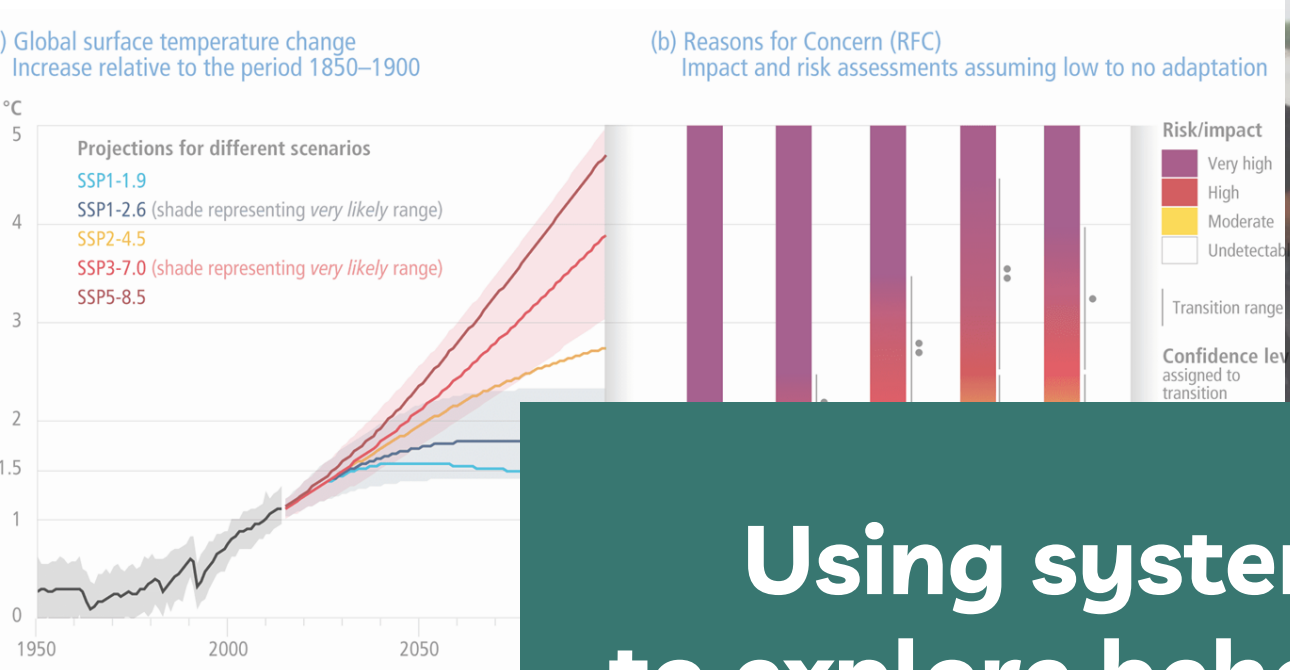
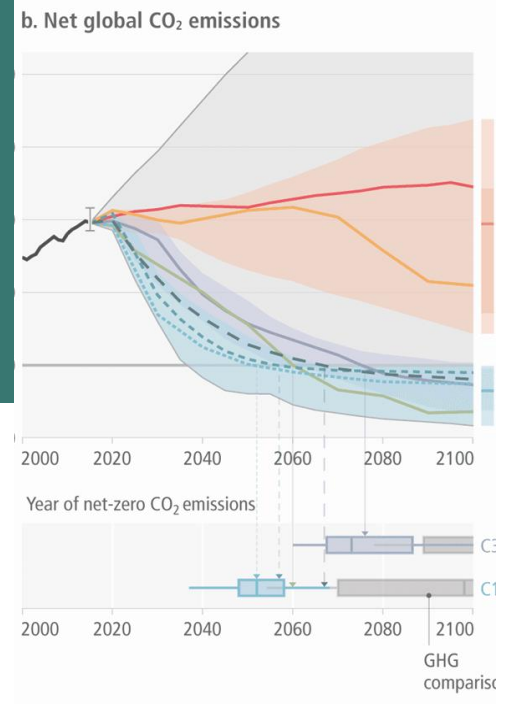


Using system dynamics to explore behavior change in integrated assessment context

Sibel EKER (sibel.eker@ru.nl)

LOOPS-5 Workshop, March 2023



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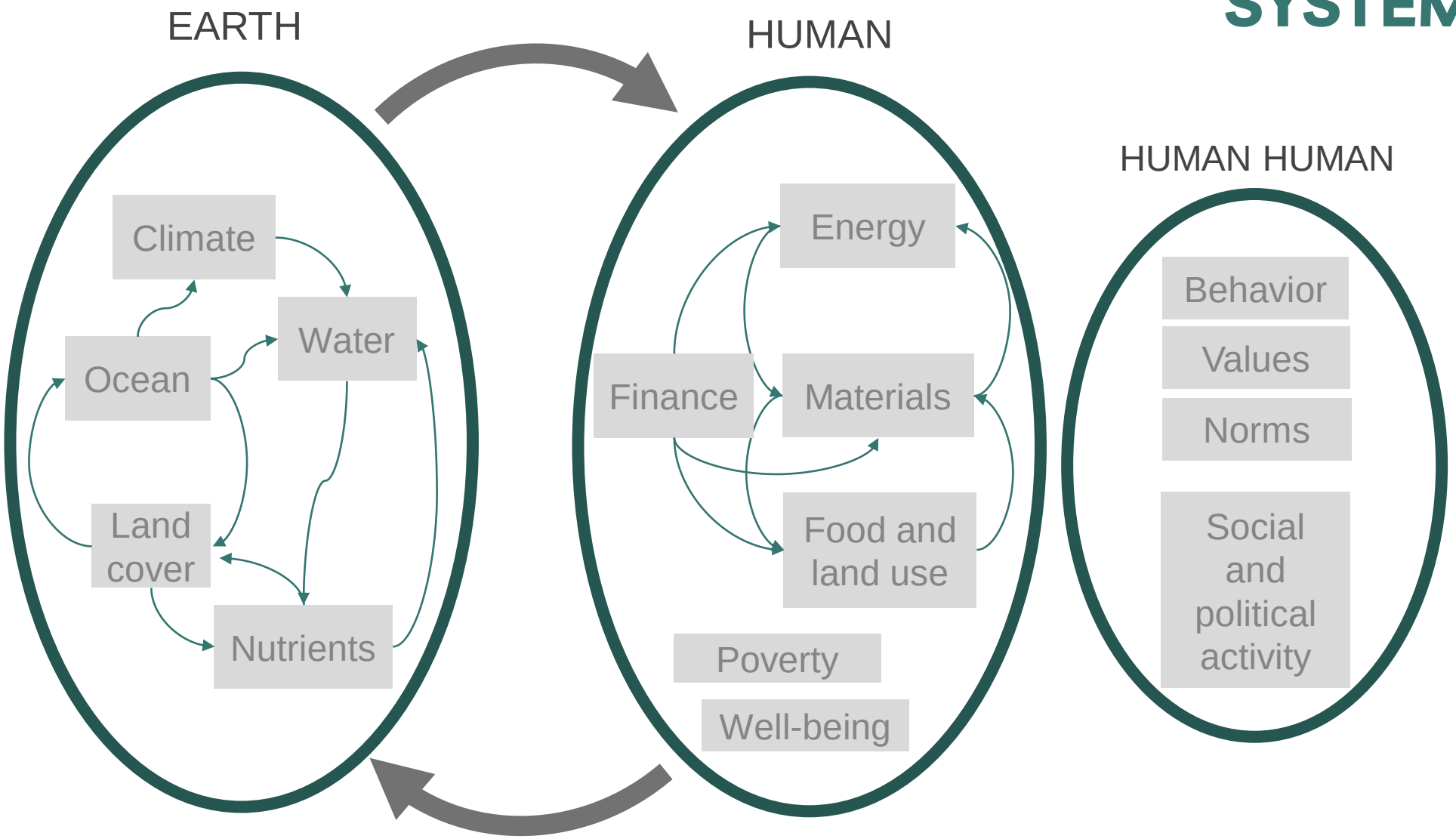
HUMAN-EARTH SYSTEMS

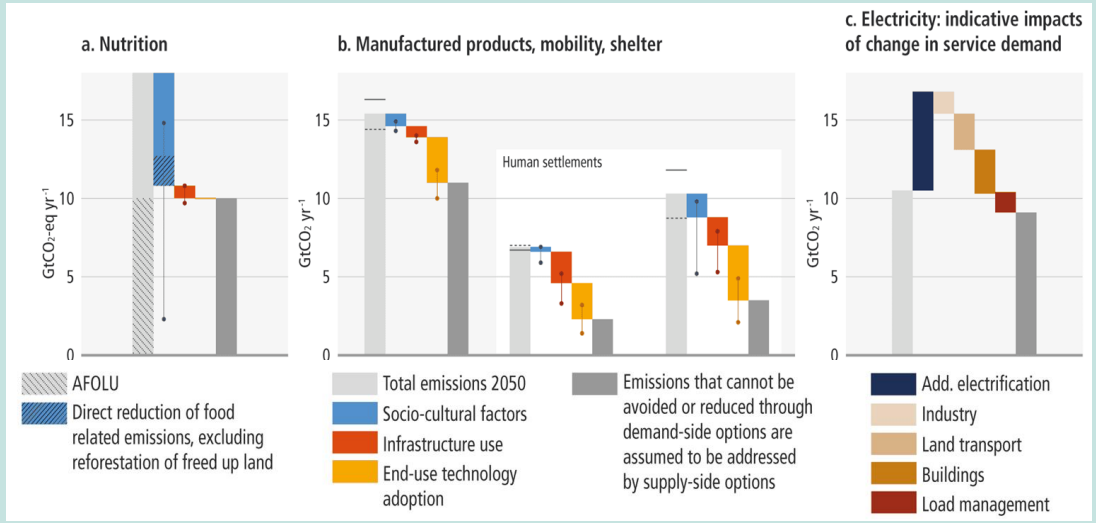


OUTLINE

- Modeling HE interactions for analyzing behavior change
- FeliX model and system dynamics
- Data requirements for modeling HE interactions

BEHAVIOR CHANGE

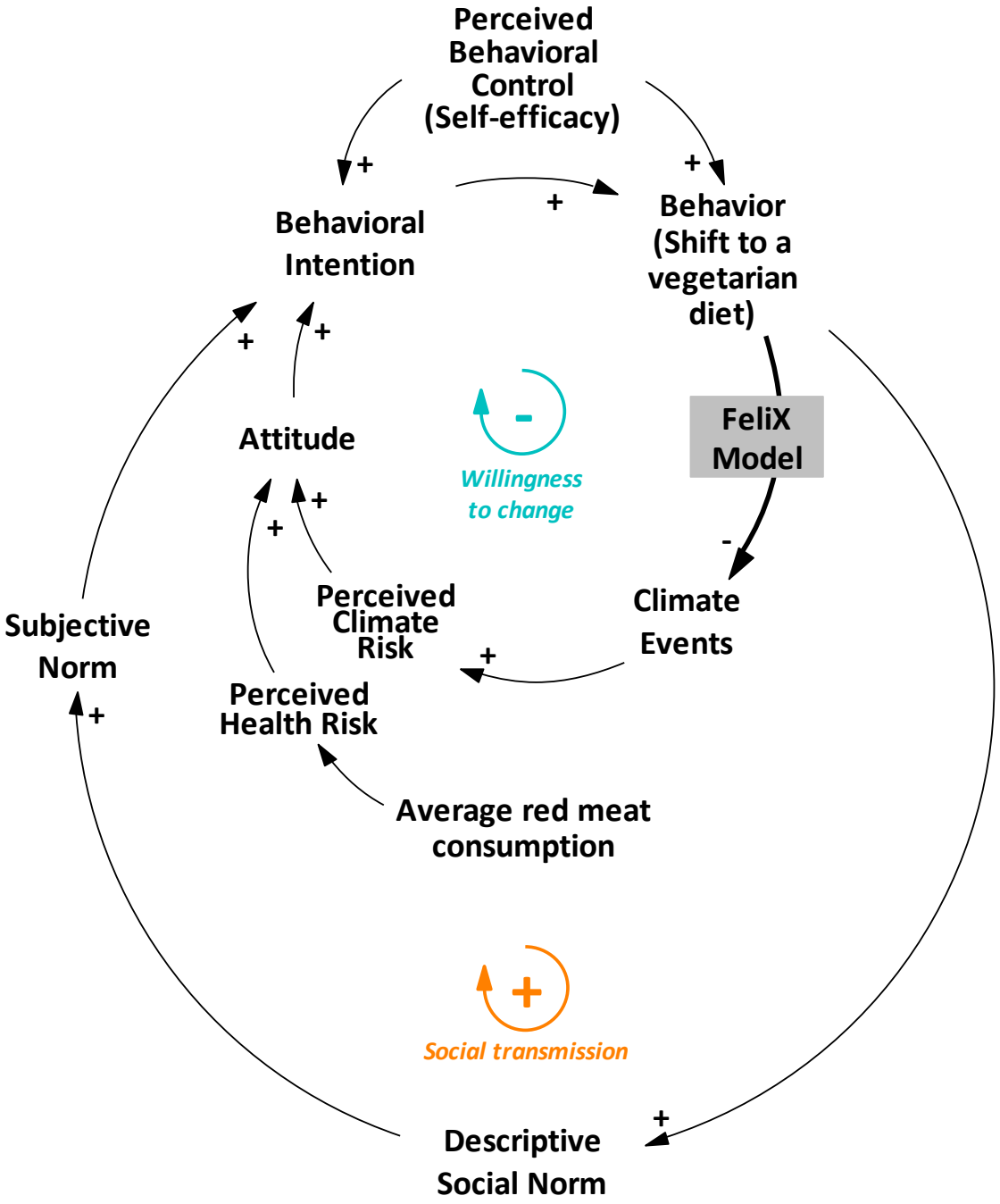
Demand-side mitigation



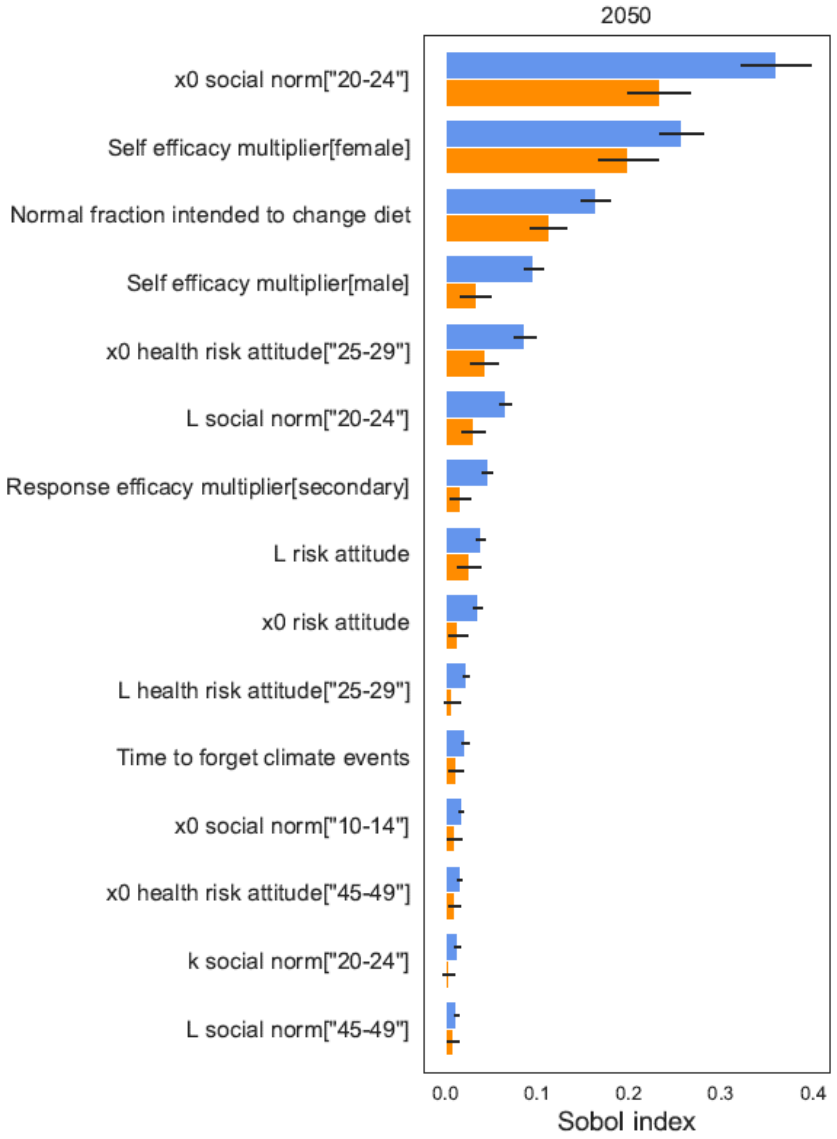
Source : IPCC WG3 (2022)

Source : UNEP(2020) *Emission Gap Report*

Drivers of low-carbon behavior

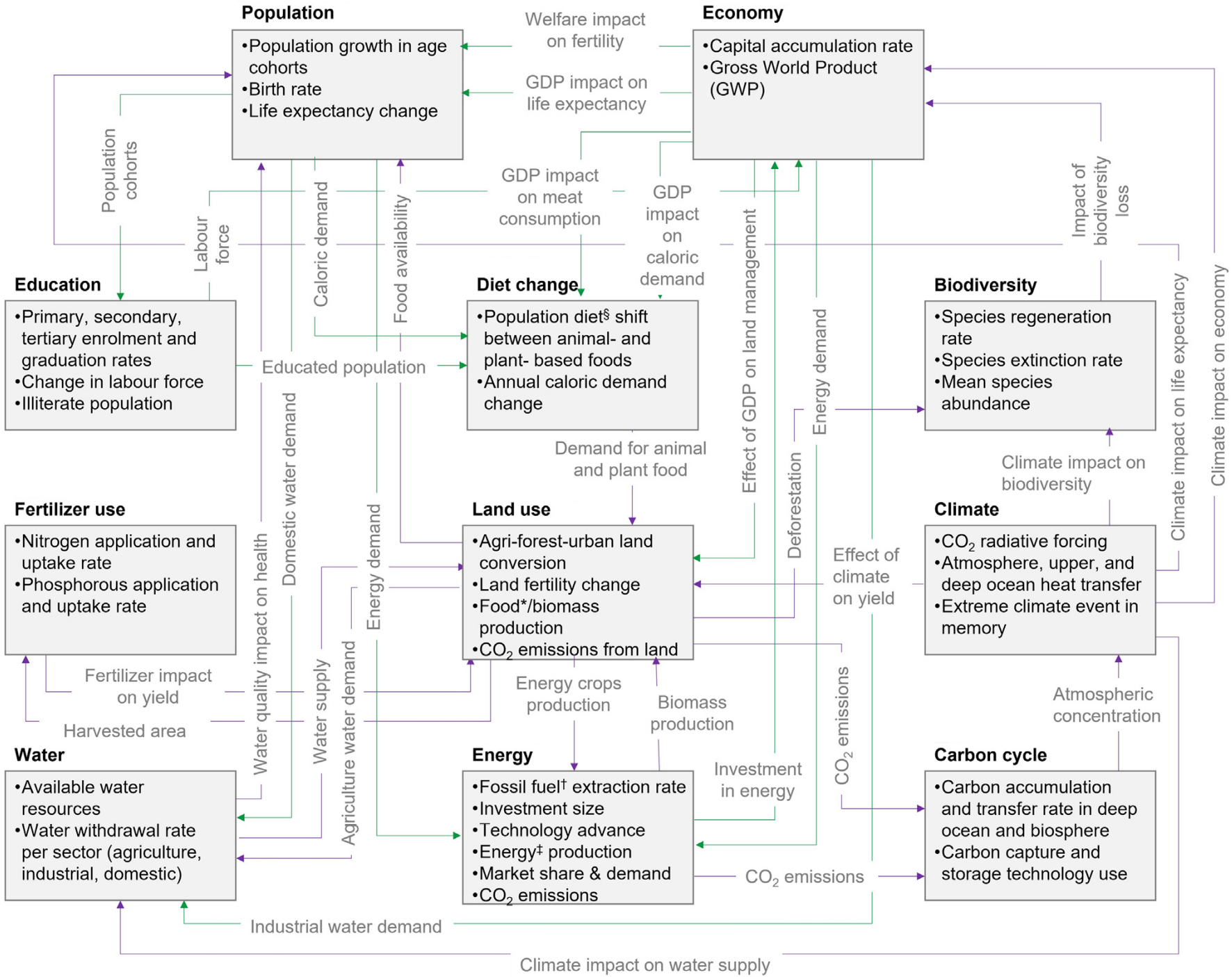


DIETARY SHIFTS

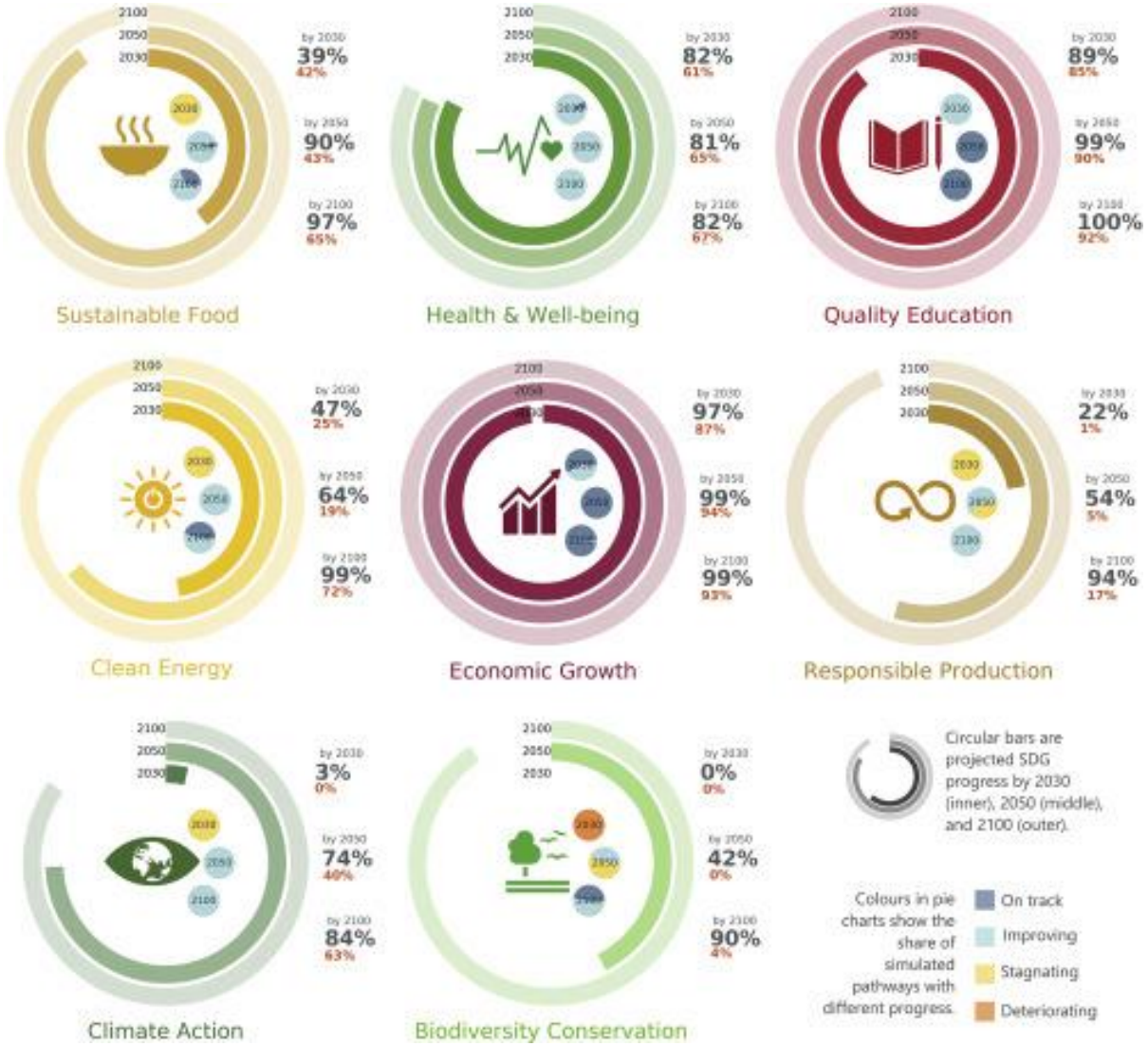


Source: Eker et al. (2019) *Nature Sustainability*

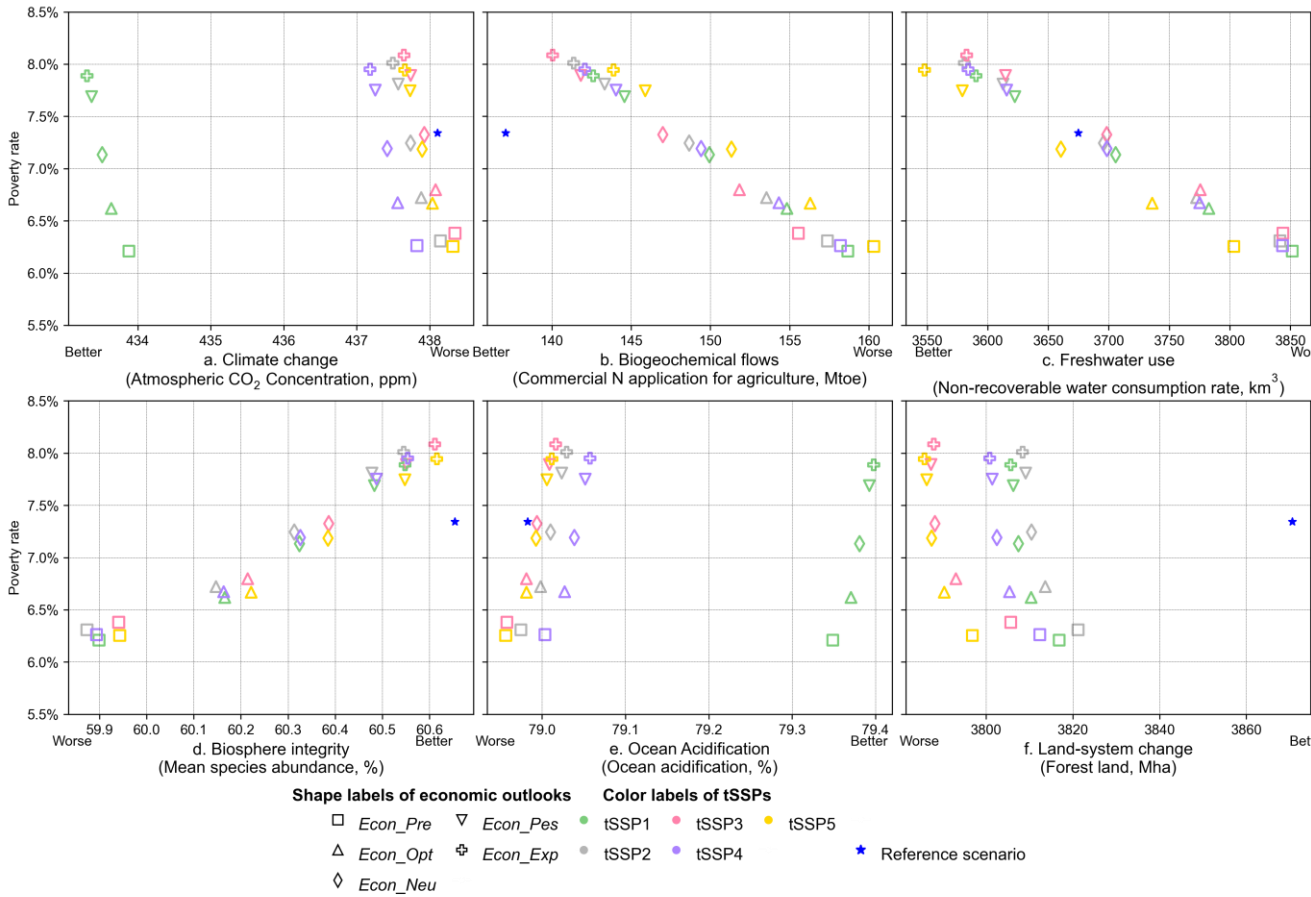
FELIX MODEL


Population
•Population growth in age cohorts
•Birth rate
•Life expectancy change
Welfare impact on fertility
GDP impact on life expectancy
Economy
•Capital accumulation rate
•Gross World Product (GWP)
Population cohorts
Labour force
Caloric demand
Food availability
GDP impact on meat consumption
GDP impact on caloric demand
Impact of biodiversity loss
Climate impact on life expectancy
Climate impact on economy
Education
•Primary, secondary, tertiary enrolment and graduation rates
•Change in labour force
•Illiterate population
Educated population
Diet change
•Population diet§ shift between animal- and plant- based foods
•Annual caloric demand change
Effect of GDP on land management
Energy demand
Biodiversity
•Species regeneration rate
•Species extinction rate
•Mean species abundance
Demand for animal and plant food
Climate impact on biodiversity
Fertilizer use
•Nitrogen application and uptake rate
•Phosphorous application and uptake rate
Land use
•Agri-forest-urban land conversion
•Land fertility change
•Food*/biomass production
•CO_2 emissions from land
Deforestation
Effect of climate on yield
Climate
•CO_2 radiative forcing
•Atmosphere, upper, and deep ocean heat transfer
•Extreme climate event in memory
Water quality impact on health
Domestic water demand
Energy demand
Water supply
Agriculture water demand
Fertilizer impact on yield
Harvested area
Energy crops production
Biomass production
Atmospheric concentration
Water
•Available water resources
•Water withdrawal rate per sector (agriculture, industrial, domestic)
Energy
•Fossil fuel† extraction rate
•Investment size
•Technology advance
•Energy‡ production
•Market share & demand
•CO_2 emissions
Investment in energy
CO_2 emissions
Carbon cycle
•Carbon accumulation and transfer rate in deep ocean and biosphere
•Carbon capture and storage technology use
CO_2 emissions
Industrial water demand
Climate impact on water supply

FELIX MODEL

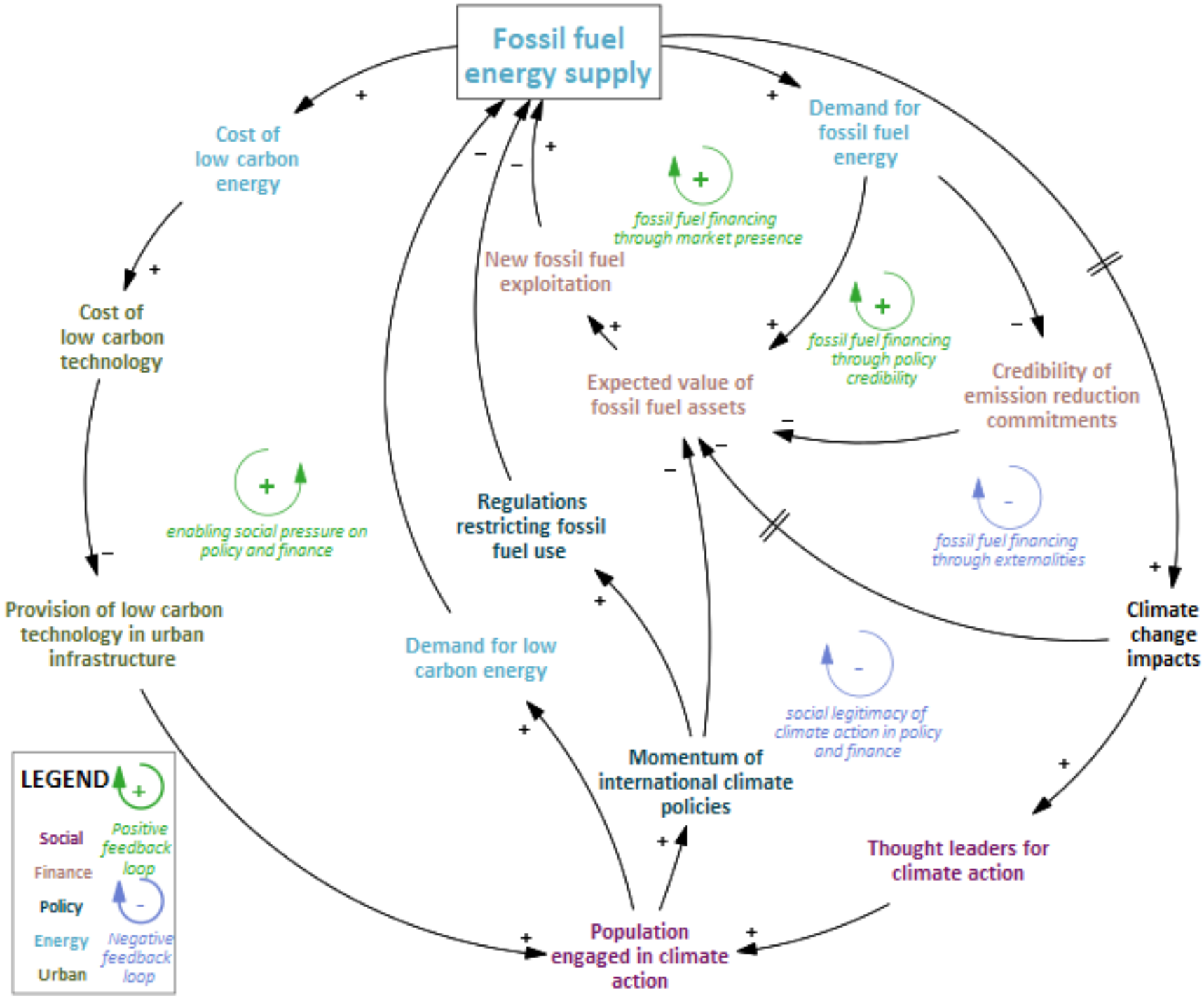


Moallemi et al. (2022) *One Earth*



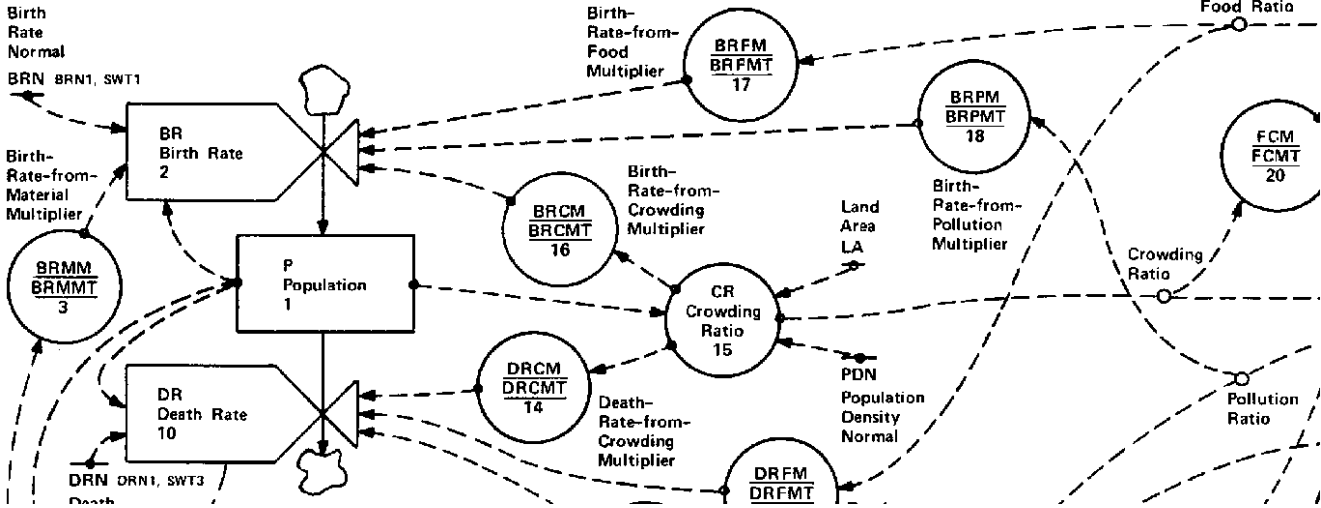
Liu et al. (in press) *One Earth*

Social tipping dynamics



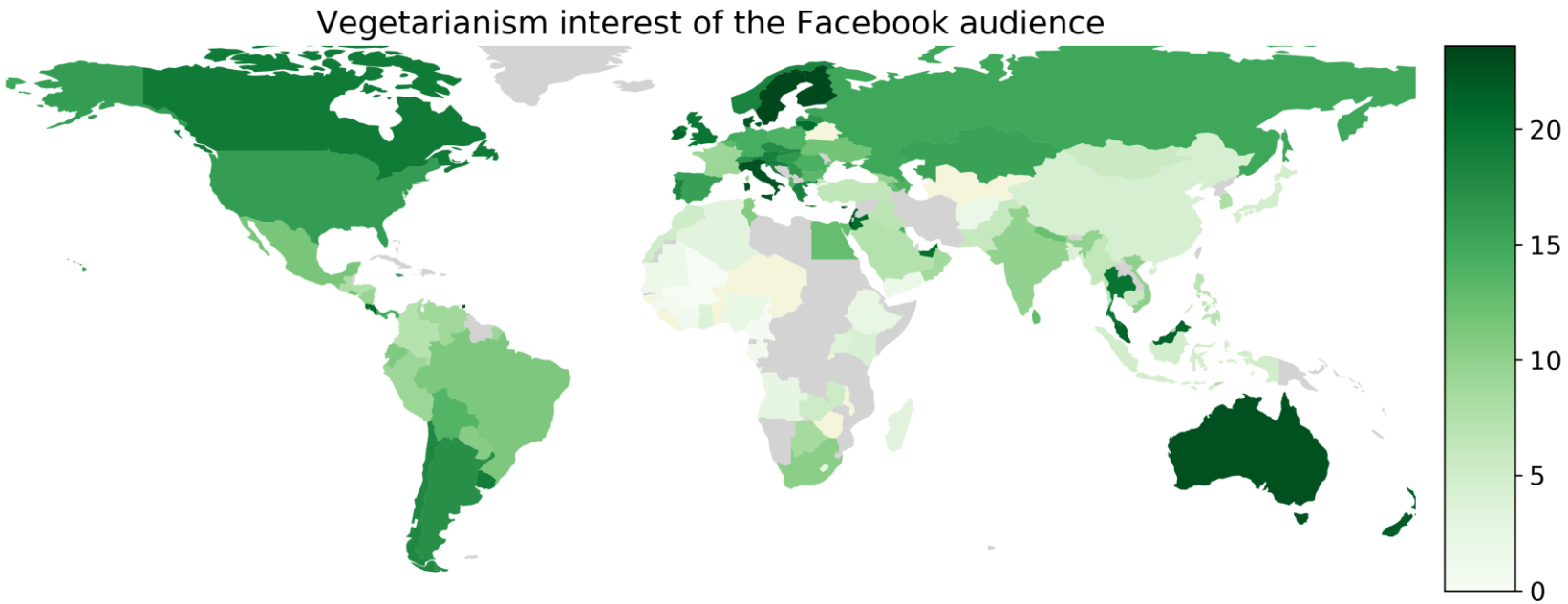
Eker and Wilson (2022)
IIASA Report

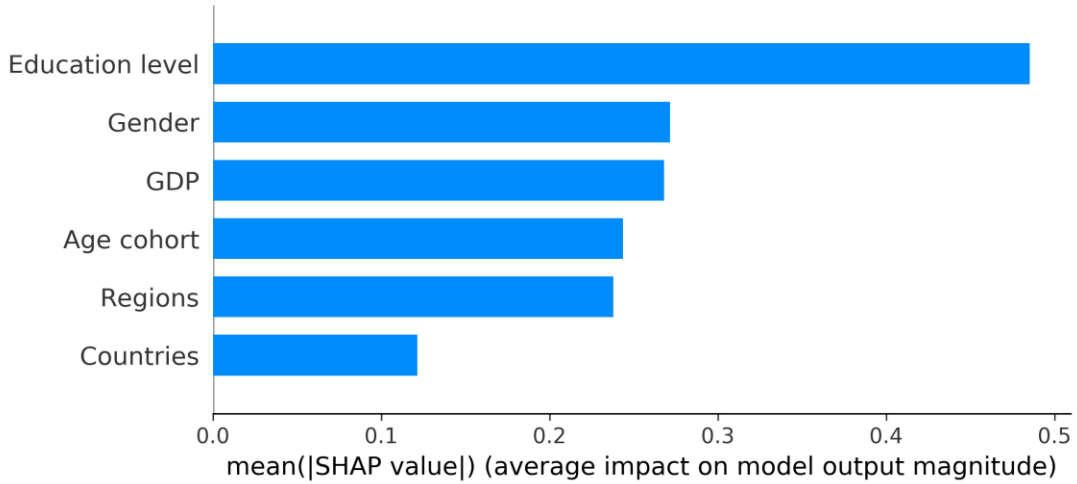
SYSTEM DYNAMICS



- Descriptive
  - not prescriptive cost-minimizing CGE or partial equilibrium models
- Based on the core concepts of systems thinking
  - stocks, flows, delays and feedback loops
- Dynamic, time-continous
  - endogenous dynamic behavior created by feedbacks
- Ordinary differential equations, integration
  - computationally efficient

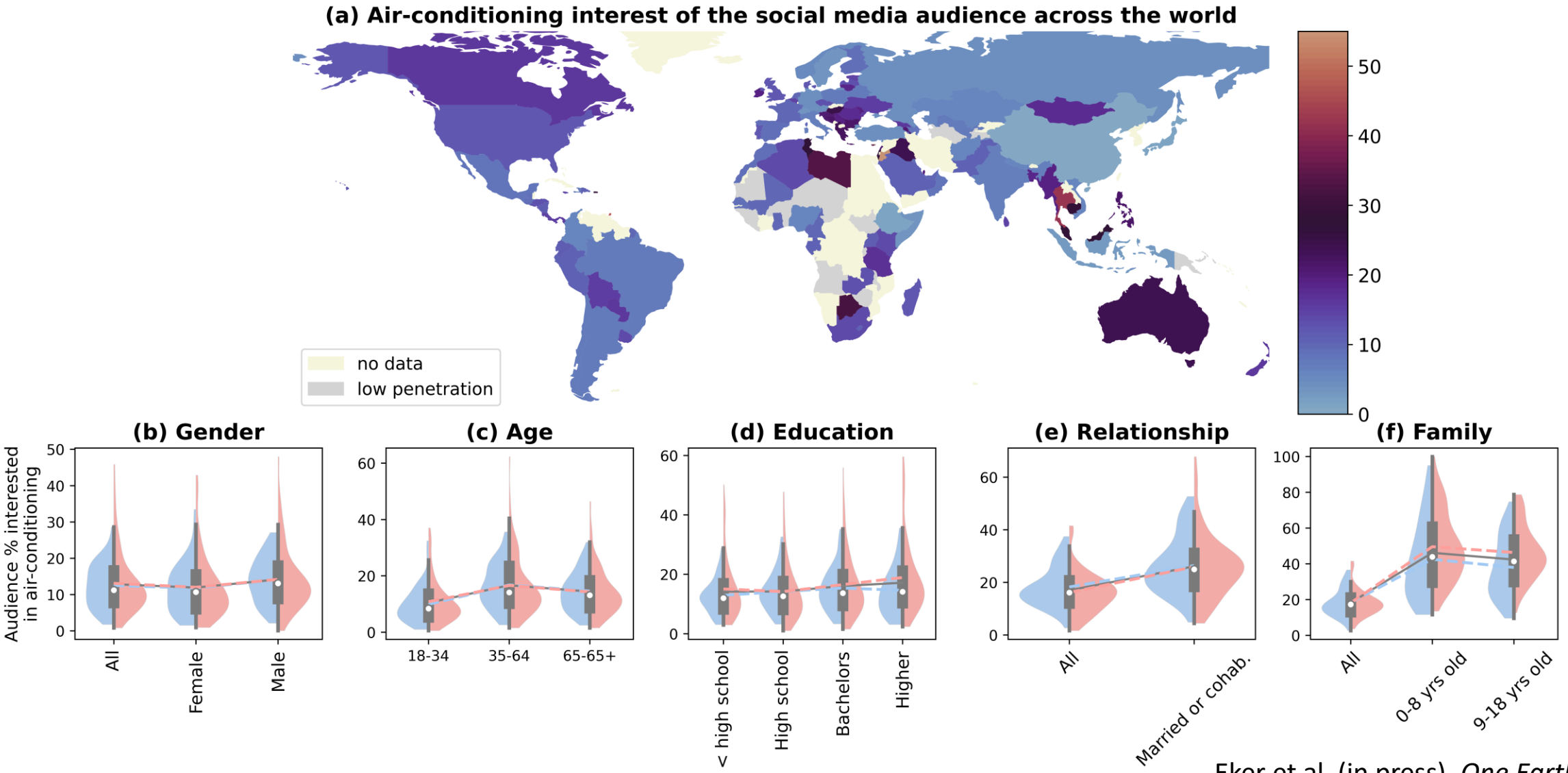
DATA FOR MODELLING HUMAN SYSTEMS





Eker et al. (2021). *Environmental Research Letters*

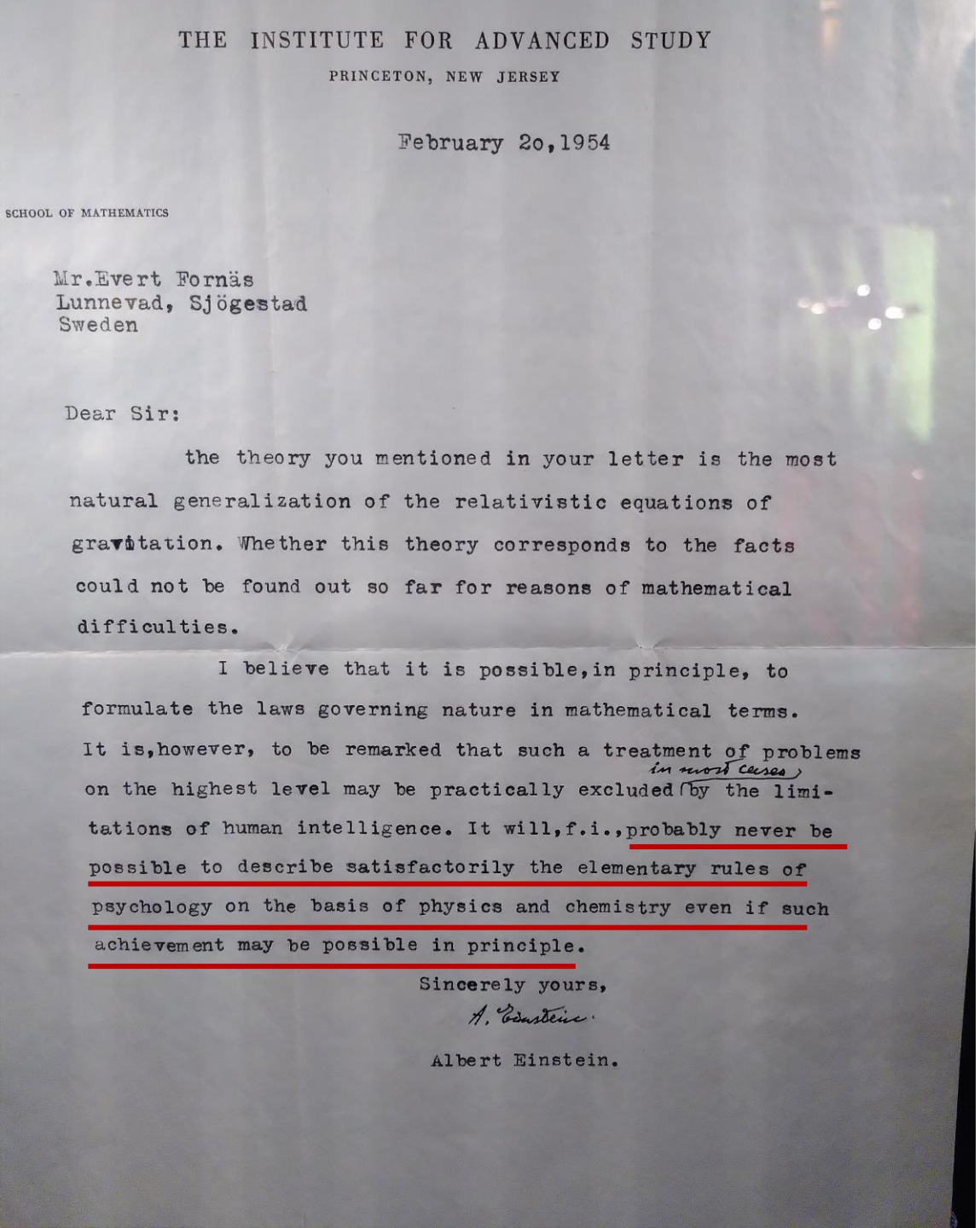
DATA FOR MODELLING HUMAN SYSTEMS



Eker et al. (in press). *One Earth*

DATA FOR MODELLING HUMAN SYSTEMS

	Surveys	Social media data
Scope	• Limited geographically, temporally and contextually	✓ Wide coverage geographically and temporally, possibility to explore interactions
Cost	• Costly	✓ Lower cost
Data collection	• Self-reported behavior	✓ Based on observed online behavior
Representativeness	✓ Direct and purposeful measurement	• Not customizable and based on black-box algorithms



THE INSTITUTE FOR ADVANCED STUDY

PRINCETON, NEW JERSEY

February 2o,1954

SCHOOL OF MATHEMATICS

Mr.Evert Fornäs
Lunnevad, Sjögestad
Sweden

Dear Sir:

the theory you mentioned in your letter is the most natural generalization of the relativistic equations of gravitation. Whether this theory corresponds to the facts could not be found out so far for reasons of mathematical difficulties.

I believe that it is possible,in principle, to formulate the laws governing nature in mathematical terms. It is,however, to be remarked that such a treatment of problems on the highest level may be practically excluded (in most cases) by the limitations of human intelligence. It will,f.i.,probably never be possible to describe satisfactorily the elementary rules of psychology on the basis of physics and chemistry even if such achievement may be possible in principle.

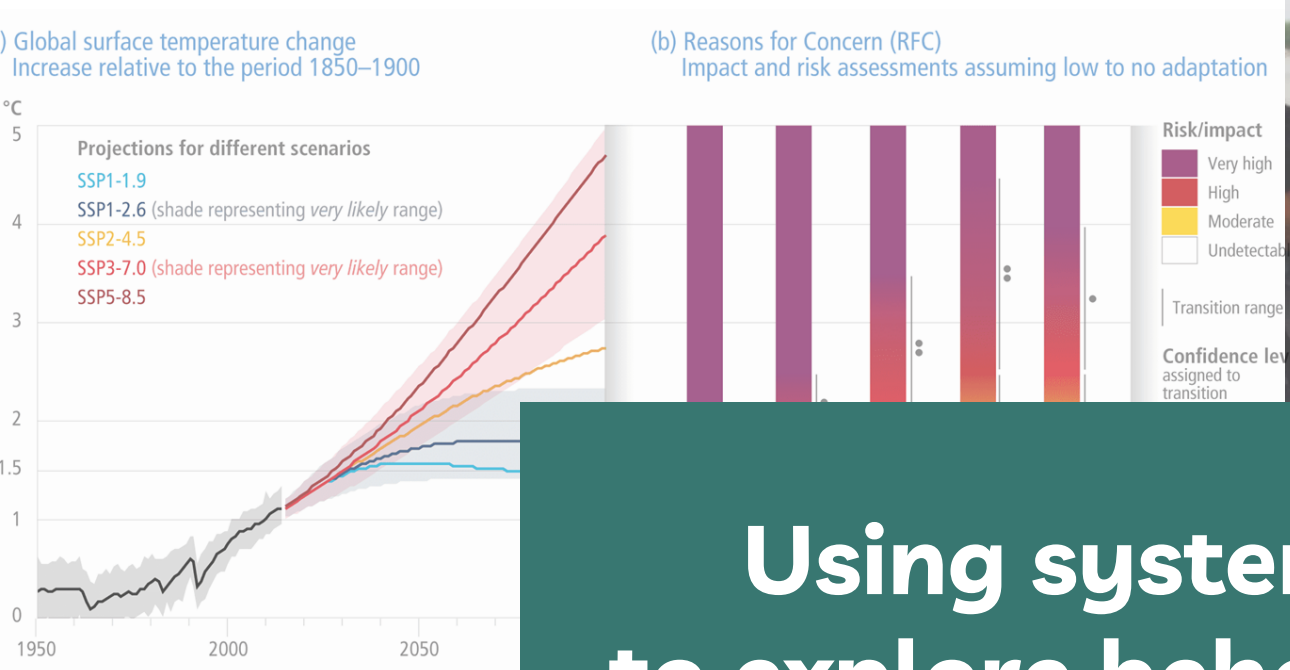
Sincerely yours,

A. Einstein

Albert Einstein.

TO CONCLUDE

- Modelling human behavior is an enormous challenge,
- … but necessary.
- Descriptive, computationally efficient models can help.



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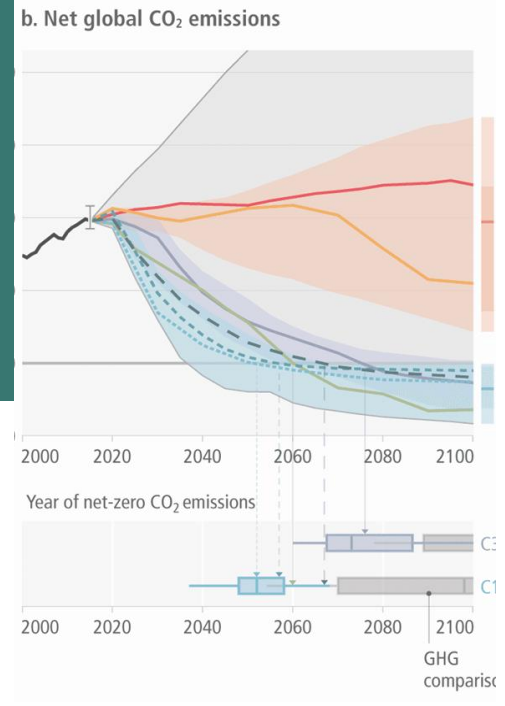

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