

Original Titel

Assessing current livestock-induced biomass flows in Europe's NUTS2 regions for evaluating feasible food option spaces in 2050

How to address tradeoffs and synergies in livestock farming systems?

Starting with livestock induced biomasse flows and feasible food systems in 2050 and ending with choices at the farm level

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Livestock's pivotal role in the global biomass metabolism

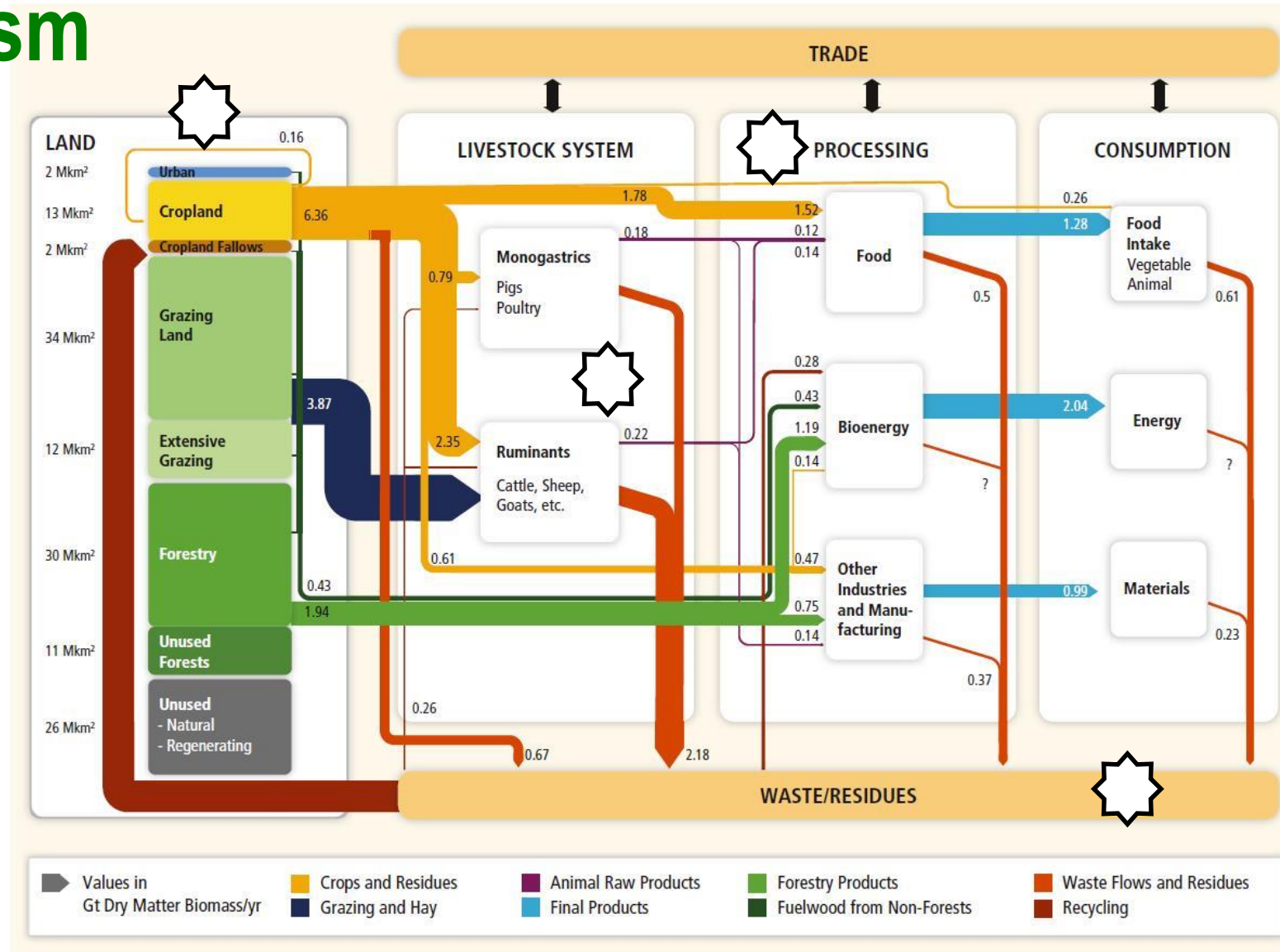


Competing land uses

Livestock mix (rumi vs. Mono)

Feed basis (grain/roughage)

Environmental dimensions (GHG mitigation vs. N-use efficiency)



Farm LEVEL

Farmer face different trade-offs/synergies

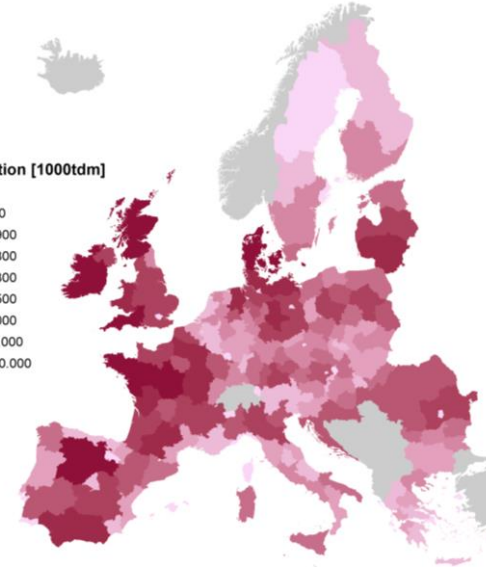
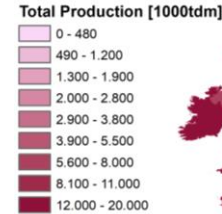
Smith et al., 2014, based on Krausmann et al., 2008, Wirsenius 2000, 2003, Haberl et al., 2007, Sims et al., 2007, Kummu et al., 2012, Faostat

Europe's production system

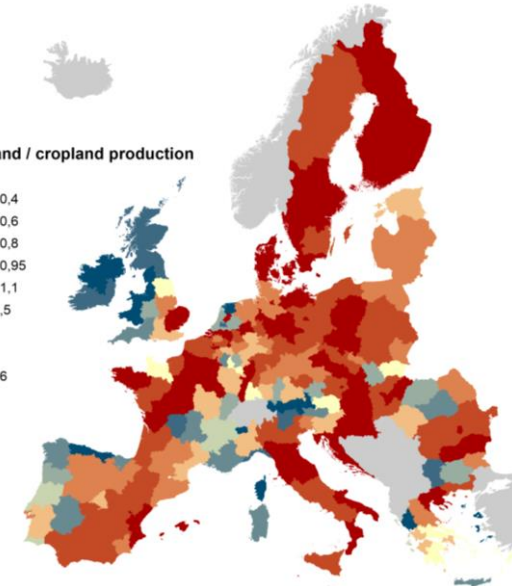
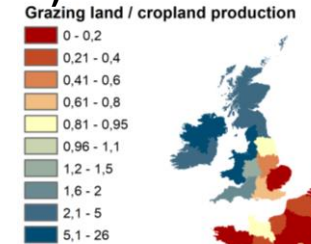
Total production on arable land and grazing land (a)

- high-producing regions: NW parts of France, central and Southern Spain, Denmark, and the UK and Ireland (a)
- In the majority of NUTS2 regions: share of biomass harvested from grazing land is smaller than cropland production (b)
- Cropland and grazing land productivity: c) Ober-&Niederbayern, Benelux d) UK, Ireland, Schleswig-Holstein, NL

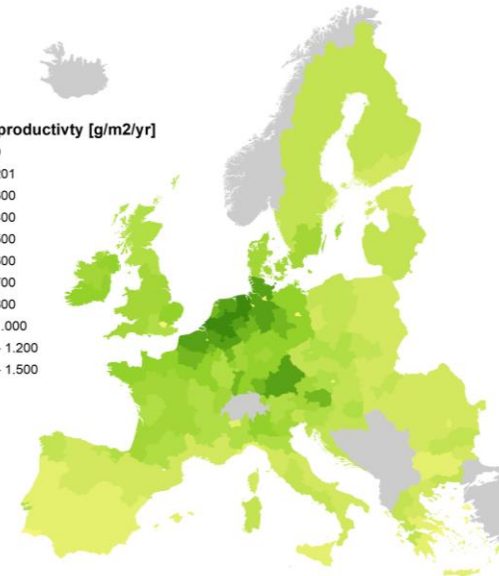
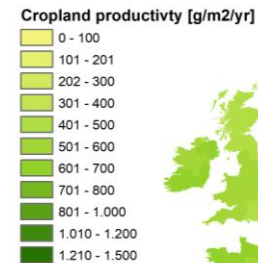
a)



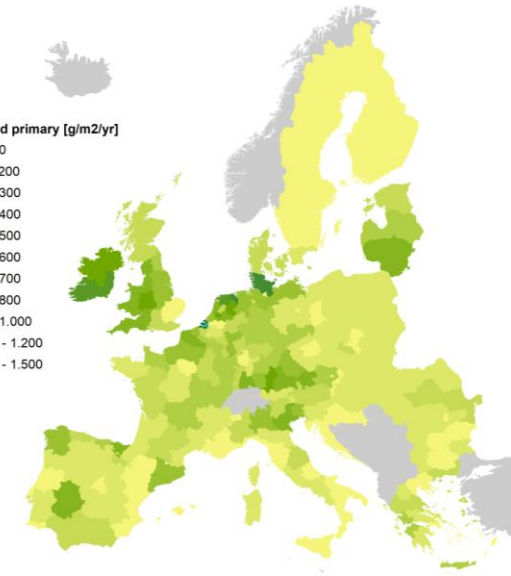
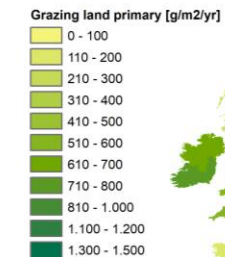
b)



c)



d)



The biophysical option space 2050 in a Zero-Deforestation World

Our: **BioBaM Modell** (biomass balance model)

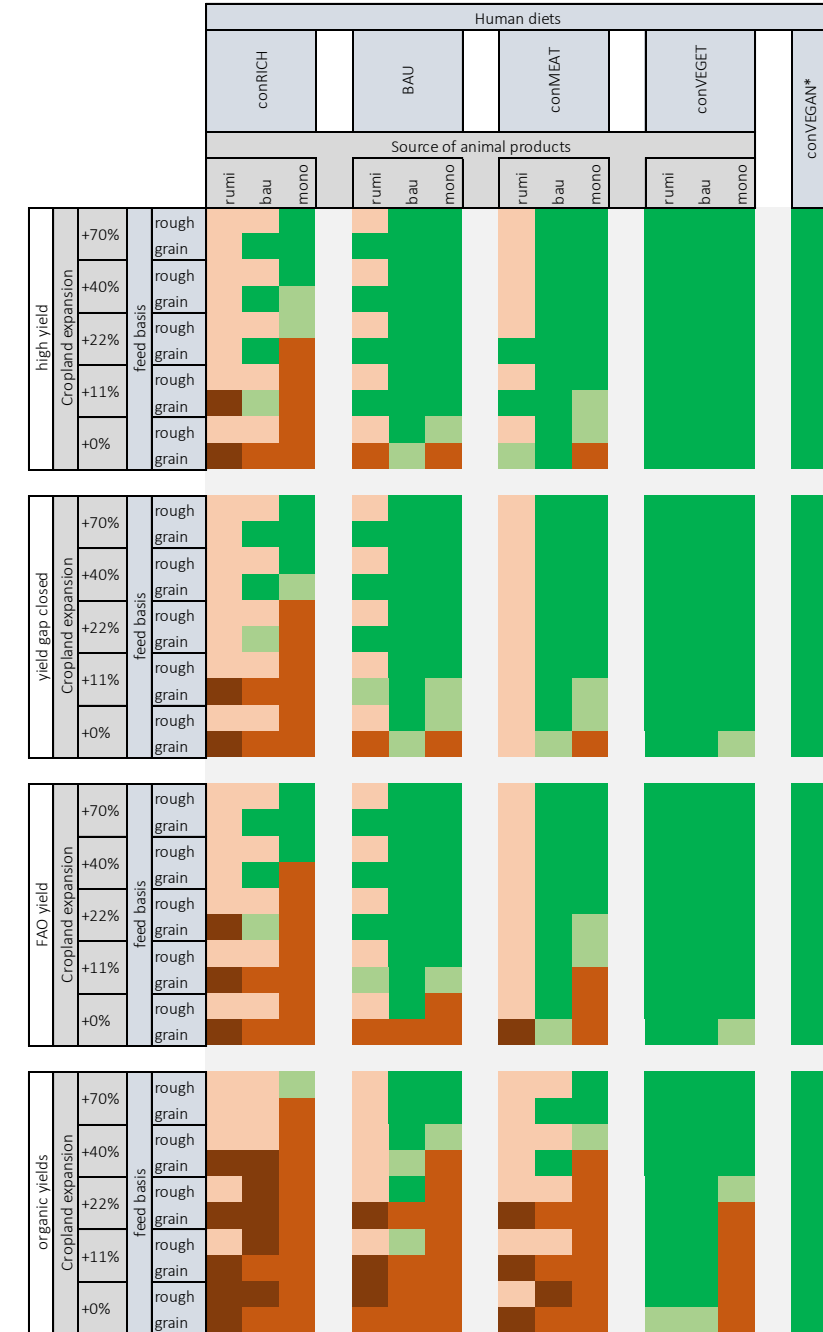
>> Objective: analyzing the biophysical dimension of trade-offs
with food security

Systematic variation of 5 crucial parameters:

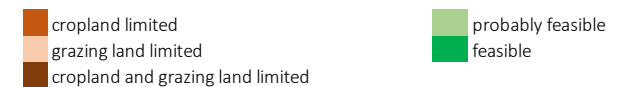
- 5 human diets.
- Within diets: 3 animal product compositions.
- 2 types of livestock feed.
- 4 crop yield projections.
- 5 assumptions of cropland expansion.

>> All combinations: 520 scenarios.

Of this: 317 scenarios feasible (“option space”)



Erb et al. 2016



Net-GHG emissions of the biophysical option space



[Gt CO₂e/2050]

		Human diets												conVEGAN*		
		conRICH			BAU			conMEAT			conVEGET					
		Source of animal products														
Crop yield	feed basis	rumi	bau	mono	rumi	bau	mono	rumi	bau	mono	rumi	bau	mono			
High yields	grain		10.2	-0.7		12.0	1.0	-4.9		6.9	-4.0		-4.2	-4.6	-6.4	10.6
			10.4	-0.2		12.0	1.6	-4.5		7.6	-3.8		-4.0	-4.4	-6.3	10.5
			10.2	-0.2		12.0	1.5	-4.6		7.5	-3.8		-4.1	-4.5	-6.3	10.6
						6.3	-1.9		8.2	-0.9		-2.4	-2.7	-4.1		-9.2
Yield gap closed	roughage			0.3		8.6	-4.3		10.9	-3.4		-0.1	-1.1	-6.1	10.6	
				1.2		8.7	-3.9		11.0	-3.2		0.1	-0.9	-5.9	10.5	
				1.9		8.8	-3.6		11.1	-2.8		0.3	-0.6	-5.5	10.2	
						8.8	-1.4			-0.3		3.0	1.5	-4.0		-9.2
FAO yields																
Organic yields																

Cells are colored according to traffic light system, positive values (i.e. emissions sources) are reddish, negative values (i.e. net-carbon sinks) in green.

- Trade-off: roughage based livestock systems are confronted with grazing land availability
- Trade-off: grain-feed livestock systems show lower GHGs compared to roughage systems in scenarios where enough grazing land is available, but put pressure on croplands with high GHG emissions
- Synergy between high yields and freeing-up land for C-sequestration > huge potential for GHG savings through vegetation regrowth (not afforestation)

Reference 2000: 6.3 Gt CO₂e

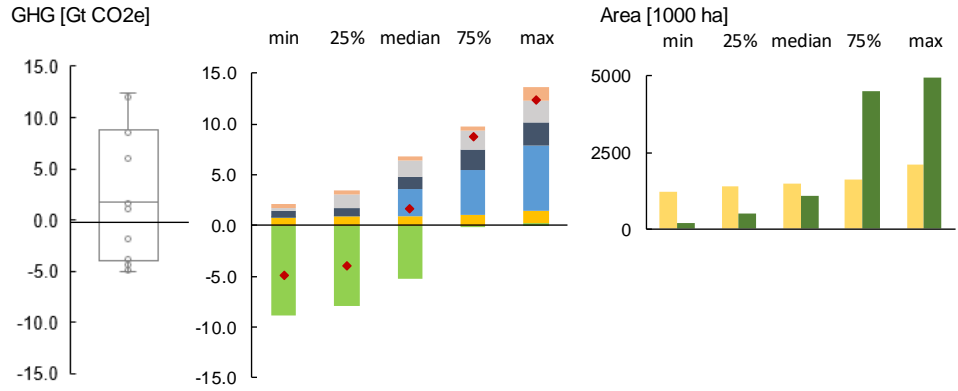
Theurl et al. in prep.

GHG from different agricultural stages in 2050

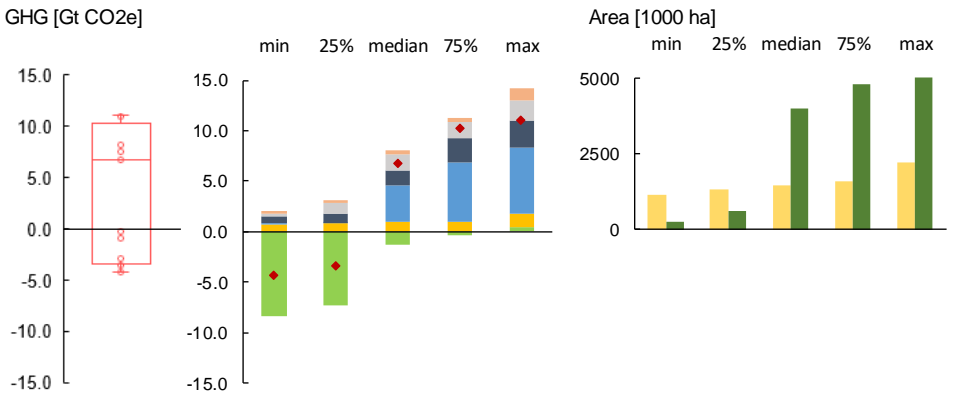


GHG emissions [Gt CO₂e yr⁻¹]

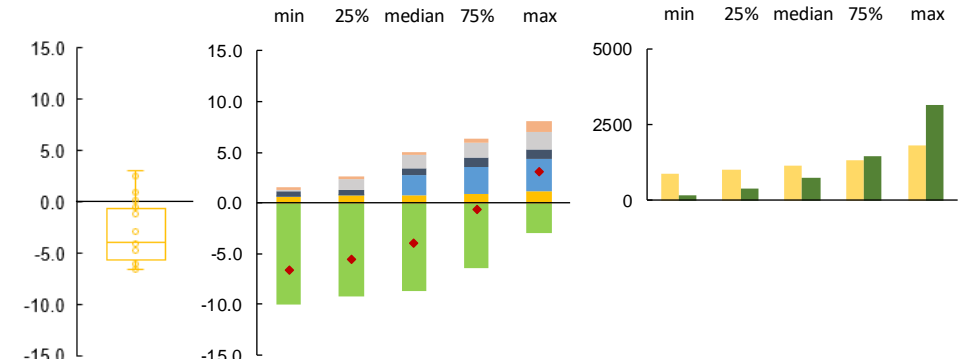
BAU



MEAT



GHG [Gt CO₂e]



- GHGs vary between option spaces
- Trade-offs result within each dietary pathway

- MEAT and BAU world: depending on type of livestock product > free areas!
- global convergence to MEAT diets can have negative emissions and contribute to reach climate targets due to vegetation regrowth
- >> guaranteed: free areas for vegetation regrowth only

- Actual used cropland
- Actual used grazing land

- residues, N-fixing crops
- external inputs (+application)
- livestock manure (management at)
- enteric fermentation
- paddy rice
- net C-stock changes
- GHG net-value

Agent-based model (ABM)

Our: SECLAND Modell

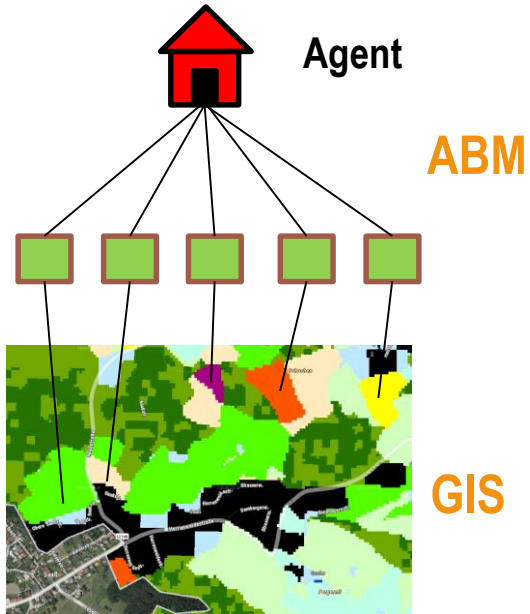
>> Objective: analyzing the socio-ecologic dimension of land use changes for future scenarios (SSPs and RCPs)

- The ABM focuses on individual agents (farms) for a study region (Eisenwurzen AT)

- Agents represent different farming types (crop, processing, livestock) and farming styles (value systems: e.g. idealist, traditionalist)

- 3 Scenarios:

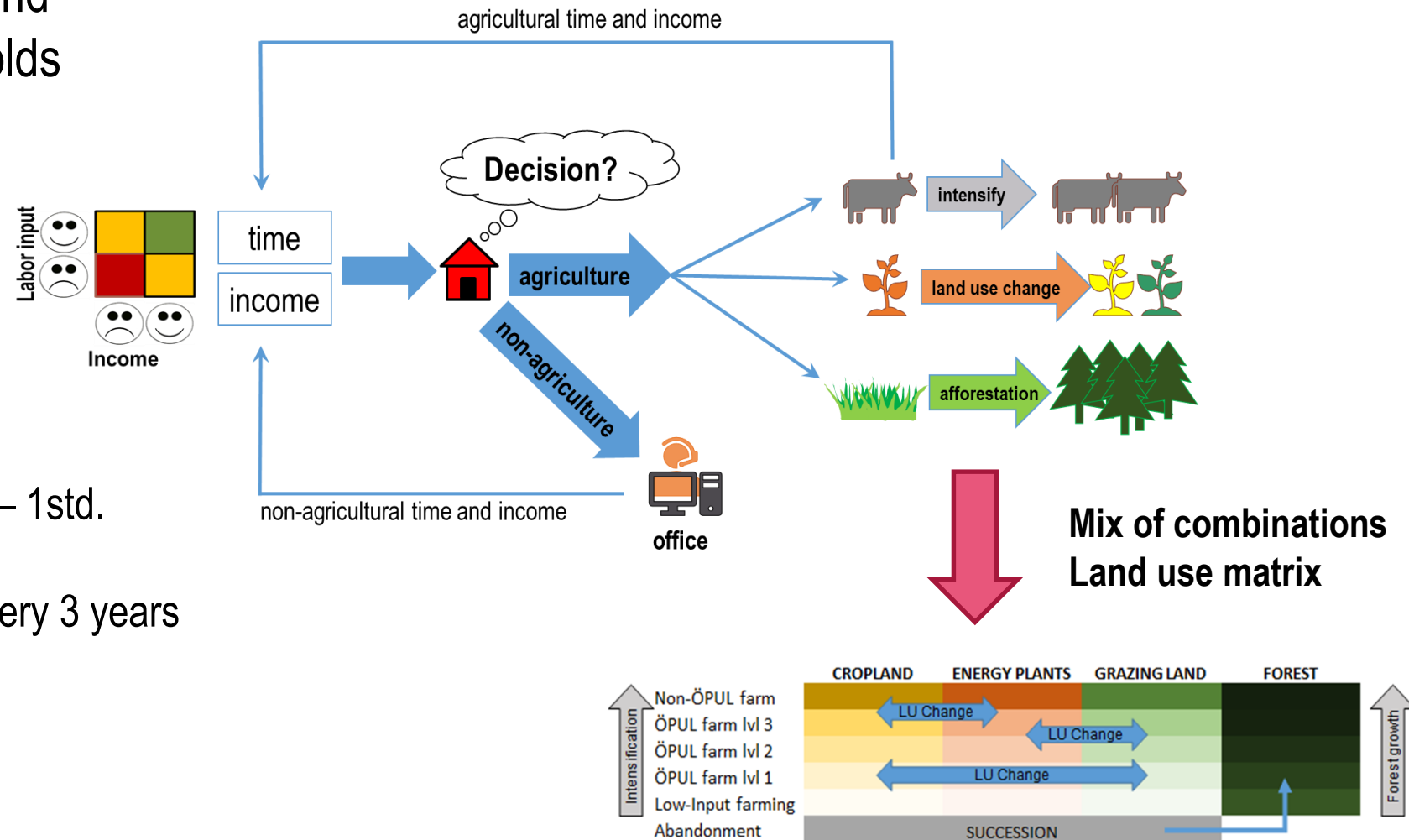
- BAU (business as usual)
- Sustainability (no fossil fuels, subsidies for lowinput production and energyplants)
- Globalisation (strong globalisation, dependence on fossil fuels, subsidies decline to 0)



Decision making in the SECLAND model

- Farms seek „happiness“ and want to stay within thresholds for time use and income

- Baseline Assumptions:
 - ≤ 1800 hrs
 - $\geq 20'000$ € total income per year
 - \geq Agri.income per hour – 1std.

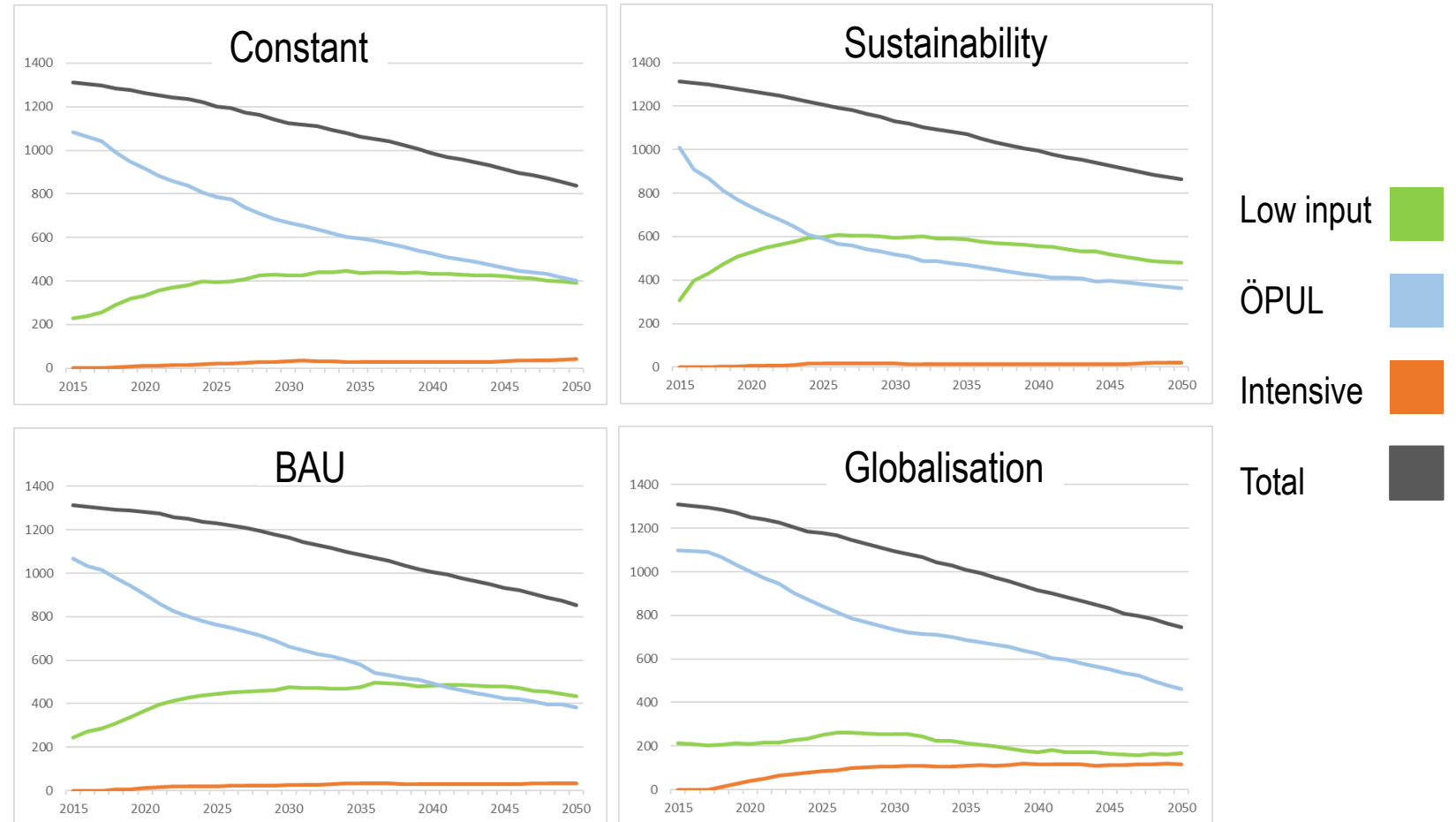


Active farms intensity trends until 2050 for the Eisenwurzen



[number of active farms]

- Reduction of active farms in all scenarios (-35% to -44%)
- Extensivisation vs. globalisation
- **Trade-off:** scenario vs. socio-demographic factors



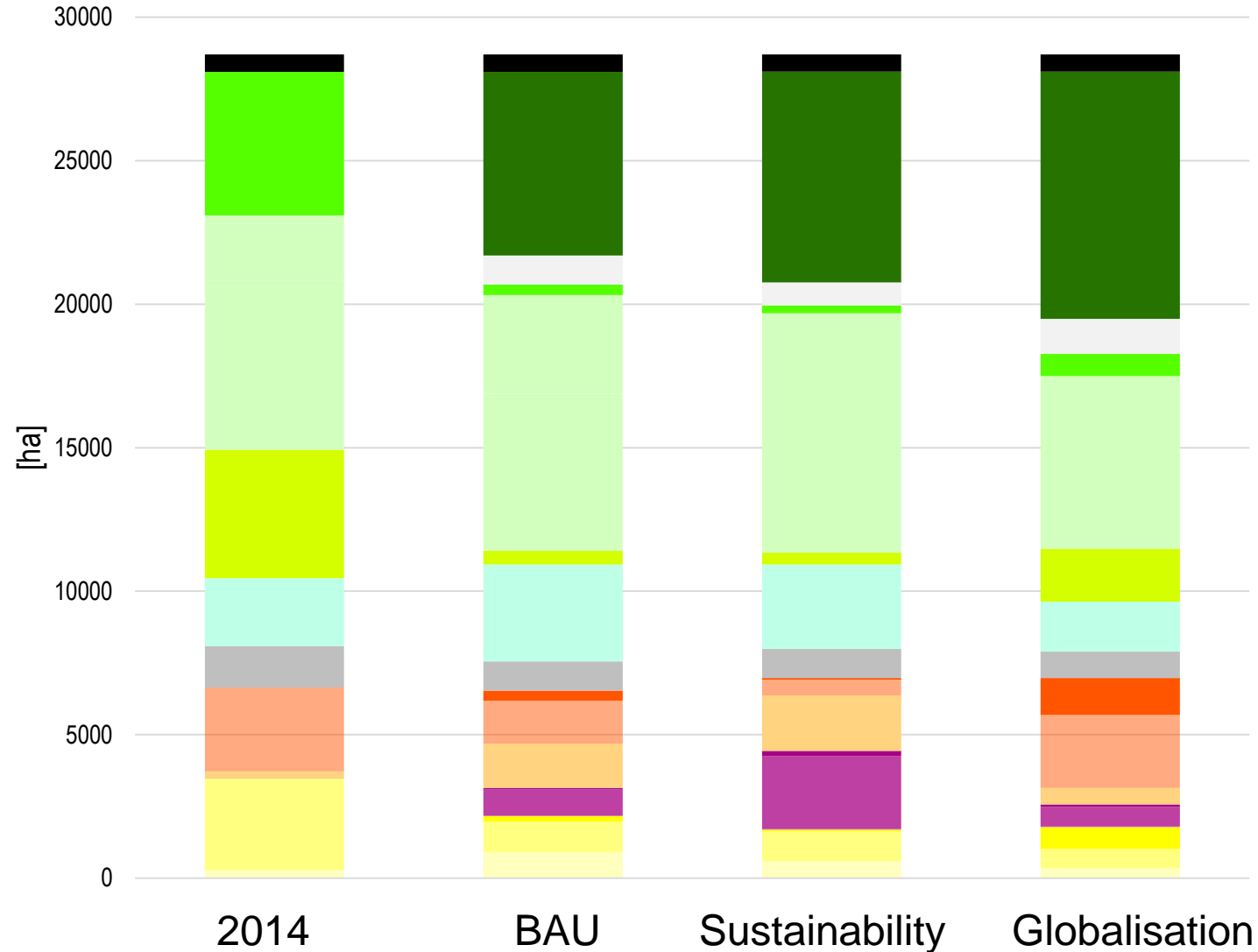
Land use shifts 2014 to 2050 in the Eisenwurzen



- Strong land use shifts
 - grassland to forest
 - max. -47% grassland
 - cropland to energyplants
 - max. -40% Cropland

- Intensity shifts
 - intensive to extensive

- Trade-off:
 - Food vs. fuel



Land-use maps for the northern Eisenwurzen in 2050

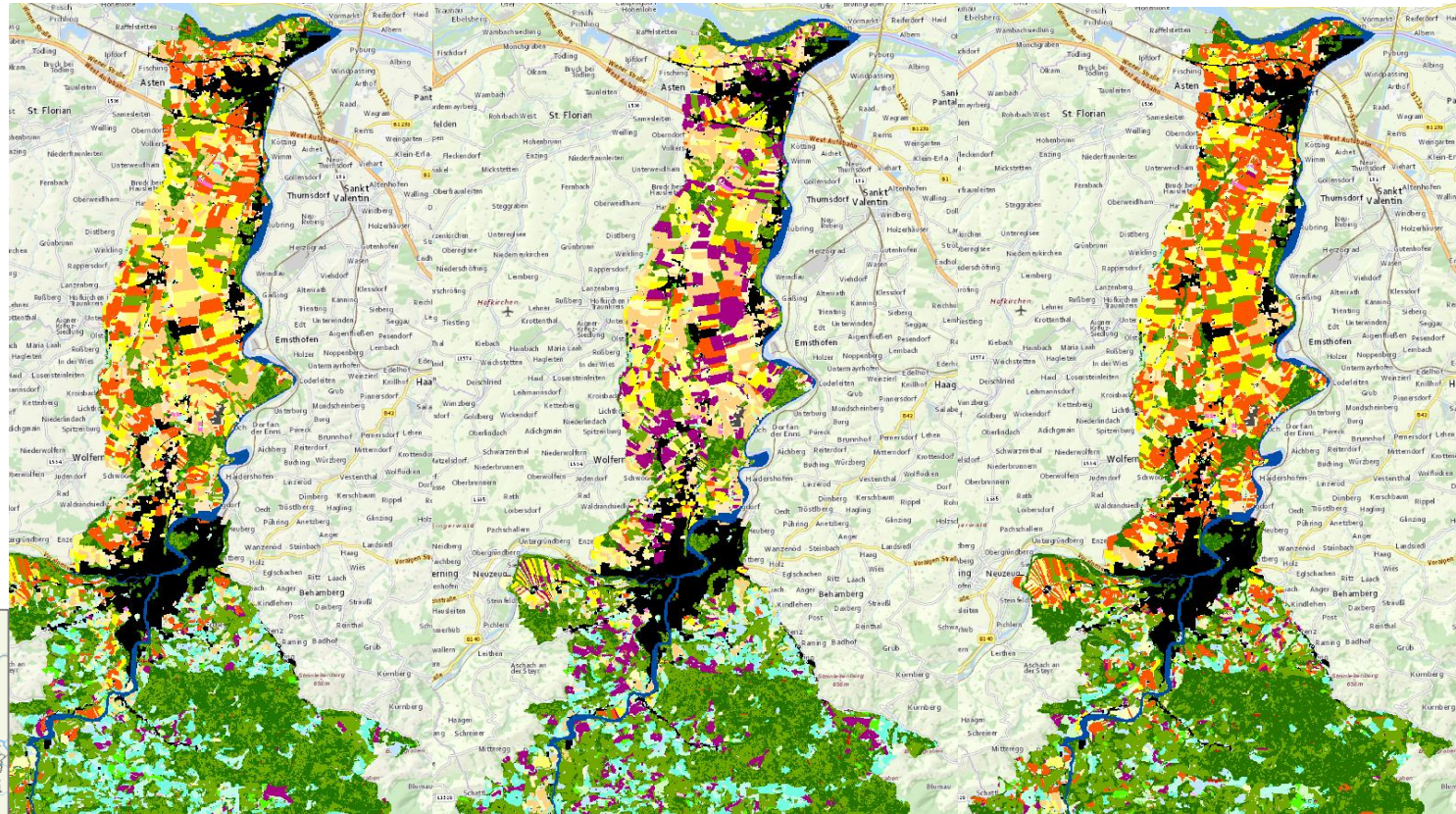


BAU

Sustainability

Globalization

- Conifer forest
- Broad-leaved forest
- Felling area
- Scrub and Shrub
- Scrub and Shrub seasonal use
- Misc. arable land
- Non-cereal crop
- Energy crop
- Non-cereals low-input
- Cereal
- Cereal low-input
- Cropland fallow
- Orchard / fruit plantation
- Lake
- River
- Road
- Built-up area
- Extractive industrial site
- Intensive pasture
- Intensive meadow
- Intensive pasture sown in
- Extensive pasture
- Extensive pasture NP
- Extensive meadow
- Extensive meadow fallow
- Alpine grassland
- Wetland
- Dry grassland
- Rock and scree



Source: <https://www.gisualize.org/lubio/>

- Scenario Trade-offs
extensive production vs. energy plants vs. intensive cropland and forest

Conclusion & outlook

- We showed different perspectives on analyzing trade-offs and synergies
- Important to analyze supply and demand to complement the picture
- Exploring future option spaces top-down and bottom-up
 - Analyze scenarios from different angles:
 - Low-in/out vs. High-in/out
- our assessment here serves as a starting point which allows to model the territorial impacts of e.g. the implementation of livestock-related innovations and to assess limitations in land availability and emissions at the European level.

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