SYNERGIES AND CONFLICTS BETWEEN MULTIPLE SUSTAINABILITY GOALS

MASTER'S THESIS PRESENTATION – JAN STEINHAUSER

SUPERVISED BY

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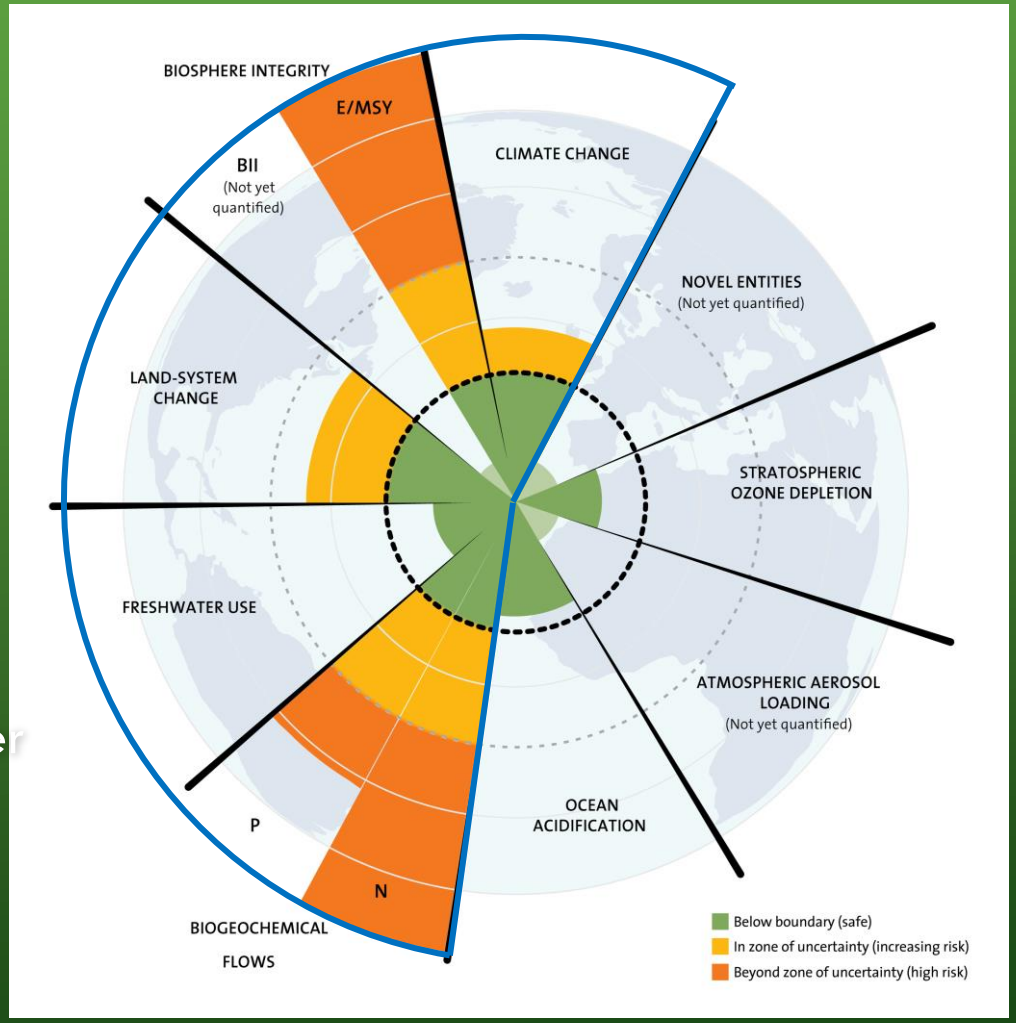
How strong are synergies and conflicts between different planetary impacts of land use?

- Created an agricultural sector model
- Estimated 8 planetary impact indicators in 6 different scenarios
- Compared scenario impacts to find impact interactions

PLANETARY BOUNDARIES

- „Safe operating space for humanity“ (Rockström et al., 2009)
- Critical Earth systems at risk of tipping into rapid change towards new stable states – both detrimental to human development and wellbeing
- Five boundaries considered: climate change, biosphere integrity, land-system change, freshwater use, biogeochemical flows



Rockström et al. (2009)

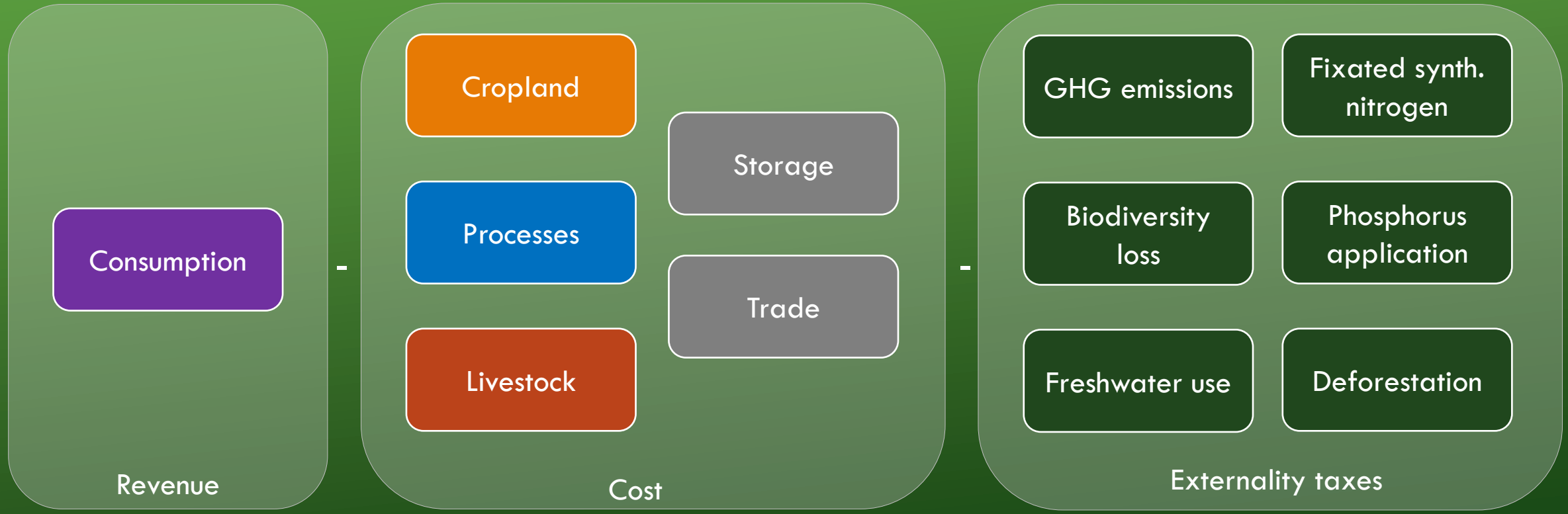
PLANETARY IMPACTS

	Rockström et al. (2009)	Model
Climate Change	Atmospheric CO_2 (ppm), radiative forcing	Net GHG emissions (CO_2eq)
Biosphere Integrity	Extinction rate	Loss of ecosystem quality
Land-system change	Share of cropland	Cropland, deforestation, afforestation
Freshwater use	Consumption of water	Consumption of water
Biogeochemical flows	Anthropogenic nitrogen fixation	Anthropogenic nitrogen fixation
	Anthropogenic phosphorus input into ocean	Anthropogenic phosphorus application

MODEL + DATA

- 6 taxed externalities, 1 per scenario
- Global scale (28 EU countries + 5 rest of the world regions)
- 2015–2050 (5-year steps)
- 34 raw and processed crop and livestock products
- 5 management types
  - conventional, organic, extensive (permaculture)
  - Rainfed, irrigated
- Data: Primarily FAOSTAT + IIASA SSP

MODEL STRUCTURE – OBJECTIVE



MODEL STRUCTURE – OBJECTIVE

Revenue

Crop

Livestock

$$\max W = \sum_{t,r,p} \left(z_{r,p} \cdot Q_{t,r,p}\right) - \sum_{t,r,c,m} \left(c^{c}_{r,c} \cdot c^{m}_{m} \cdot C_{t,r,c,m}\right) - \sum_{t,r,l} \left(c^{l}_{r,l} \cdot L_{t,r,l}\right)$$

Processes

$$- \sum_{t,r,q} \left(c^{q}_{r,q} \cdot P_{t,r,q}\right)$$

$$- \sum_{t,r',r,p} \left(z_{r,p} \cdot 0.15 \cdot T_{t,r',r,p}\right)$$

Trade

$$- \sum_{t,r,p} \left(z_{r,p} \cdot \left(0.01 \cdot \left(S^{+}_{t,r,p} + S^{-}_{t,r,p}\right) + 0.03 \cdot S^{L}_{t,r,p}\right)\right)$$

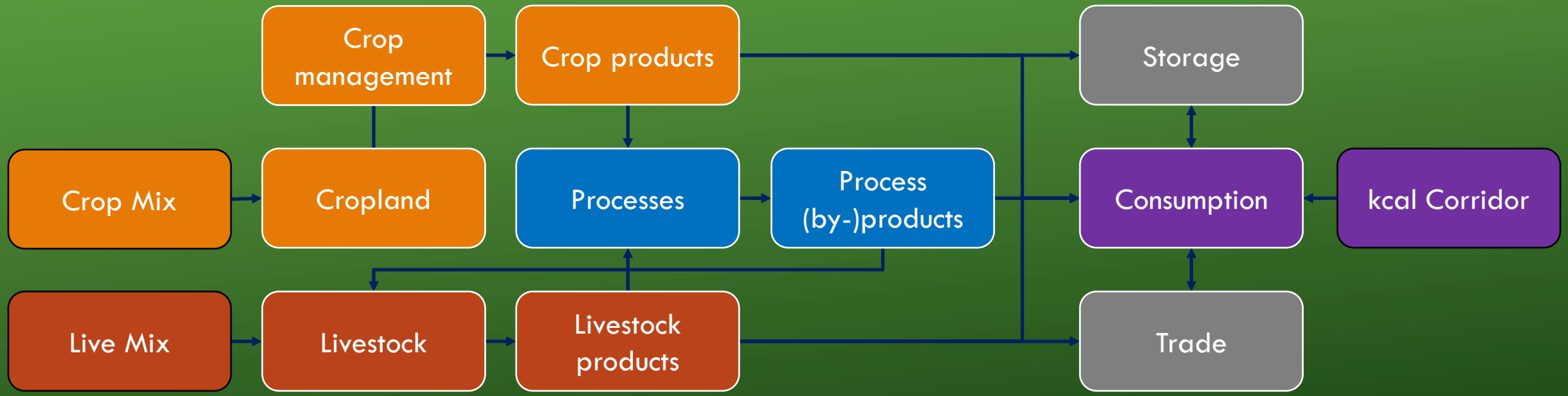
Storage

$$- \sum_{t,r,e} \left(t_e \cdot E_{t,r,e}\right)$$

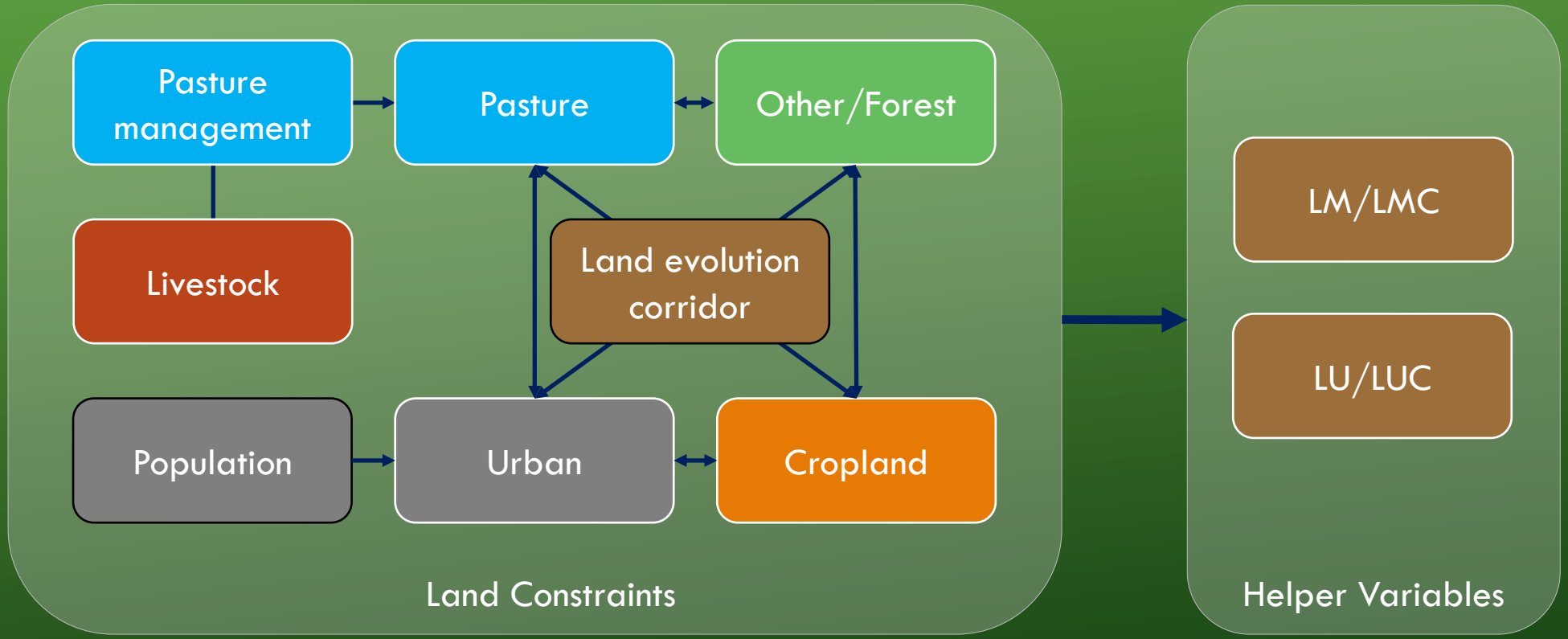
Externalities

Capitals: variables
Lower case: parameters
Subscript: sets

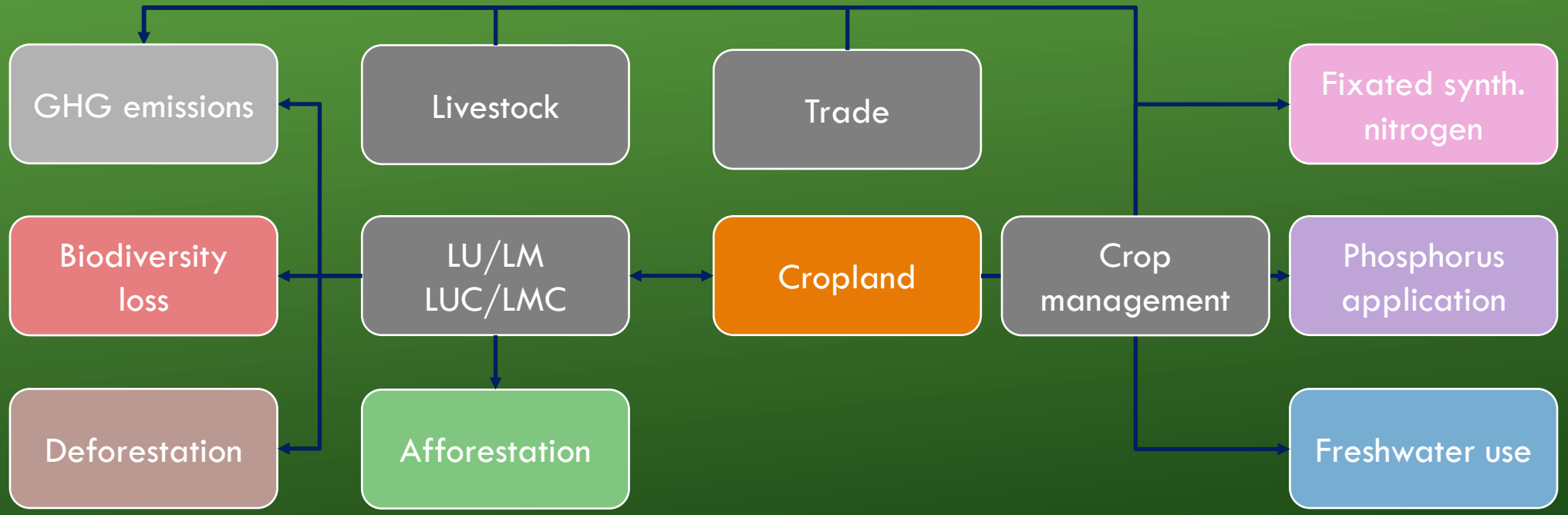
MODEL STRUCTURE – PRODUCT BALANCE



MODEL STRUCTURE – LAND USE

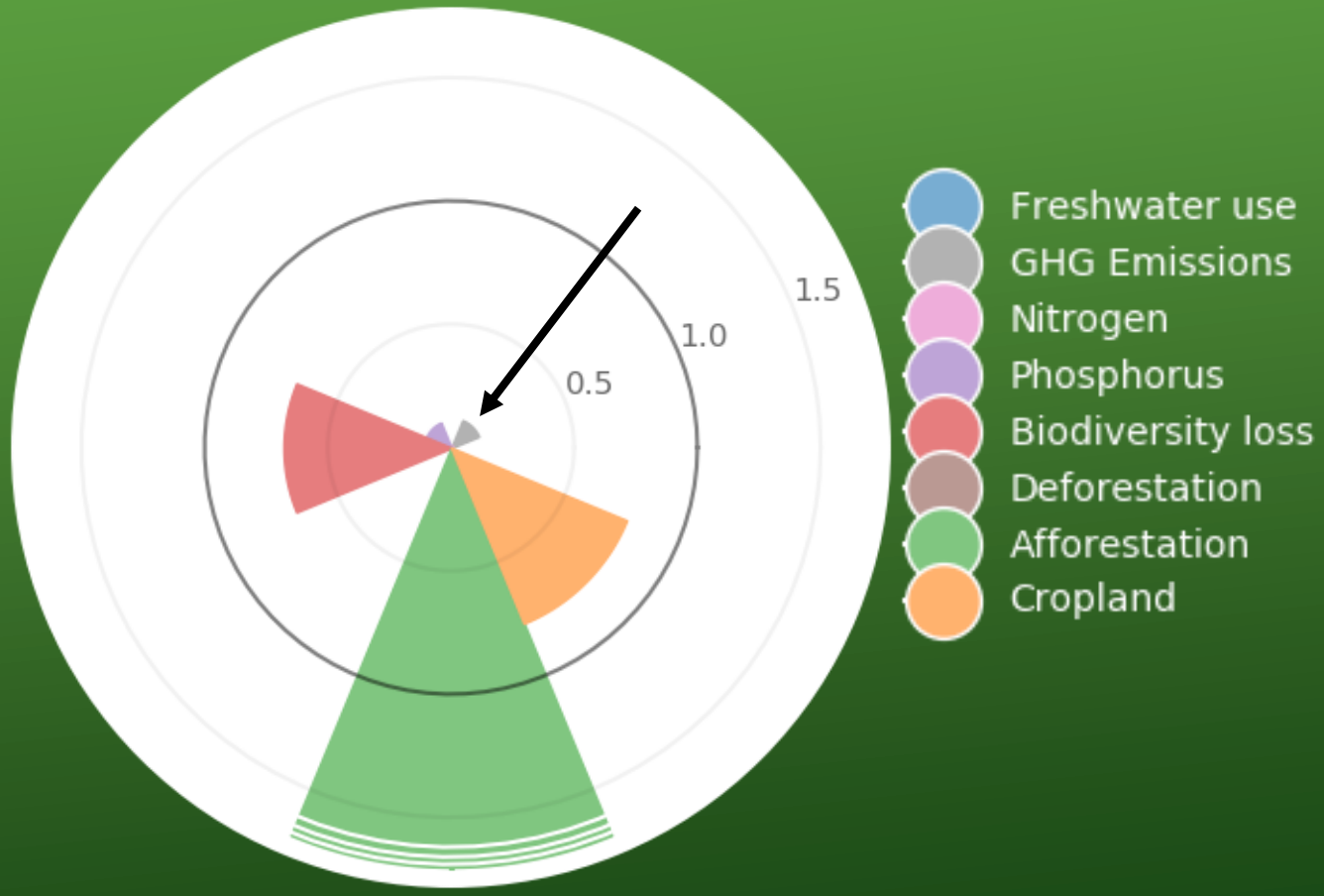


MODEL STRUCTURE – INDICATORS



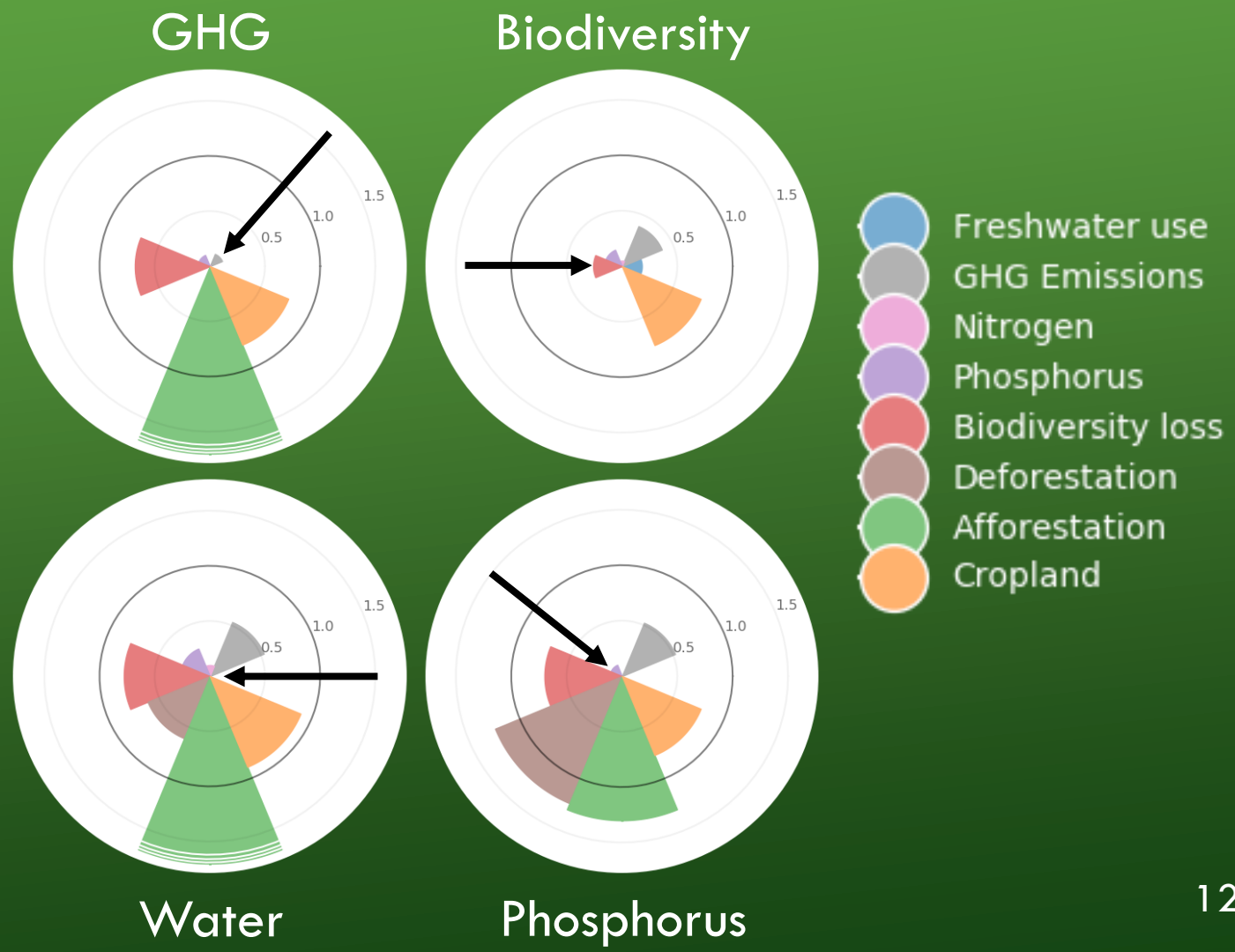
RESULTS – GHG

- 6 Scenarios
- 1 Externality taxed and forced to unknown minimum
- 8 Planetary Impact indicators compared to normalized base scenario (1.0 ring)
- Comparison of cross-behavior (B reacting to A-tax, A reacting to B-tax)



RESULTS – STRONG SYNERGIES

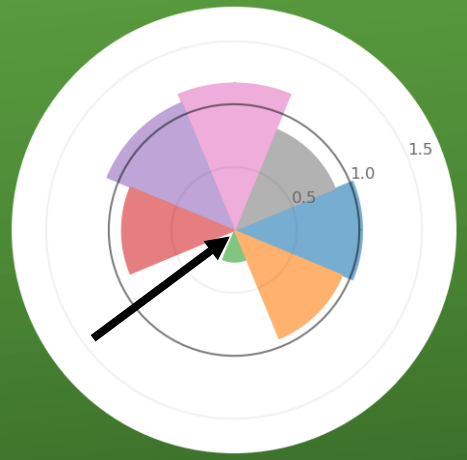
- Strong synergy (relative change > 20%) between GHG, biodiversity, water, and phosphorus
- Mixed relation with land-system change
- One-sided synergy with nitrogen

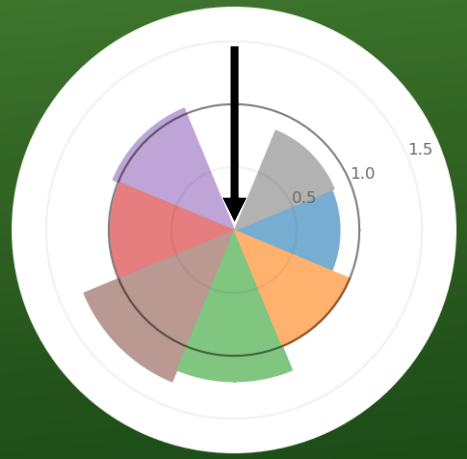


RESULTS – NO OR WEAK SYNERGIES

- Mostly weak relations in deforestation and nitrogen scenario (relative change < 20%)
- Despite 90-130% relative change of nitrogen indicator in other scenarios

Deforestation

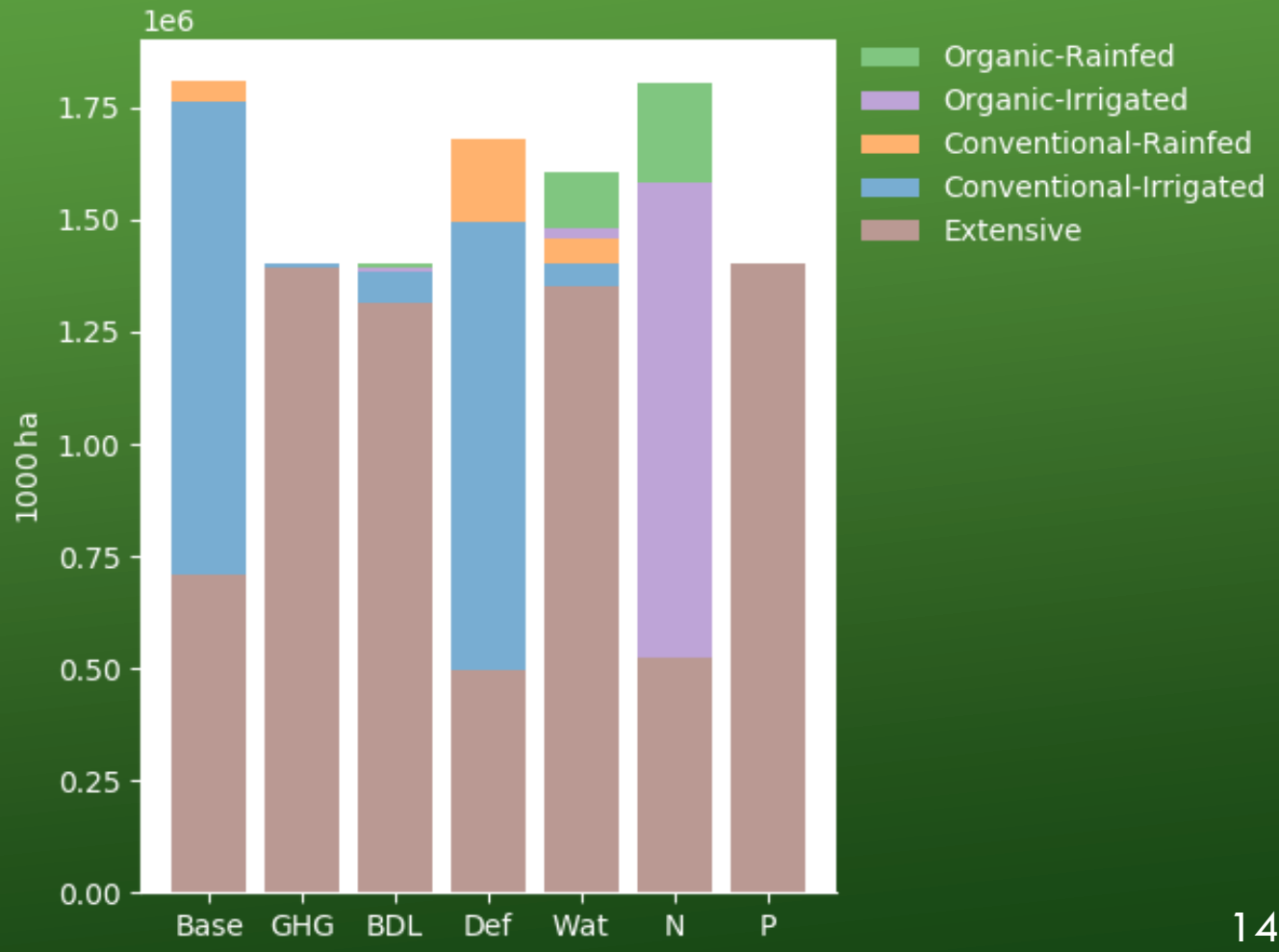




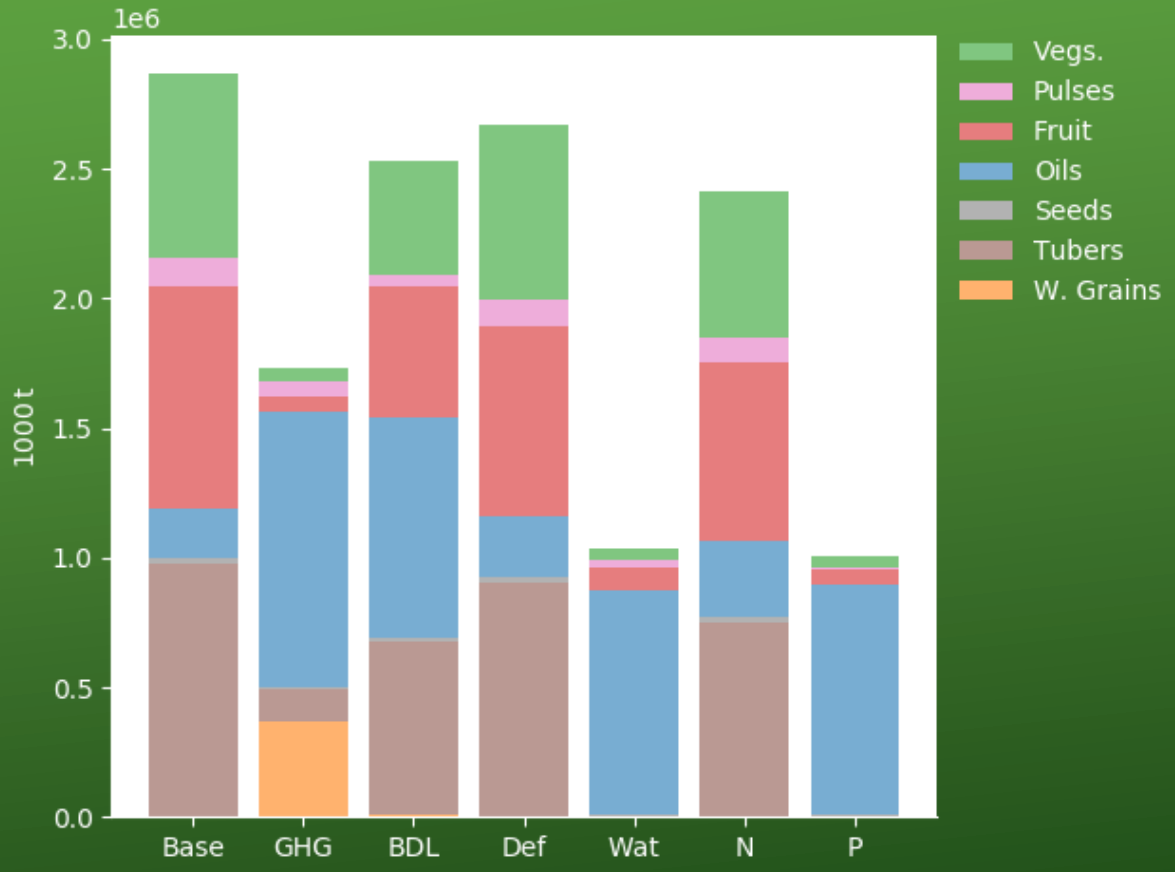
Nitrogen

RESULTS – CROP MANAGEMENT

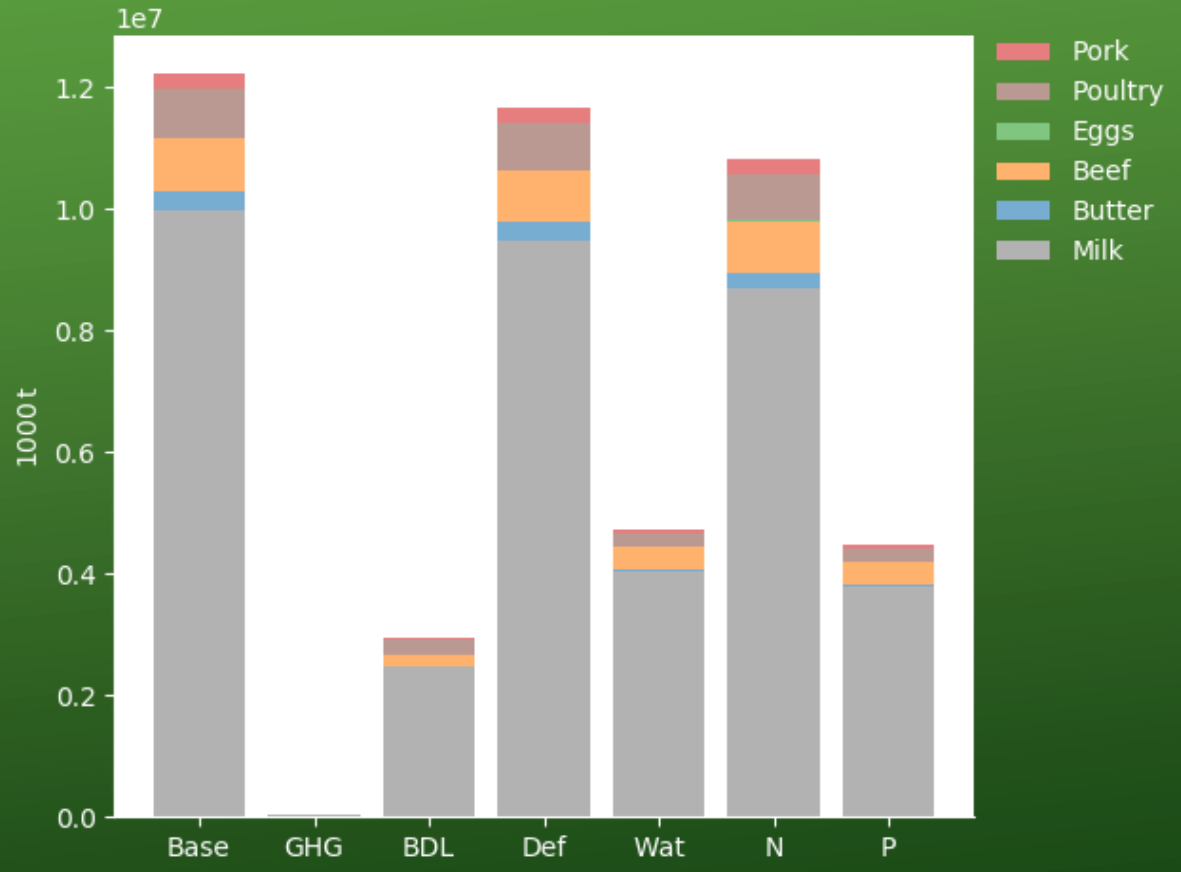
- Crop reduction + shift to extensive management in synergetic scenarios
- Extensive parameters:
  - GHG: 0-0.19
  - BDL: 0.65
  - Water: 0
  - N: 0
  - P: 0.1



RESULTS – CONSUMPTION



Crop products



Livestock products

How strong are synergies and conflicts between different planetary impacts of land use?

- Strong synergies between GHG emissions, biodiversity loss, water use, and phosphorus application
- Mixed behavior for land-system change and nitrogen fixation
- Due to strong shift to extensive farming and unrealistic consumption mix
- Future work: Investigate and correct the underlying assumptions

Thank you!