Research Institute of Organic Agriculture FiBL
info.suisse@fibl.org, www.fibl.org

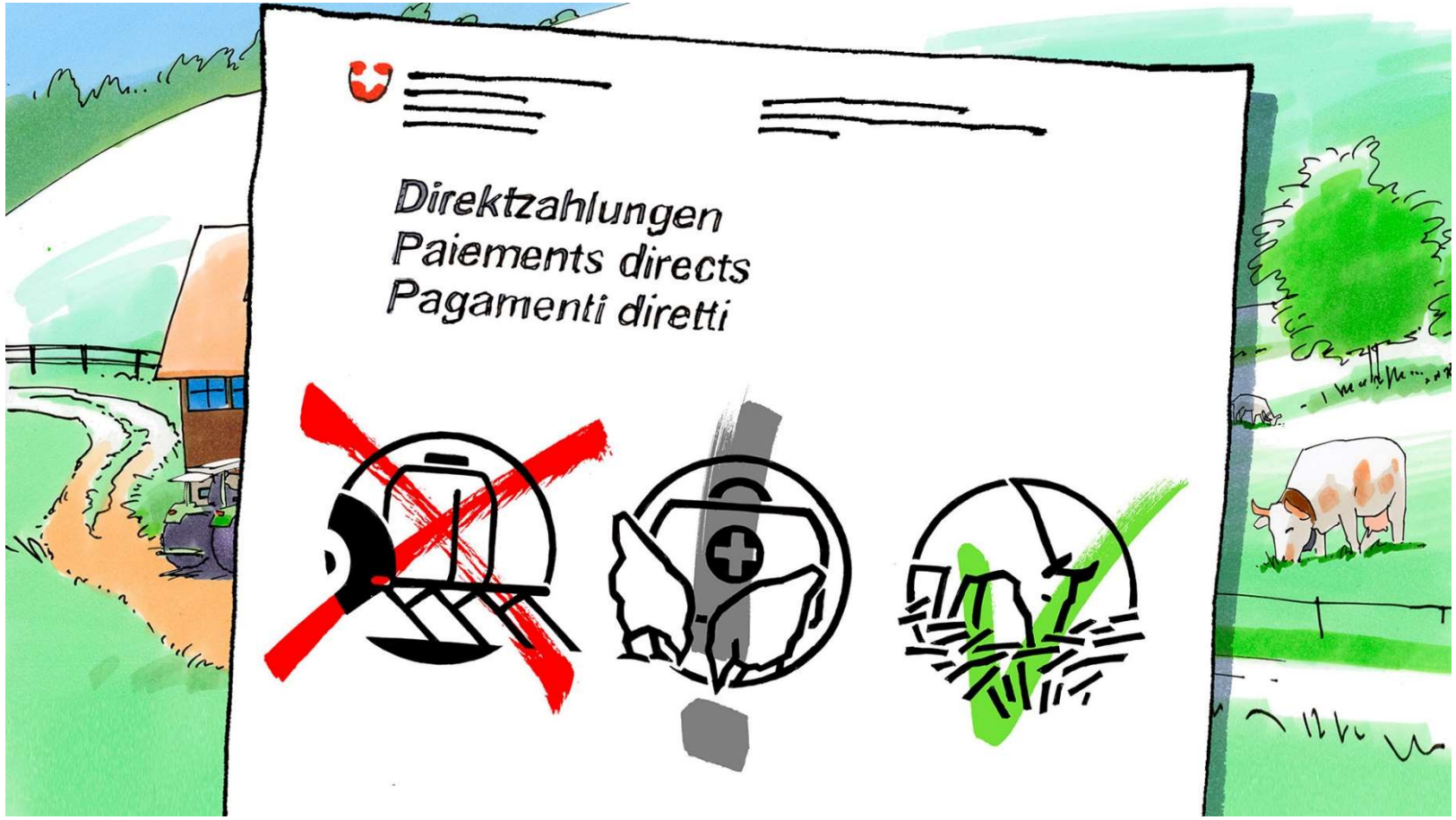
Modelling Organic Agriculture and Agroforestry

Adrian Muller (adrian.mueller@fibl.org)

FABLE Technical Working Group

Online, 25.5.2021

Why is modelling organic agriculture / agroforestry / etc. important?

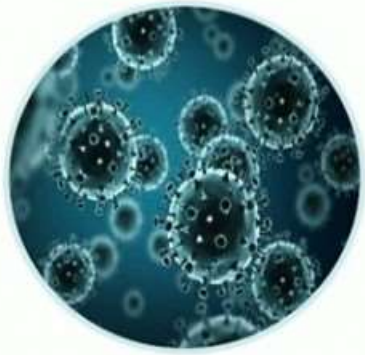


"Direktzahlungen" = "direct payments"

2030 Targets for sustainable food production

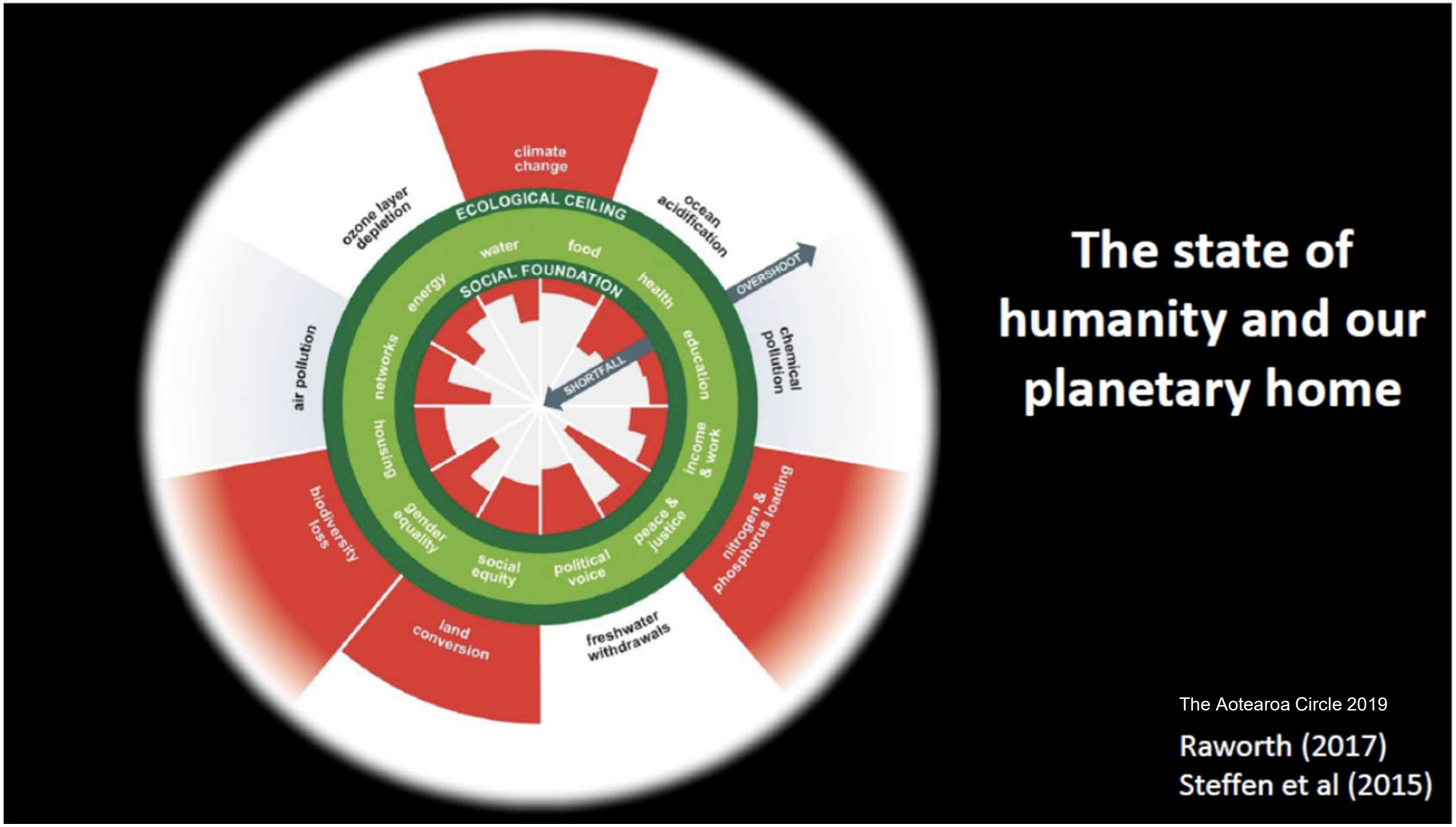
Reduce by 50% the overall use and risk of **chemical pesticides** and reduce use by 50% of more hazardous **pesticides**

Reduce **nutrient losses** by at least 50% while ensuring no deterioration in soil fertility; this will reduce use of **fertilisers** by at least 20 %



Reduce sales of **antimicrobials** for farmed animals by 50%

Achieve at least 25% of the EU's agricultural land under **organic farming** and a significant increase in **organic aquaculture**


climate change
ocean acidification
chemical pollution
nitrogen & phosphorus loading
freshwater withdrawals
land conversion
biodiversity loss
air pollution
ozone layer depletion
ECOLOGICAL CEILING
SOCIAL FOUNDATION
OVERSHOOT
SHORTFALL
water
food
health
education
income & work
peace & justice
political voice
social equity
gender equality
housing
networks
energy
The state of humanity and our planetary home
The Aotearoa Circle 2019
Raworth (2017)
Steffen et al (2015)

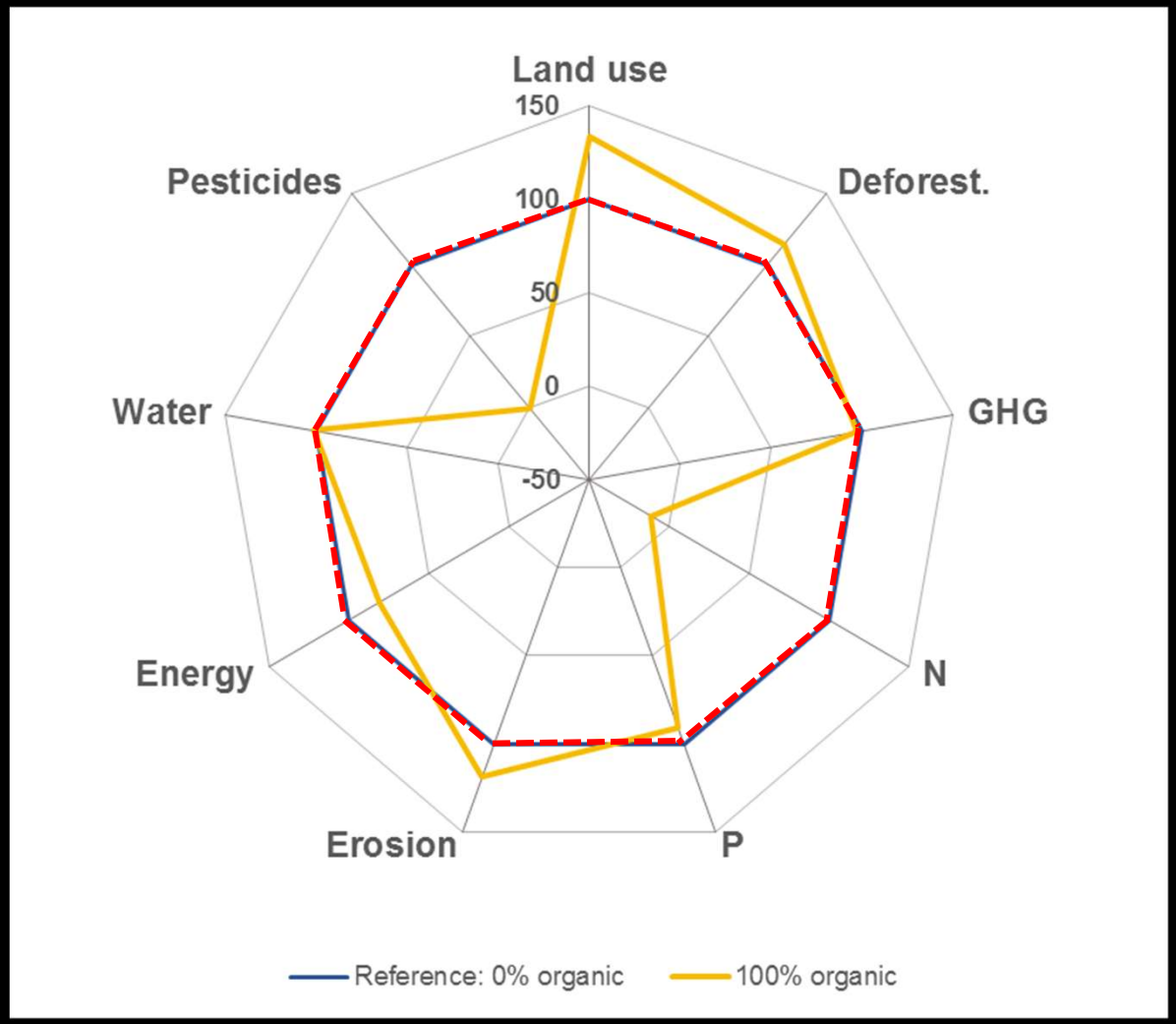
What would happen if we went for large-scale implementation of alternative production and food systems?

Key topics

- **trade-offs** and **synergies**
- (biophysical) **viability** of various options
- (biophysical) **consistency** of various options
- total versus relative assessments – **sufficiency vs. efficiency**

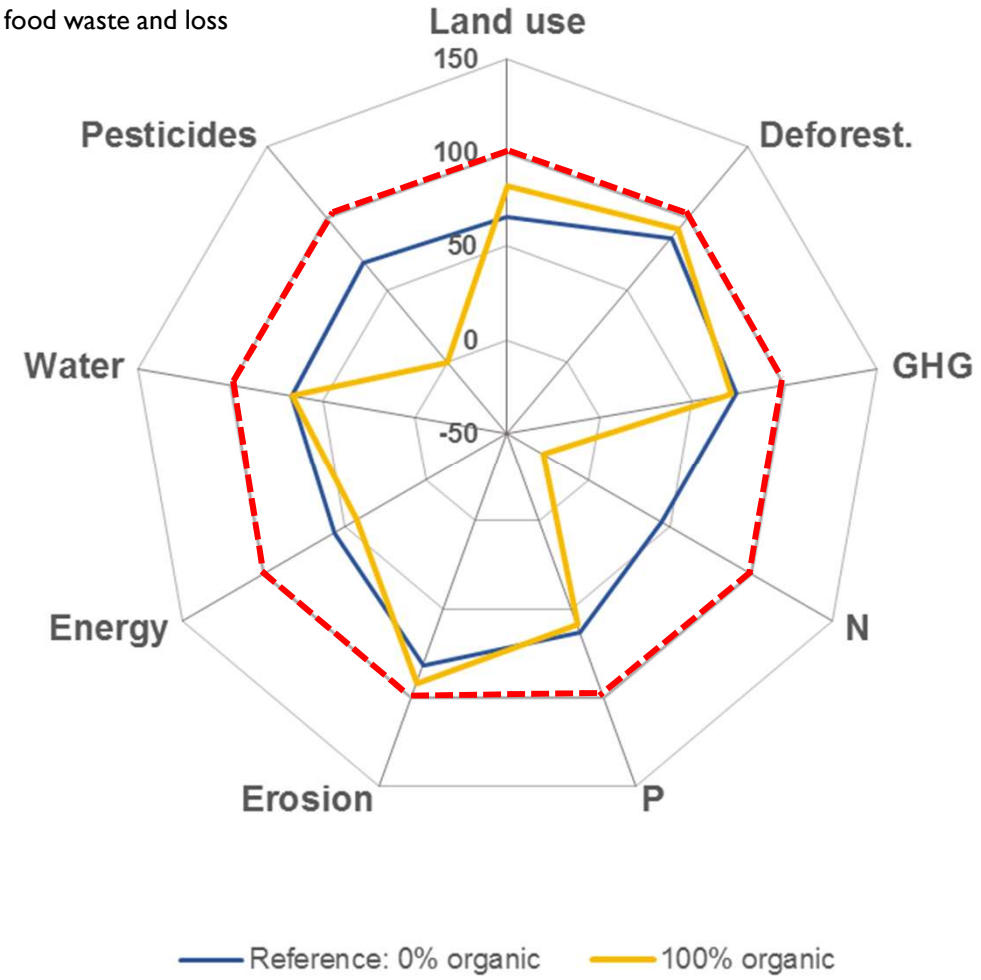
Some thoughts on model types:

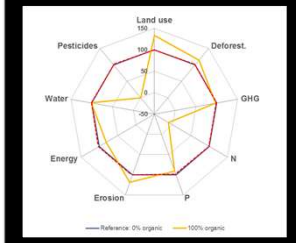
- **biophysical** vs. **economic**
- optimisation vs. **no optimisation**
- internal consistency vs. **consistency with existing databases** (e.g. FAOSTAT)



Muller et al. 2017

100% food competing feed reduction
50% less food waste and loss





Muller et al. 2017

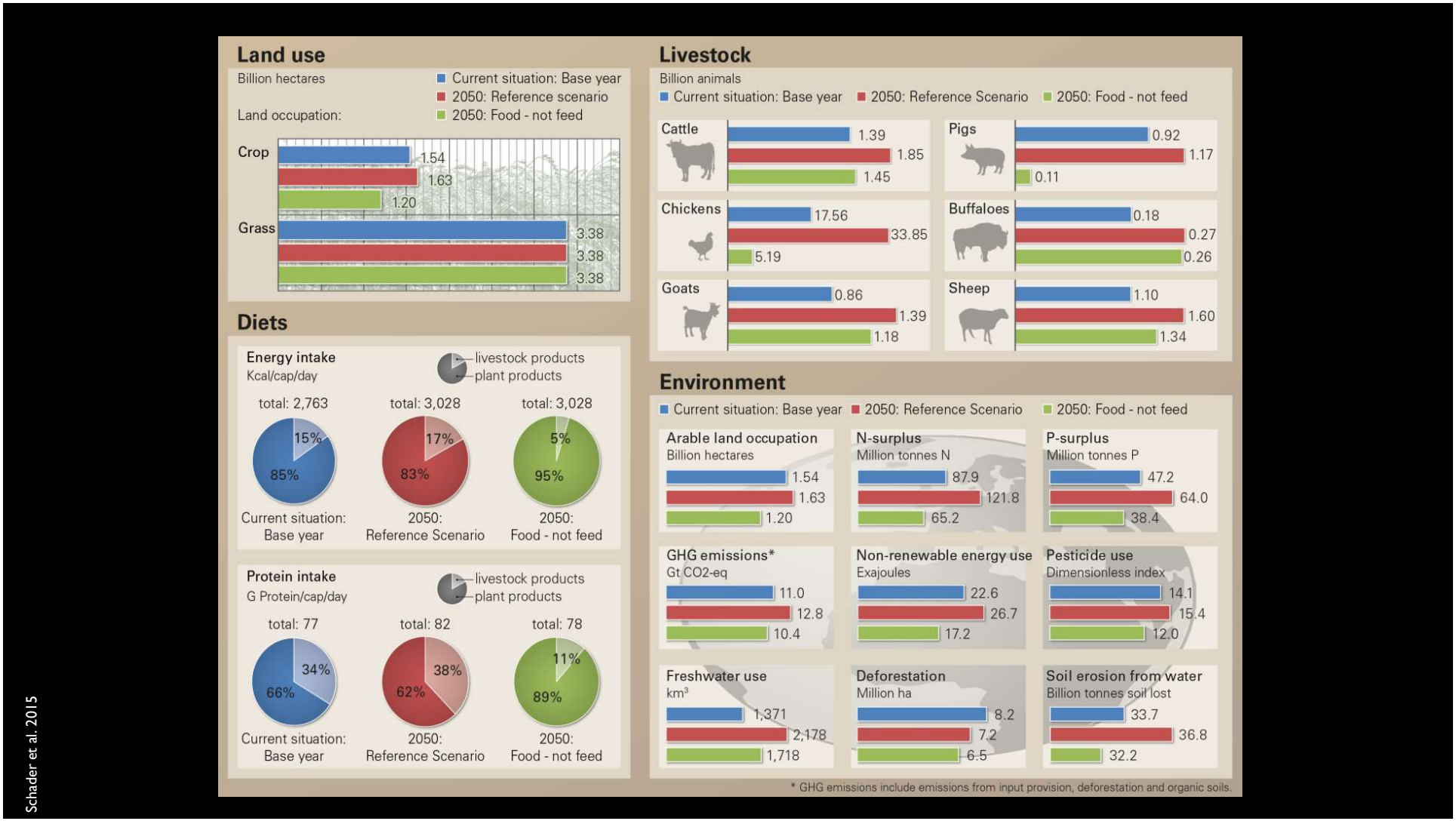
% Wastage reduction	% Reduction in food-competing feed	Climate change impact on yields: Zero — % Organic 0	20	40	60	80	100	Medium — % Organic 0	20	40	60	80	100	High — % Organic 0	20	40	60	80	100
0	0	0	5	10	17	25	33	21	26	33	40	47	57	46	50	54	58	64	71
	50	−16	−12	−8	−4	2	8	2	7	10	16	22	27	25	26	29	32	35	40
	100	−26	−24	−20	−16	−12	−8	−9	−6	−3	1	5	9	12	13	14	15	17	20
25	0	−6	−1	5	10	18	26	14	20	25	32	40	48	39	42	45	50	56	61
	50	−22	−18	−13	−8	−4	−2	−4	0	5	9	14	21	18	20	22	25	27	32
	100	−30	−27	−25	−21	−17	−13	−14	−11	−8	−5	−1	4	6	7	8	8	10	13
50	0	−11	−7	−1	5	11	20	8	13	18	25	32	40	30	34	38	42	47	53
	50	−25	−23	−19	−14	−9	−4	−9	−6	−2	3	8	14	10	12	15	17	21	25
	100	−35	−32	−29	−25	−22	−18	−19	−17				−3	−1	0	1	3	4	7

3

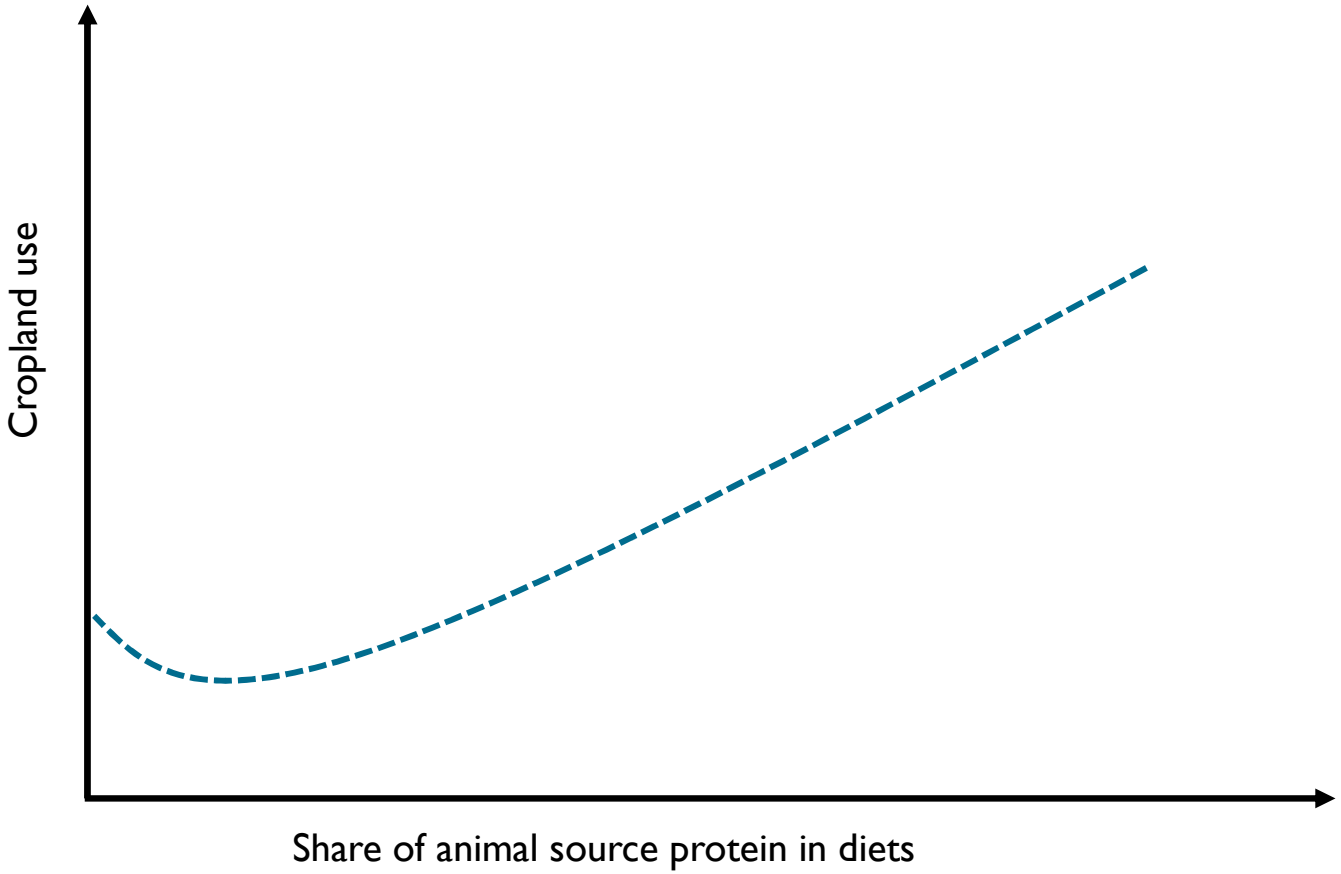
% Wastage reduction	% Reduction in food-competing feed	Climate change impact on yields: Zero — % Organic 0	20	40	60	80	100	Medium — % Organic 0	20	40	60	80	100	High — % Organic 0	20	40	60	80	100
0	0	25	21	15	10	4	−3	23	19	14	8	3	−3	21	16	12	7	1	−4
	50	20	16	12	7	2	−4	18	14	10	6	1	−4	17	13	9	4	0	−5
	100	15	11	7	3	−1	−5	13	10	7	3	−1	−5	12	9	5	2	−2	−6
25	0	23	19	14	8	2	−4	21	17	12	7	1	−4	19	15	10	5	0	−5
	50	18	14	10	6	1	−5	17	13	9	5	0	−5	15	11	7	3	−1	−5
	100	13	10	6	2	−2	−6	12	9	5	2	−2	−6	11	8	4	1	−3	−6
50	0	21	17	12	7	1	−5	19	15	10	5	0	−6	17	13	9	4	−1	−6
	50	16	12	8	4	0	−6	15	11	7	3	−1	−6	14	10	6	2	−2	−6
	100	11	8	5	1	−3	−7	10	7				−7	10	7	3	0	−3	−7

3

Muller et al. 2017; Courtesy: R. Zürcher



Schader et al. 2015


Cropland use
Share of animal source protein in diets

Key aspects of modelling organic agriculture and agroforestry

Organic agriculture:

Assumptions on

- Yield gaps
- Crop rotations
  - in particular on legume shares
- No mineral fertilizer use
  - alternative N sources: legumes on set-aside land, human excreta, etc.
- Reduced pesticide use

- Different assumptions on various (emission) factors
  - organic fertilizers, C-sequestration, …
- Biodiversity effects

Key aspects of modelling organic agriculture and agroforestry

Agroforestry

Assumptions on

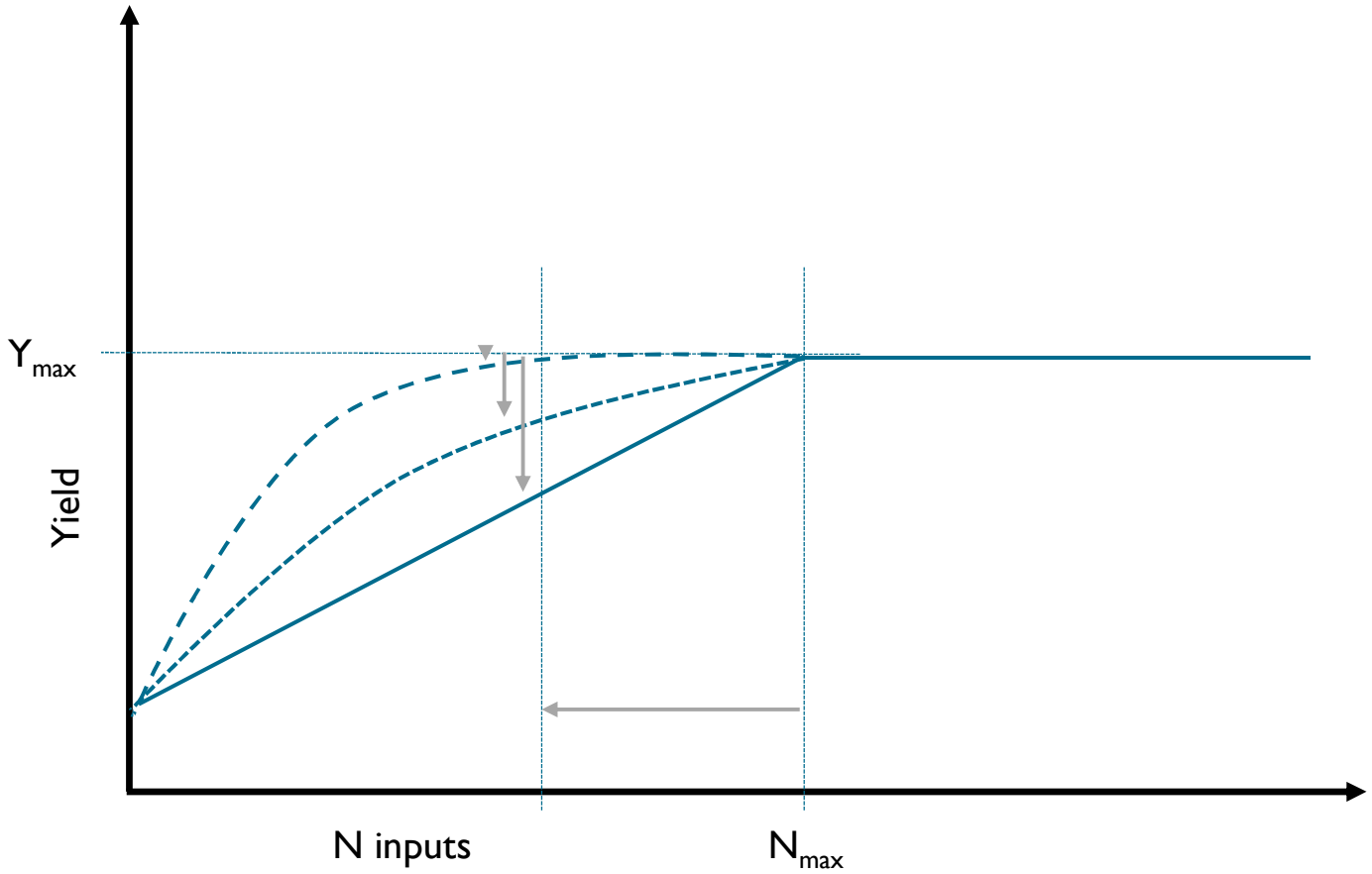
- Crop and tree shares per area
- Yields
- Sequestration in woody biomass

- Different assumptions on various (emission) factors
  - organic fertilizers, C-sequestration, …
- Biodiversity effects

Challenges of modelling organic agriculture and agroforestry

Nitrogen-Yield relation

(cf. Barbieri et al. 2021)



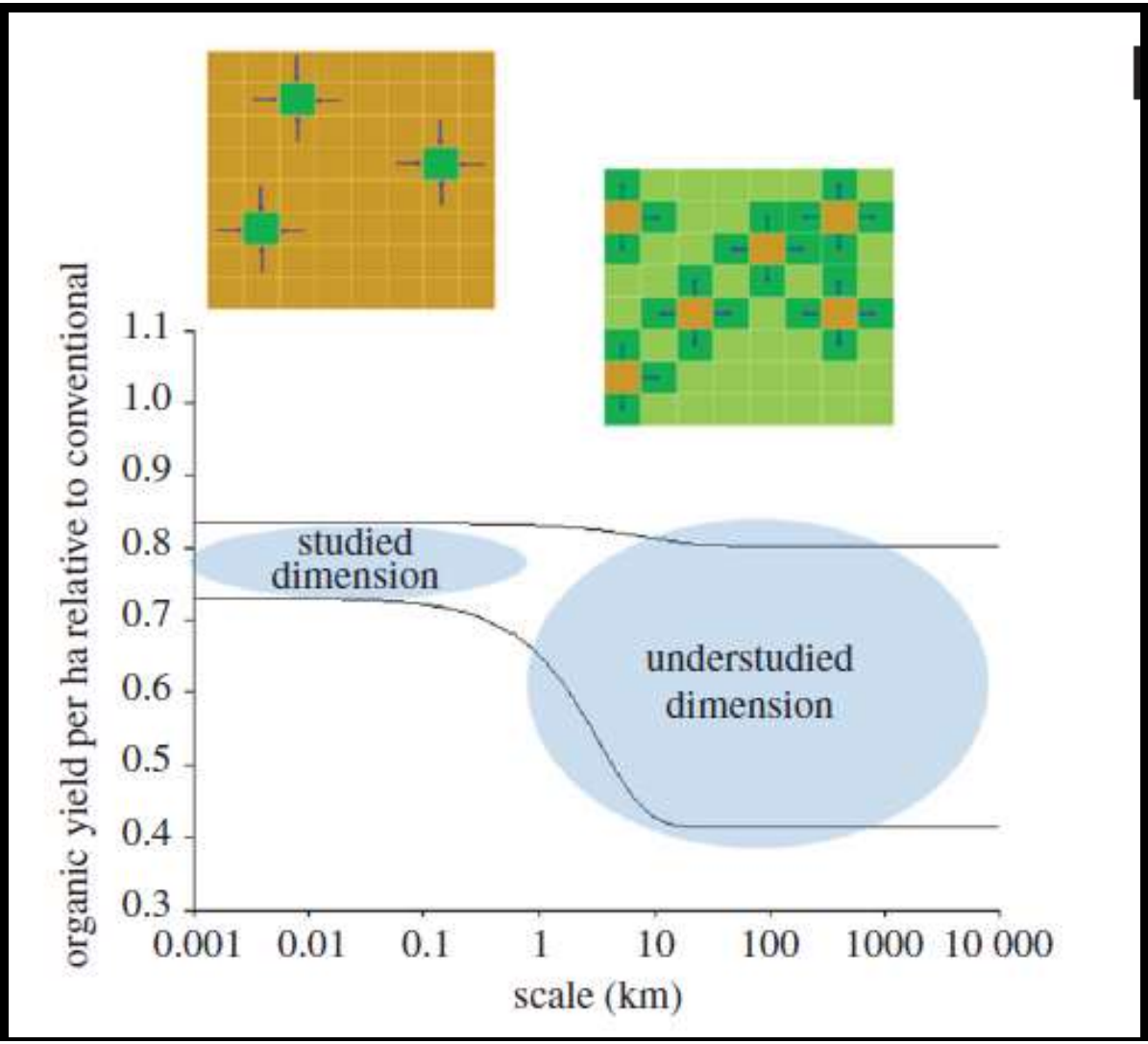
Challenges of modelling organic agriculture and agroforestry

- crop rotations
- component area shares (trees – crops)
- yields in agroforestry

- N cycle
  - characteristics of organic fertilizers vs. mineral fertilizers and their dynamics in the soils, etc.
- P and C cycles

- many data issues, such as related to
  - suitability of soils and regions

- (economic and social aspects)



Leifeld 2016

Ongoing work and future plans with SOLm

SOLm is available on Bitbucket (Code, Documentation) and an ftp-server (Data)

- Better representation of the N-Y-dynamics (MA thesis 1)
- Better representation of crop rotations (MA thesis 2)
- Better representation of P and soil C (PhD thesis 1)

- Agroforestry scenarios for the EU (EU project 1)
- (Bio-)vegan scenarios (MA thesis 2)
- Bioenergy in sustainable food systems (PhD thesis 2)

- Country scenarios built on National GHG Inventory reports (no plan yet)
- Comparison of LCA footprints with food-system-derived footprints (no plan yet)

- Landscape-level biophysical food-systems model for localised policy advice (PhD thesis 3; EU project 2)
- Output: Shiny-App interface, etc. (maybe MA thesis 2)