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Agroecology and sustainable Food Systems

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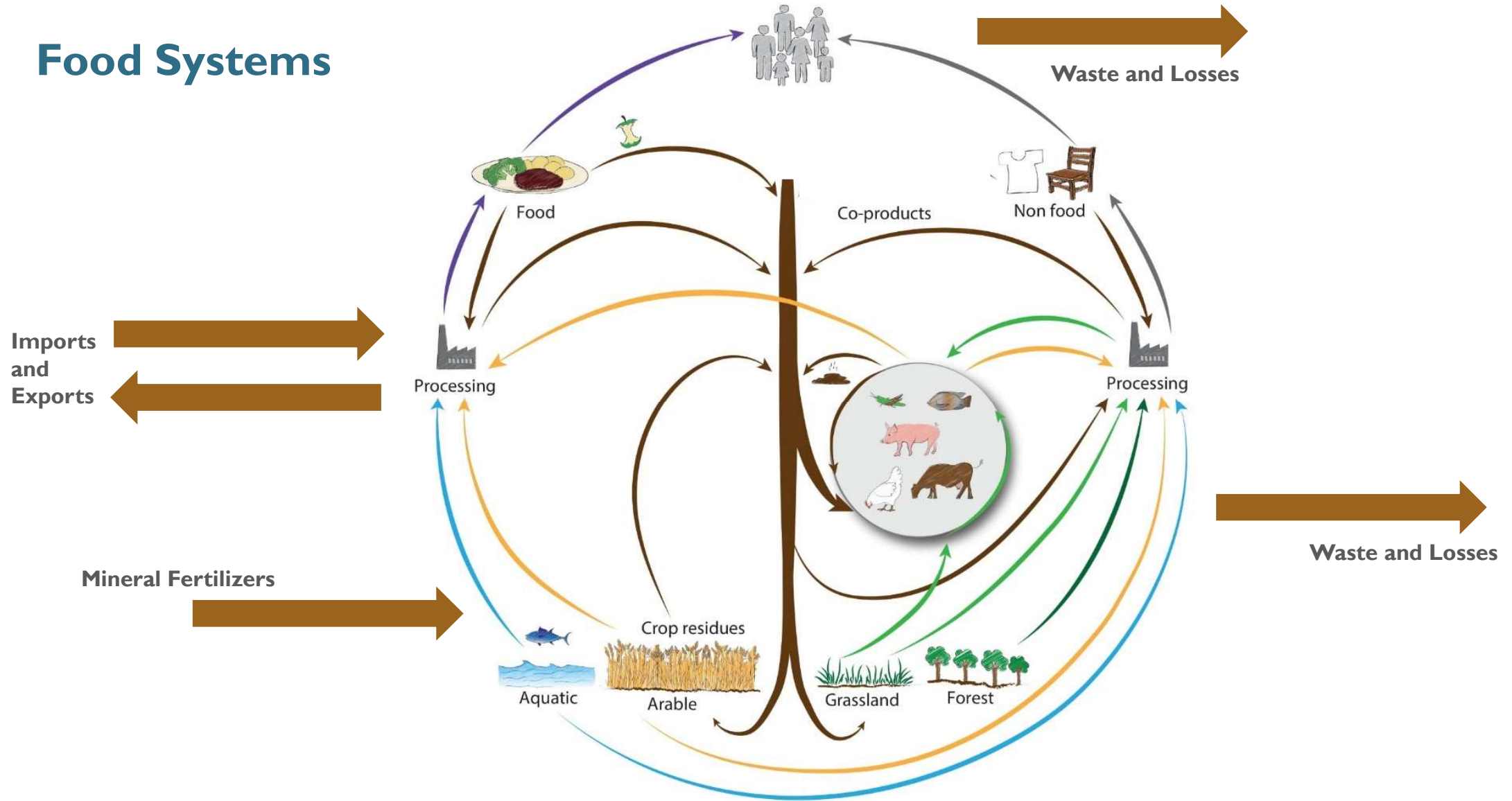
Guest lecture in the master course on “Nature-Based Solutions for Climate Change Adaptation and Mitigation”

Wyss Academy for Nature, University of Berne, February 6, 2023

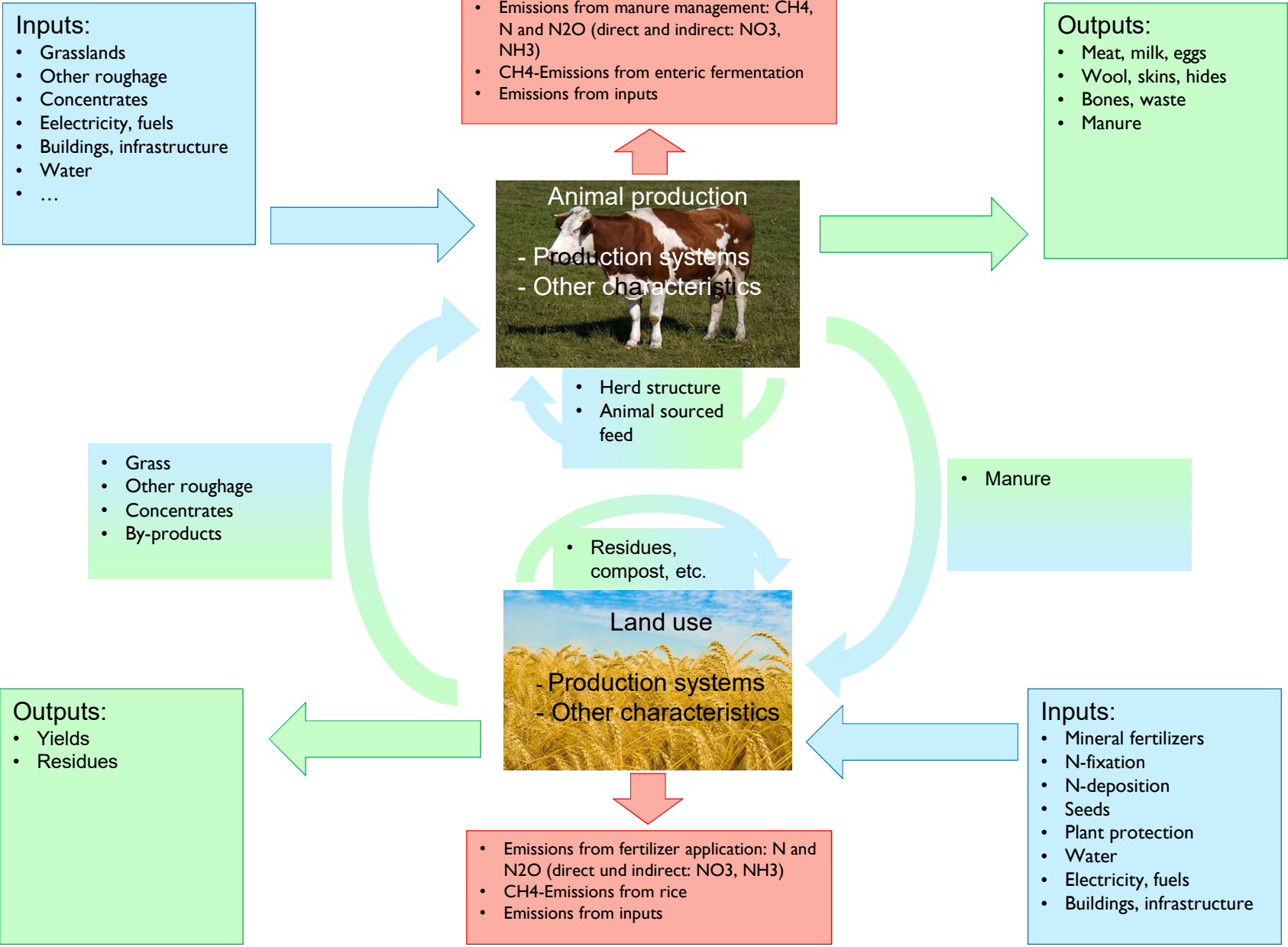
Learning Goals

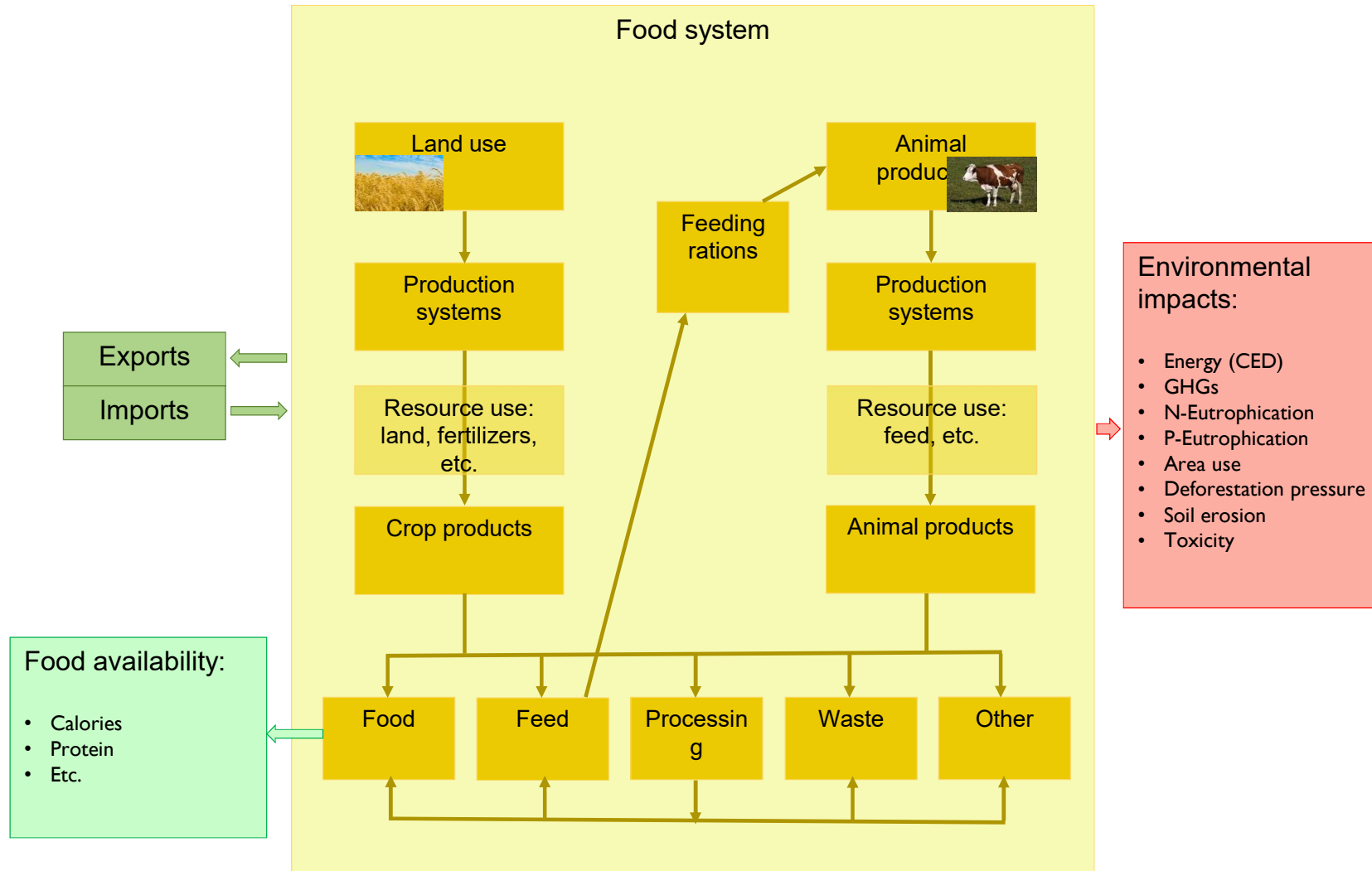
- You can explain what a circular food system is.
- You can explain and critically assess the key aspects of agroecology.
- You can explain how reducing the size of the food system allows for sustainable production.
- You can explain why sustainable agriculture cannot be addressed independently of consumption patterns, or, stated differently, why we need a food-systems approach when talking about sustainable agriculture.

Food Systems

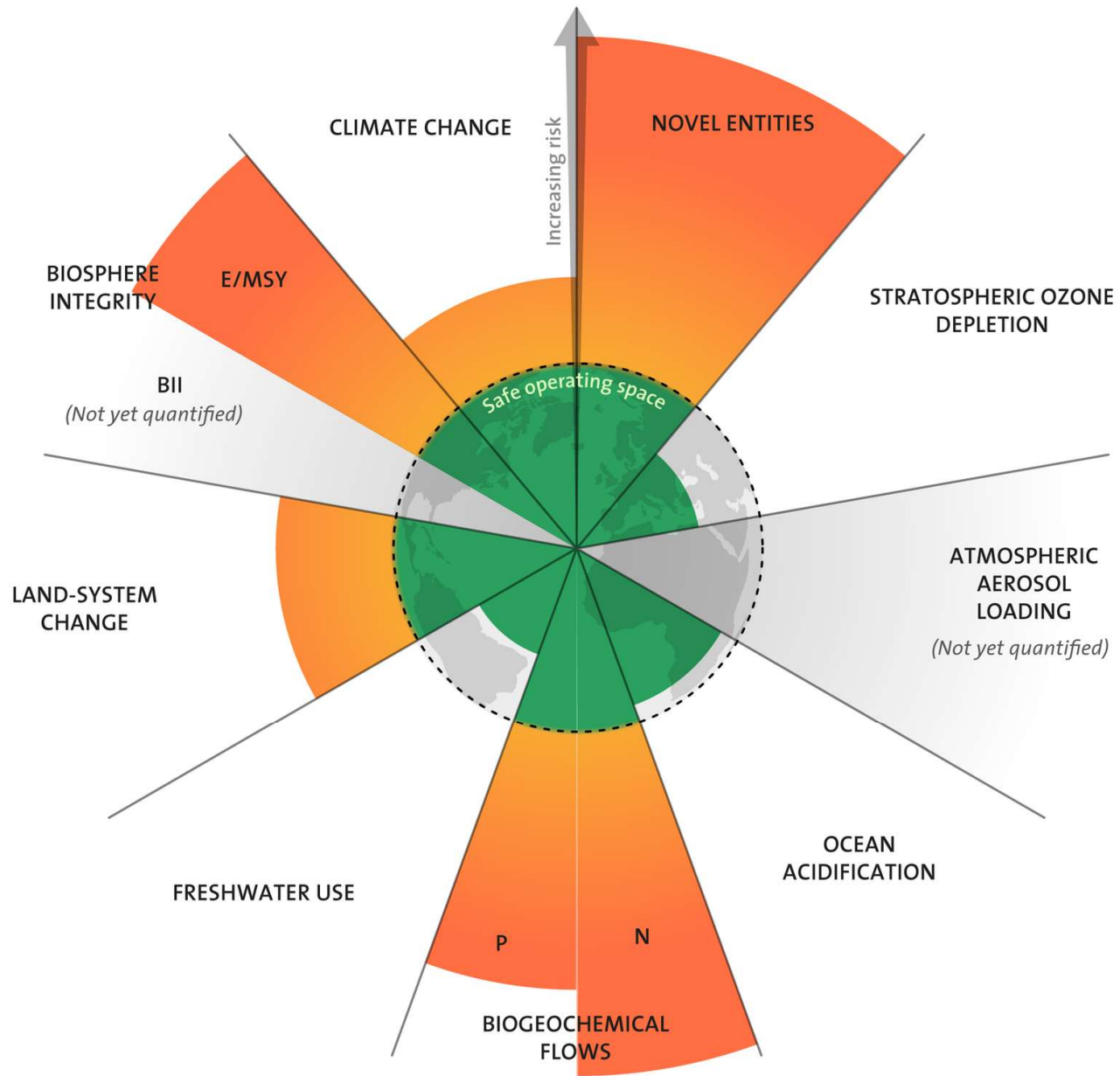


adapted from Muscat et al. 2021

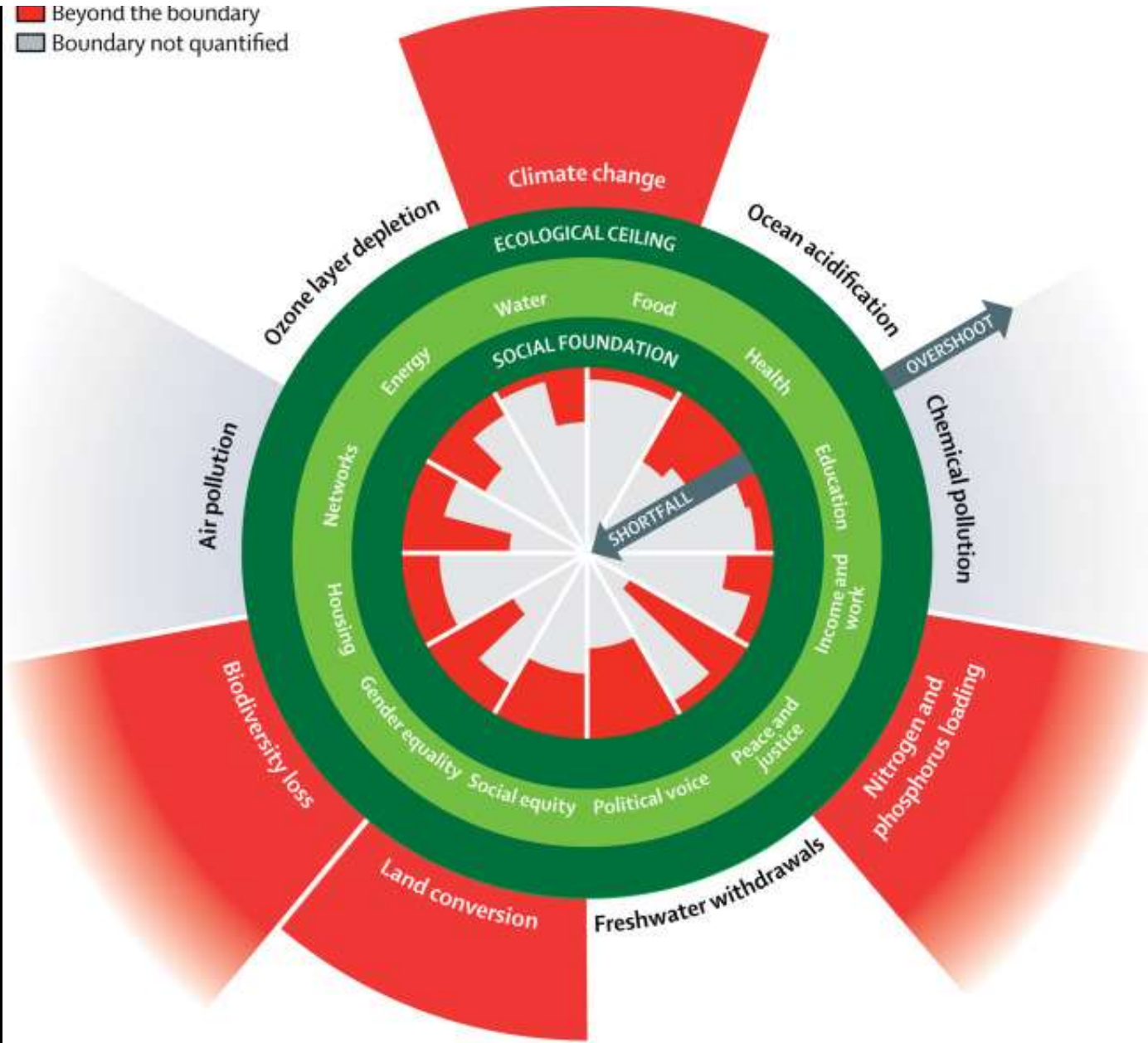




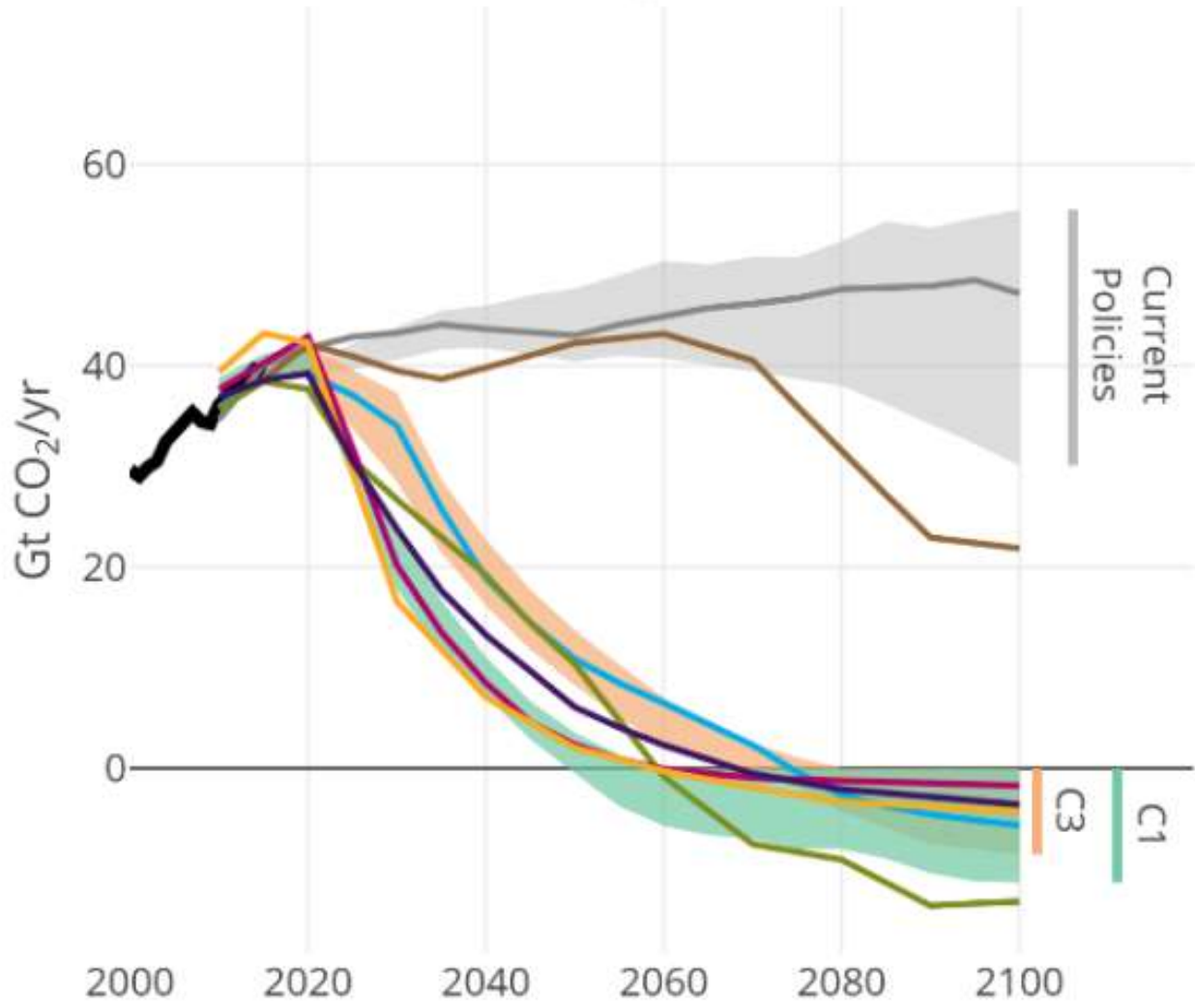




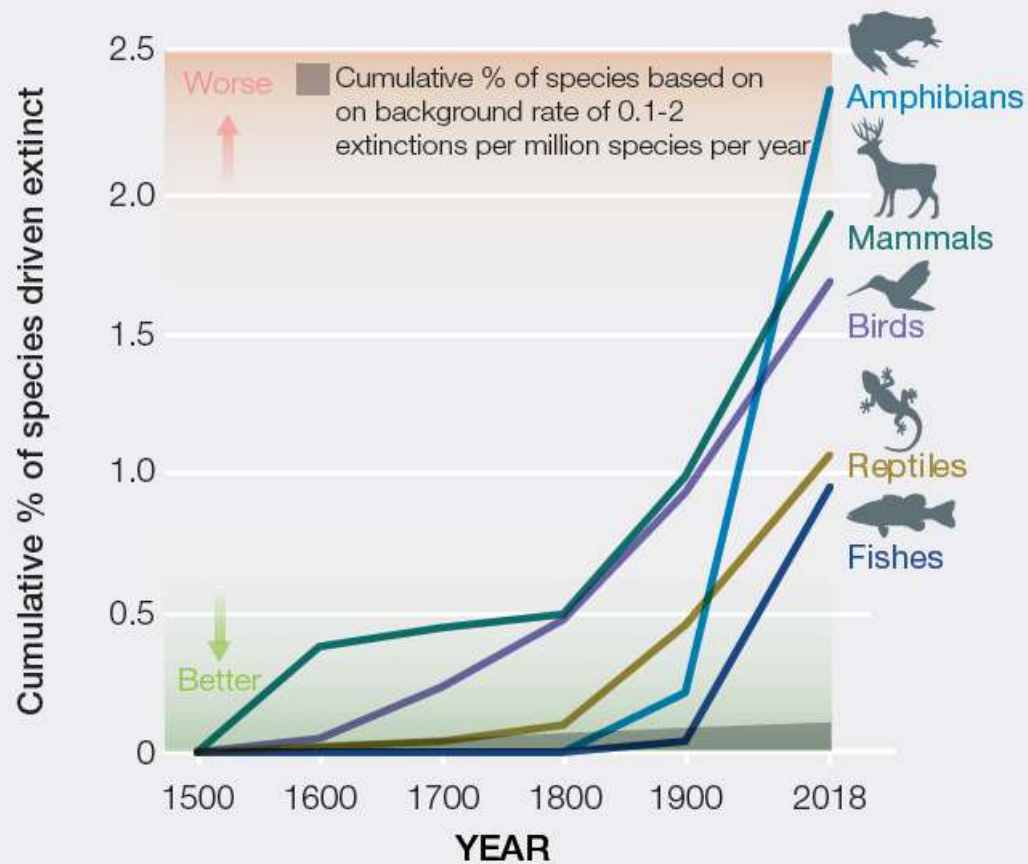
■ Beyond the boundary
■ Boundary not quantified



a. Net CO₂ emissions



B Extinctions since 1500



C Declines in species survival since 1980 (Red List Index)

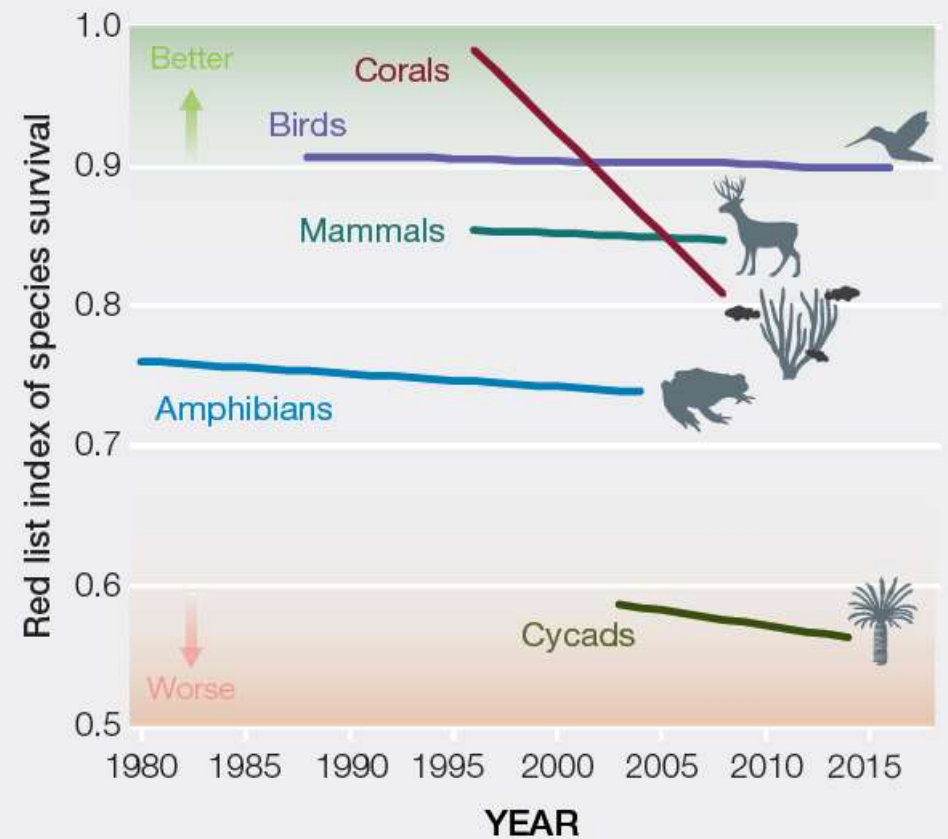
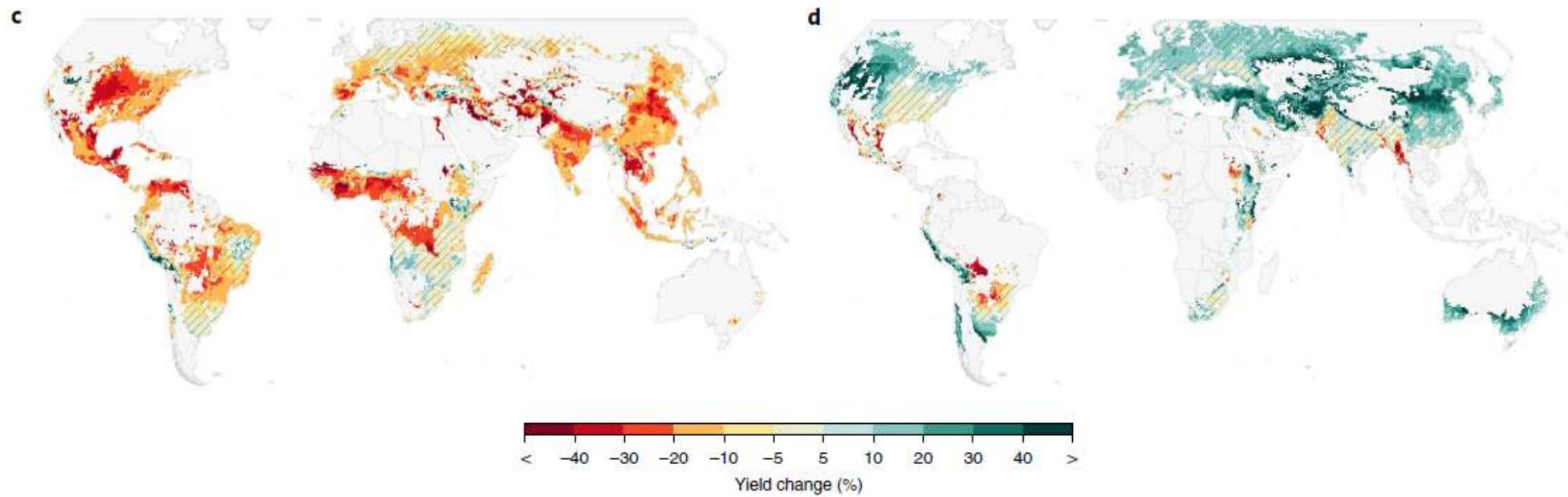
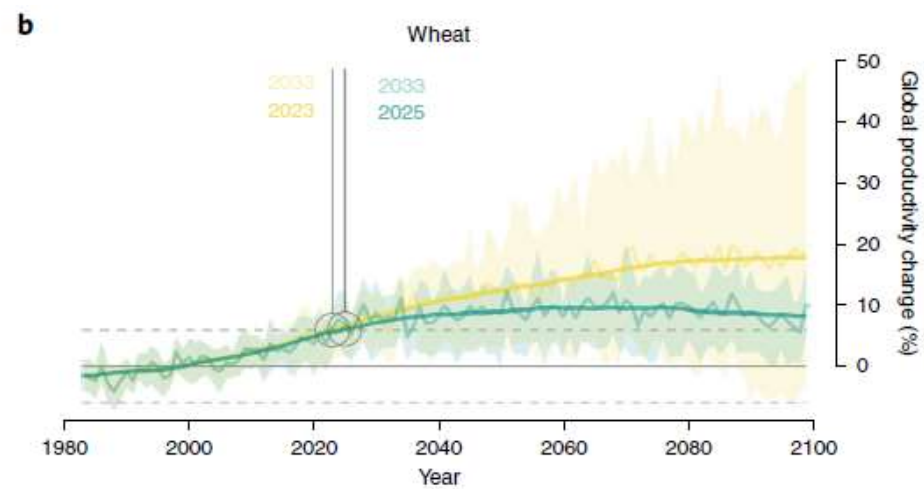
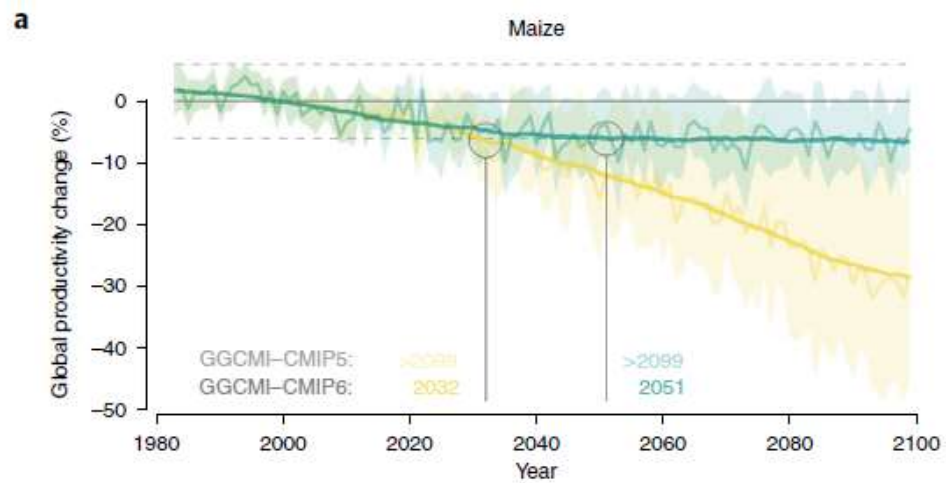
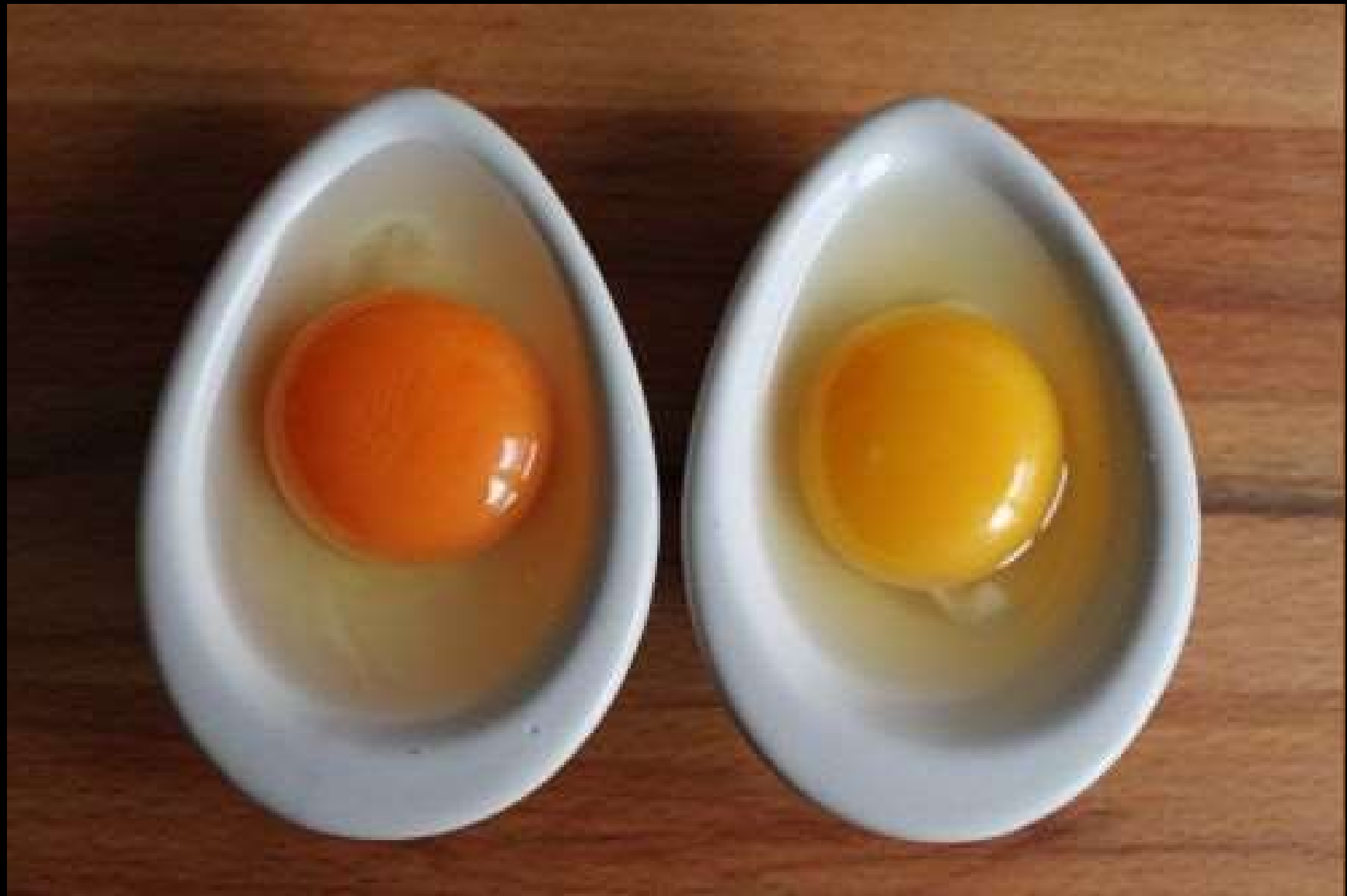
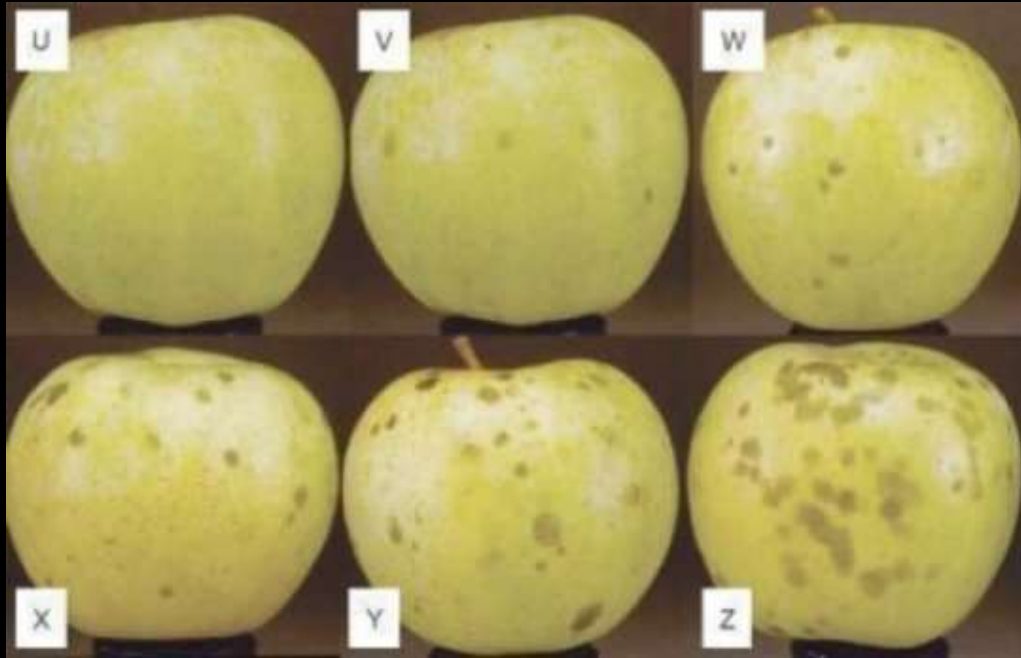


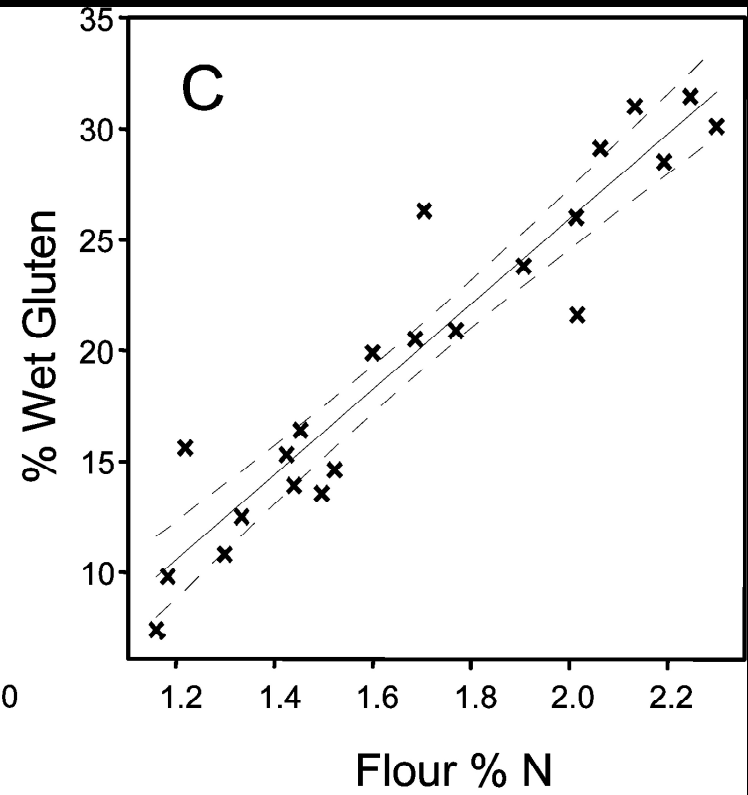
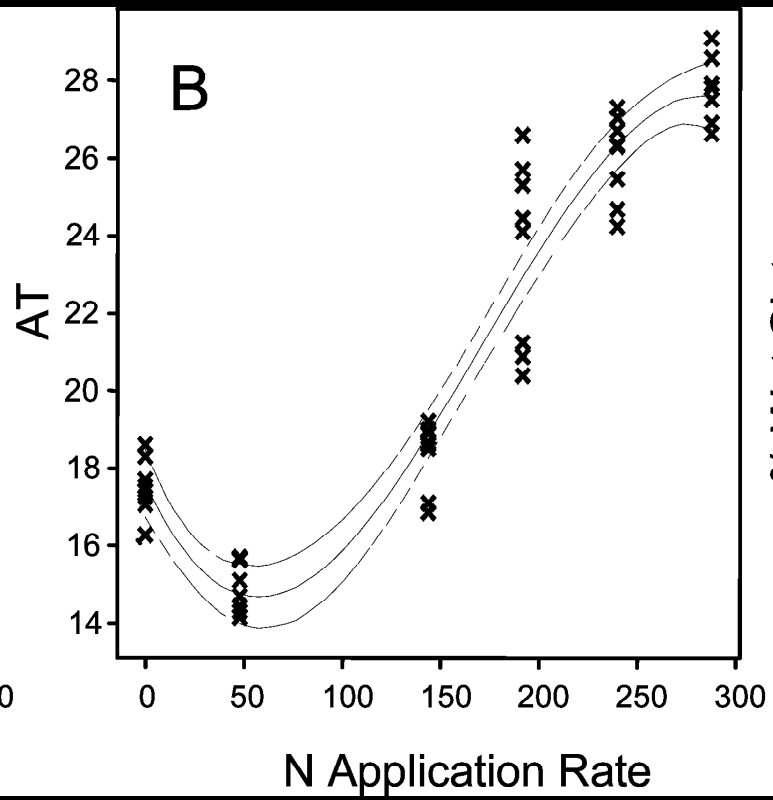
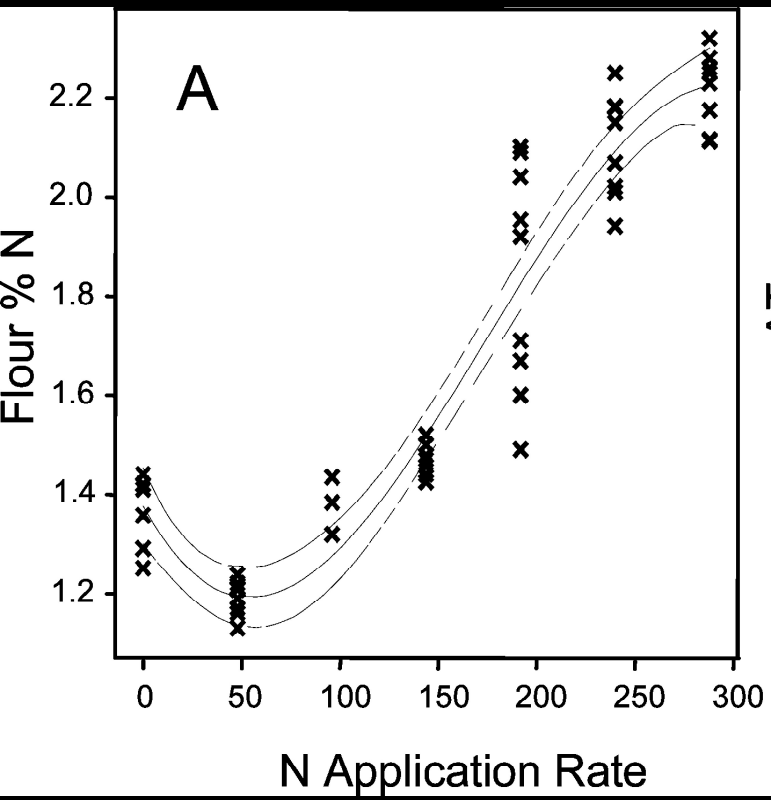
Figure SPM 3 A substantial proportion of assessed species are threatened with extinction and overall trends are deteriorating, with extinction rates increasing sharply in the past century.

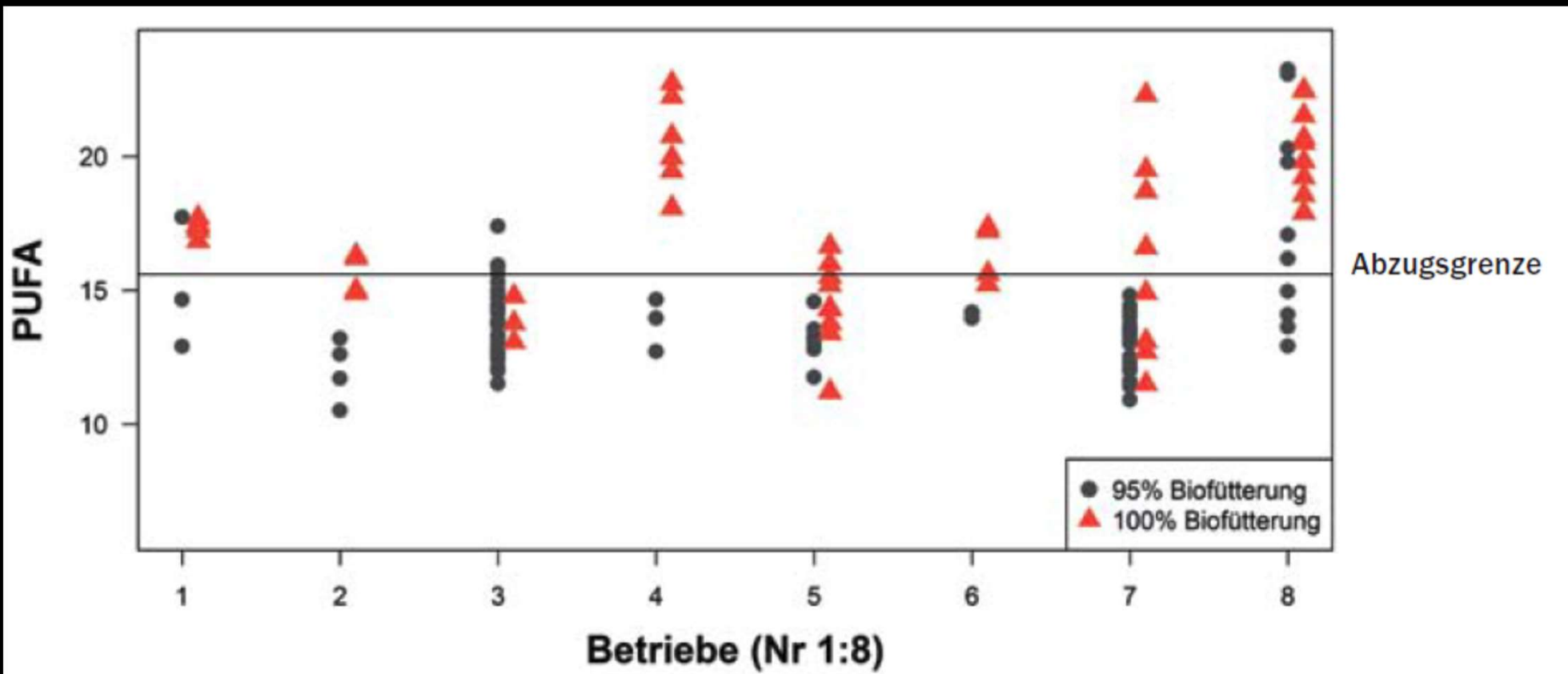












Vergleich der PUFA-Zahl-Messungen zwischen 100 Prozent Biofütterung und 95 Prozent Biofütterung auf acht Versuchsbetrieben mit unterschiedlichen Futterrationen. Grafik: FiBL





Today's and future business as usual food systems



- 3000 kcal per capita and day (global)
 - 35-40% protein from animal sources
- 30% food waste and losses
- High shares of feed from croplands
 - EU: 60% of croplands is used for feed production



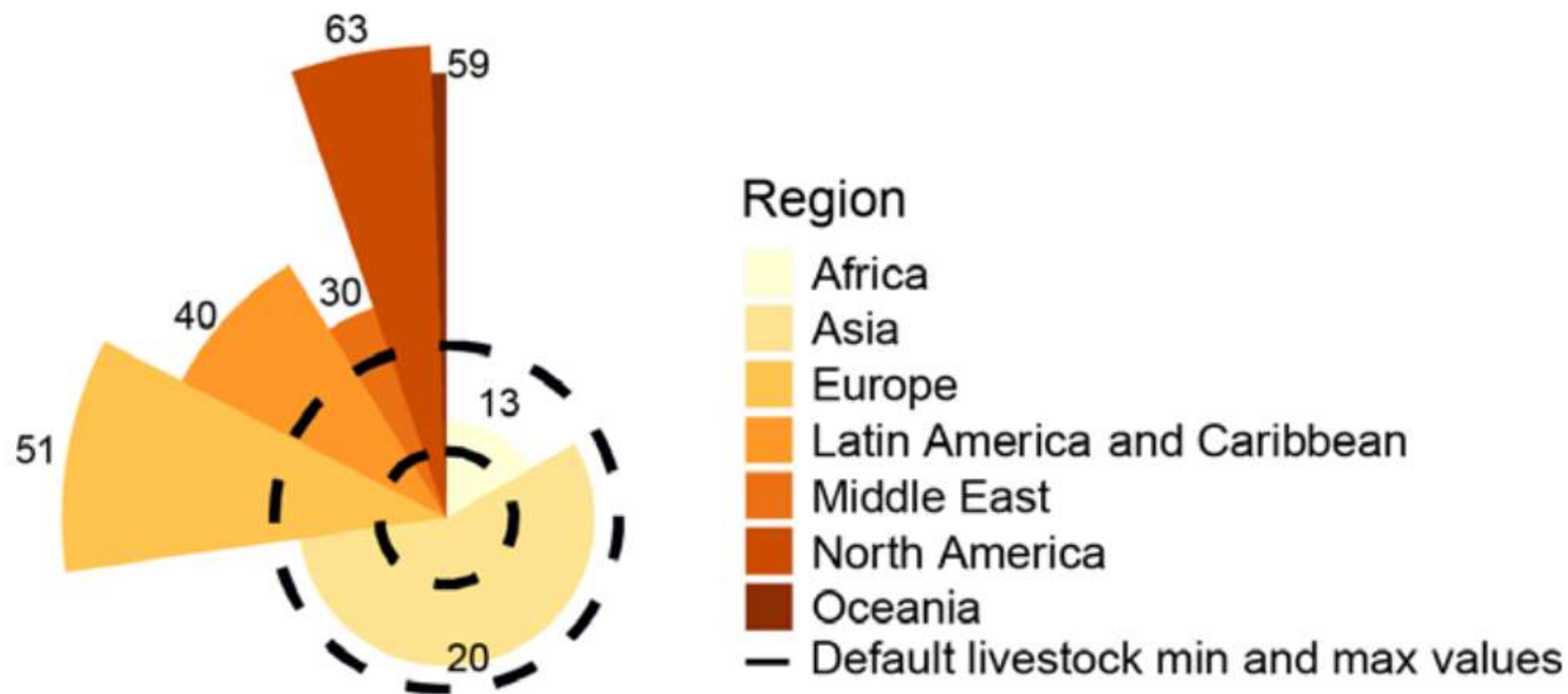
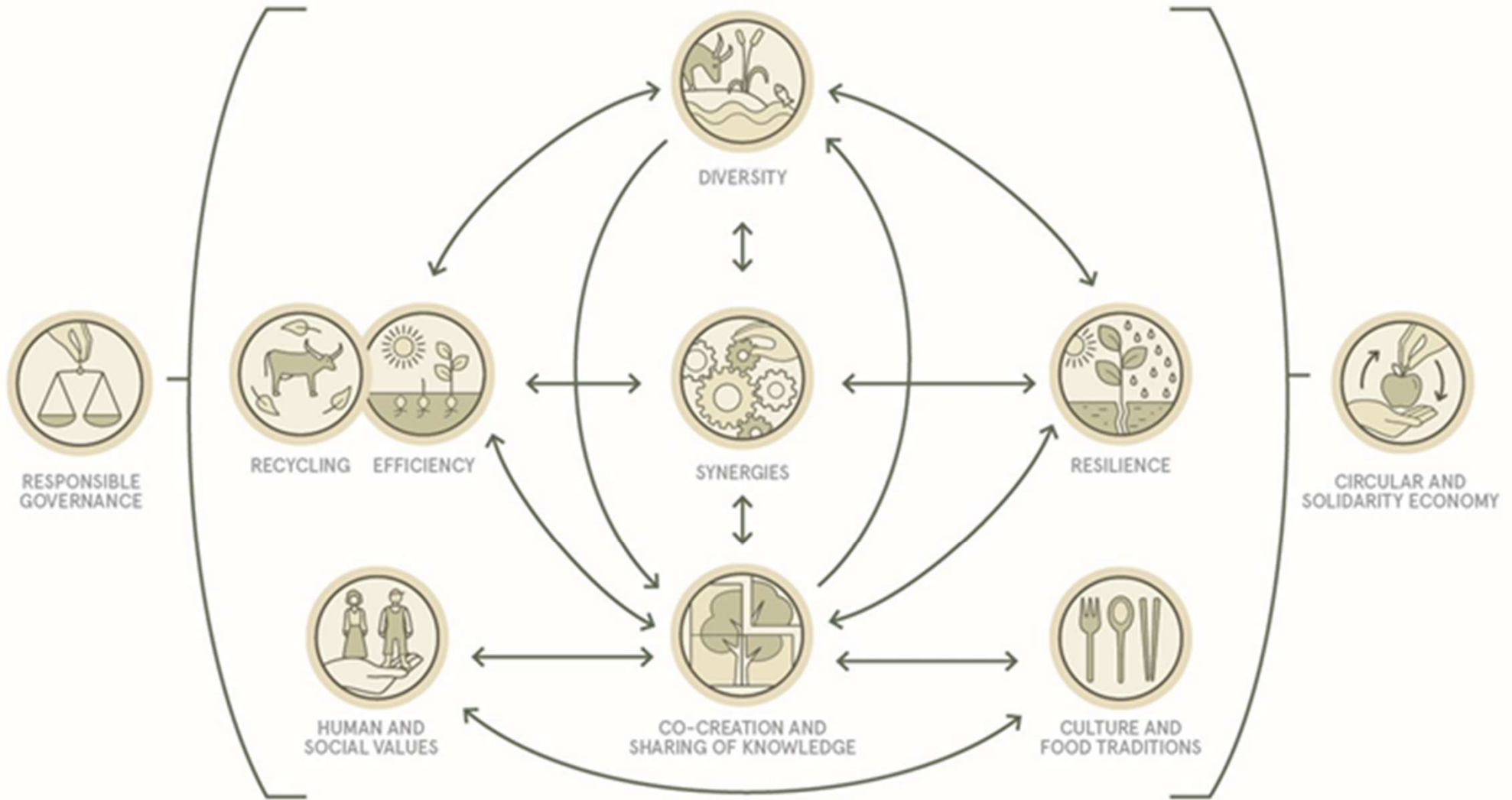


FIGURE 4 Current protein supply per person per day per region, based on (FAOSTAT, 2017) compared with the minimum global average value of low-cost livestock of Schader et al. (2015) of 9 g protein per person per day, and the maximum value of low-cost livestock based on Rööös et al. (2017a) of 23 g protein per person per day

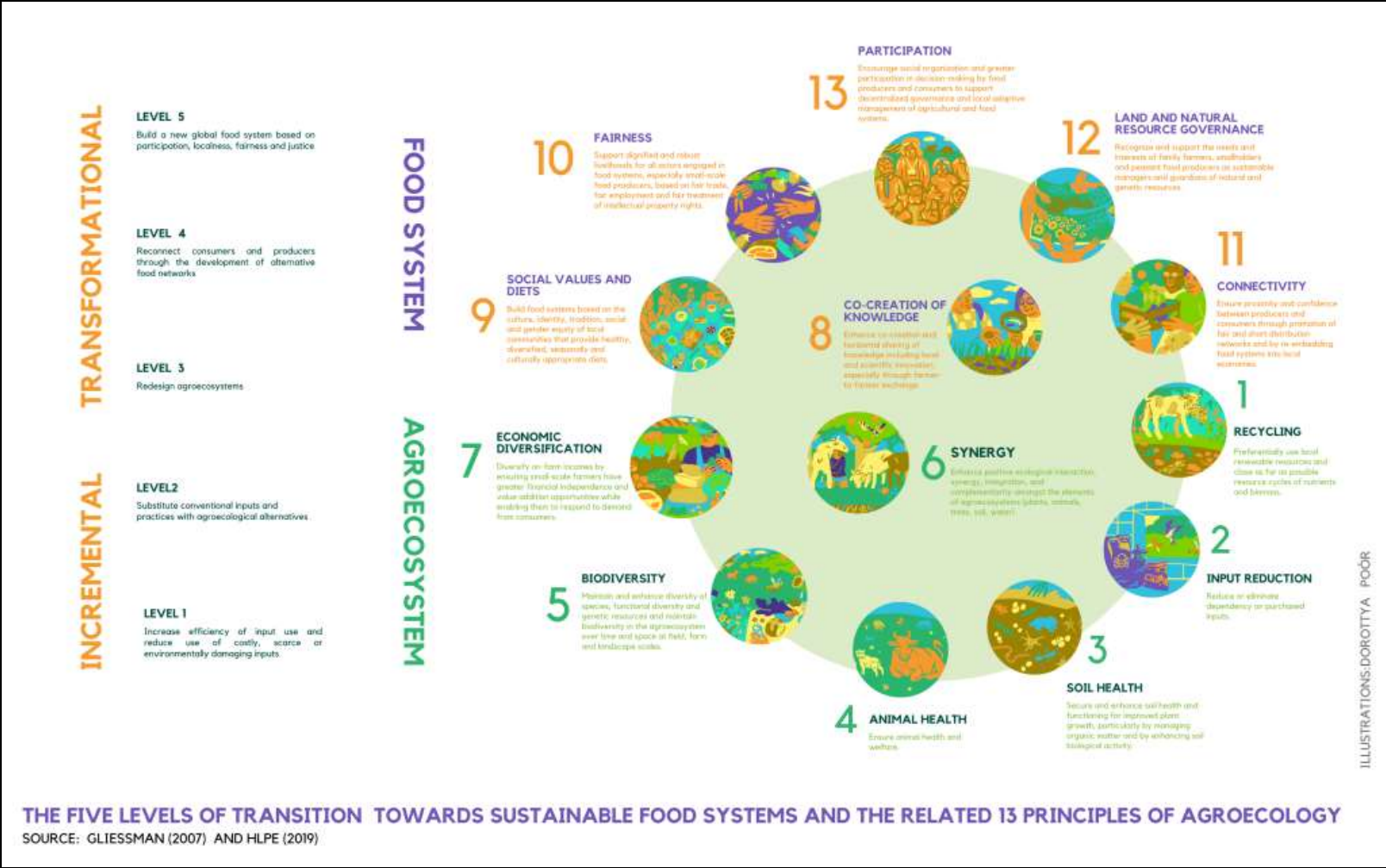
Nature based solutions – definition from the first lesson (from IUCN)

“Actions to
protect, sustainably manage and restore
natural or modified ecosystems
that address societal challenges
effectively and adaptively,
simultaneously providing
human wellbeing and biodiversity benefits.”

The 10 Elements of Agroecology according to the FAO



The 13 Principles of Agroecology according to Wezel et al. 2020 and the 5 Gliessman levels



What is organic agriculture?

„We define Organic Agriculture as

a production system that

sustains the health of soils, ecosystems and people;
relies on ecological processes, biodiversity and cycles adapted to local conditions,
rather than the use of inputs with adverse effects; and
combines tradition, innovation and science
to benefit the shared environment and
promote fair relationships and a good quality of life for all involved.“

In practice, simplistic formulation:

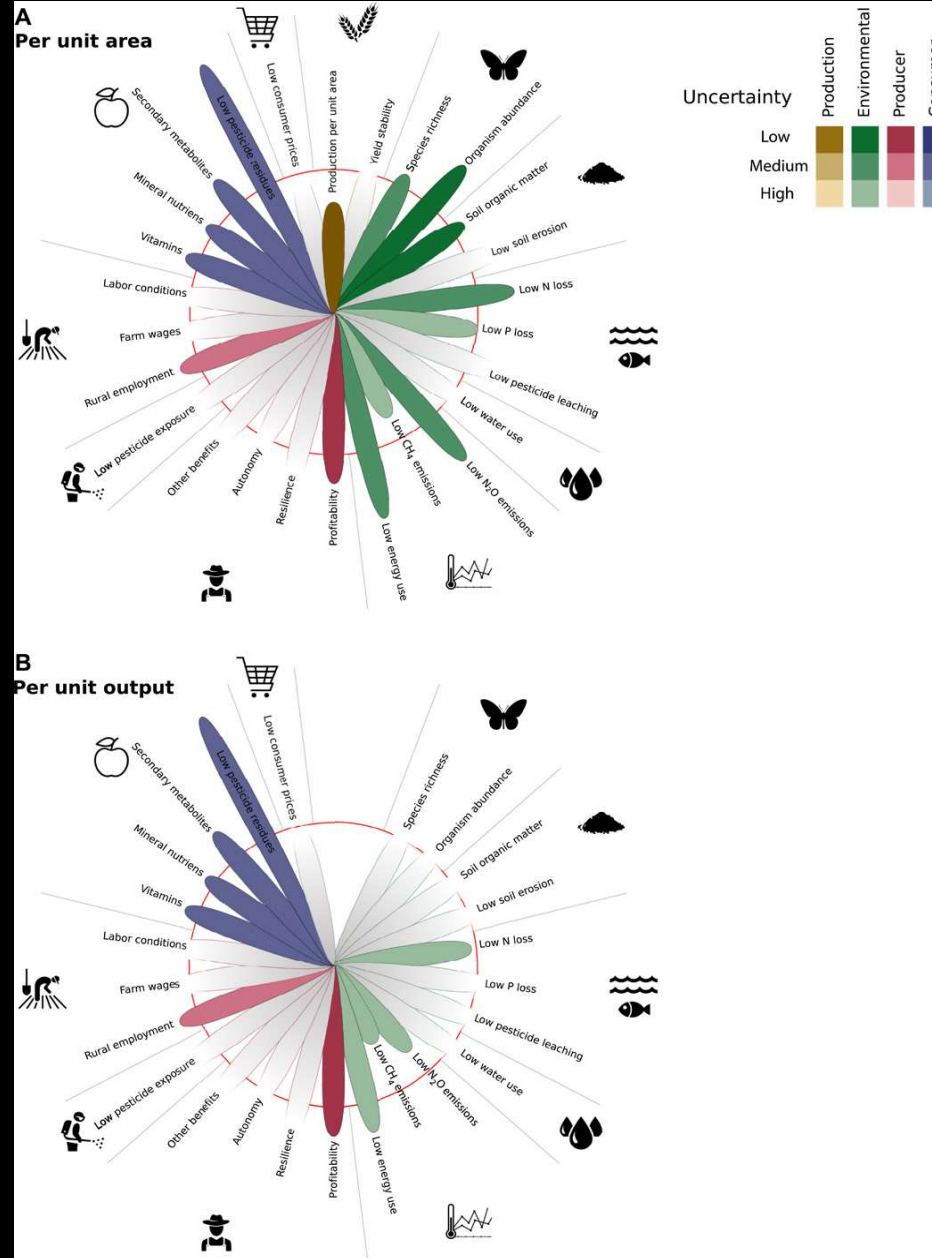
- no mineral fertilizer
- no synthetic pesticides
- focus on good crop rotations and good soils
- biological plant protection

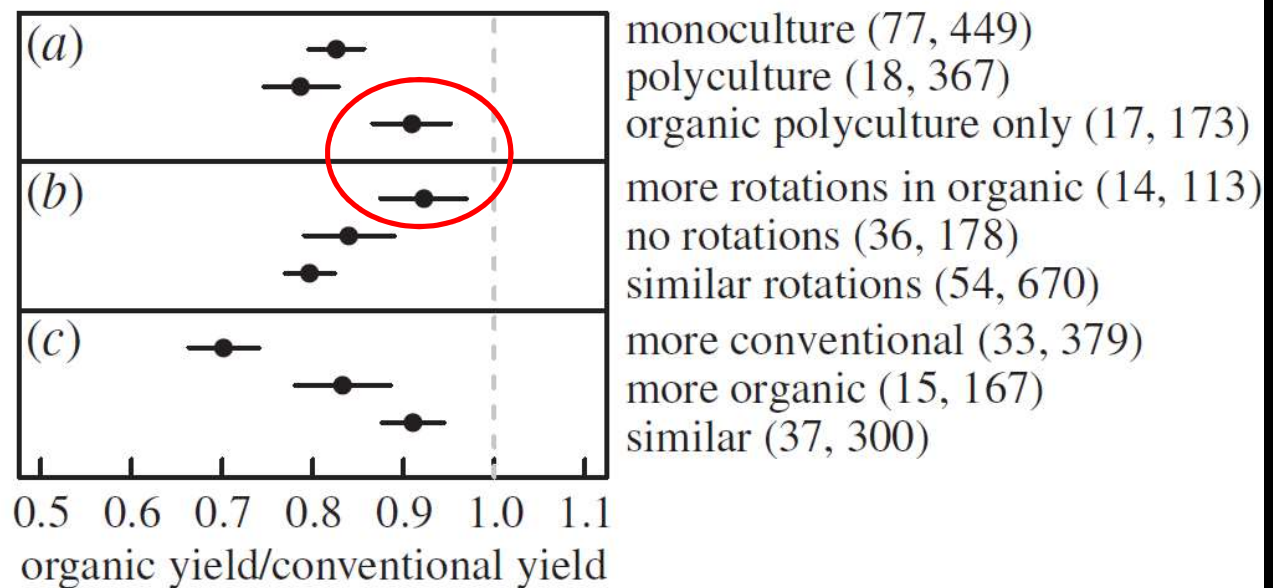
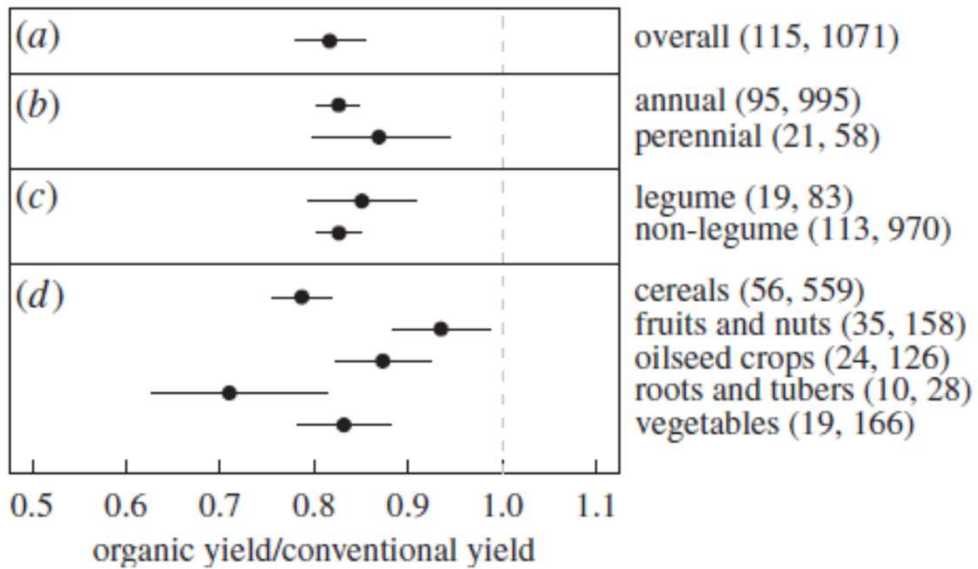
		Indicators for climate change adaptation																	
		Soil health		Biodiversity		Plant protection			Productivity									Employment	Health
		Soil organic carbon	Soil fertility	Species richness/abundance/diversity	Stability of species richness/abundance	Natural plant protection	Weed abundance	Pathogen abundance	Total biomass production	Stability in total production	Yield	Yield stability	Pollination services	Resource use efficiency	Eco-system services stability	Profitability	Stability of costs and profits	Rural employment	Exposure to pesticides
Agroecological practices	Organic agriculture	✓	✓	✓	✓		✗	✓			✗	✗						✓	✓
	Low-input systems			✓							✗								
	Agroforestry		✓	✓					✓										
	No tillage	✓	✓								✗								
	Reduced tillage	✓	✓																
	Cover crops	✓	✓																
	Biochar	✓																	
	Organic fertilizers	✓	✓						✗										
	Crop rot./diversity/intercropping	✓	✓	✓		✓				✓		✓				✓	✓		
	Grassland diversity										✓								
Practices enhancing biodiversity & complex landscapes					✓					✓		✓	✓	✓					

- Environmental impacts

per hectare

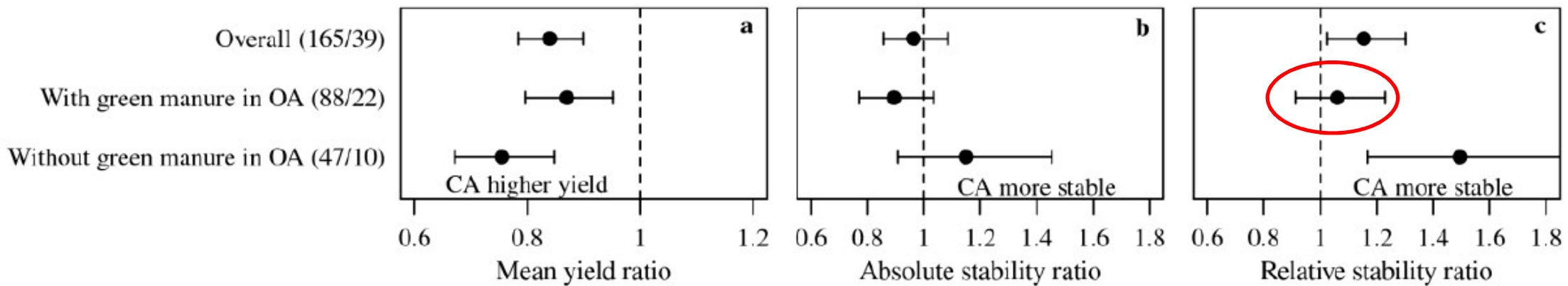
per kg product





Yields

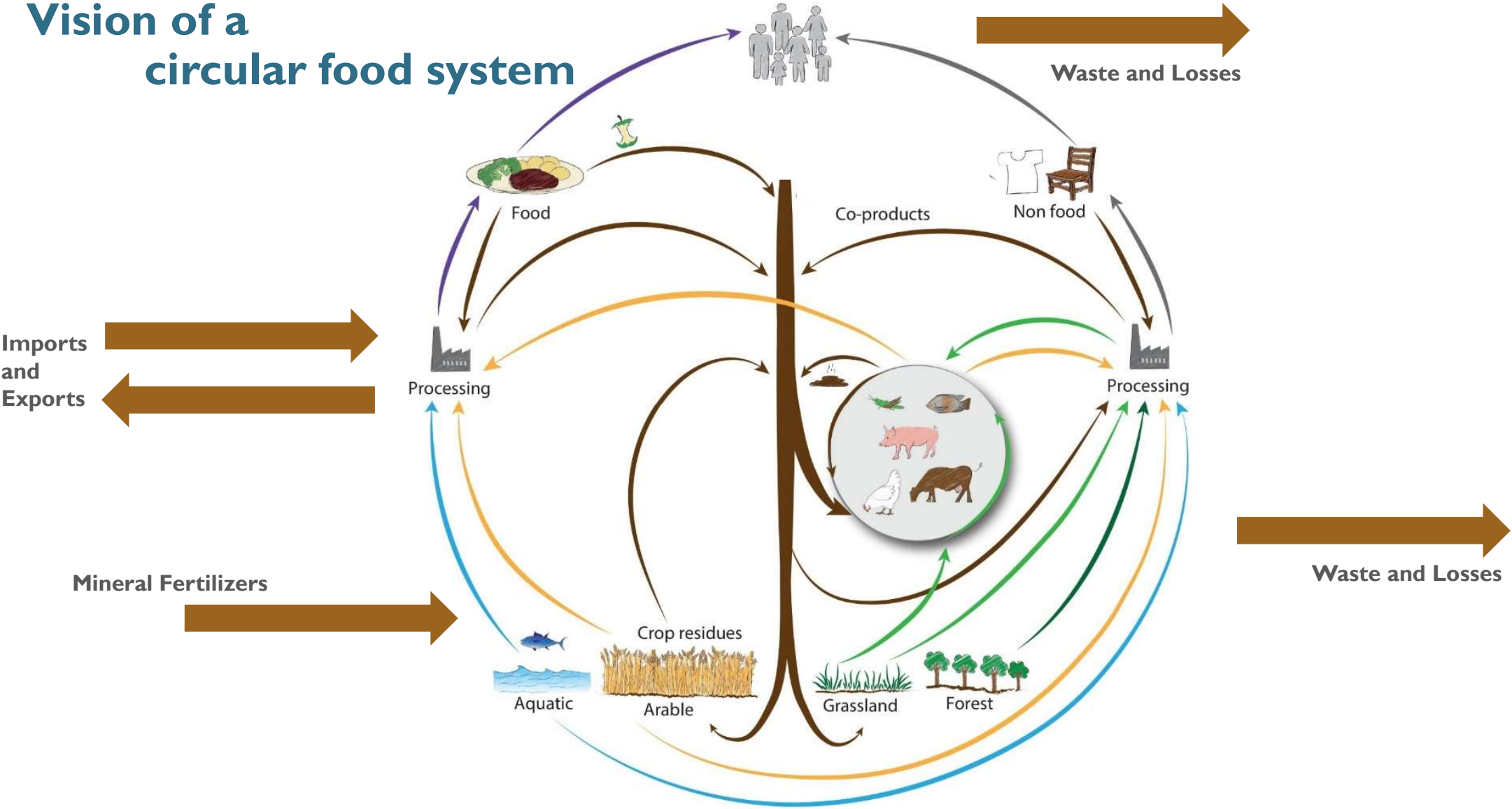
Yield stability

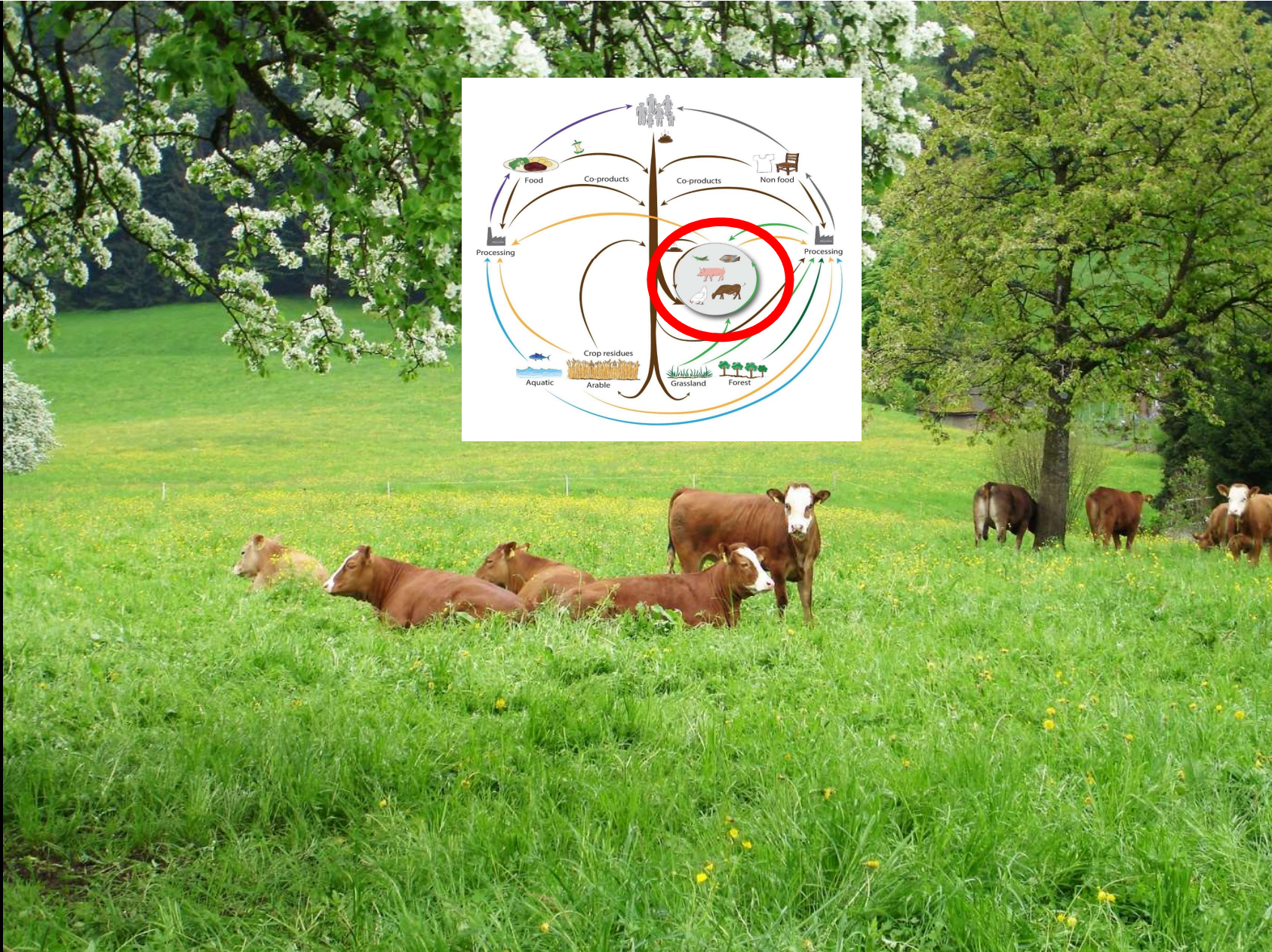


Lack of diversity in organic agriculture?

cf. e.g. large-scale organic operations in eastern Europe

Vision of a circular food system







% Reduction in
food-competing feed

0

50

100

% Organic

0

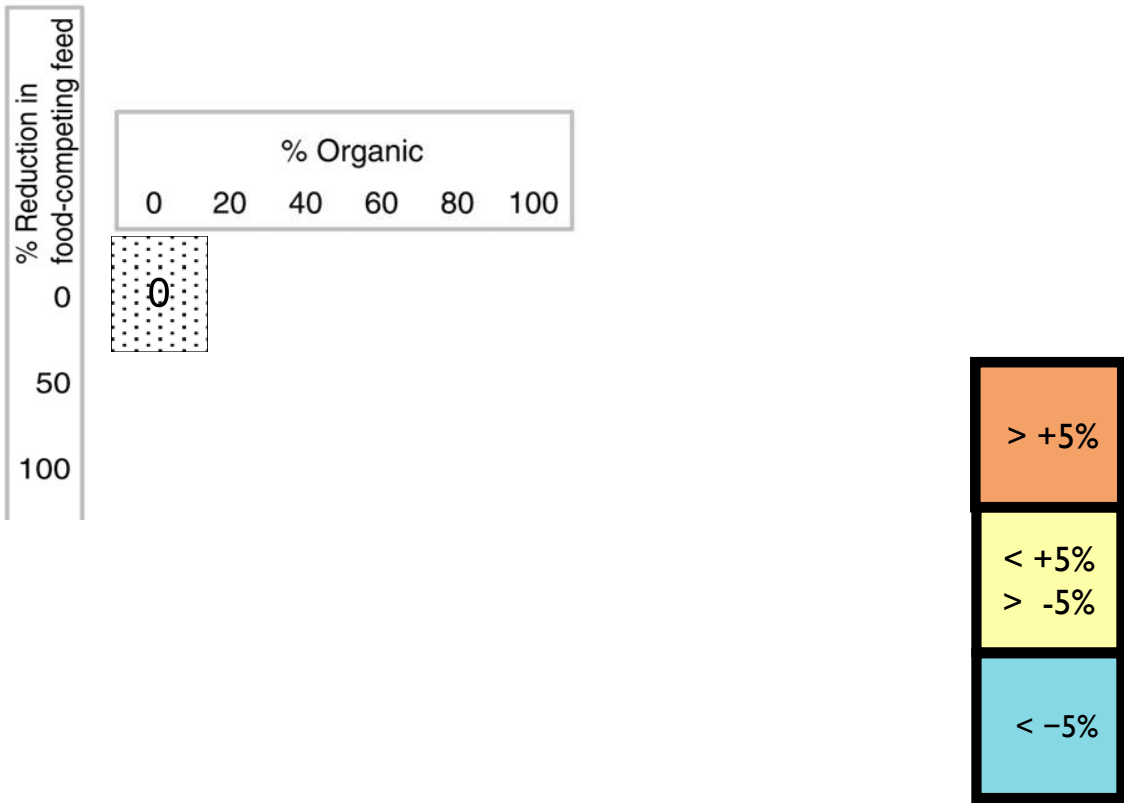
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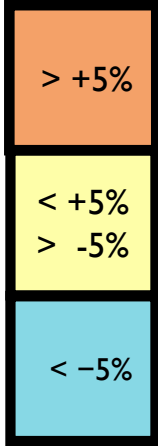
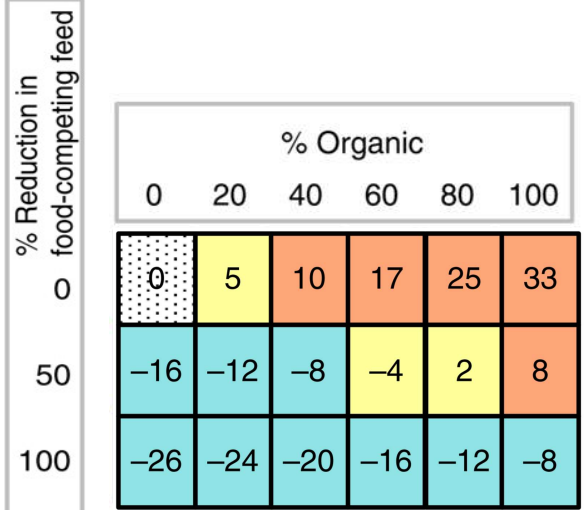
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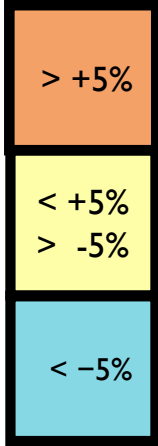
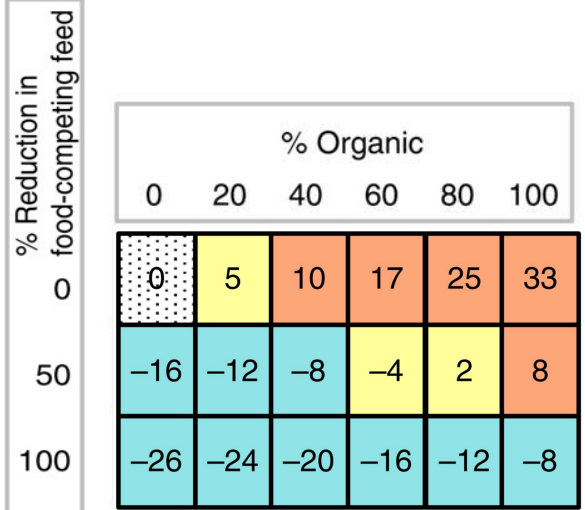
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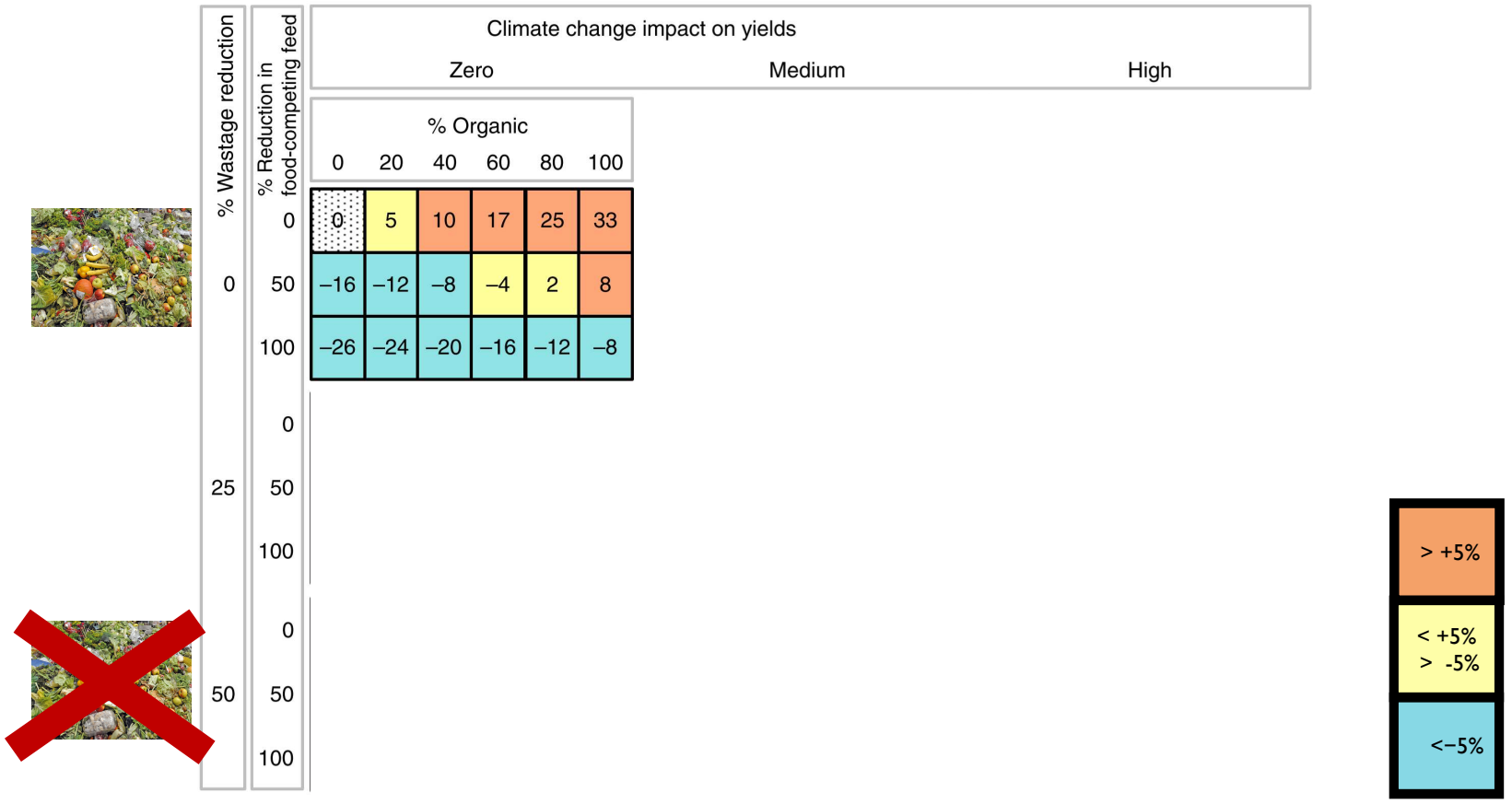
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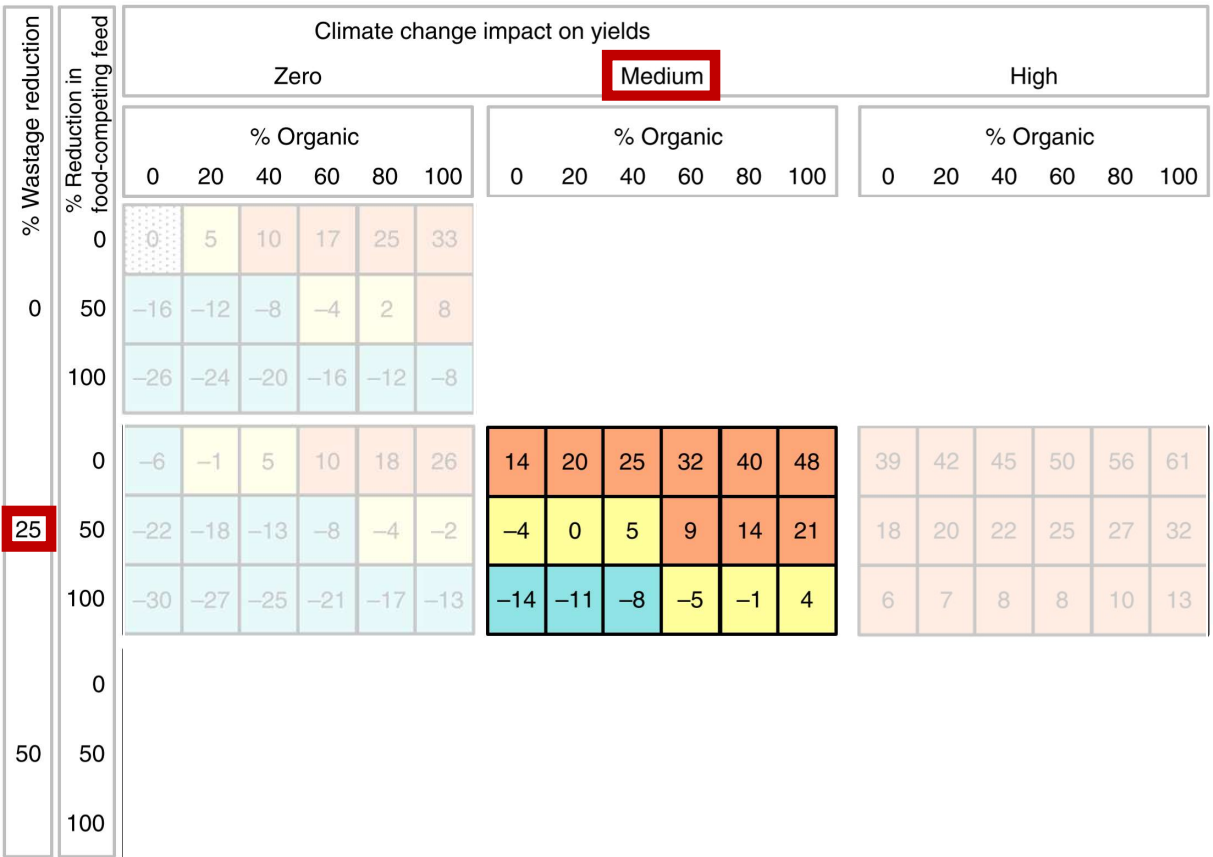
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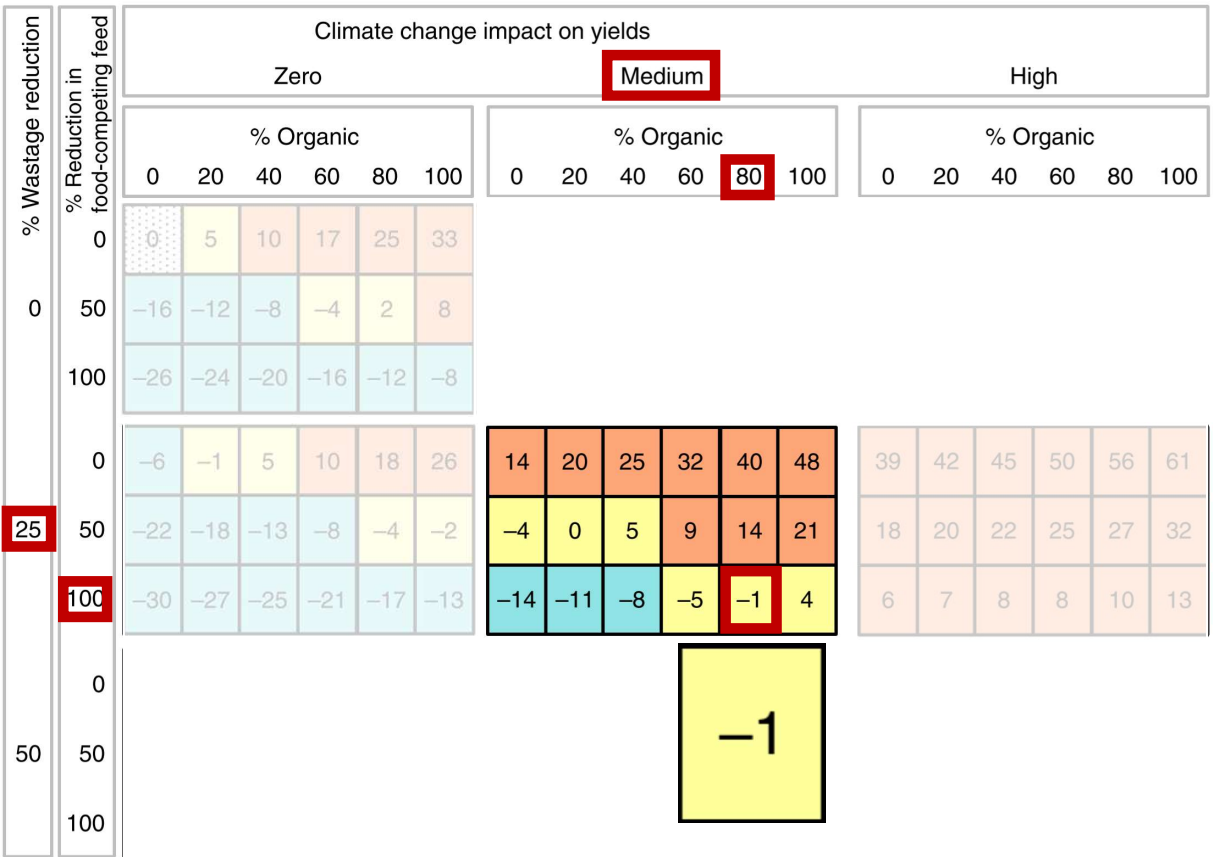




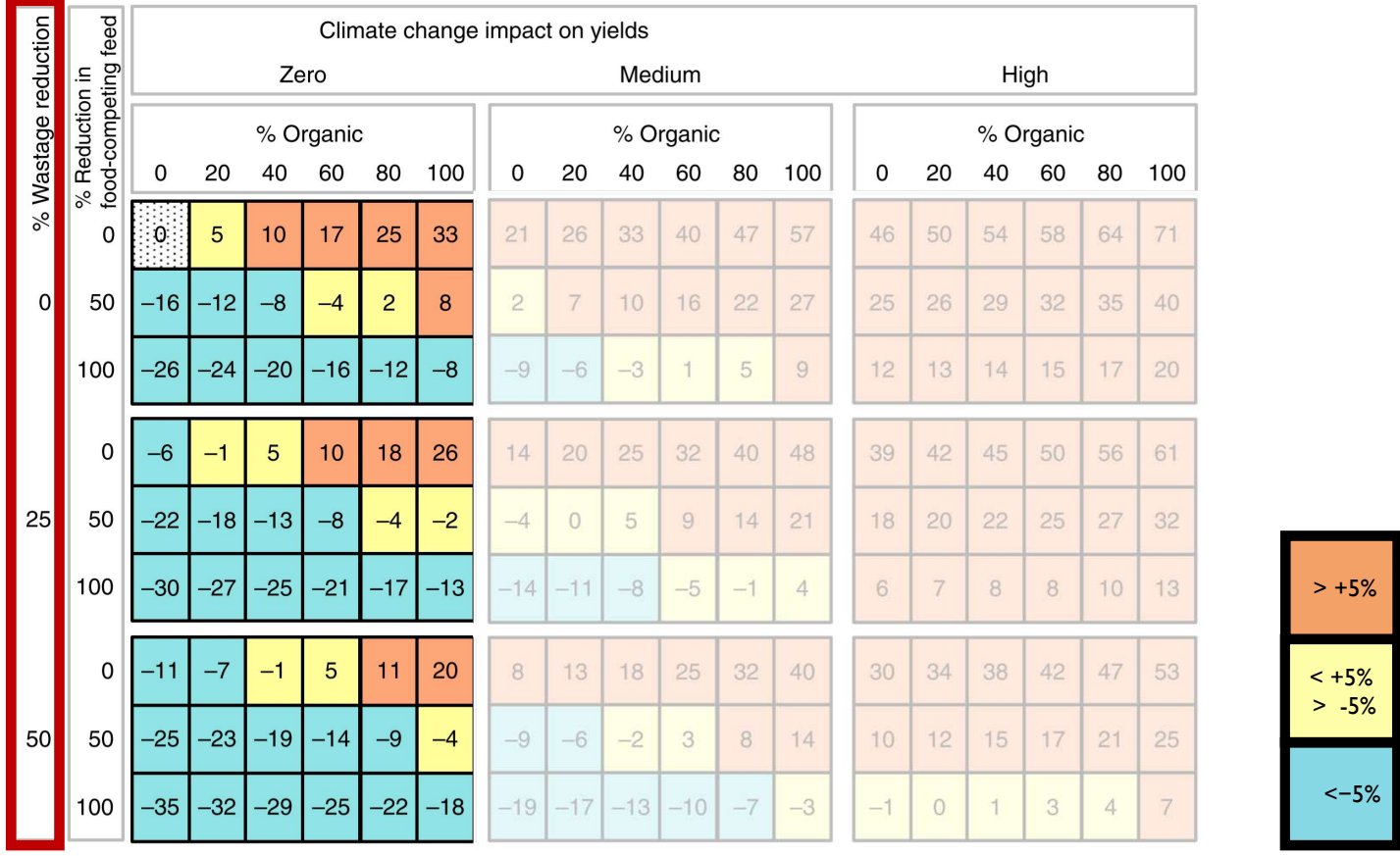


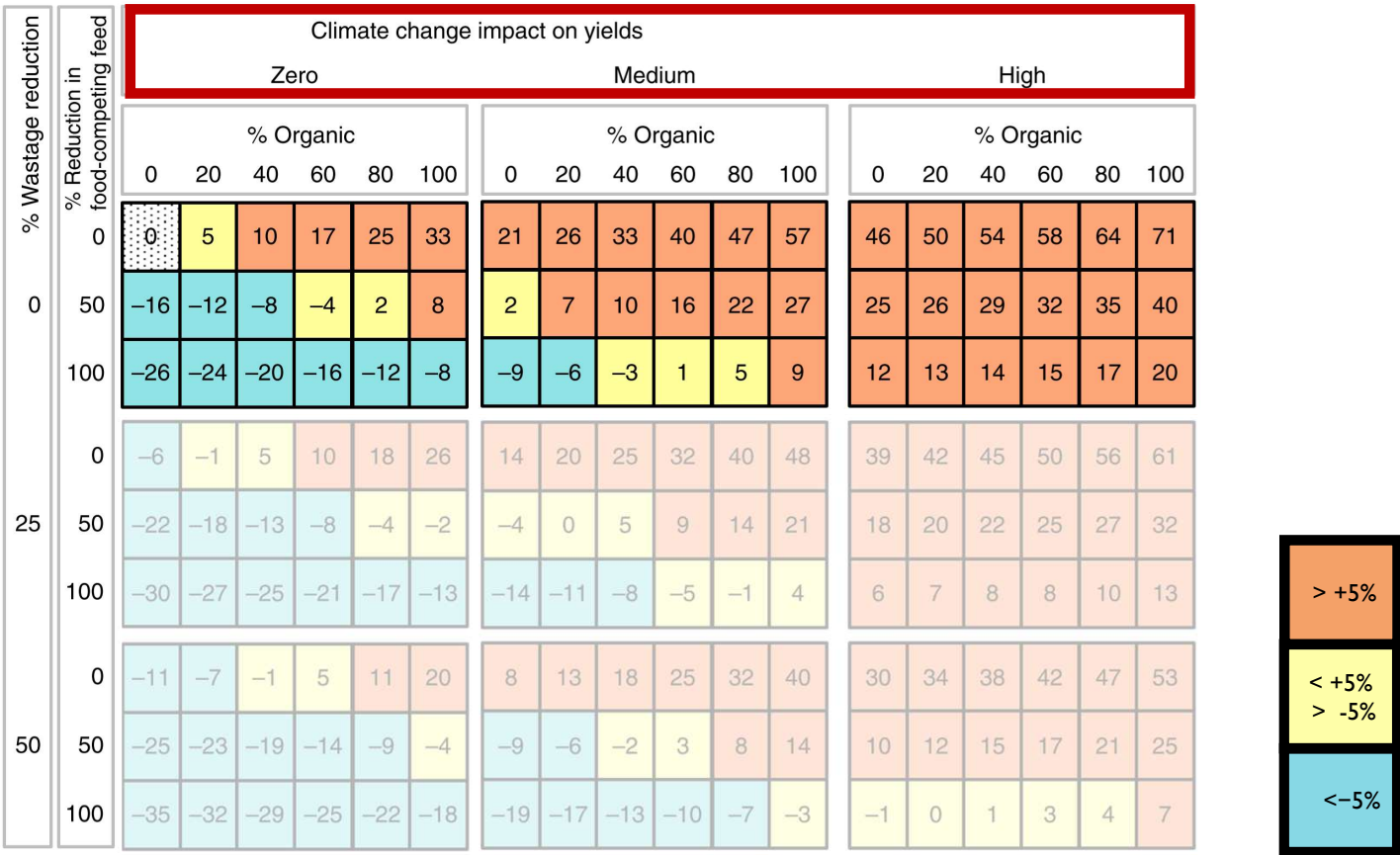


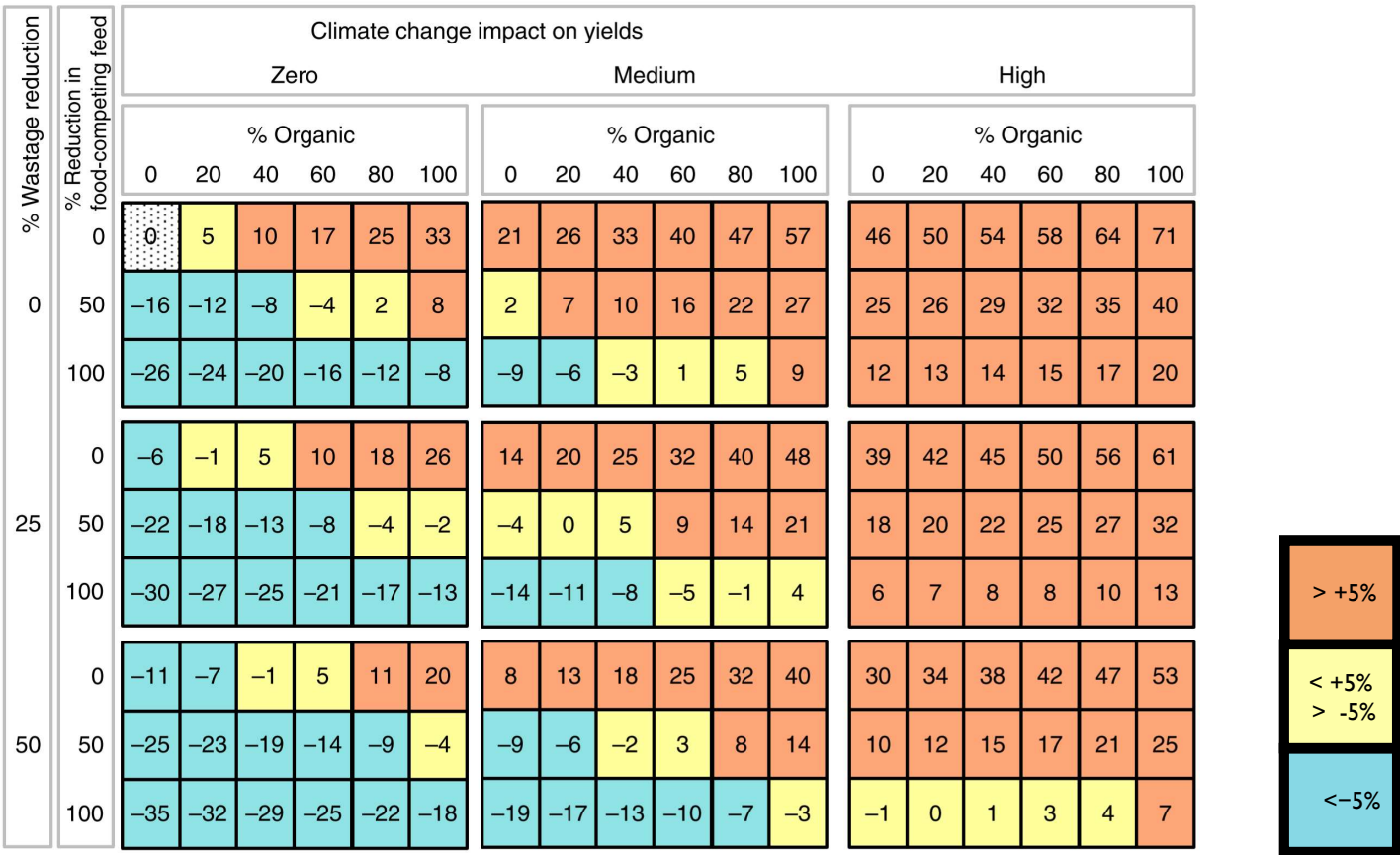




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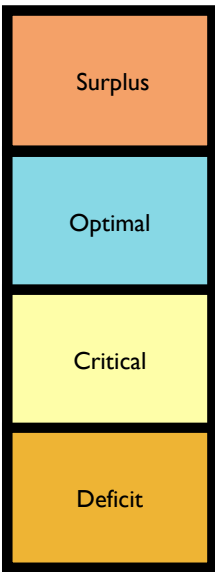
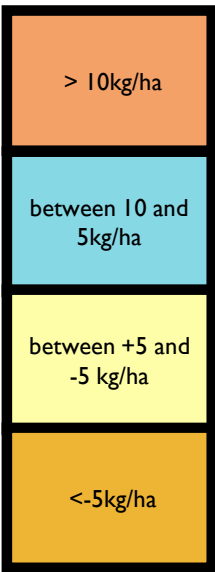


Nutrient supply in organic agriculture

- Not only the products, but also the fertilizer is produced on the fields.
- Challenge to provide sufficient nutrients, especially N and P

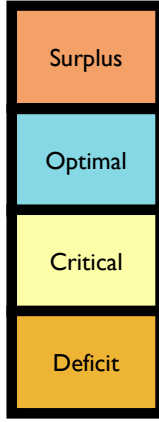


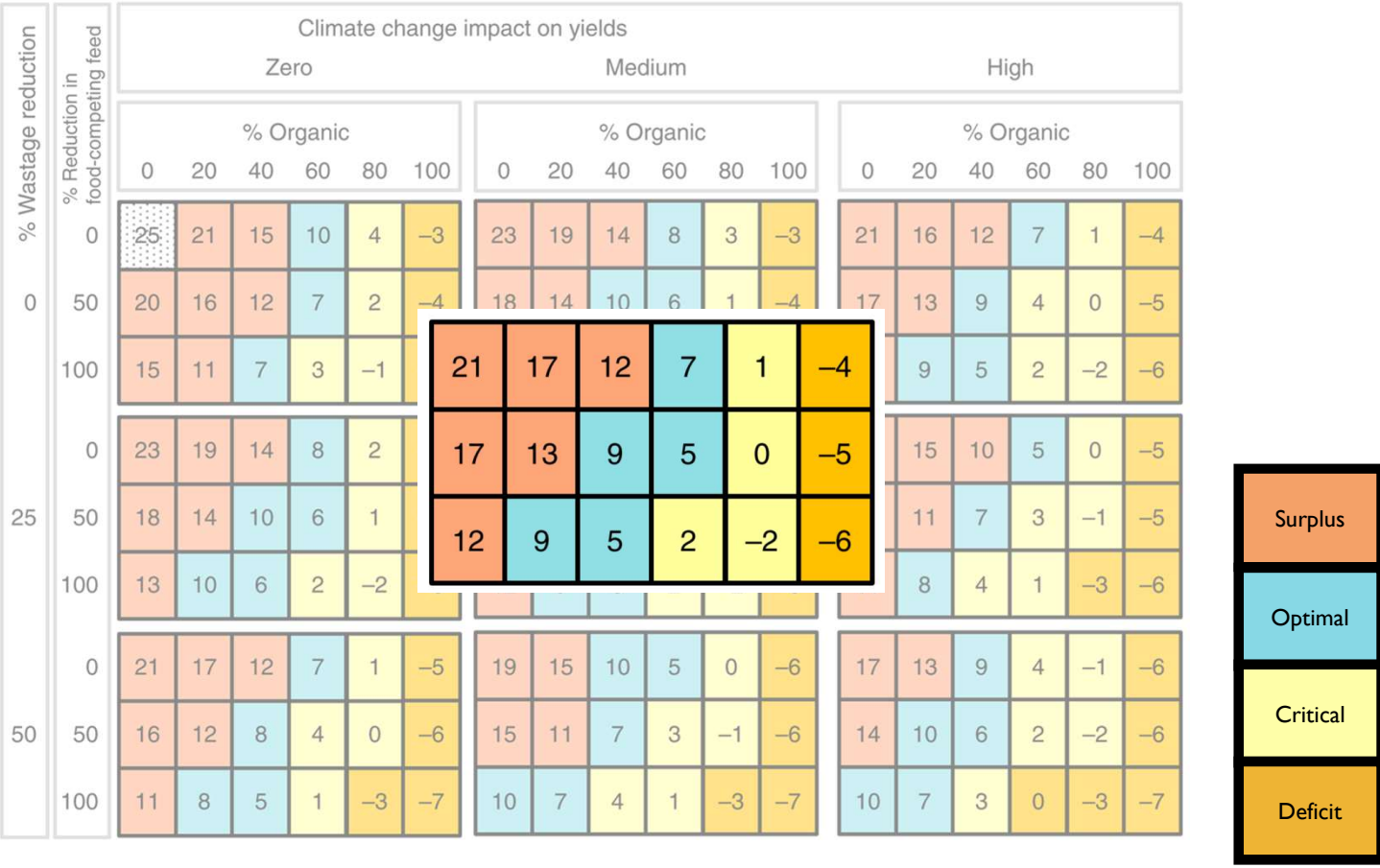
		Climate change impact on yields																	
		Zero						Medium						High					
		% Organic						% Organic						% Organic					
% Wastage reduction	% Reduction in food-competing feed	0	20	40	60	80	100	0	20	40	60	80	100	0	20	40	60	80	100
		0	0	25	21	15	10	4	-3	23	19	14	8	3	-3	21	16	12	7
50	20		16	12	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	4	1	-3	-7	10	7	3	0	-3	-7



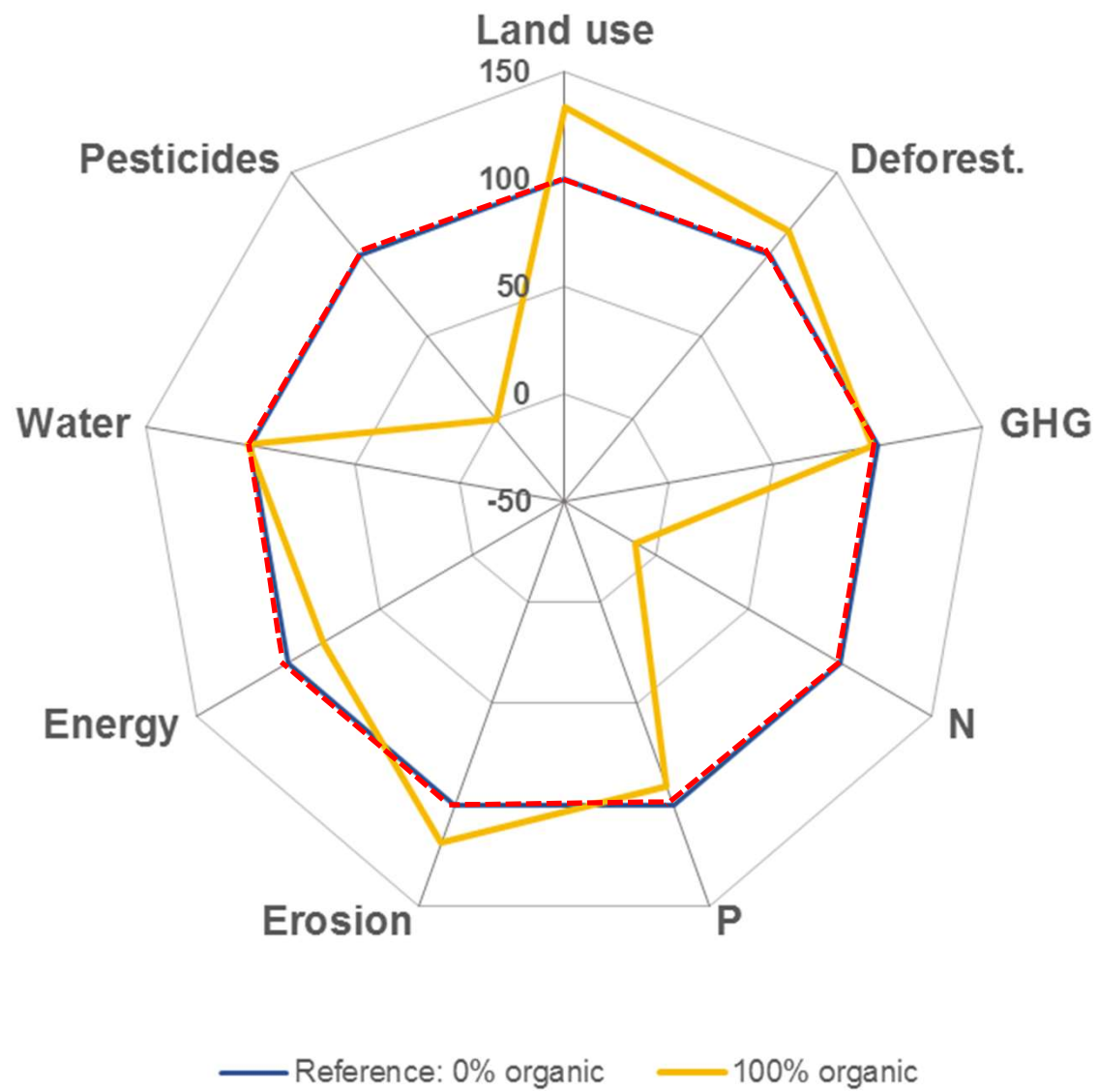
		Climate change impact on yields																	
		Zero						Medium						High					
		% Organic						% Organic						% Organic					
% Wastage reduction		0	20	40	60	80	100	0	20	40	60	80	100	0	20	40	60	80	100
0	0	25	21	15	10	4	-3	23	19	14	8	3	-3	21	16	12	7	1	-4
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25	0	23	19	14	8	3	-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
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	50	16	12	8	4	0	-6	15	11	7	3	-1	-6	14	10	6	2	-2	-6
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25

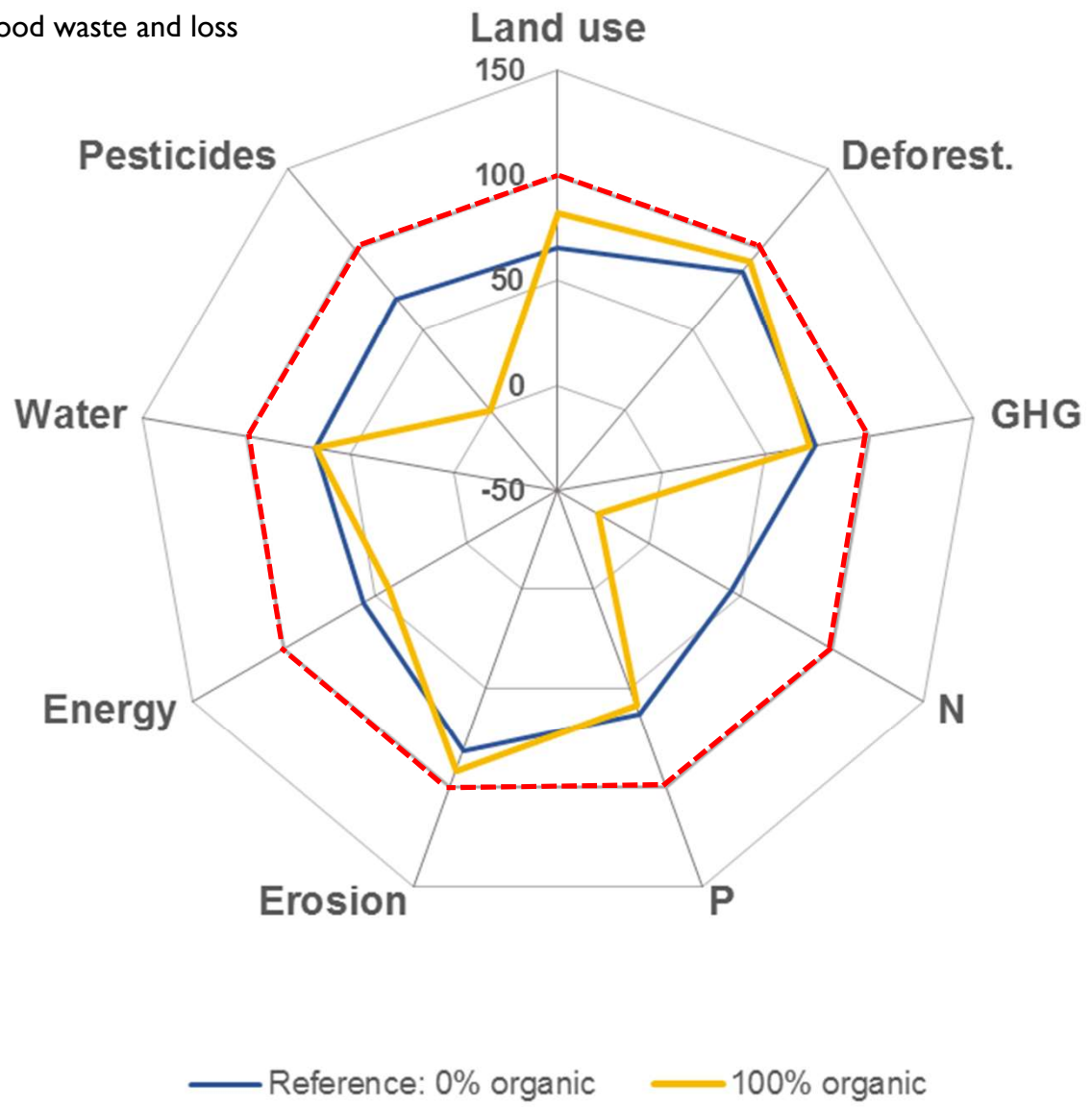




**Other environmental impacts besides
Land use and nitrogen supply**



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





% Wastage reduction % Reduction in food-competing feed		Climate change impact on yields																	
		Zero					Medium					High							
		% Organic					% Organic					% Organic							
		0	20	40	60	80	100	0	20	40	60	80	100	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
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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
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	100	-35	-32	-29	-25	-22	-18	-19	-17	-13	-9	-5	-1	-1	0	1	3	4	7

% Wastage reduction % Reduction in food-competing feed		Climate change impact on yields																	
		Zero					Medium					High							
		% Organic					% Organic					% Organic							
		0	20	40	60	80	100	0	20	40	60	80	100	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
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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	4	0	-3	-7	10	7	3	0	-3	-7



Size of the food system



**We know what to do for
being able to build on NBS/agroecology
for sustainable food systems:**

- less waste and losses
- less feed from cropland
- less animals
- (less fossil energy)

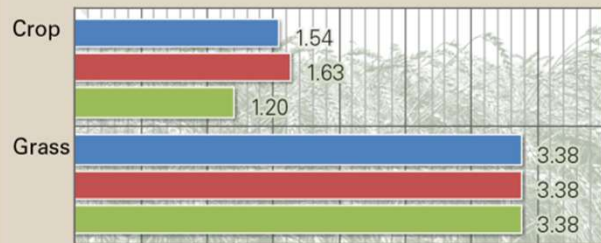


Land use

Billion hectares

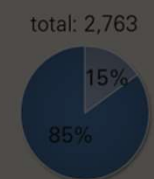
Land occupation:

- Current situation: Base year
- 2050: Reference scenario
- 2050: Food - not feed



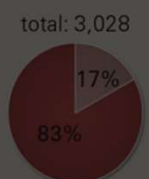
Diets

Energy intake
Kcal/cap/day



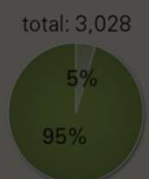
Current situation:
Base year

Energy intake
Kcal/cap/day



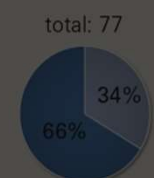
2050:
Reference Scenario

Energy intake
Kcal/cap/day



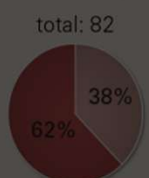
2050:
Food - not feed

Protein intake
G Protein/cap/day



Current situation:
Base year

Protein intake
G Protein/cap/day



2050:
Reference Scenario

Protein intake
G Protein/cap/day

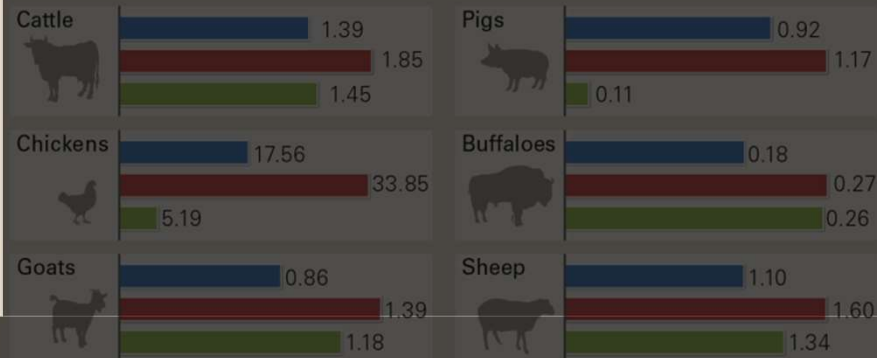


2050:
Food - not feed

Livestock

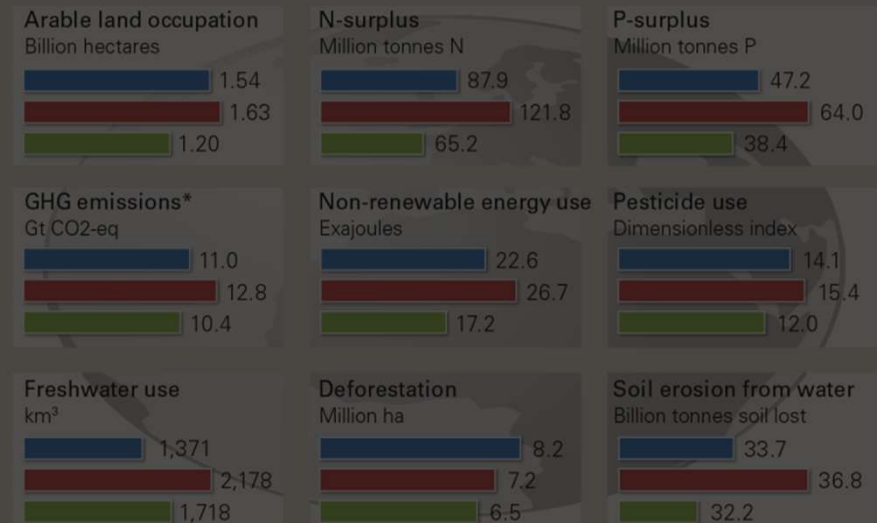
Billion animals

- Current situation: Base year
- 2050: Reference Scenario
- 2050: Food - not feed



Environment

- Current situation: Base year
- 2050: Reference Scenario
- 2050: Food - not feed



* GHG emissions include emissions from input provision, deforestation and organic soils.

Land use

Billion hectares

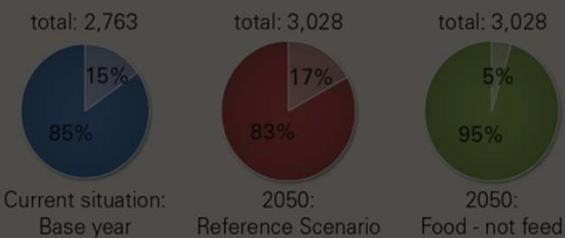
Land occupation:

- Current situation: Base year
- 2050: Reference scenario
- 2050: Food - not feed

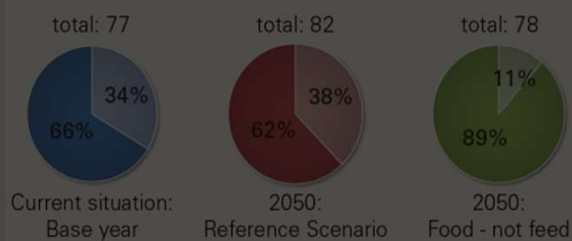


Diets

Energy intake
Kcal/cap/day



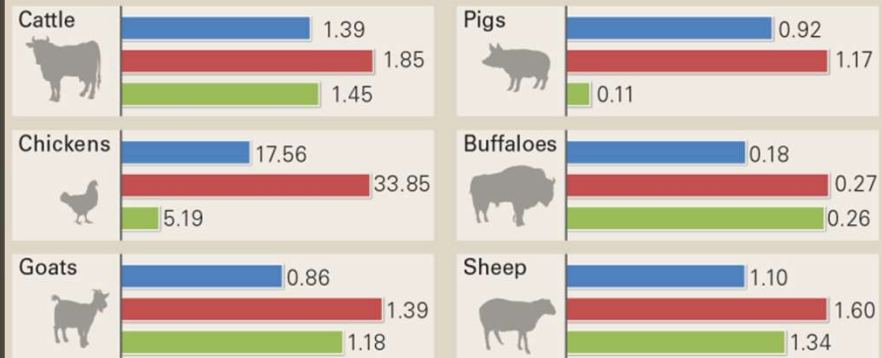
Protein intake
G Protein/cap/day



Livestock

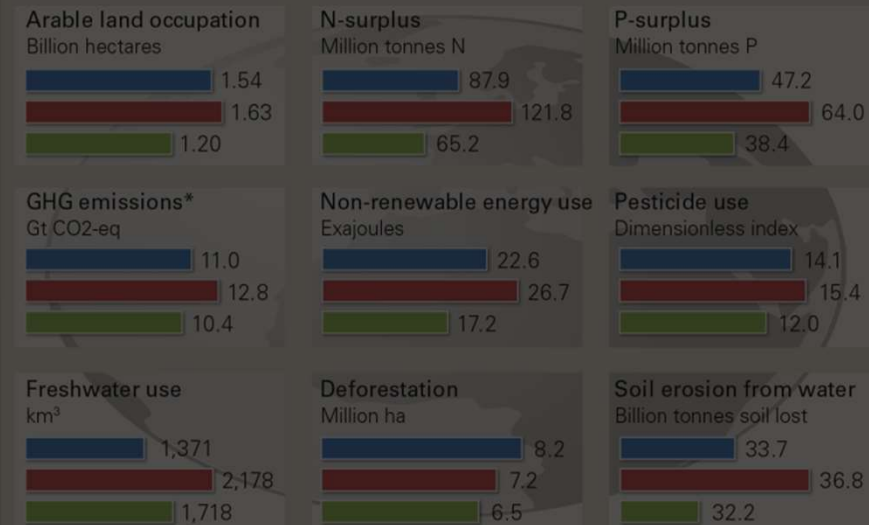
Billion animals

- Current situation: Base year
- 2050: Reference Scenario
- 2050: Food - not feed



Environment

- Current situation: Base year
- 2050: Reference Scenario
- 2050: Food - not feed



* GHG emissions include emissions from input provision, deforestation and organic soils.

Land use

Billion hectares

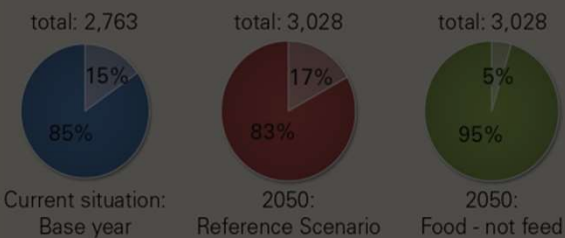
Land occupation:

- Current situation: Base year
- 2050: Reference scenario
- 2050: Food - not feed

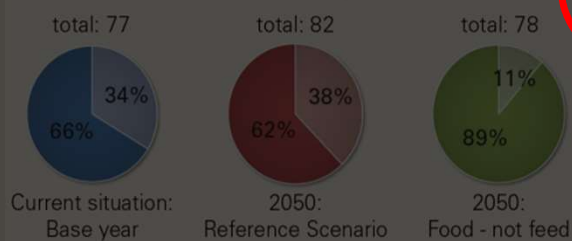


Diets

Energy intake
Kcal/cap/day



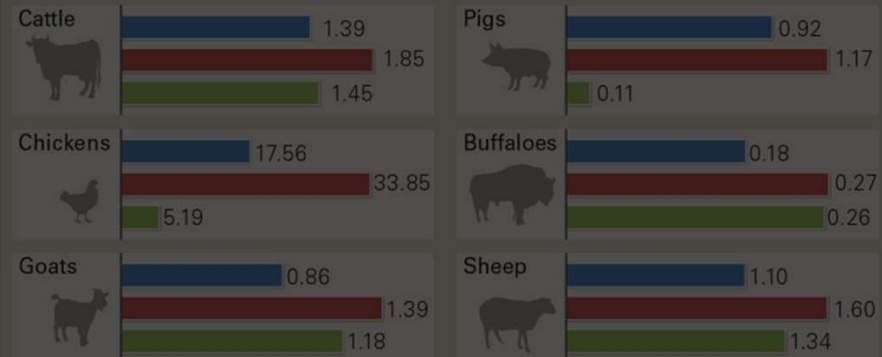
Protein intake
G Protein/cap/day



Livestock

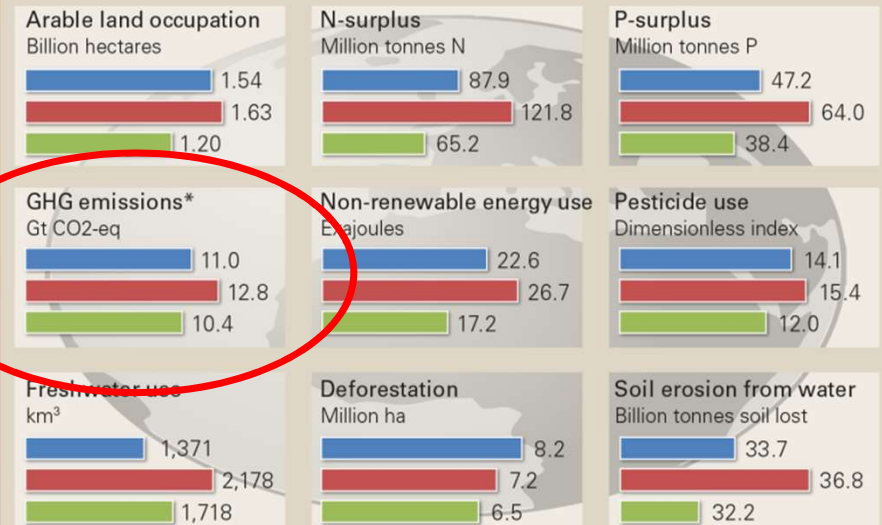
Billion animals

- Current situation: Base year
- 2050: Reference Scenario
- 2050: Food - not feed



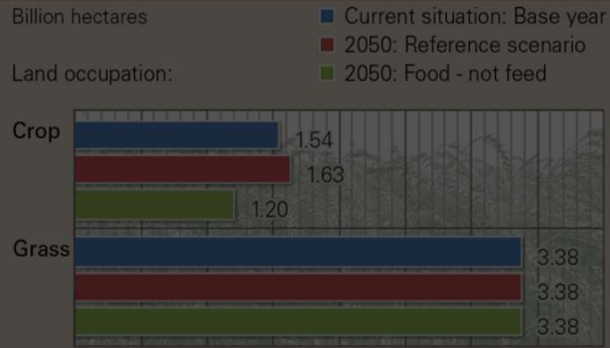
Environment

- Current situation: Base year
- 2050: Reference Scenario
- 2050: Food - not feed



* GHG emissions include emissions from input provision, deforestation and organic soils.

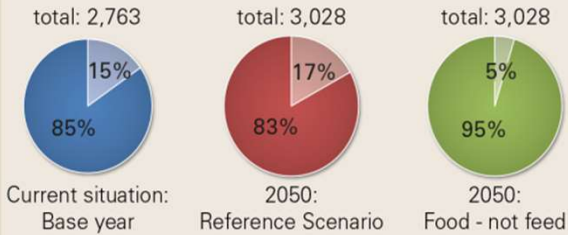
Land use



Diets

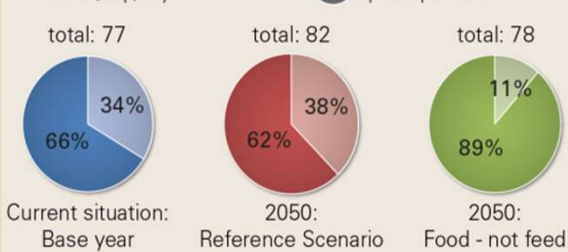
Energy intake

Kcal/cap/day

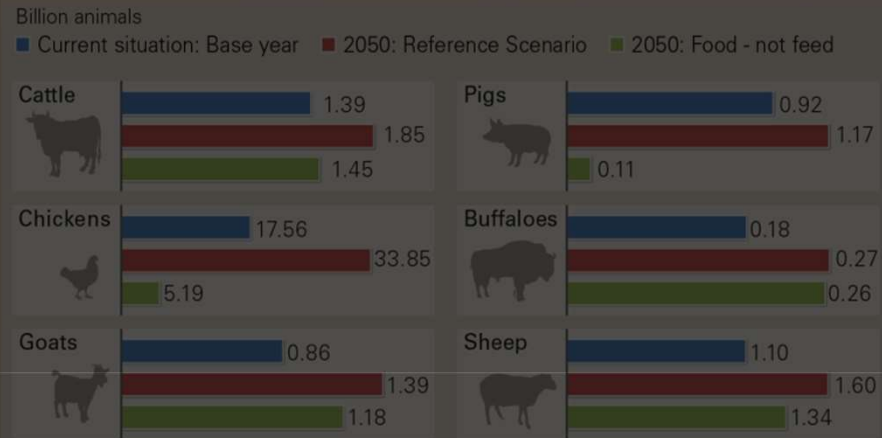


Protein intake

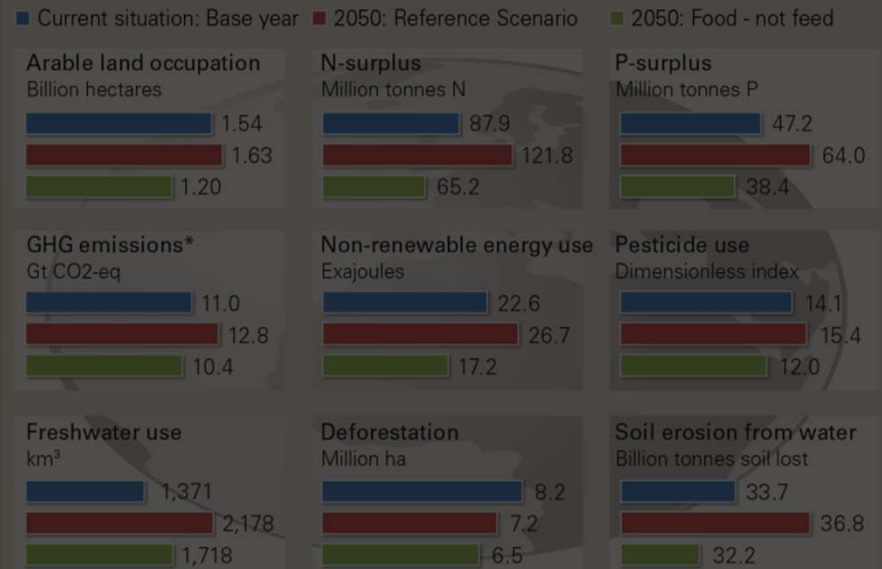
G Protein/cap/day



Livestock

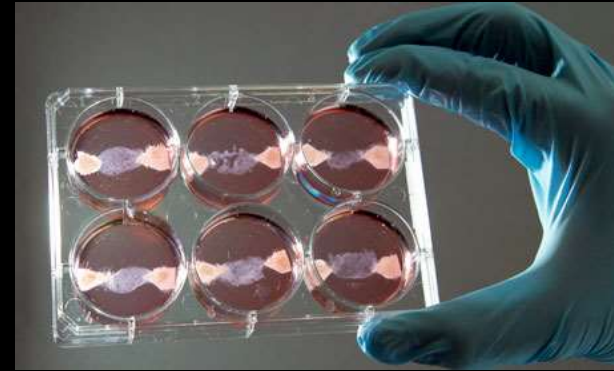


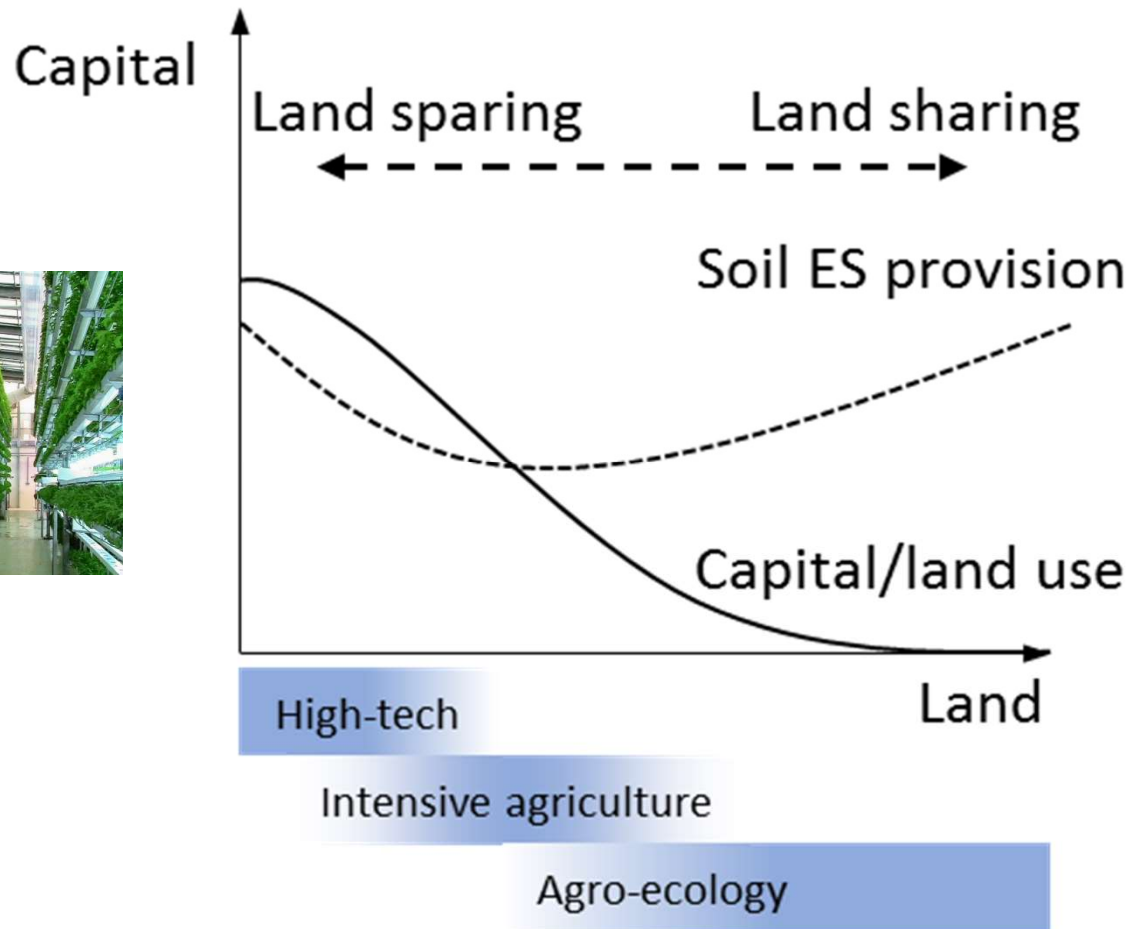
Environment



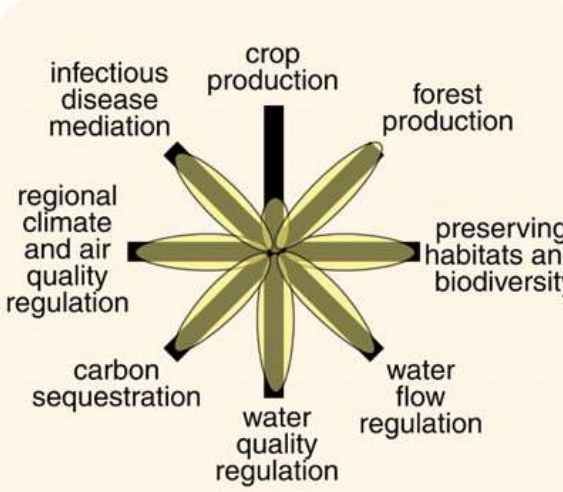
* GHG emissions include emissions from input provision, deforestation and organic soils.

NBS vs. Other, technical approaches? What is a «farm»?






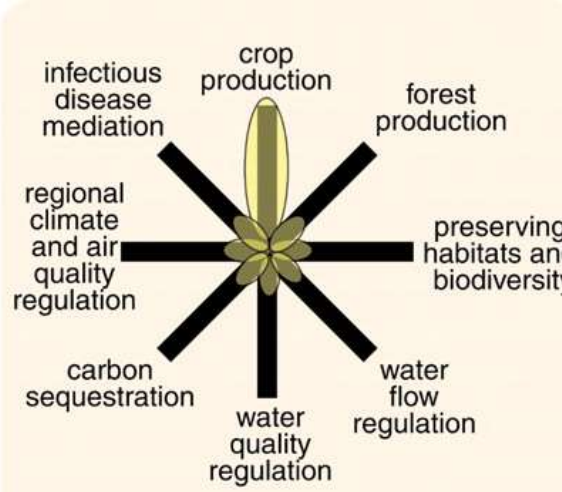
Impacts on/services from landscapes – «share vs. spare»




A diagram of a natural ecosystem represented as a flower with eight petals. Each petal is connected to a specific ecosystem service by a thick black line. The services are: crop production (top), forest production (top-right), preserving habitats and biodiversity (right), water flow regulation (bottom-right), water quality regulation (bottom), carbon sequestration (bottom-left), regional climate and air quality regulation (left), and infectious disease mediation (top-left).



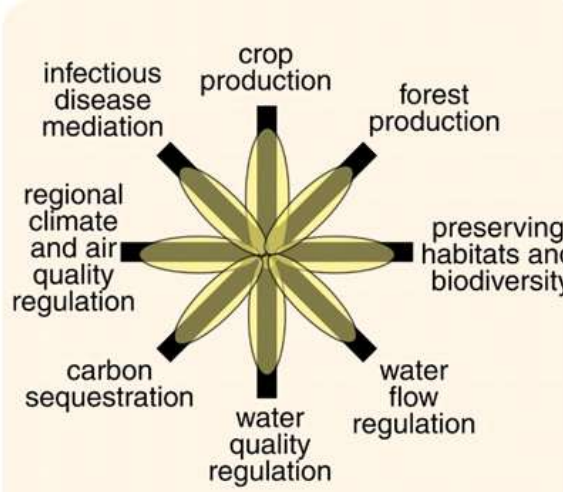
natural ecosystem




A diagram of intensive cropland represented as a flower with eight petals. Each petal is connected to a specific ecosystem service by a thick black line. The services are: crop production (top), forest production (top-right), preserving habitats and biodiversity (right), water flow regulation (bottom-right), water quality regulation (bottom), carbon sequestration (bottom-left), regional climate and air quality regulation (left), and infectious disease mediation (top-left).



intensive cropland



A diagram of cropland with restored ecosystem services represented as a flower with eight petals. Each petal is connected to a specific ecosystem service by a thick black line. The services are: crop production (top), forest production (top-right), preserving habitats and biodiversity (right), water flow regulation (bottom-right), water quality regulation (bottom), carbon sequestration (bottom-left), regional climate and air quality regulation (left), and infectious disease mediation (top-left).



cropland with restored ecosystem services

Optimal cropland distribution

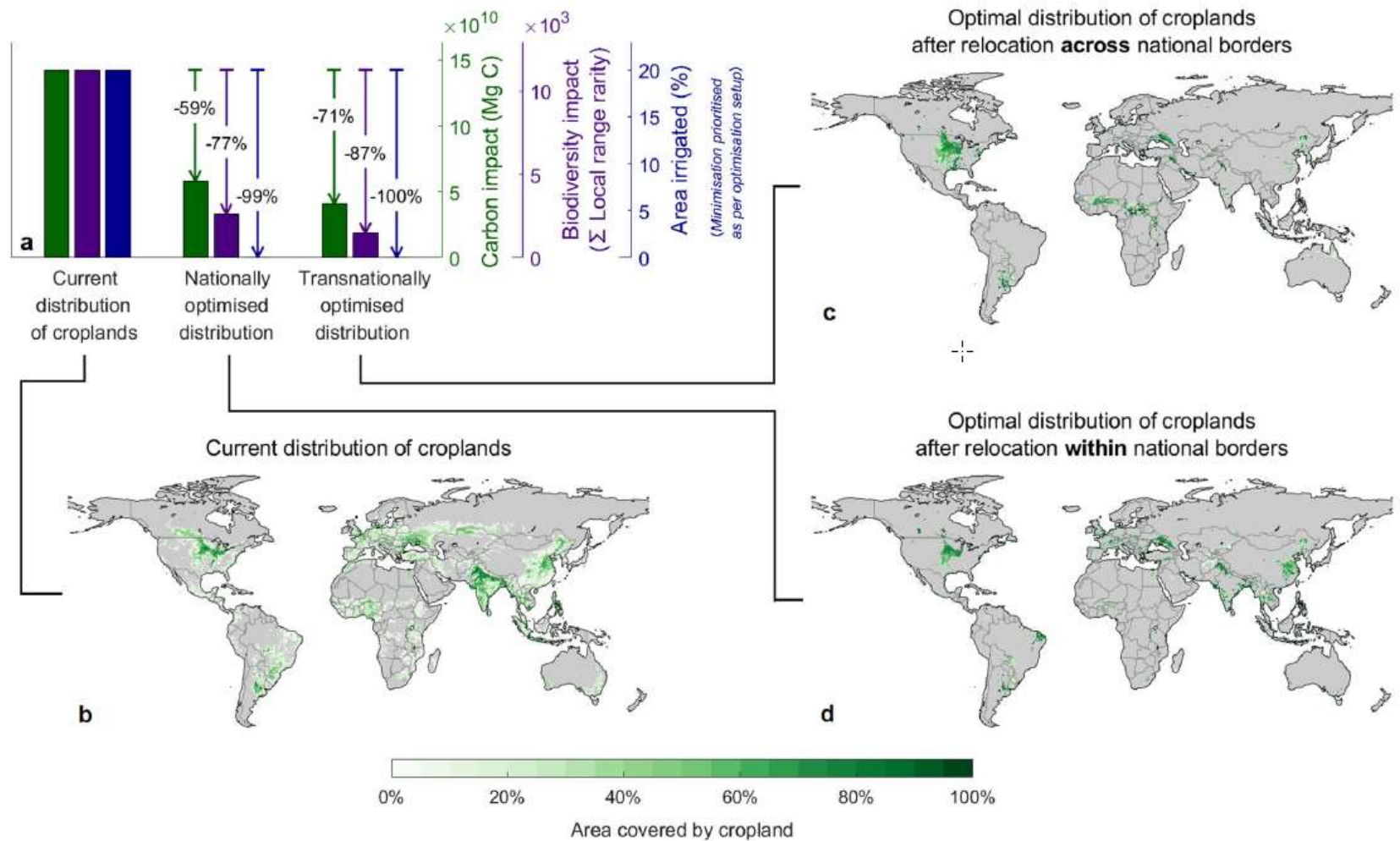
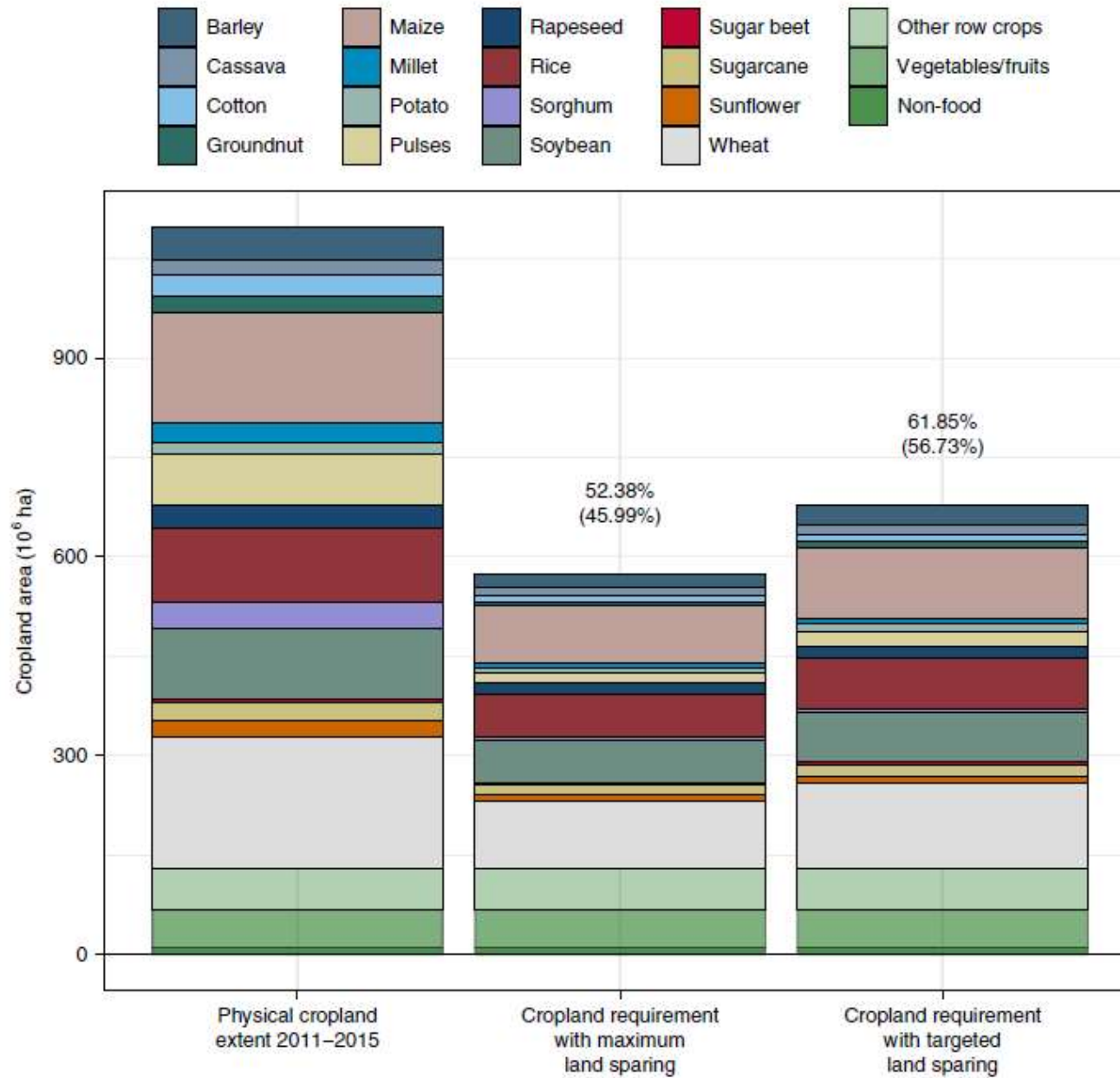


Fig. 1 Current and environmentally optimal distributions of global croplands. The estimated reduction potentials in **a** are based on an optimal trade-off between carbon and biodiversity impacts (see the “Methods” section). Potential yield data used here are based on current climatic conditions and assume high-input crop management and rainfed water supply, so that relocated areas are, by design of the approach, not irrigated. The global production levels of individual crops for optimally distributed areas are identical to current levels; in the scenario of national relocation, this is additionally the case for national production levels. For visualisation purposes, in **b-d**, the 25 crops were grouped together; maps of the optimal distribution of individual crops for across- and within-border relocation are shown in Supplementary Movie 1.

Optimal cropland distribution



Conclusions

- Business as usual is no option for future food systems – but changing to agroecology on the production side without any other changes is neither.
- Making the food system smaller is the key leverage point for achieving sustainable food systems building on agroecology;

making food systems smaller provides the room to produce less intensively with lower yields without compromising food security.
- Sustainable agriculture cannot be addressed without talking about consumption;

we need to adopt a food systems perspective to utilize the sustainability potential of NBS/agroecology.
- Avoid ideological approaches – non-NBS may also play their role.

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