Professur für Ökologischen Landbau

中德农业中心 Deutsch-Chinesisches AGRARZENTRUM (DCZ)

With support from Federal Ministry of Food and Agriculture by decision of the German Bundestag

JLU NEUE WEGE. SEIT 1607.

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

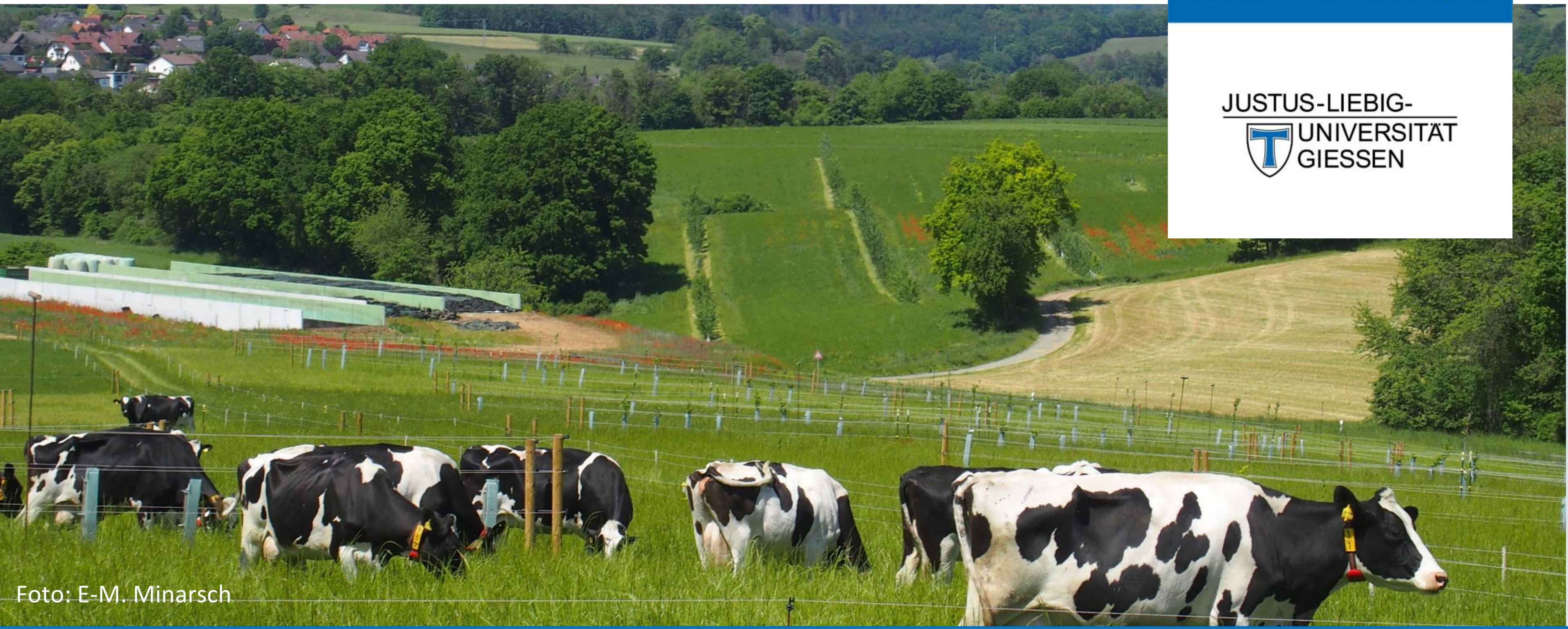
Foto: E-M. Minarsch

Eco-functional intensification and circularity through organic soil-crop-livestock systems

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Where we are


DENMARK
North Sea
Baltic Sea
Hamburg
Bremen
Berlin
POLAND
NETHERLANDS
GERMANY
Giessen
Cologne
Dresden
BELGIUM
Gladbacherhof
Frankfurt
LUXEMBOURG
CZECH REPUBLIC
Nürnberg
Stuttgart
FRANCE
Munich
AUSTRIA
SWITZERLAND
LIECHTENSTEIN

High productivity gains in German agriculture…

+283%

Ernteertrag für 1 ha Weizen (Winterweizen einschl. Dinkel und Einkorn)

1950:*	*2.580 kg*
1980:*	*4.890 kg*
Durchschnitt 2017–19:	*7.303 kg*

Ernteertrag für 1 ha Kartoffeln

1950:*	*24.490 kg*
1980:*	*25.940 kg*
Durchschnitt 2017–19:	*40.400 kg*

+333%

Milchleistung pro Kuh und Jahr

1950:*	*2.480 kg*
1980:*	*4.538 kg*
2019:	*8.250 kg*

Legeleistung einer Henne pro Jahr

1950:*	*120 Eier*
1980:*	*242 Eier*
2019:	*298 Eier*

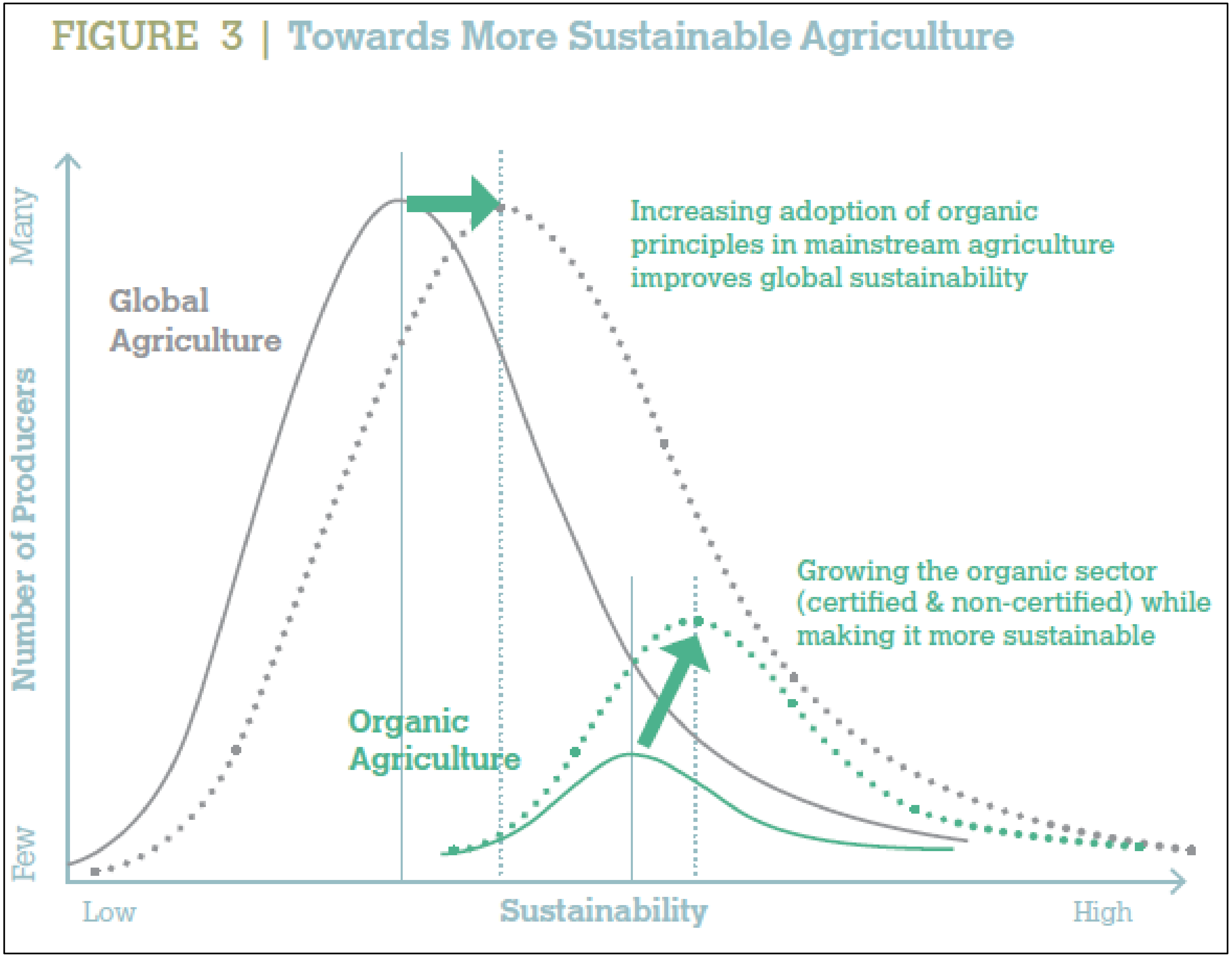
** früheres Bundesgebiet*

BMEL (2020) Landwirtschaft verstehen

…but at the expenses at high external costs! (ZKL, 2021):

(21bn € < 90bn €)

Organic farming as role model for agricultural tranformations



Eyhorn et al., Nature Sustainability, 2019

Eco-functional intensification and circularity through organic soil-crop-livestock systems

1. Success story organic farming

2. „Standard" (organic) farming is not enough!

3. Eco-functional intensification and circularity through improved organic <u>cropping</u> systems

4. The potential of integrated animal-plant agricultural systems: developing agriculture and food within planetary boundaries

1. **Success story organic farming**

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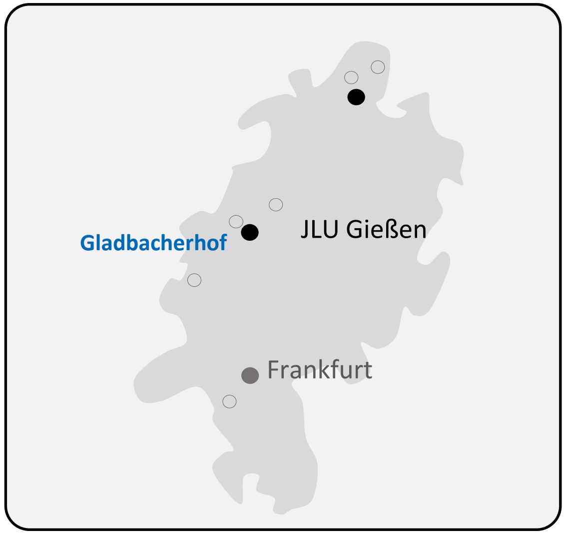
Research Farm Gladbacherhof

- Agricultural Teaching and Research Facility for Organic Farming at the JLU Gießen (since 1990)

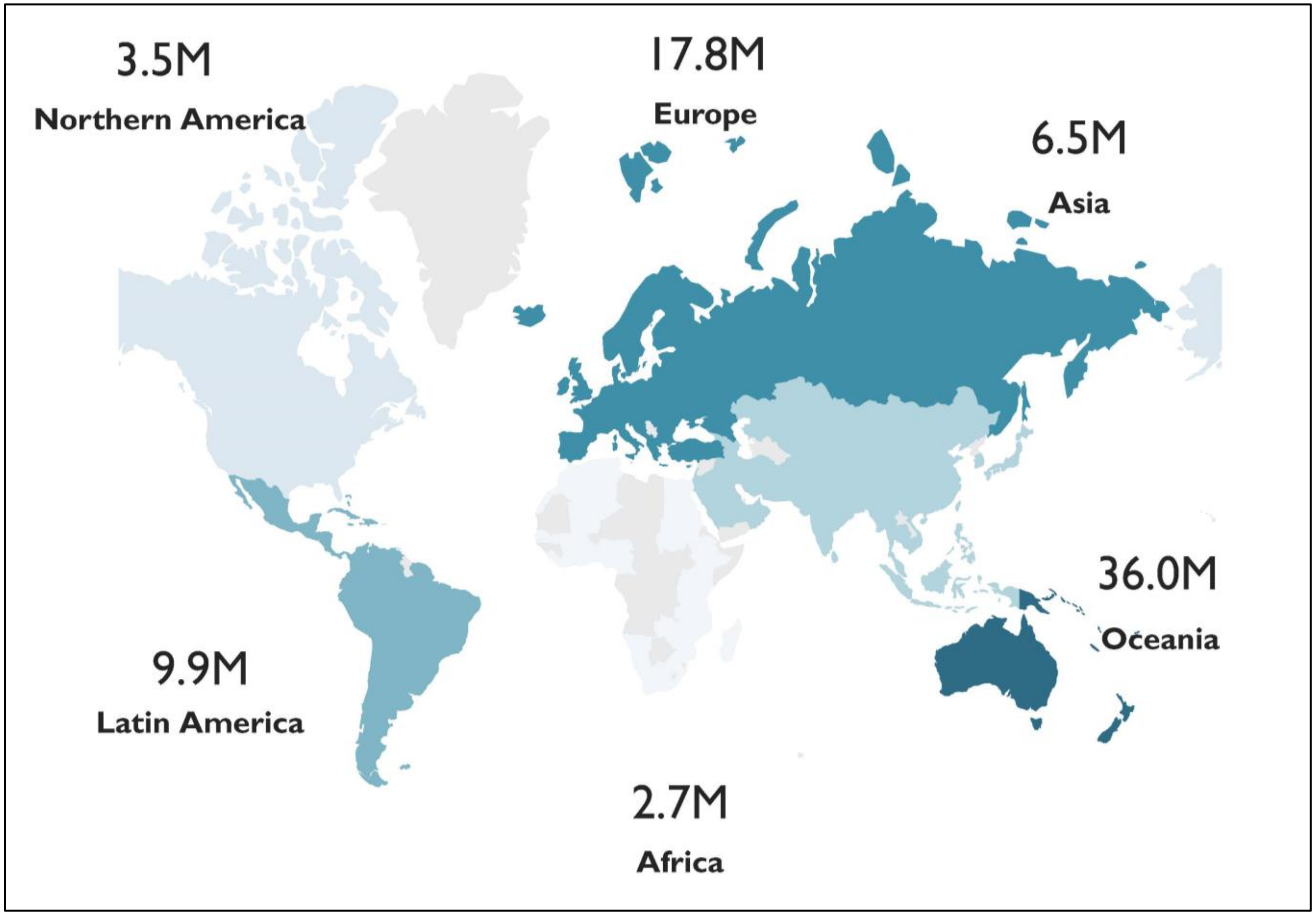
- Mixed-use farm in a mid-mountainous area
- (9.5°C average annual temperature, 655 mm annual precipitation)
- 110 hectares of arable land, 77 hectares of permanent grassland
- 8-year crop rotation with maize cultivation



Operation Focus Areas:

- Dairy cattle (100 Holstein-Friesian cows with 8,500 kg of milk per cow per year), breeding goal: lifetime performance
- Seed and plant material production
- Laying hens (mobile chicken coops)
- direct sales to customers

Global: Organic farming area

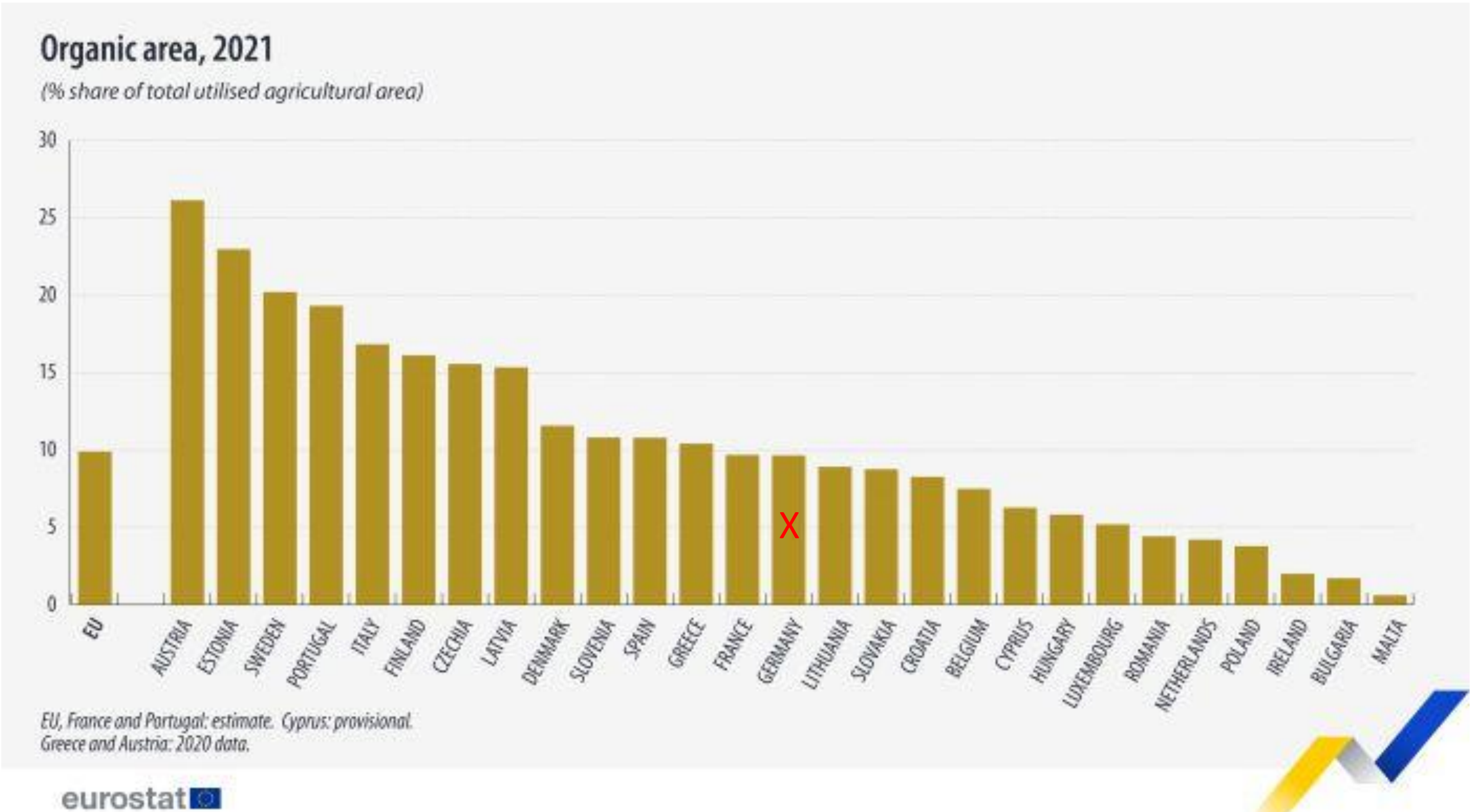


(in M= million hectares; in total 76.4M, 1.6.% of farmed land)

Source: FiBL survey 2023

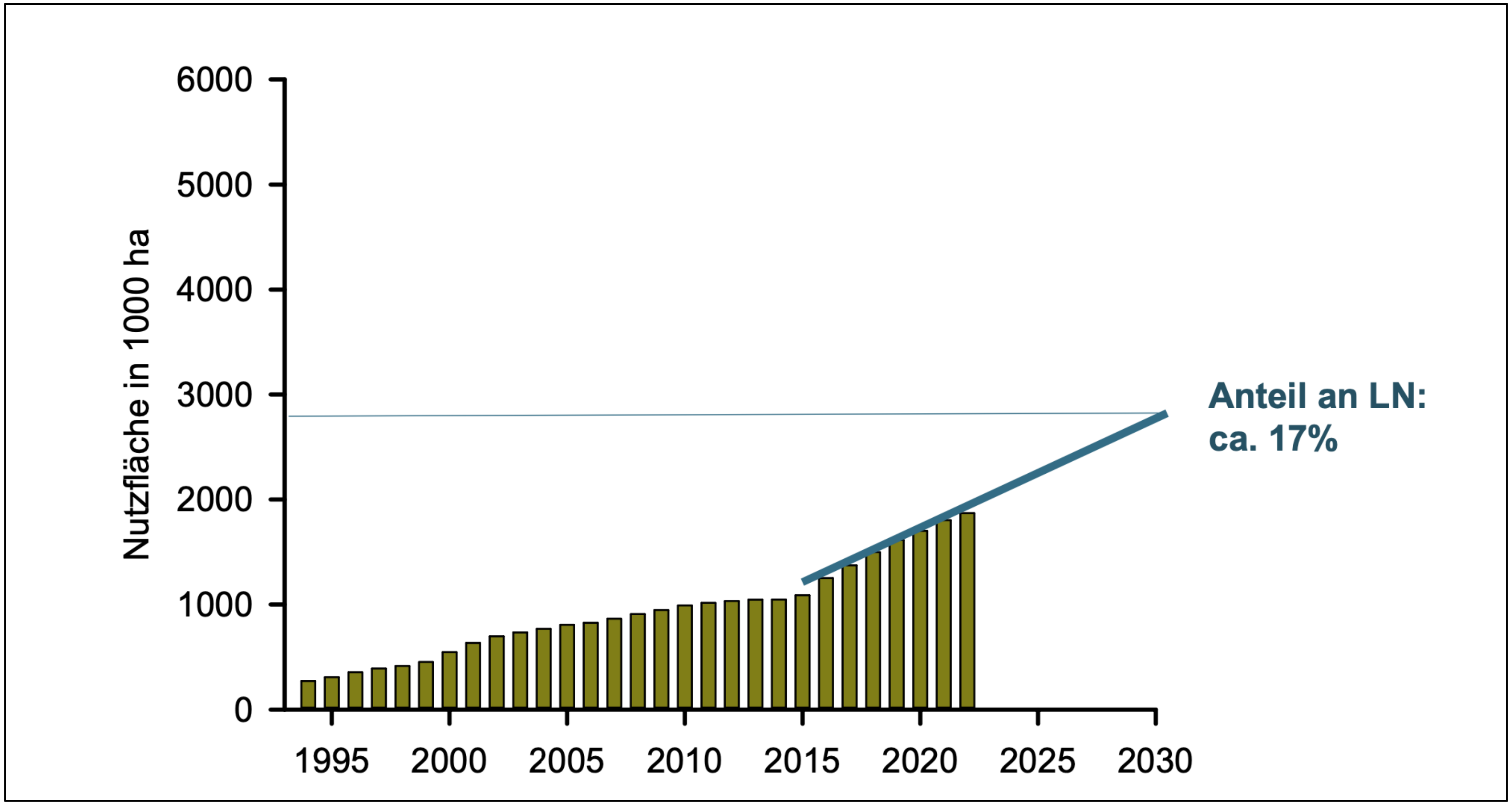
Organic Farming in Europe

EU-target: 25% organic farming area by 2030



Ambitious targets for organic farming…

Target: 30% organic farming in Germany by 2030



Development of organic farming area in Germany including projection 2030 (assumed constant growth rate); (BMELV 2022, BÖLW 2023)

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Organic Agriculture – the benefits for ecosystems and society

Enhanced microbial biomasses and N transformation activities in soils under organic farming (global meta-analysis)

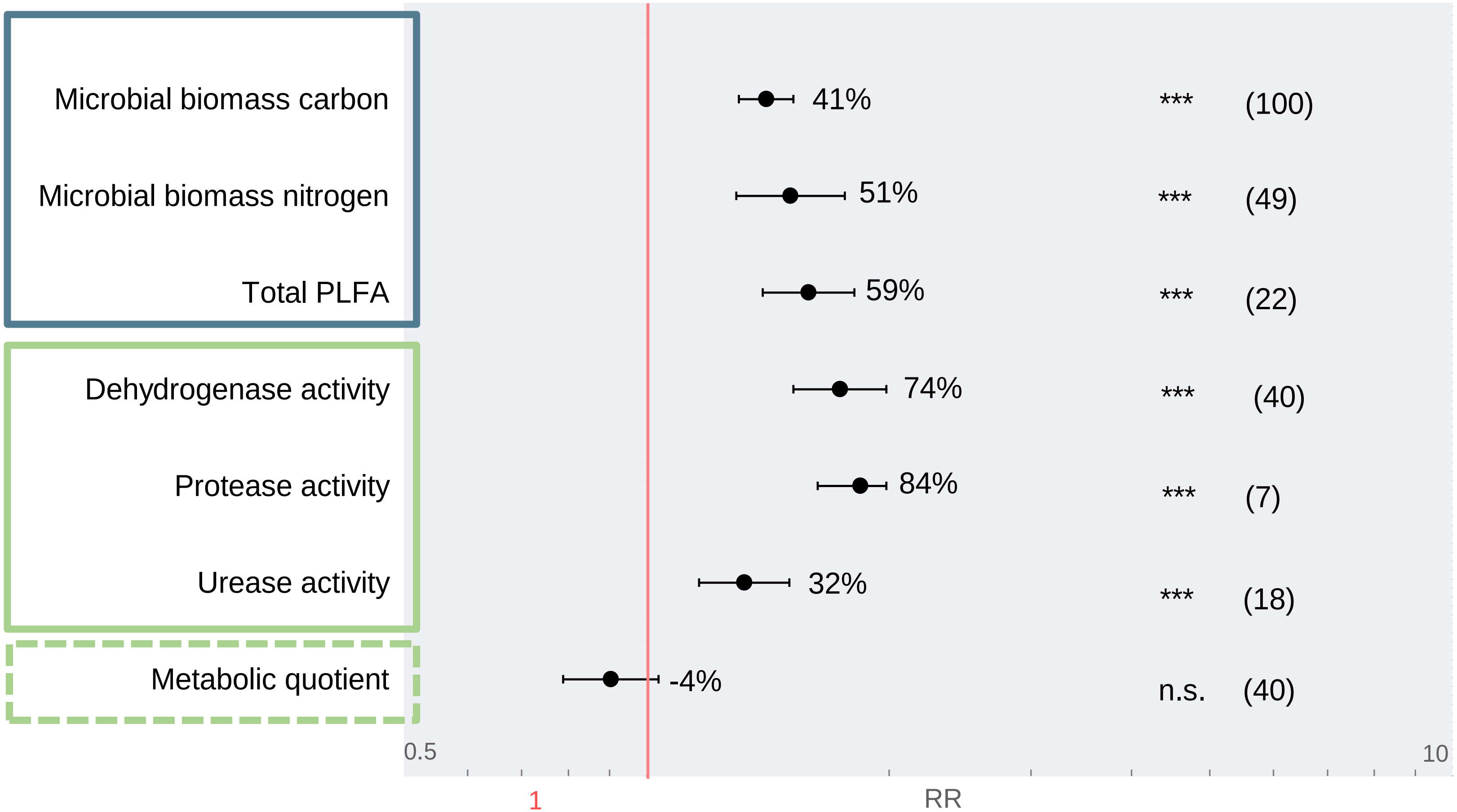


Figure 3: Summary of overall response ratios (RR). Random effects model with a Z-Distribution and a 95 % confidence interval was applied on eight target variables listed on the y-axis. The red line (RR=1) indicates no difference between organic and conventional systems. X-axis is given in log-scale as indicated with grey numbers. Numbers in brackets display the number of pairwise comparisons included in each calculation. Numbers beside the confidence intervals indicate the overall percentage difference per target variable. *≥0.05, **≥0.01, ***≥0.001, n.s.=not significant

Lori et al., 2017, PLoS ONE

Productivity and ecosystem services in organic agriculture (in comparision to conventional) – in short

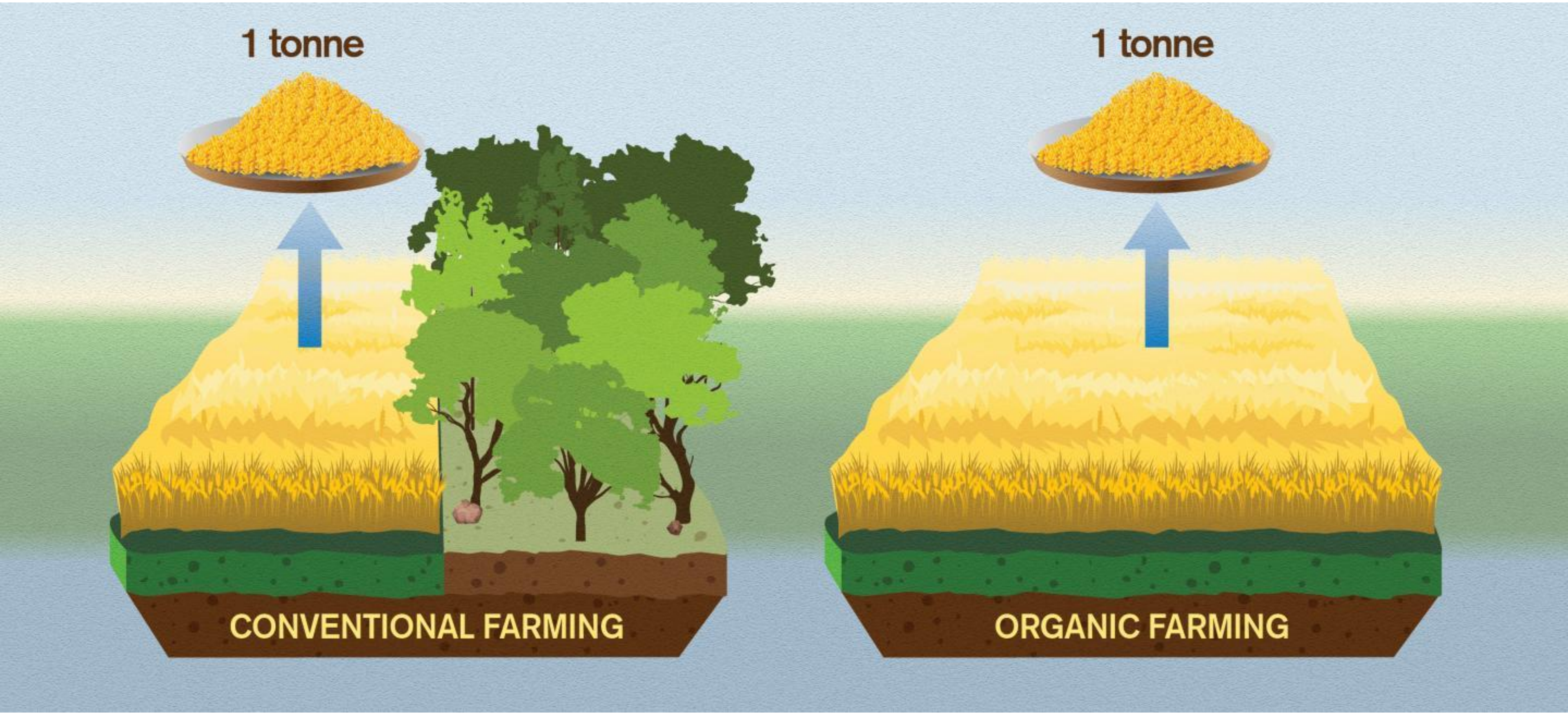
- Enhanced **soil life** (Lori et al. 2017;Lichtenberg et al. 2017; Hess & Sanders, 2019)
- Enhanced **carbon stocks** in organic farming (Gattinger et al. 2012; Aguilera et al. 2013)
- Less area-scaled and equal/lower yield scaled **GHG emissions** (Skinner, Gattinger et al. 2014 & 2019; Chiriaco et al. 2022)
- Higher above-ground **diversity** (Stein-Bachinger et al. 2021)
- Equal **animal welfare** (health, behaviour, emotions) (Brinkmann et al. 2019)
- Equal **food quality**, lower abundance of unwanted residues (Baranski et al. 2013)

- But **lower yields**:

  Globally: -9 to -25% (Seufert et al. 2012, De Ponti et al. 2012, Ponisio et al. 2015, Wilbois & Schmidt, 2019)

  Germany: -20 to -43% (Noleppa 2016, Treu et al. 2017, BMEL 2019)

Organic Farming and the long shadow of less yield…



Assessing the efficiency of changes in land use for mitigating climate change (Searchinger et al. Nature, 2018)

Yen Strandqvist/Chalmers University of Technology

Long-term organic farming and soil quality
(DOK Trial Switzerland, *1977)

Conventional (CONMIN)

Organic (BIODYN)

Mäder et al. 2002, Science

Water retention of arable soils after heavy rain (20 mm/h)
DOK Trial Switzerland

Conventional (CONMIN)

Organic (BIODYN)

Mäder et al. 2002, Science

Low resilience against extreme rainfall

(110 mm/h on 5th July 2018) despite 35 years of organic farming at Gladbacherhof, Germany



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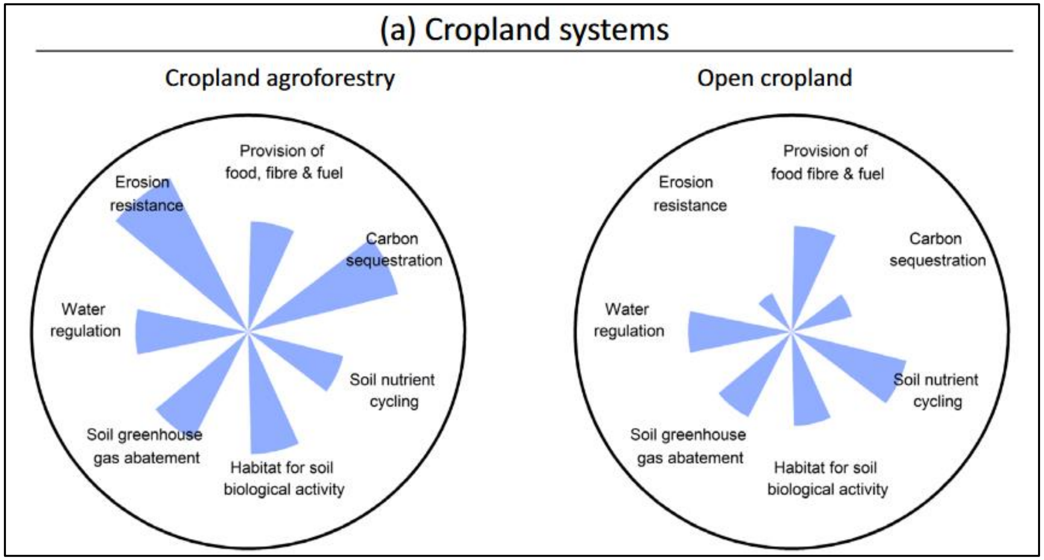
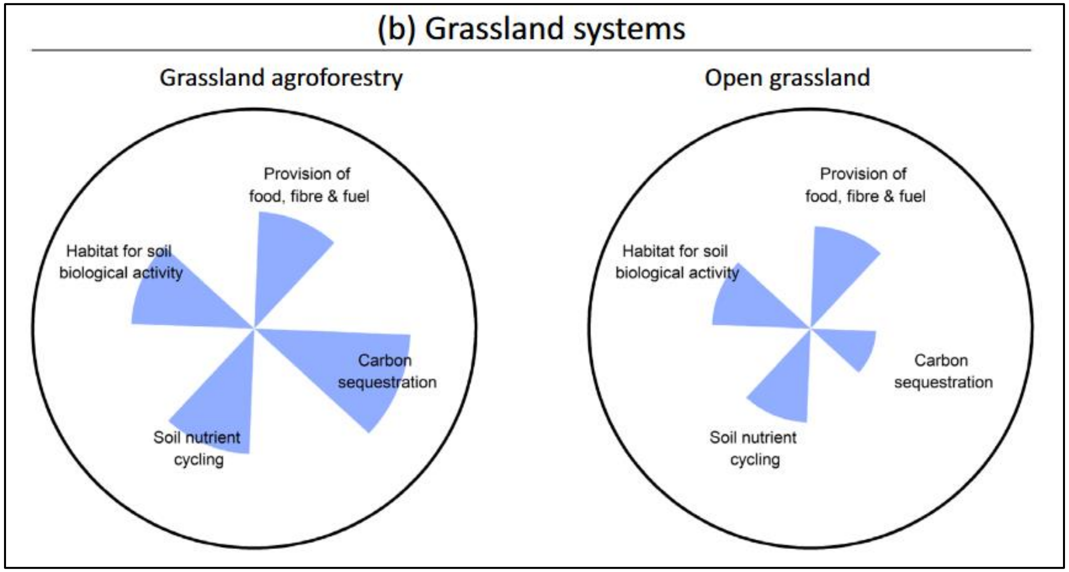
Eco-functional intensification and circularity through organic soil-crop-livestock systems

- Closing the yield and efficiency gaps according to best ecological and agronomic practice
- Targeted use of natural processes and ecosystem services for improved resilience
- Close integration of crop production and animal husbandry
- Symbioses, synergies, multidimensionality including bioeconomy

Agroforestry, ecosystem services and resilience

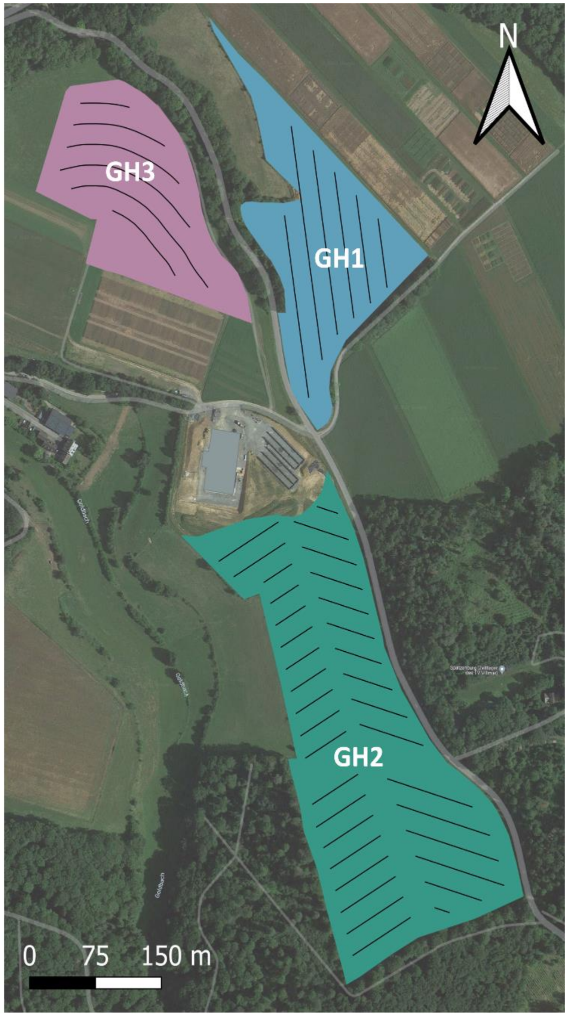




Veldkamp et al. 2023; Communications Earth & Environment

Agroforestry Systems Hessen at Gladbacherhof (GH1-GH3)

	GH1	GH2	GH3
Type	Silvoarable	Silvopastoral	Silvoarable
Main aims	Erosion reduction + WP products	Shade for animals + WP products	Water retention + WP products
Establishment	February 2020	November 2021	November 2022
Size [ha]	3.5	8.0	3.3
Slope orientation	North-West	North-East	North
Slope [grade]	0.2-31.0, Ø 6.6	0.5-24.0, Ø 6.9	0.1-18.0, Ø 6.4
TS orientation	North-South	East-West	East-West
TS number	6	34	6
TS width [m]	3	2	4
AS width [m]	18	21	18
TS total length [m]	986	1900	771
TS share [%]	8.5	4.8	9.4
Number of trees	786	612	503



Weckenbrock et al., submitted

Agroforestry Systems at Gladbacherhof

Silvopastoral Agroforestry System

Agroforestry System

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Mulch vegetable farming

- Planting vegetables in a mulched biomass system facilitates open-field vegetable production without the need for irrigation
- This approach also promotes increased soil carbon retention and reduces greenhouse gas emissions, enhancing sustainability in agriculture

Saat einer geeigneten Zwischenfrucht

- Gemenge aus Grünschnittroggen-Zottelwicke- Erbse (60;20;20)
- Benötigt ca. die geplante Gemüsefläche x Faktor 2 (zzgl. 100 %)

Mulchen und Nachstreuen

- Geräte: Schlegelmulcher, Ladewagen mit Streuwerk
- Ziel: min. 15 t TM ha^{-1}

Pflanzung der Jungpflanzen

- Pflanzung mit spez. Pflanzmaschine („MulchTec“)

Dix, Hauschild et al. 2023a, in prep.

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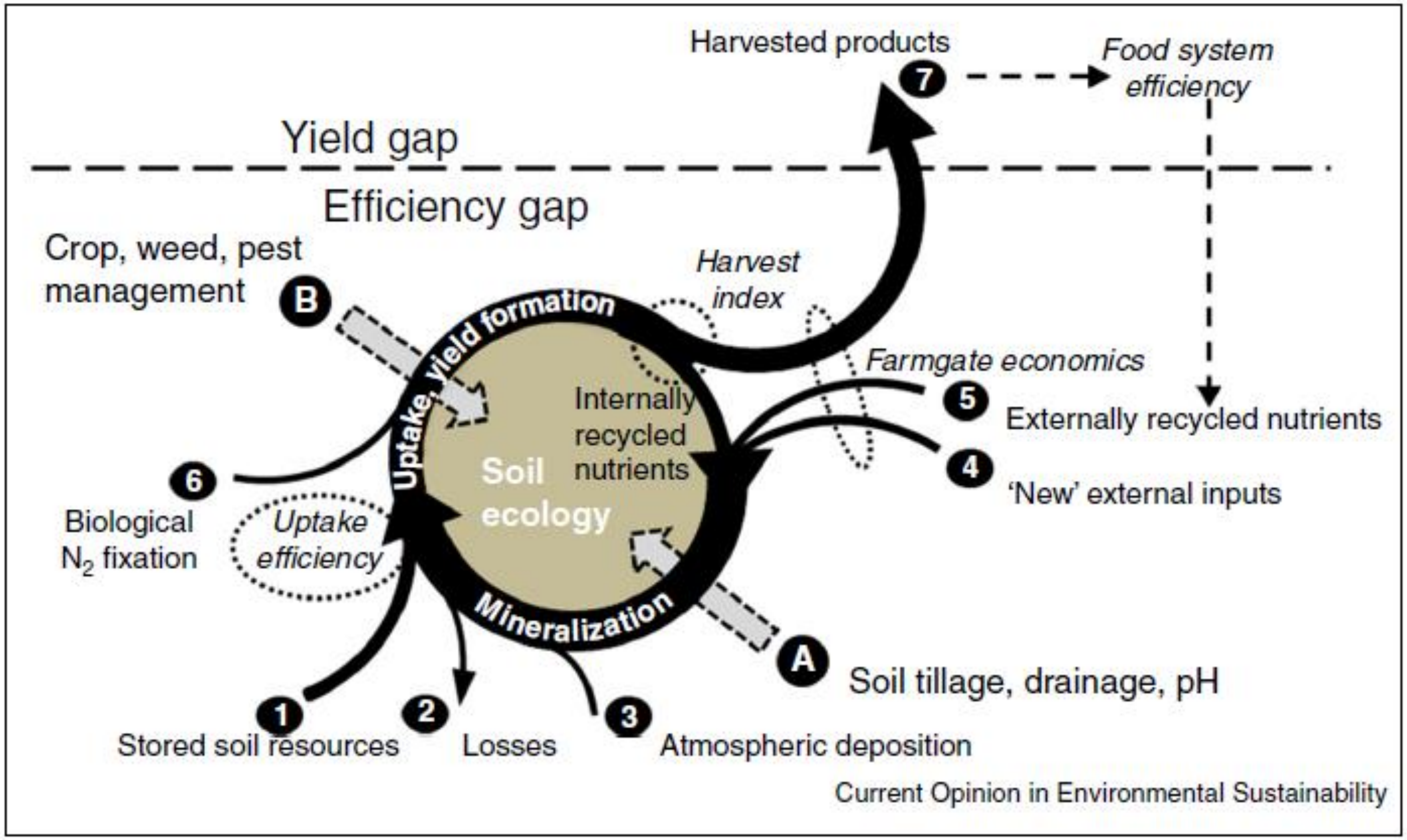
Future research and development: eco-functional intensification to make use of the soils potential



Food system efficiency perspective on soil (A) and crop (B) management as modifying factors of field-level interactions between soil (1), losses to atmosphere or water (2), nutrient inputs (3–6), and crop growth, leading to harvested products (7). www.sciencedirect.

Nordwijk and Brussard. 2015, Curr Opion Environ Sus

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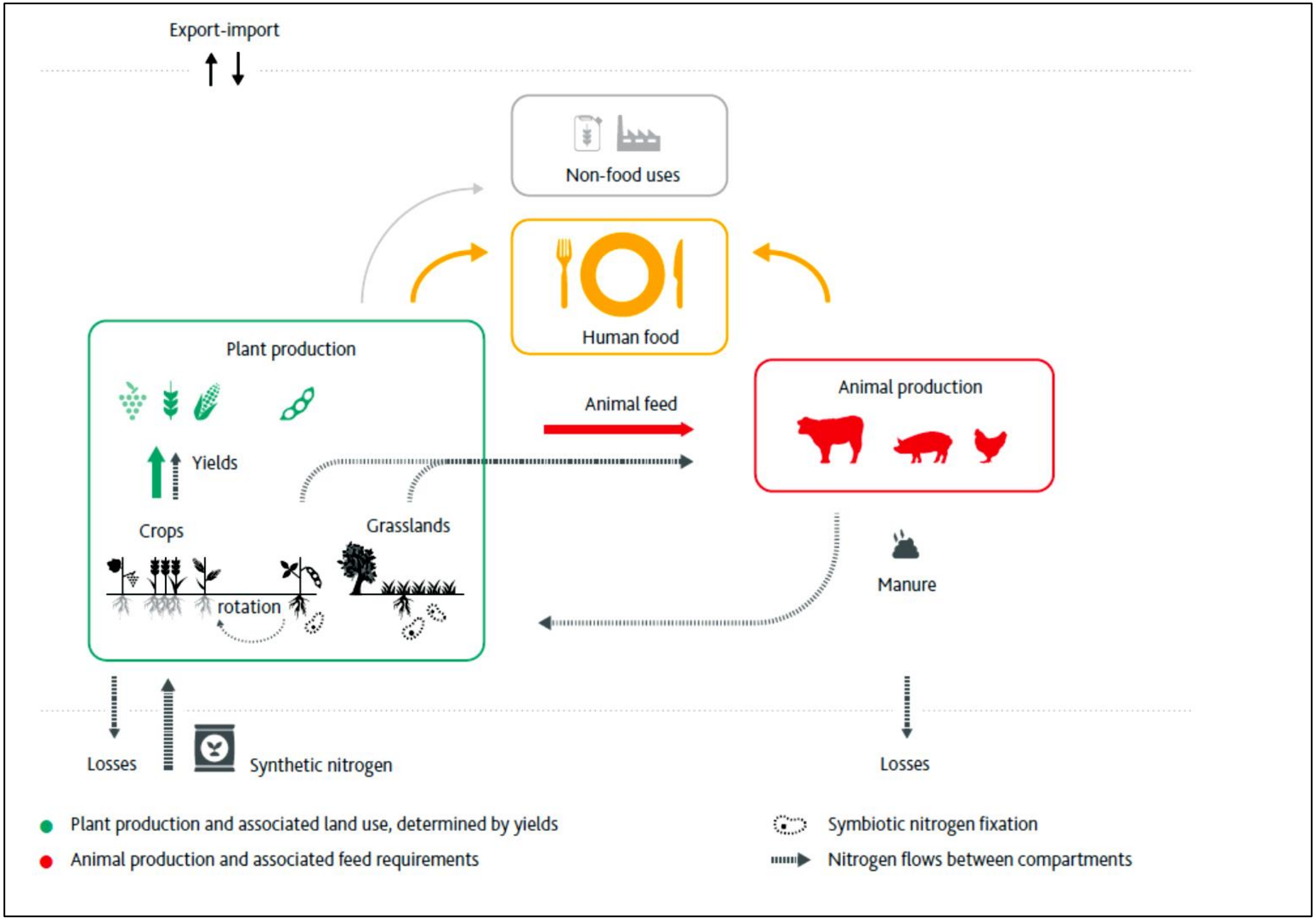
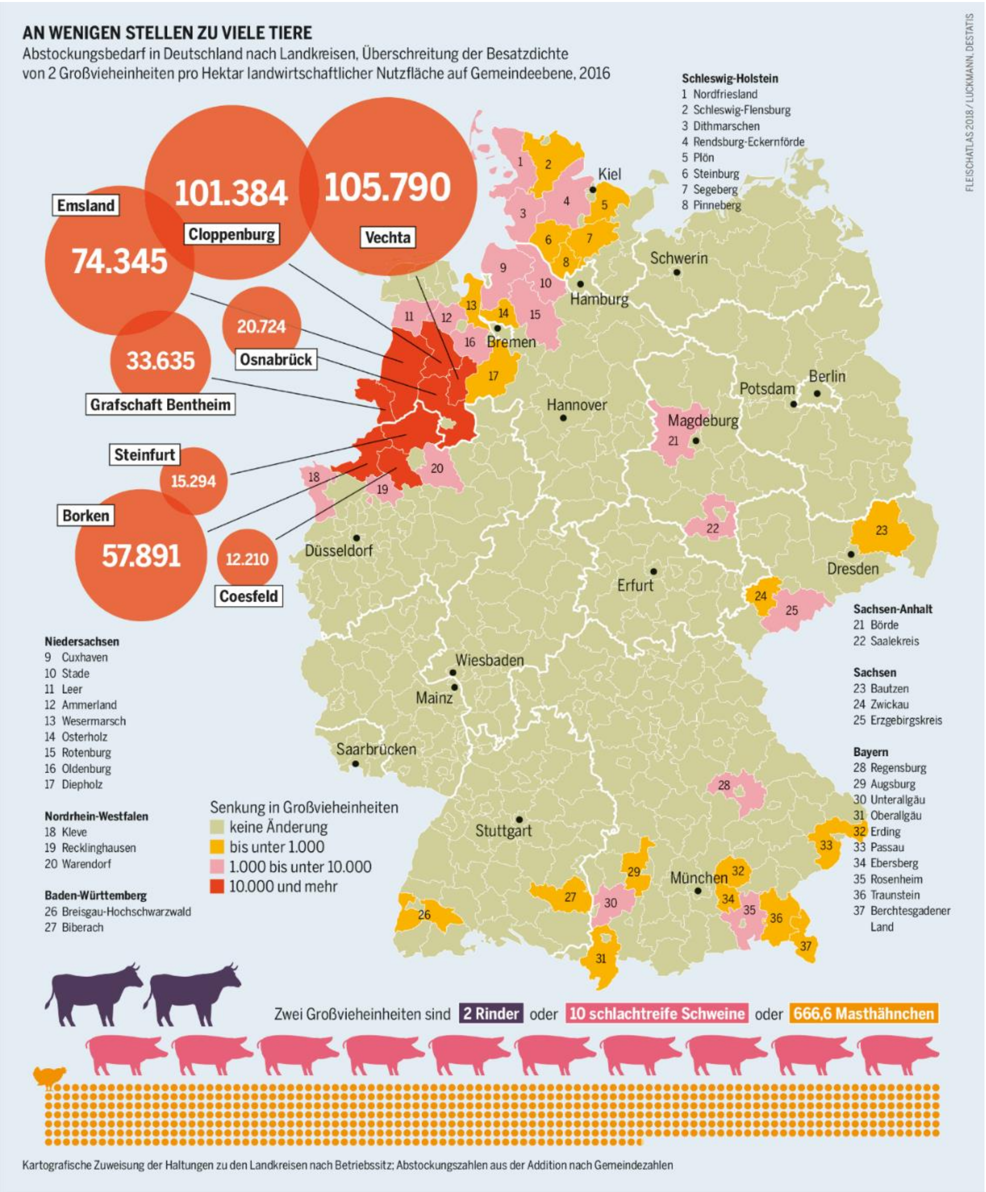
Spatial and temporal decoupling of animal husbandry from crop production (arable land and grassland)



Proplanta.de, 10/2019

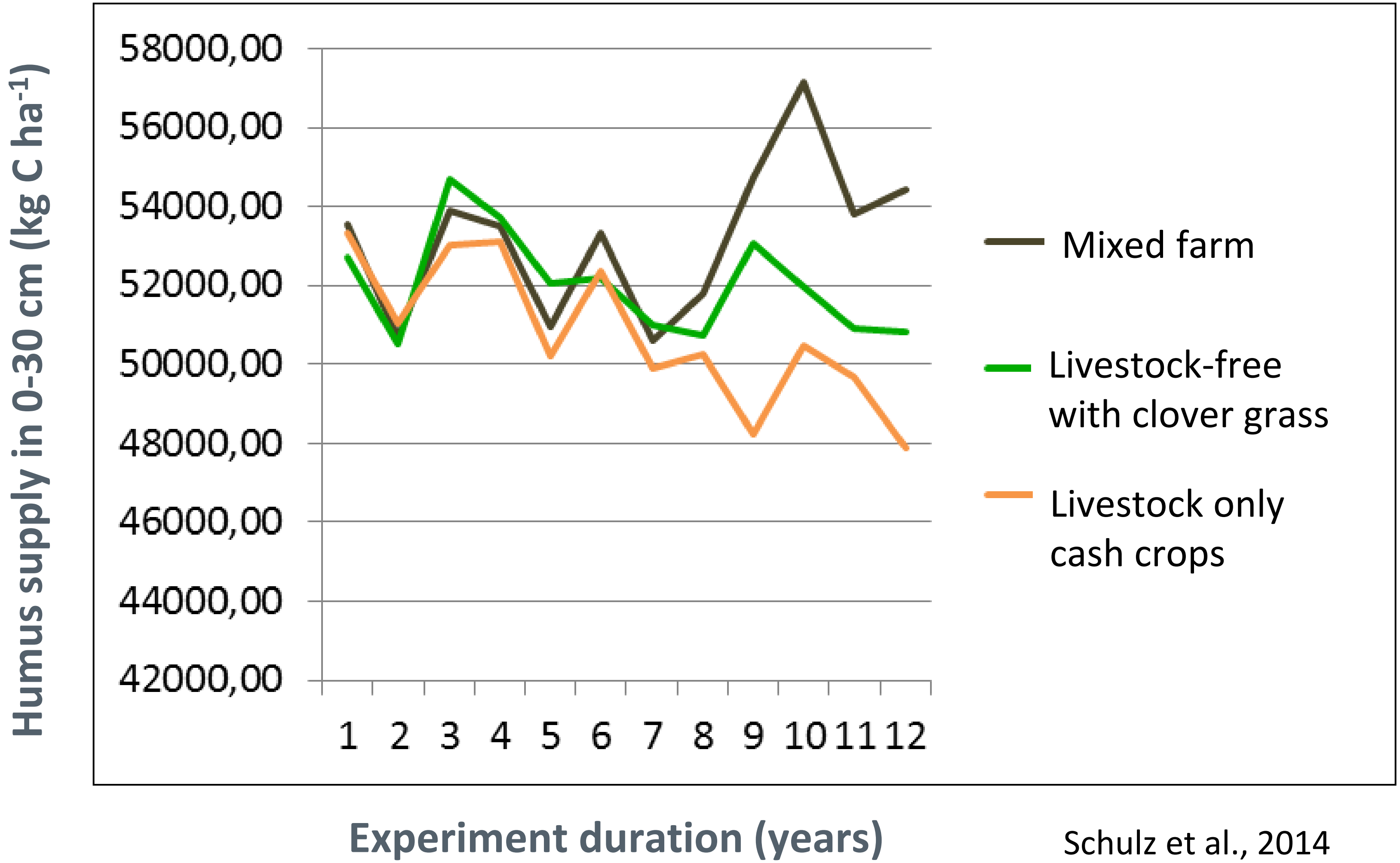
Too many animals in a few places: Over-fertilisation, feed imports (LUC), stable sizes, animal welfare,...



Luckmann, Destatis (CC BY 4.0)

- Necessary reduction of livestock units (animal numbers) in the areas marked in yellow and red in order to achieve 2.0 LU/ha (= max. value for organic farming, EU Organic Regulation)
- Prescription by law of an area-based livestock farming system that is compatible with the natural environment?

Humus accumulation only on organic mixed farms with cattle husbandry (Long-term Gladbacherhof OAFEG trial since 1998)



Schulz et al., 2014

Great nutrient potential through legumes and farm manure!

Global potential to produce 140 million tons of nitrogen on cropland
(Badgley et al., 2007)

Global potential to use 160 million tons of nitrogen (and other nutrients) from livestock manure more efficiently on cropland (calculated on the basis of 18.3 billion farm animals/FAO)

Badgley et al., 2007, Gattinger et al. 2013, Schader et al. 2015

Low "carbon footprint" in grass-based milk production despite lower productivity compared to livestock housing!

Journal of Cleaner Production 211 (2019) 161–170

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journal homepage: www.elsevier.com/locate/jclepro

Is low-input dairy farming more climate friendly? A meta-analysis of the carbon footprints of different production systems

Heike Lorenz [a,*], Thorsten Reinsch [a], Sebastian Hess [b], Friedhelm Taube [a]

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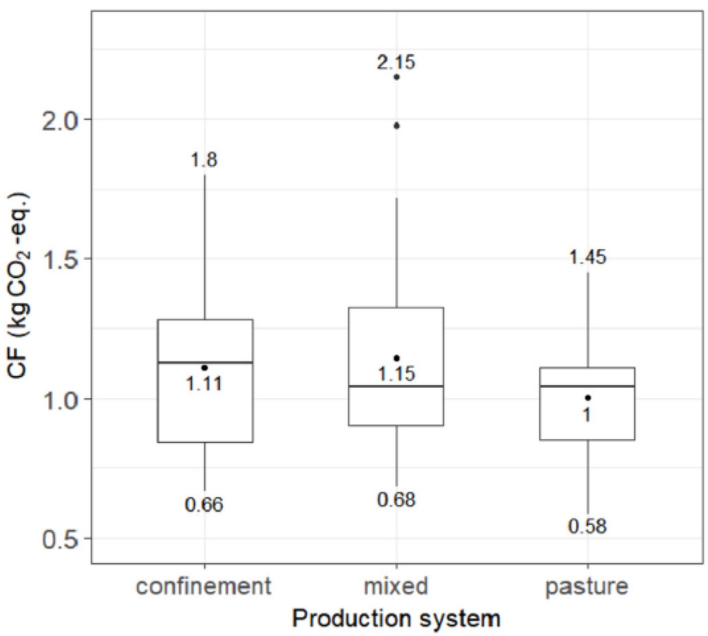
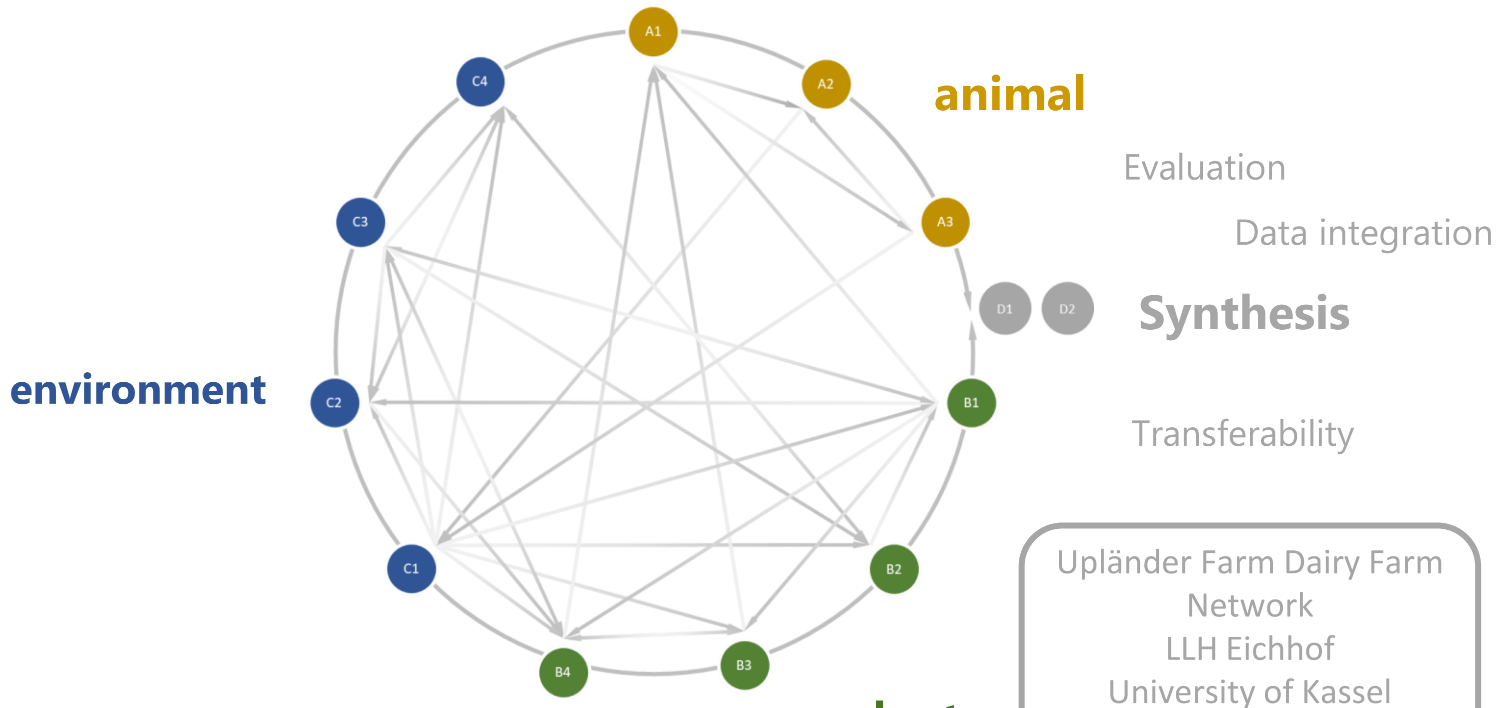
[b] Institute of Agricultural Economics – Dairy and Food Industry Economics, Kiel University, Olshausenstr. 40, 24118 Kiel, Germany



Lorenz,...Taube, 2019

GreenDairy: Goals

…to develop innovative, ecological crop-livestock systems that are both ecologically and economically sustainable, as well as enabling a special level of animal welfare, and thus enjoy a high level of acceptance in society.



Upländer Farm Dairy Farm Network
LLH Eichhof
University of Kassel
Frankenhausen

Integrated Organic Crop-Livestock Systems – GreenDairy

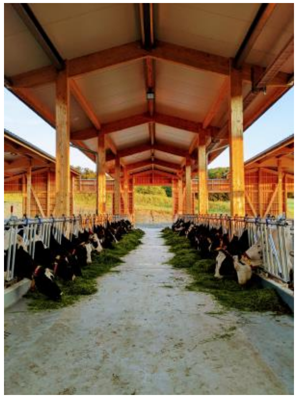
High-input: 9200 liters of milk/year, with corn silage in the diet
Low-input: 7200 liters of milk/year, without corn silage in the diet

Crop rotation	High-input	Low-input
Year		
1	Alfalfa	Alfalfa
2	Alfalfa	Alfalfa
3	Winter wheat (human nutrition)	Winter rye (human nutrition)
4	Maize/sorghum millet (animal)	Potatoes (human nutrition)
5	Winter triticale (animal)	Winter wheat (human nutrition)
6	Grain legume (animal)	Grain legume (animal)
7	Winter spelt (human nutrition)	Winter spelt (human nutrition)
8	Spring oats (animal) + alfalfa as undersowing	Spring oats (animal) + alfalfa as undersowing

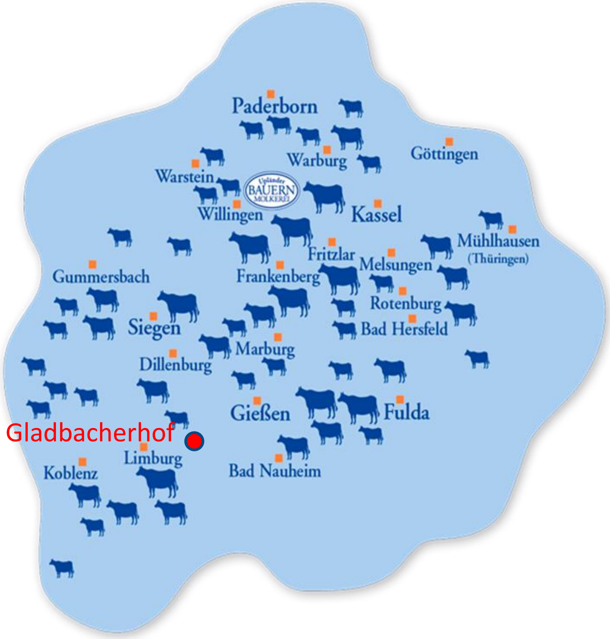
Living lab **“Organic Dairy Germany”**

- Developing innovative crop-livestock systems, which are ecologically and economically sustainable at highest animal welfare levels and so they will be accepted by the society

1 Demonstration Farm: Gladbacherhof	→	10 Lead Commercial Farms: Upländer Dairy Network	→	100 outreach farms: only Upländer Farms







Milk producer of the Organic dairy factory „Upländer Bauernmolkerei“

…on the way to "Complex, multifunctional, organic agri-food systems, that will be sustainable and socially just and will be able to feed the world with significantly reduced greenhouse gas (GHG) emissions in 2050" (The Villum Experiment, 2016)

Cow **Inge**: *2008, 122.000 l life time performance, 12. lactation

Von 100.000 aktuell lebenden hessischen Kühen
nur etwa 20 mit dieser Leistung. Unter Bio Bedingungen in Deutschland
aktuell nur 5 lebende Kühe mit solch einer Leistung