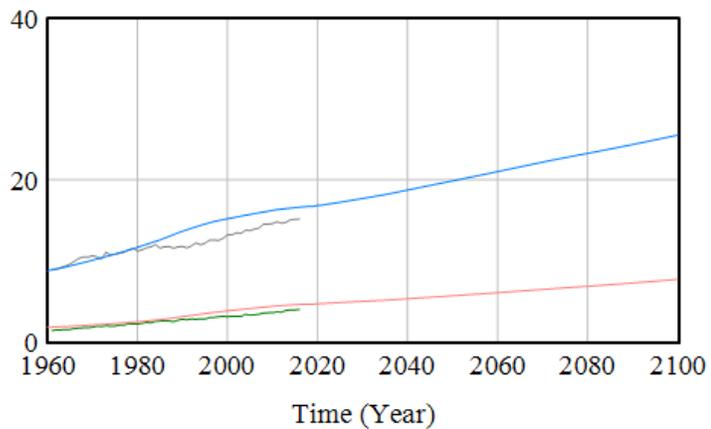
# Land Use Change



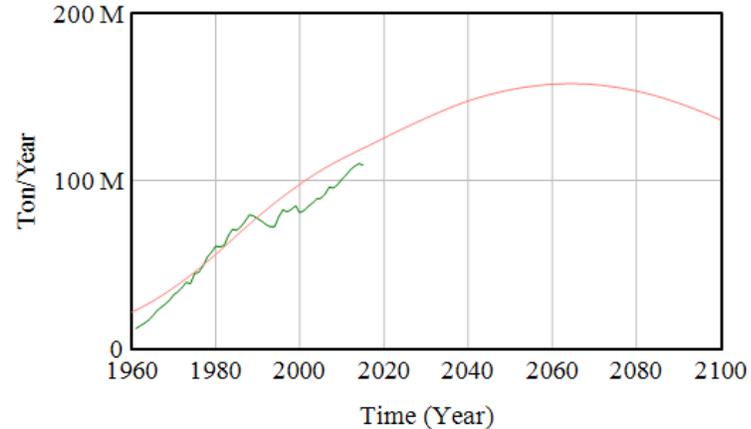
# Food Supply and Demand



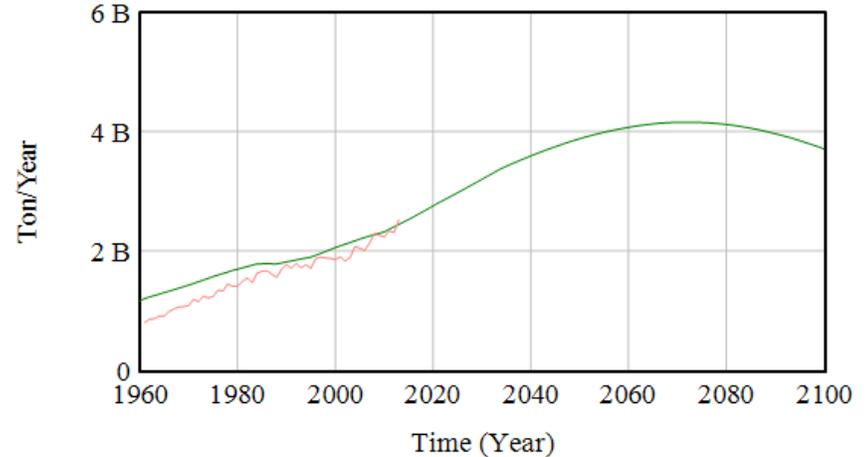
Crop yield for each category



Commercial N application for agriculture

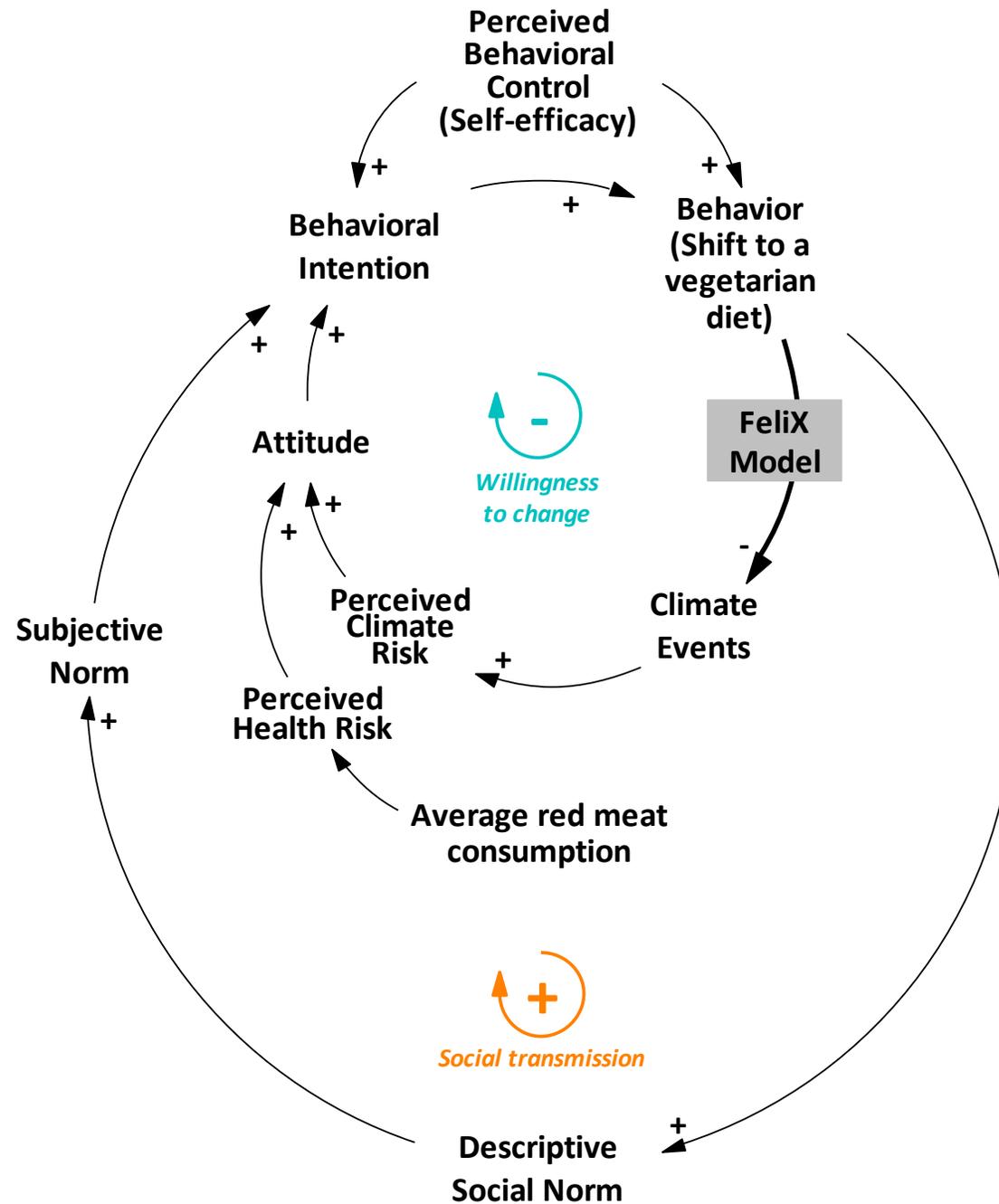


Food production rate[Grains]



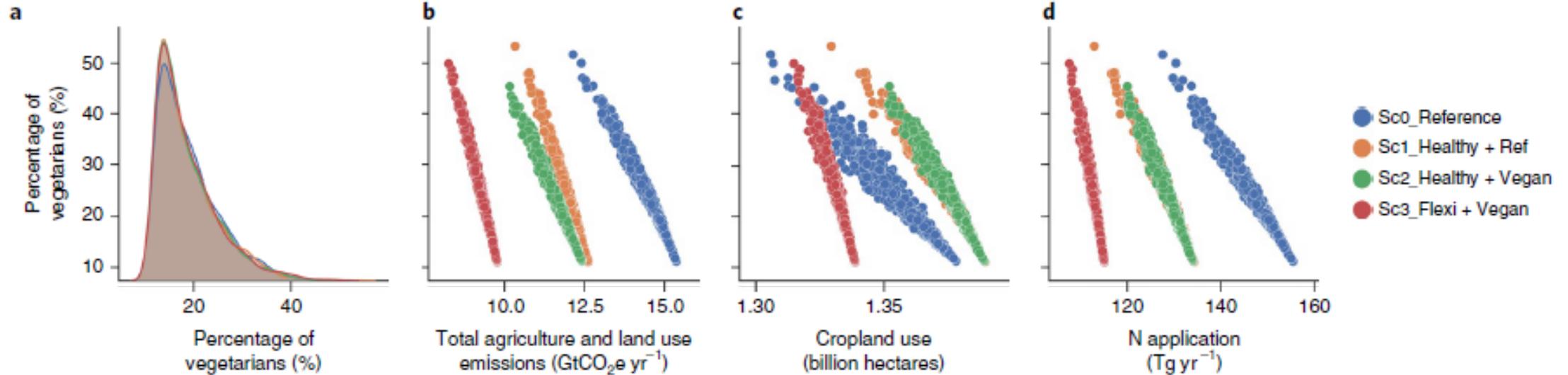
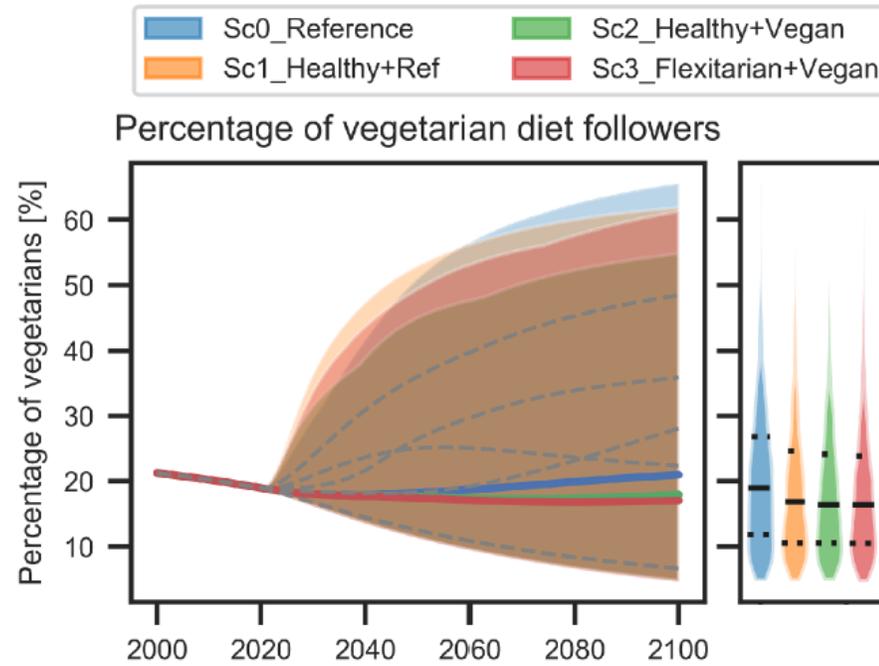
— [Grains] : SSP2\_FeliX    — [VegFruits] : SSP2\_FeliX    — SSP2\_FeliX    — Data  
— [Grains] : Data    — [VegFruits] : Data

# Dietary shifts



# Dietary shifts

*Connecting behavioral factors to environmental indicators*

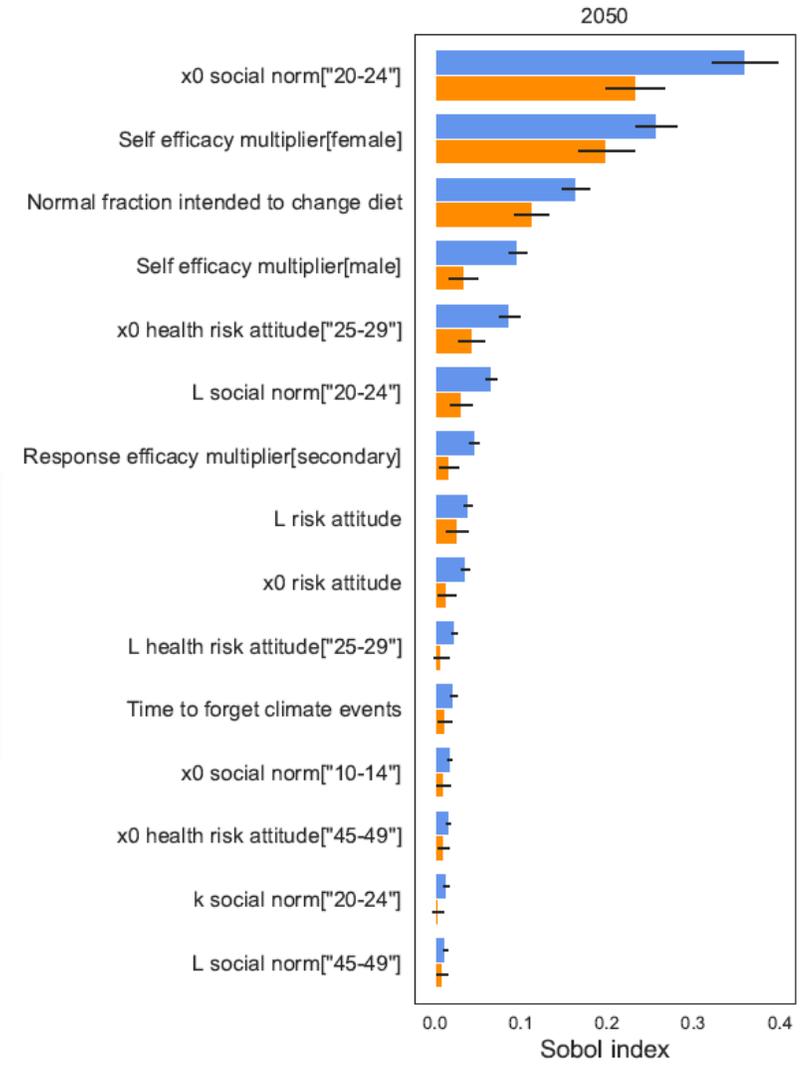
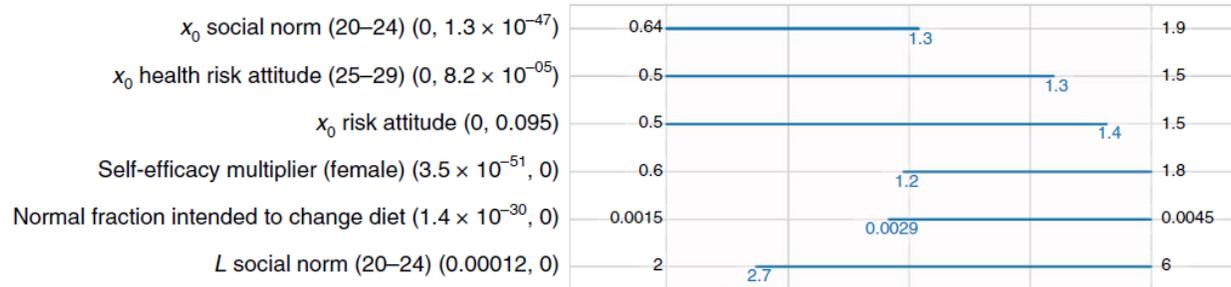


# Dietary shifts

Identifying the most 'important' elements

a

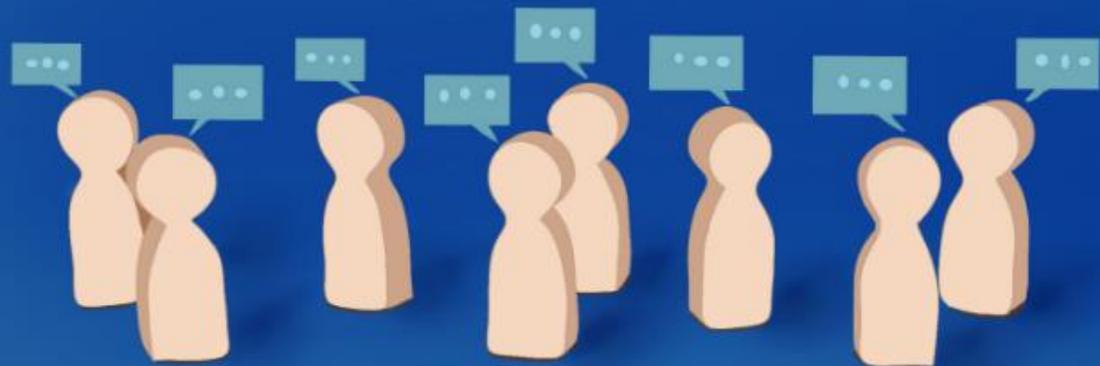
Scenario discovery results for scenario 0 and year 2050



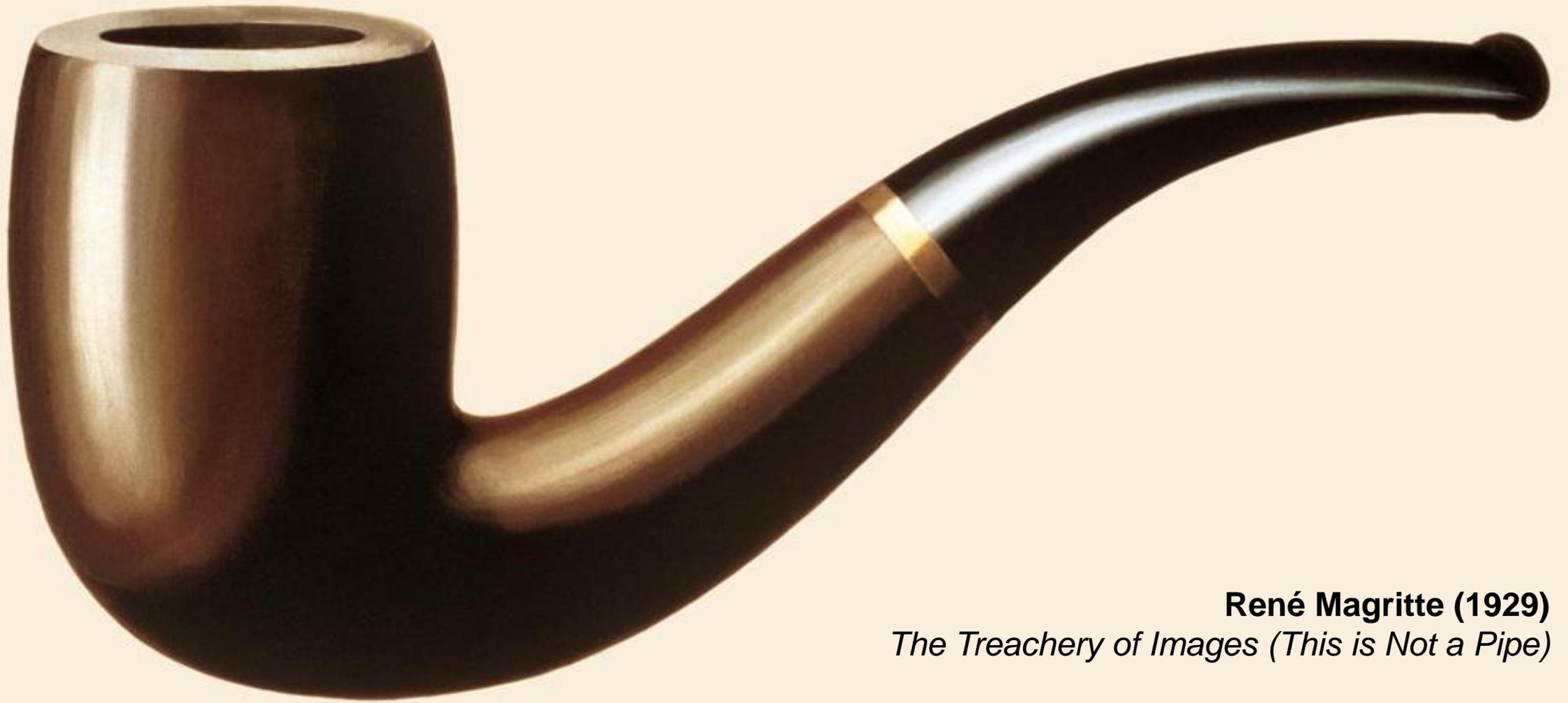
## EU projects with Felix and SD

# WorldTrans

*Transparent Assessments  
for Real People*



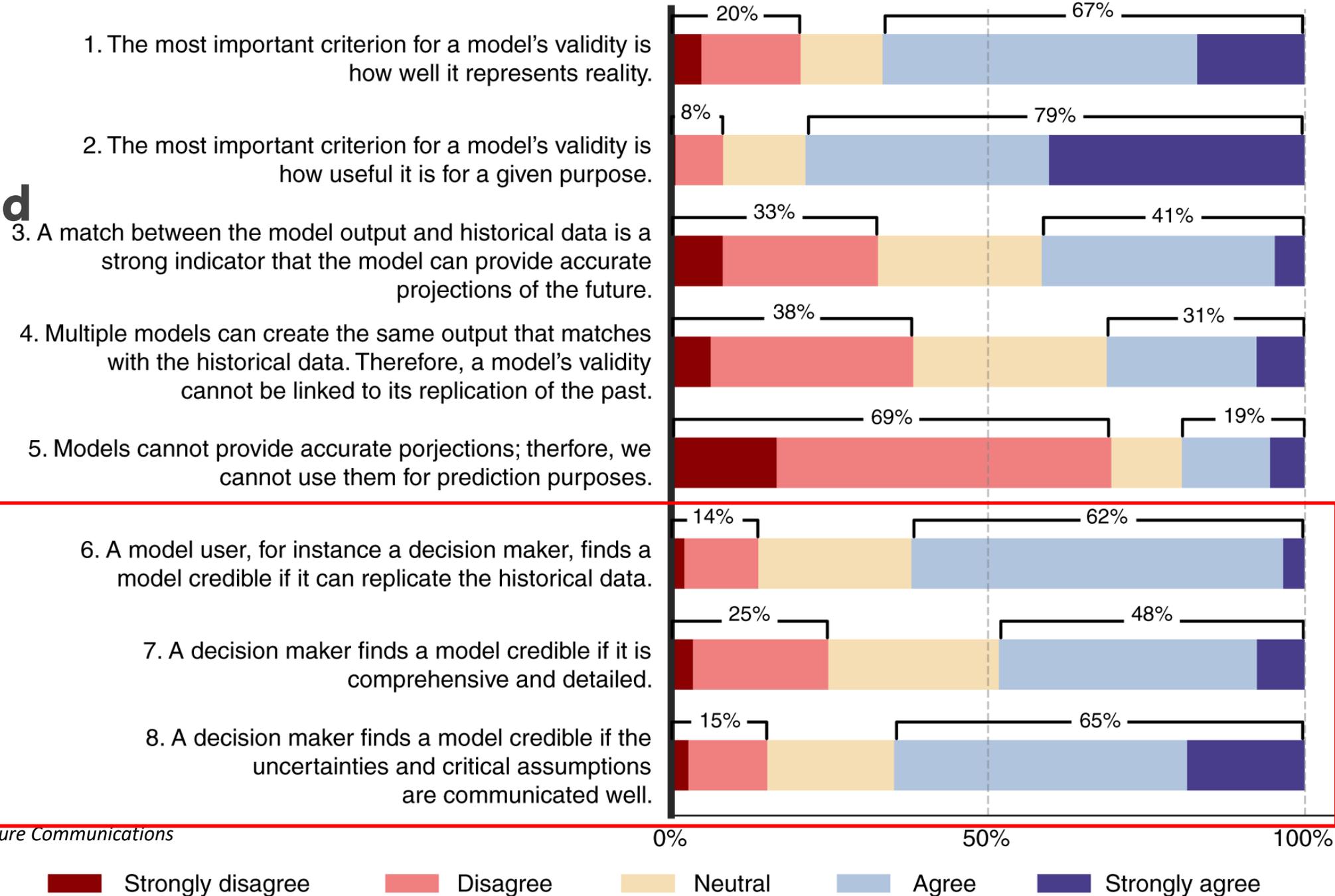
# CHOICE



**René Magritte (1929)**  
*The Treachery of Images (This is Not a Pipe)*

*Ceci n'est pas une pipe.*

# Model validity and use



Source: Eker et al. (2018) *Nature Communications*

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