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JLU
NEUE WEGE. SEIT 1607.

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Agro- food for thoughts

Prof. Dr. Andreas Gattinger

Andreas.Gattinger@agrar.uni-giessen.de

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Agro– food for thoughts

1. Characteristics of current food and farming systems, focus Germany

2. Problems & challenges

3. Solutions & visions

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Agro– food for thoughts

1. **Characteristics of current food and farming systems, focus Germany**
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A sustainable food system integrates elements to enhance environmental, economic, social and nutritional health for all

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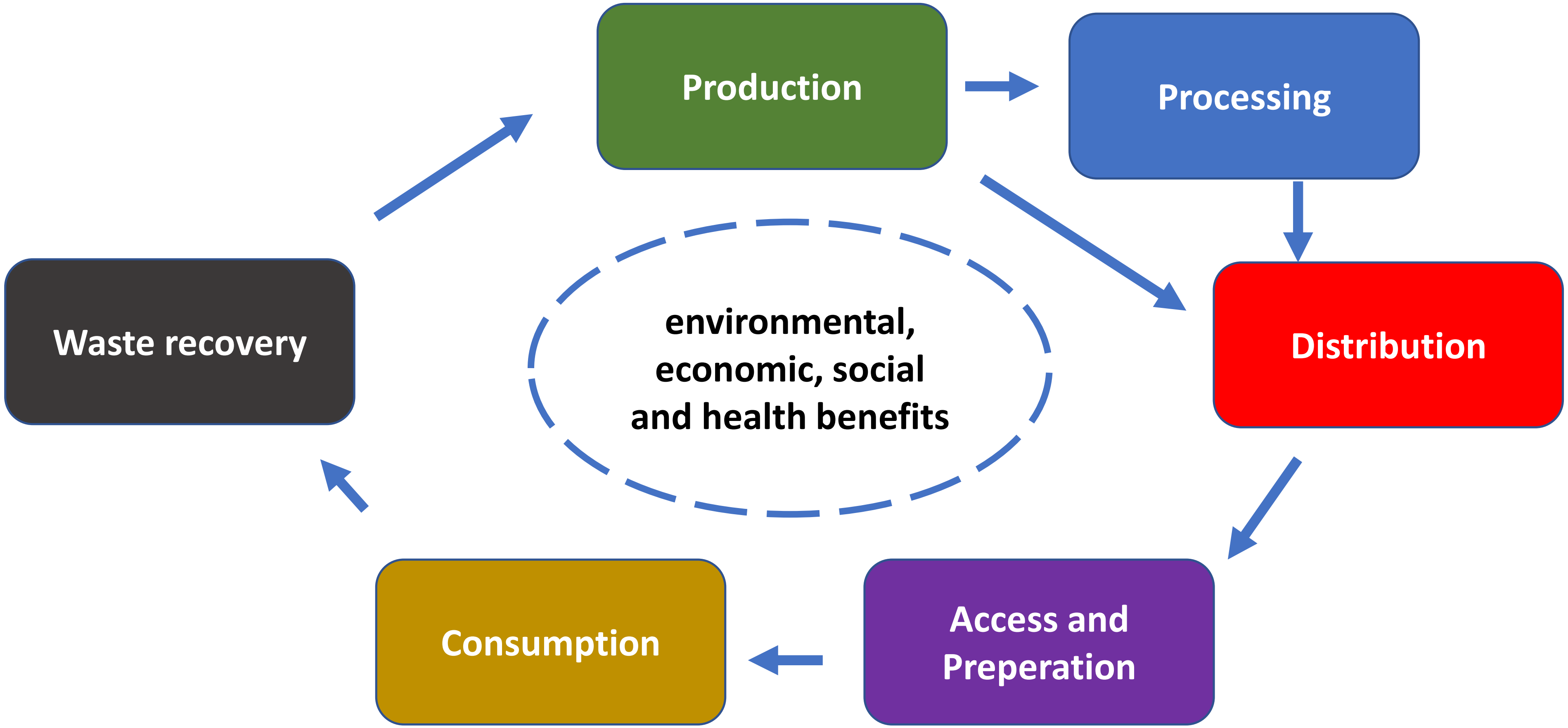

Most important numbers for agriculture in Germany

- With **16.6 million hectares** (2018), almost half of the area of the Federal Republic of Germany is used for agriculture.
- Almost **71 % of this is arable land** and **28 % permanent grassland.**
- **Grain cultivation** is the **most important arable crop** in Germany.
- Wheat remains the most important type of fruit, accounting **for 26 per cent of total arable land.**

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Most important numbers for German agriculture

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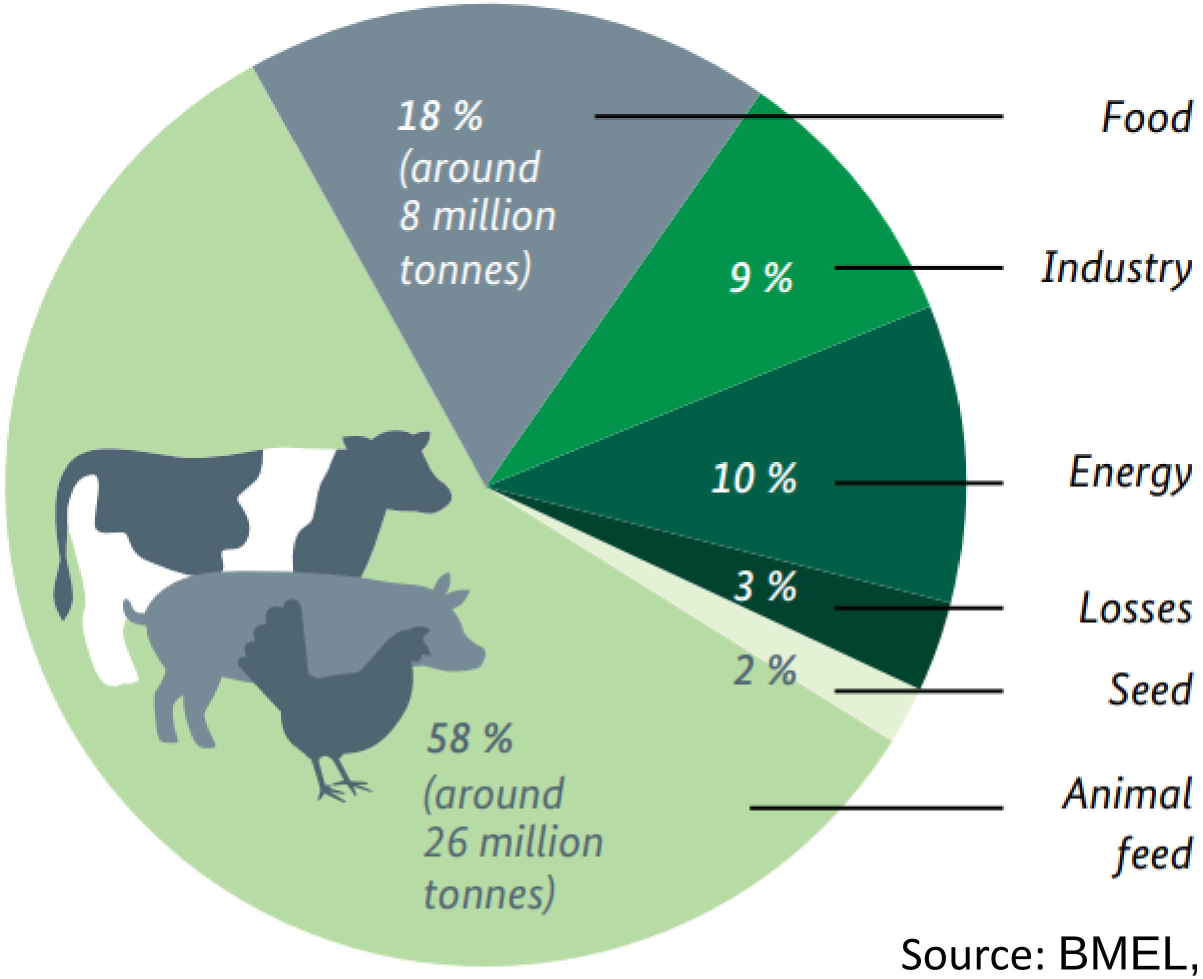
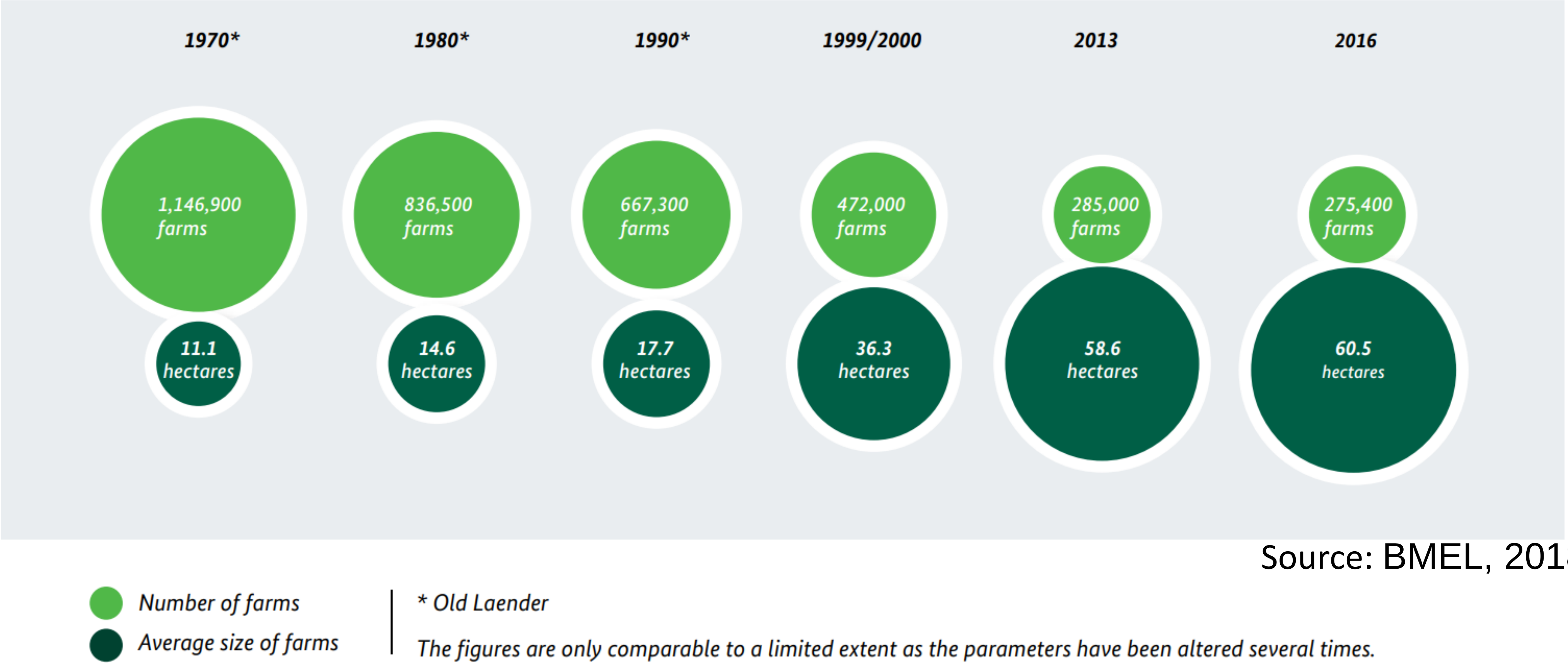


Source: BMEL, 2018

Ever fewer farms manage ever more land



Source: BMEL, 2018

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German farms by size classification of area (2013)

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Agriculture Area in ha [a]	Number of farms	%	Related area in ha	%
1 bis 5	24.600	45,0	44.700	7,5
5 bis 10	44.600		325.800	
10 bis 20	59.000		886.200	
20 bis 50	71.500	42,7	2.378.600	35,5
50 bis 100	50.200		3.550.000	
100 bis 200	23.700	12,3	3.207.700	57,0
über 200	11.500		6306.600	
Together	**285.100**		**16.699.600**	

Source: StJELF, 2016

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Average rate of self-sufficiency in Germany for selected products from 2014 to 2016

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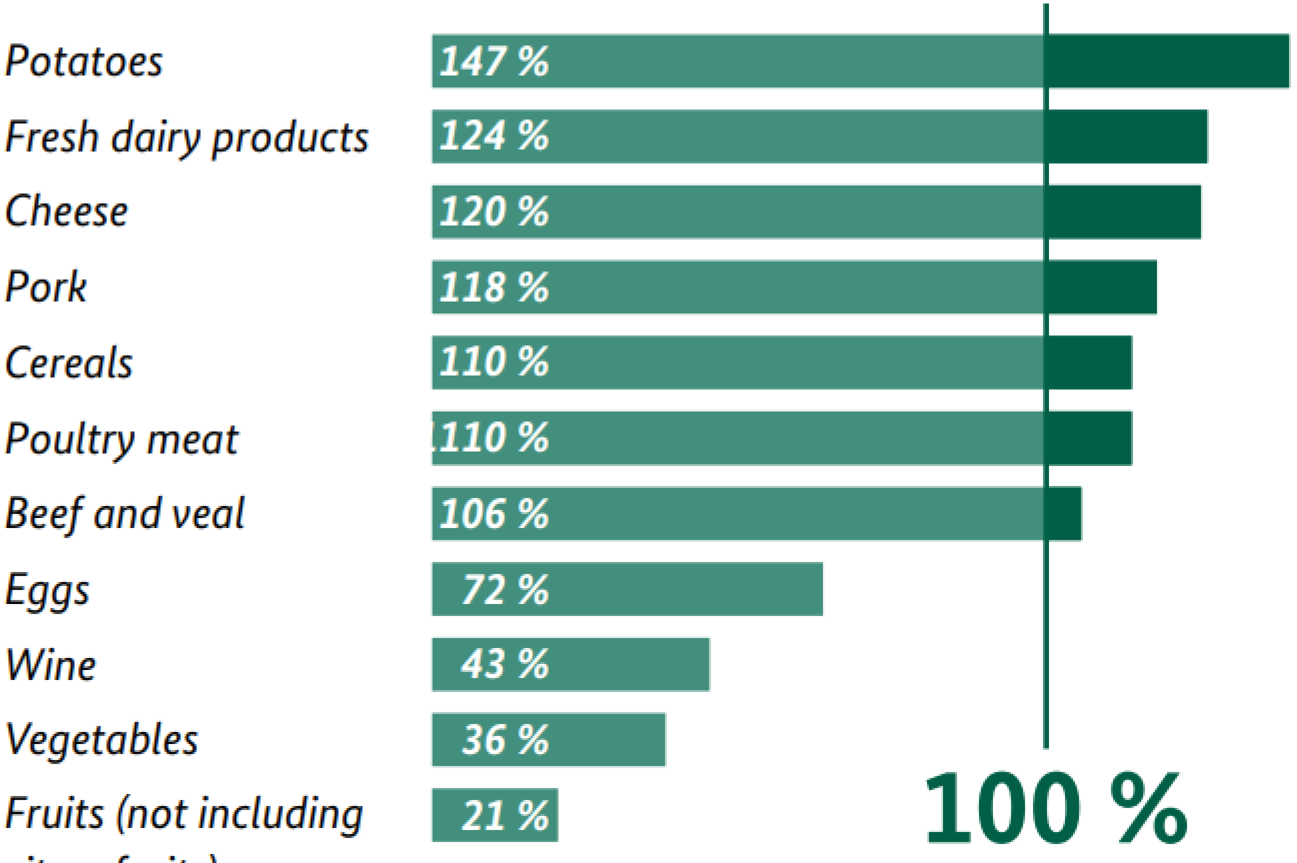

Source: BMEL, 2018

A HISTORICAL COMPARISON OF HARVEST YIELDS AND LIVESTOCK PERFORMANCE

Harvest yield for 1 hectare of wheat
1950: 2,580 kg*
1980: 4,890 kg*
2016: 7,690 kg

Harvest yield for 1 hectare of potatoes
1950: 24,490 kg*
1980: 25,940 kg*
2016: 44,420 kg

Milk yield per cow and year
1950: 2,480 kg*
1980: 4,538 kg*
2016: 7,746 kg

Egg yield per hen and year
1950: 120 eggs*
1980: 242 eggs*
2016: 297 eggs

** Old Laender*

Source: BMEL, 2018

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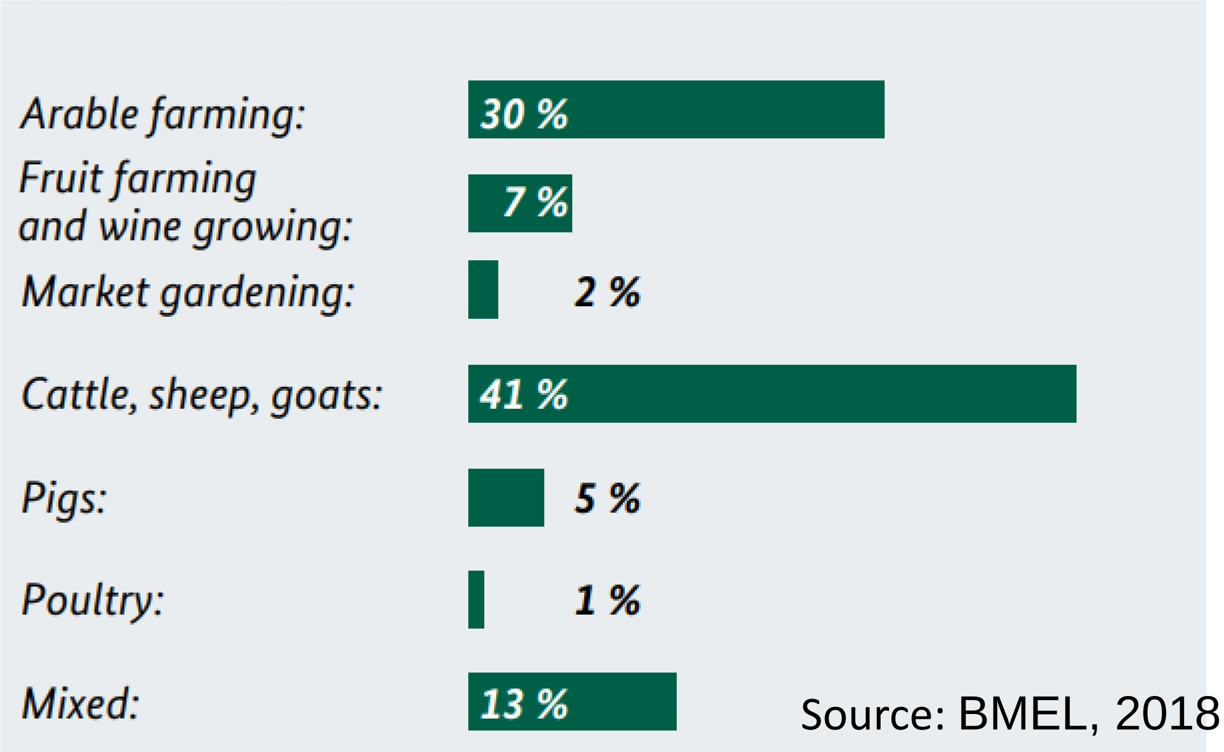
What have farms specialised in? (as of: 2016)



Source: BMEL, 2018

Anecdote:

- More than a third of the world‘s Hop harvest comes from Germany
- German wine growers produce approximately 6% of the total quantity of European wine

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Gladbacherhof training and experimental facility

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- Managed according to Bioland guidelines since 1981
- The main task of the Gladbacherhof is teaching and research in organic farming.

Bioland

Main production areas:

- Production of seed of all major cereals and seed potatoes
- 90 dairy cows are kept with the breeding goal of life performance
- There are also 100 chickens living on the domain.

Gladbacherhof training and experimental facility

- 170 ha of agricultural land (100 ha arable land and 70 ha grassland)
- Crop rotation: two years alfalfa grass, winter wheat, silage maize or potatoes, winter rye, field beans, spelt, summer wheat or oat

Agro– food for thoughts

1. Characteristics of current food and farming systems, focus Germany

2. **Problems & challenges**

3. Solutions & visions

A global transformation of the food systems is urgently needed

- A total of 842 million are estimated to be suffering from chronic hunger, regularly not getting enough food to conduct an active life
- Malnutrition is the single largest contributor to disease in the world.
- Between now and 2050, the global population is projected to rise from about 7 billion to 9.2 billion, demanding a 60 percent increase in global food production.

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Greatest threats to the human species are man-made

- artificial intelligence
- **global warming**
- nuclear war
- rogue biotechnology

Influence of global warming on important factors related to agriculture

- degradation of soil
- degradation of water ressources
- extreme heat conditions

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Many environmental systems are pushed beyond safe bounderies

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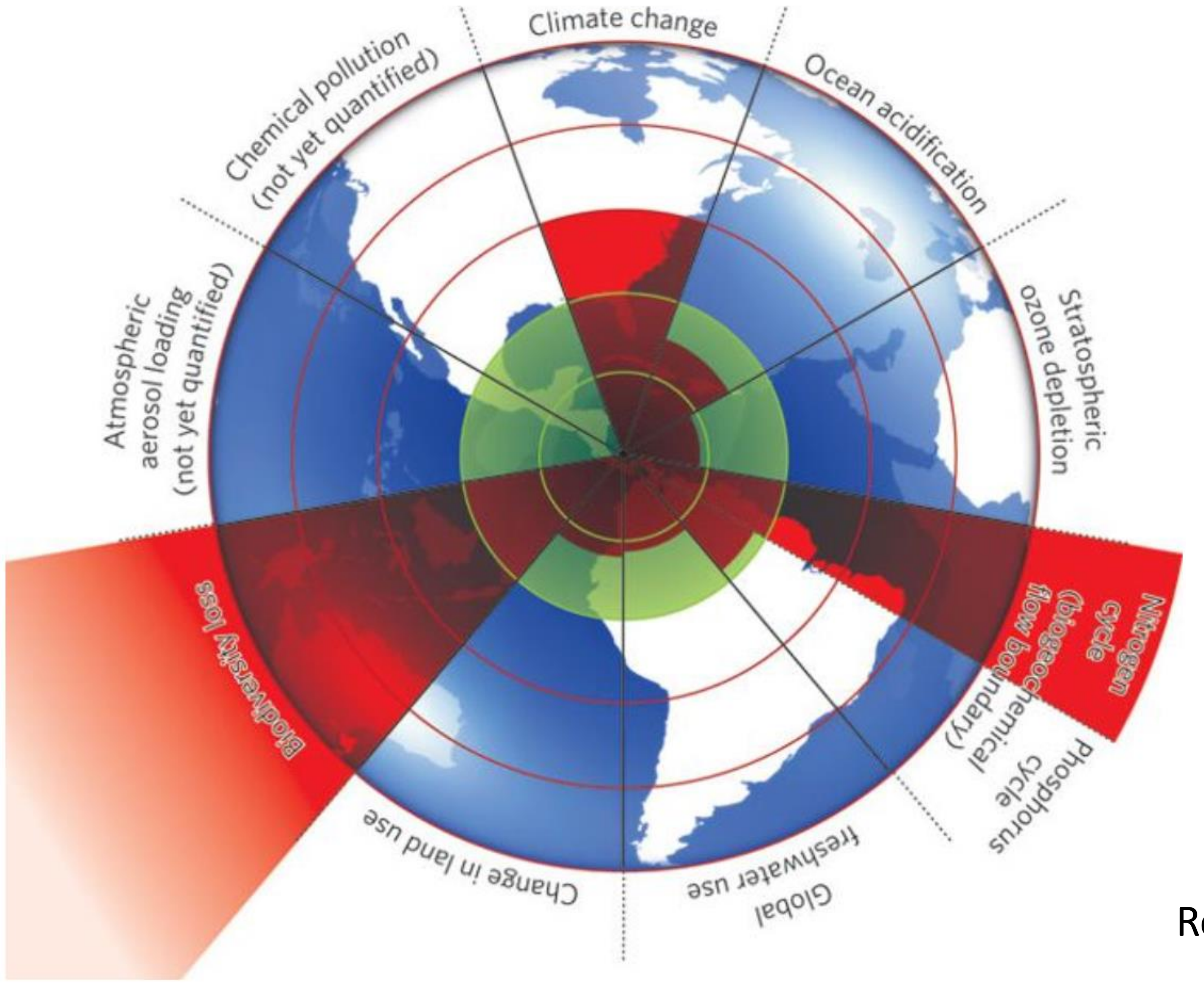

Planetary boundaries are values for control variables that are either at a 'safe' distance from thresholds

Rockström et al., 2009, Nature

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EAT- Lancet commission

19 Commissioners and 18 coauthors from 16 counties in various fields of human health.

,,Food systems have the potential to nurture human health and support environmental sustainability; however, they are currently threatening both. Providing a growing global population with healthy diets from sustainable food systems is an immediate challenge.“

Willett et al. 2019

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Importance of agriculture in the context of climate change

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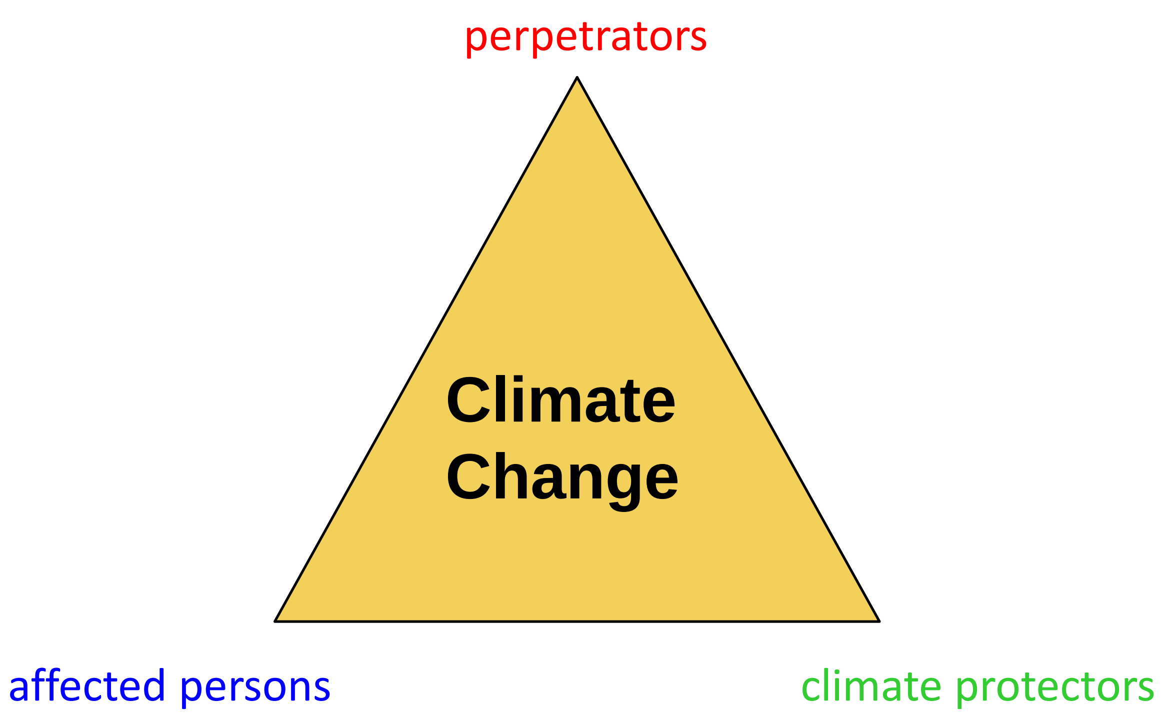

… with severe consequences

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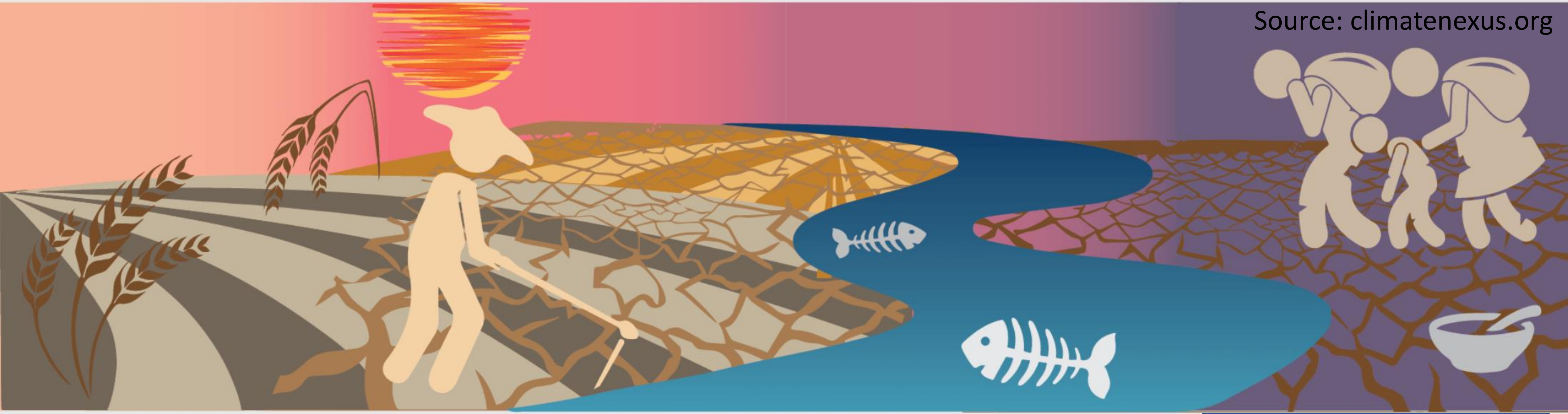


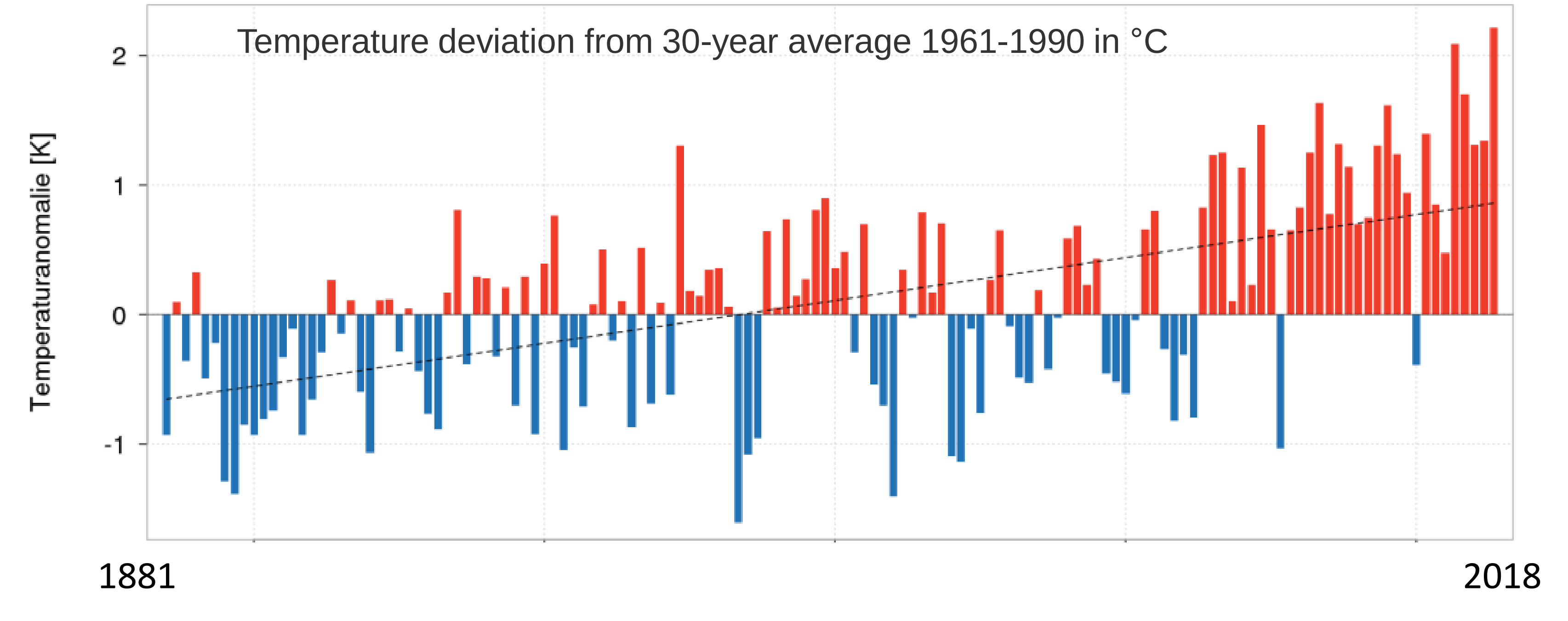
1,5°C
Wheat, rice, maize and soybean production suffers

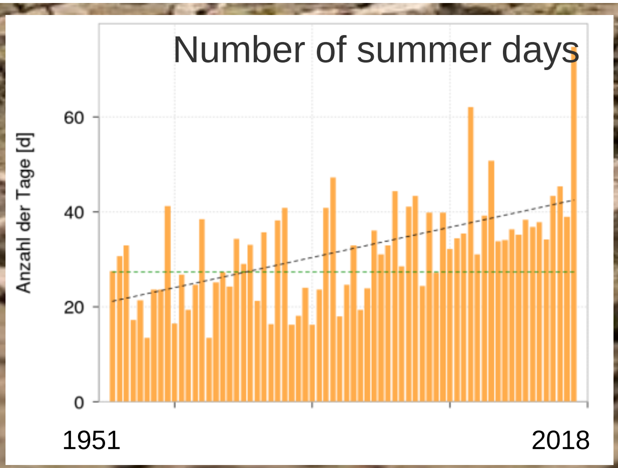
2,0°C
Agricultural yields fall rapidly

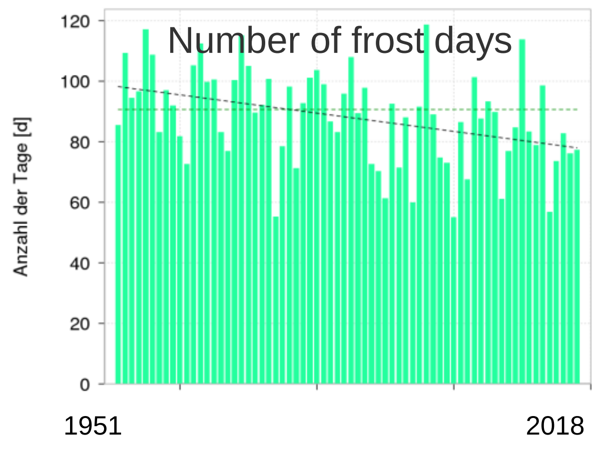
3,0°C
Fish species go extinct locally

4,0°C
High levels of food insecurity,

Temperature







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Extreme weather 2018: drought…

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Dry river near Freiburg, summer 2018.

Source: wetteronline.de

Drought

An **extreme event** in which below-average precipitation has caused a climatological drought.

manner	duration
Meteorological droughts	1 month
Agricultural droughts	2 months or longer
Hydrological droughts	4 months or longer
Socio-economic droughts	1 year or longer

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… and flooding

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Aftermath of the rainstorm at Gladbacherhof on 5 July 2018

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Extreme precipitation (110L/h) at the Gladbacherhof training and experimental farm (org. for 30 years), Villmar-Aumenau 5.7.2018

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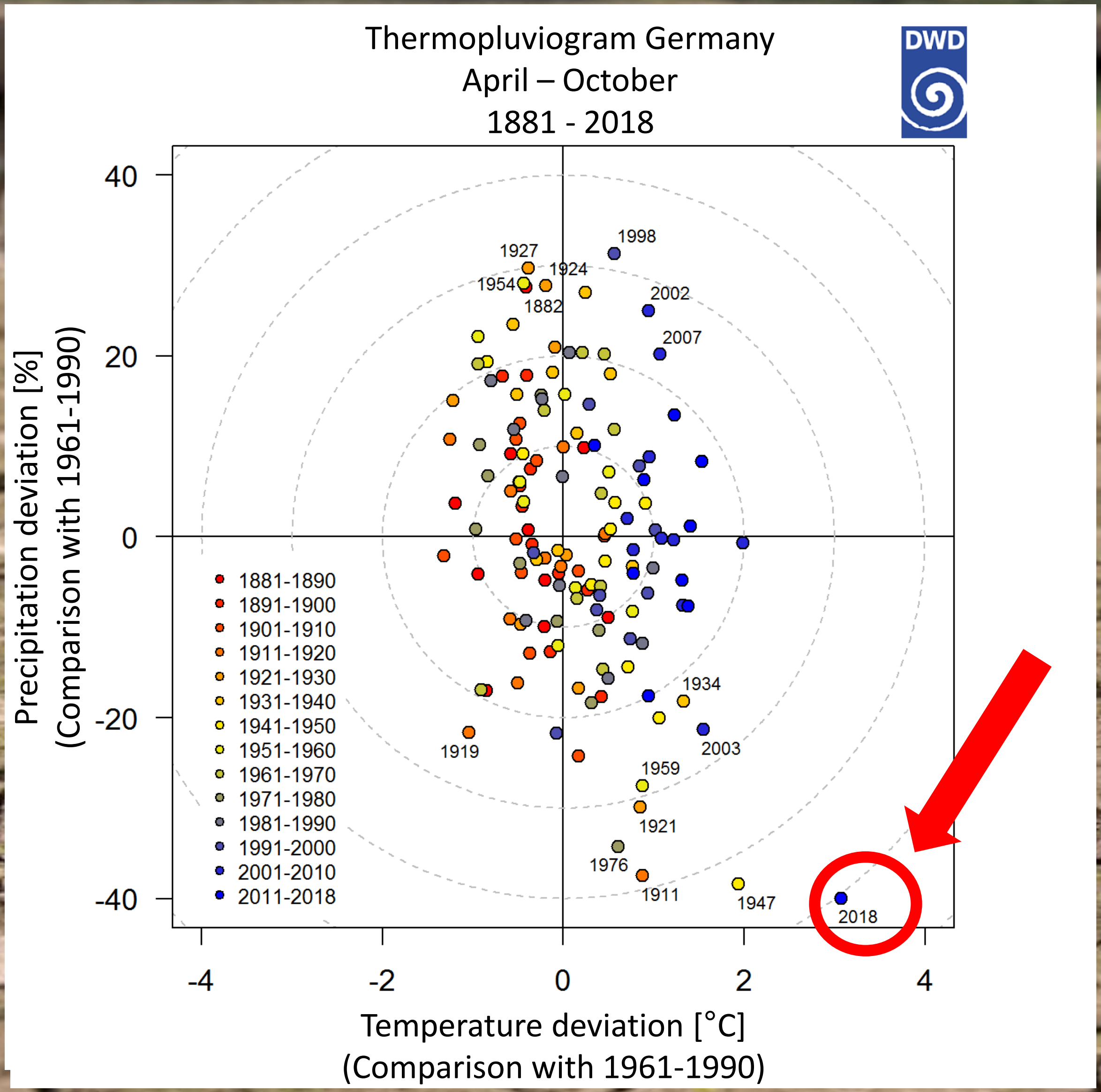
2018 - A special year!




DWD
30.07.2018
ZEIT ONLINE
Bauernpräsident Rukwied:
Landwirtschaft
"Die schlechteste Ernte des Jahrhunderts"
© DBV
Bild
ACH DU DICKE KNOLLE!
05.02.2019
Kartoffelernte auf historischem Tiefstand
Fast drei Millionen Tonnen weniger Ertrag als 2017 +++ Kartoffeln um bis 53 Prozent teurer
© picture-alliance/dpa

Agricultural greenhouse gases (without LULUCF)

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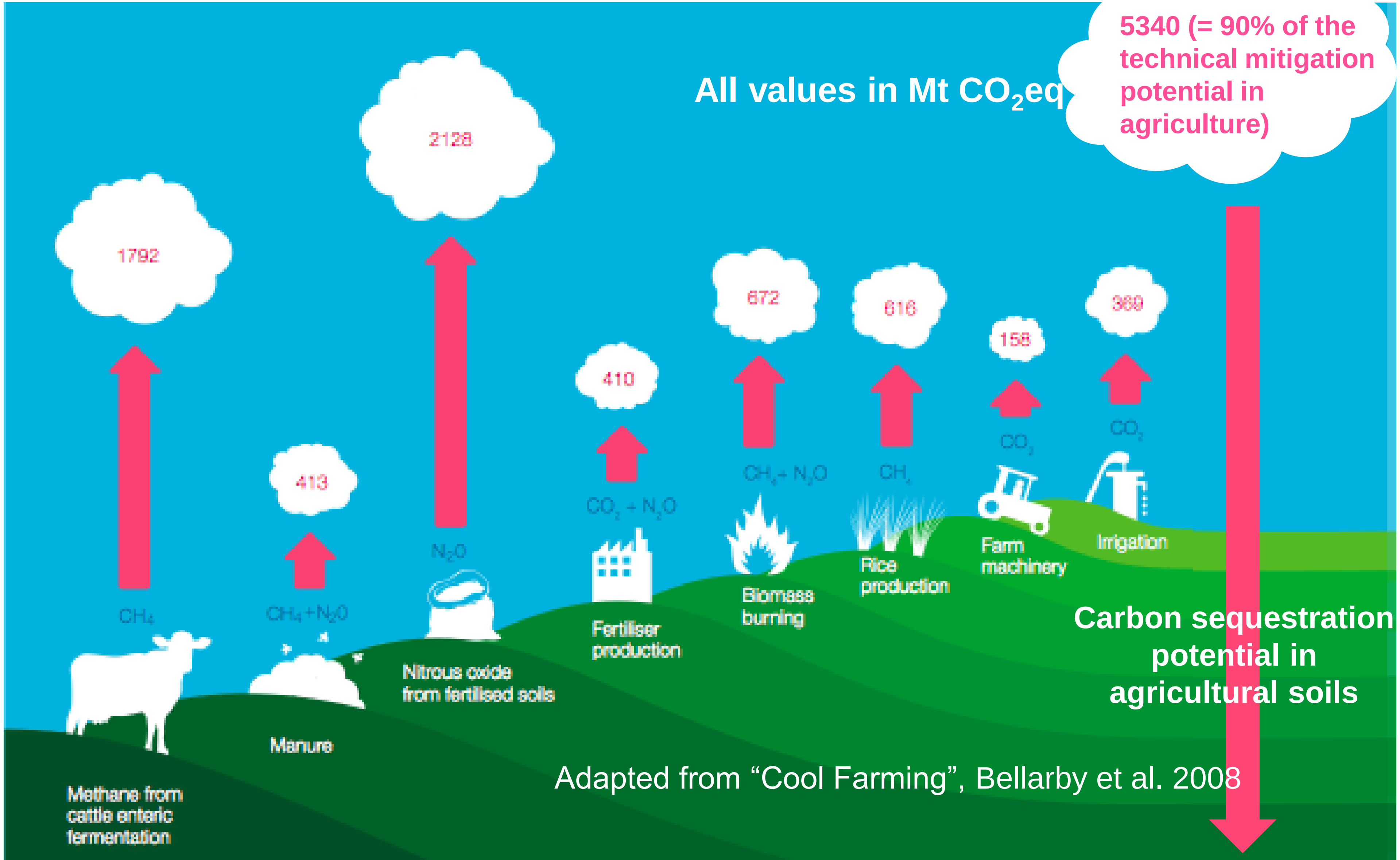

Germany: 66.3 million t CO2-eq: from agriculture (= 7.2% of total emissions)

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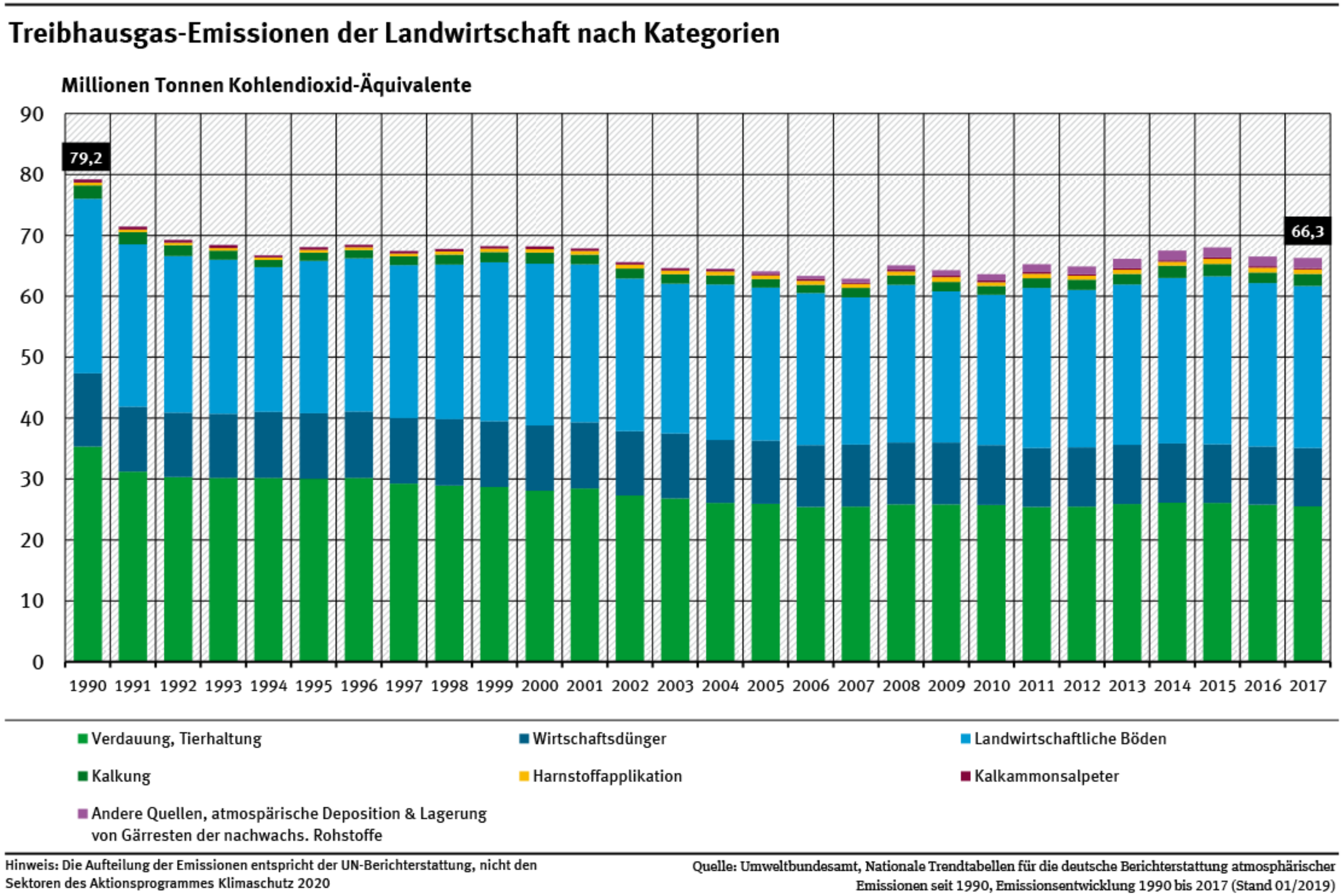

Goal: Reduction of GHG by 34% by 2030 compared with 1990 (16% to date) in accordance with the 2050 climate protection plan

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Population growth per capita 2016

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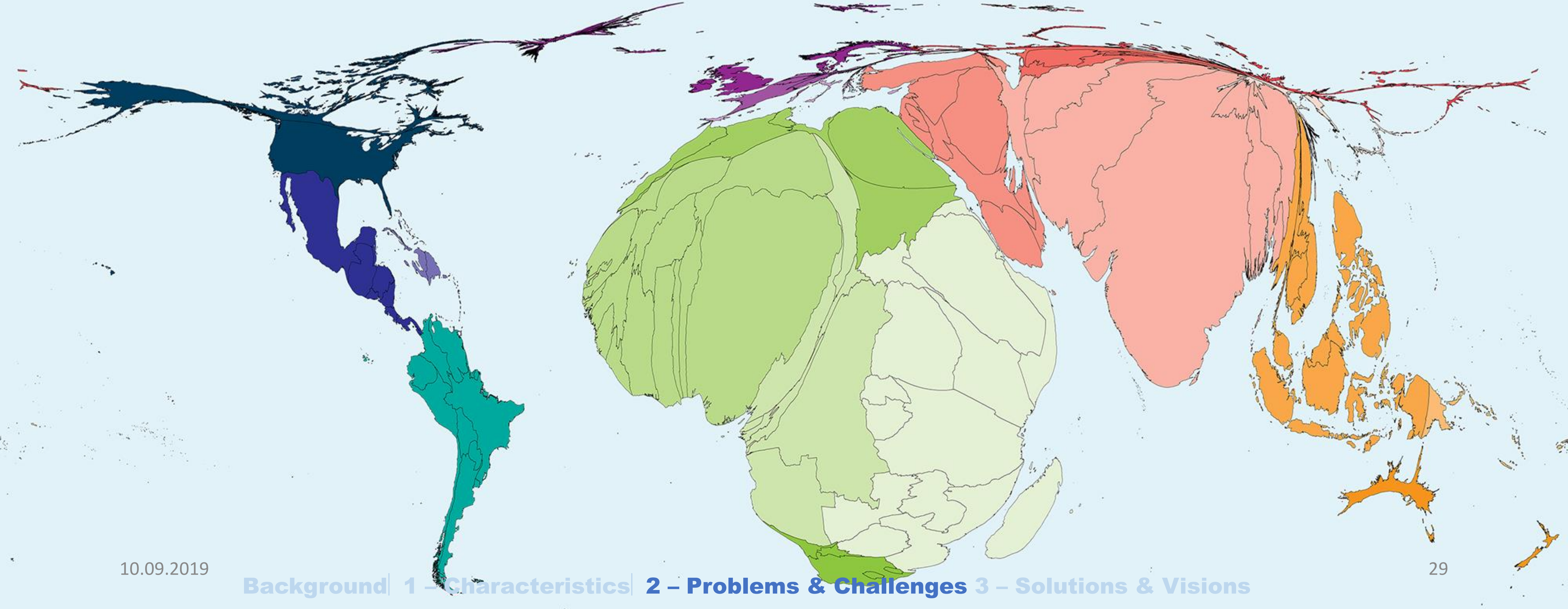
Map based on data from the United World Population Prospects, 2017 Revision. All estimates are based on the 'medium variant' (the middle of a range of estimated populations) projections.

Source: https://worldmapper.org



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Current food and farming systems are responsible for excessive ammonia (NH_3), nitrous oxide (N_2O) and methane (CH_4) emissions

- NH_3 (air quality, eutrophication/acidifiction, indirect global warming): 94% from agricultural activities
- CH_4 (air quality, global warming): 45% from agricultural activities
- N_2O (global warming): 80% from agricultural activities

The waste problem…

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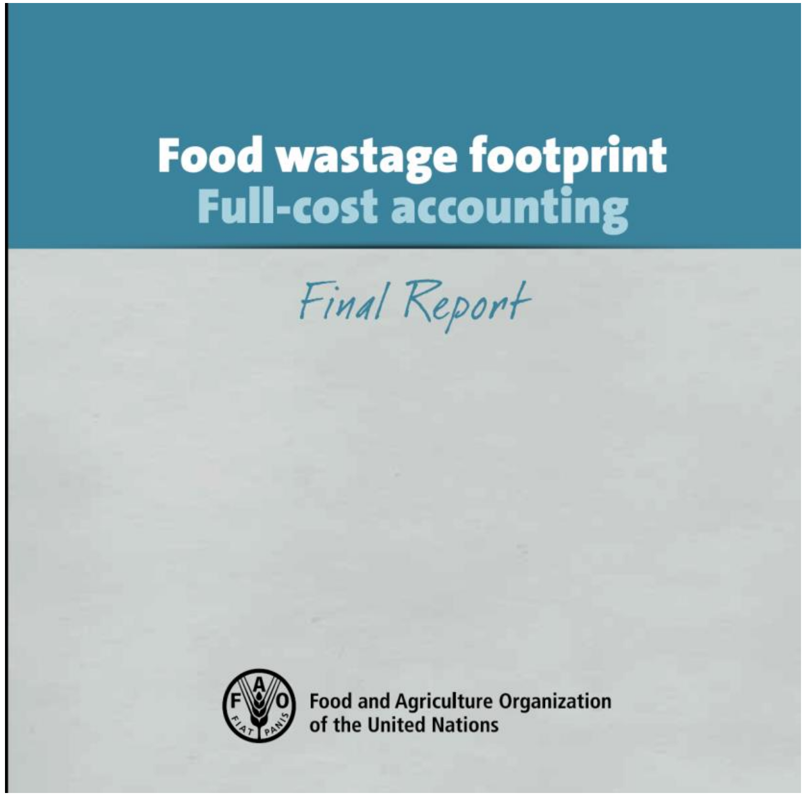
30 - 50 % of foods not directly eaten: post harvest losses, processing & householder losses, fed to ruminants for milk and meat, agro-diesel



http://www.fao.org/3/a-i3991e.pdf

Costs of lost production	1.0 trillion US$
Environmental costs	0.7 trillion US$
Social costs	0.9 trillion US$
Total:	**1.6 trillion US$ p.a.**

3-4 % of the global GDP

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Increasing efficiency urgently needed

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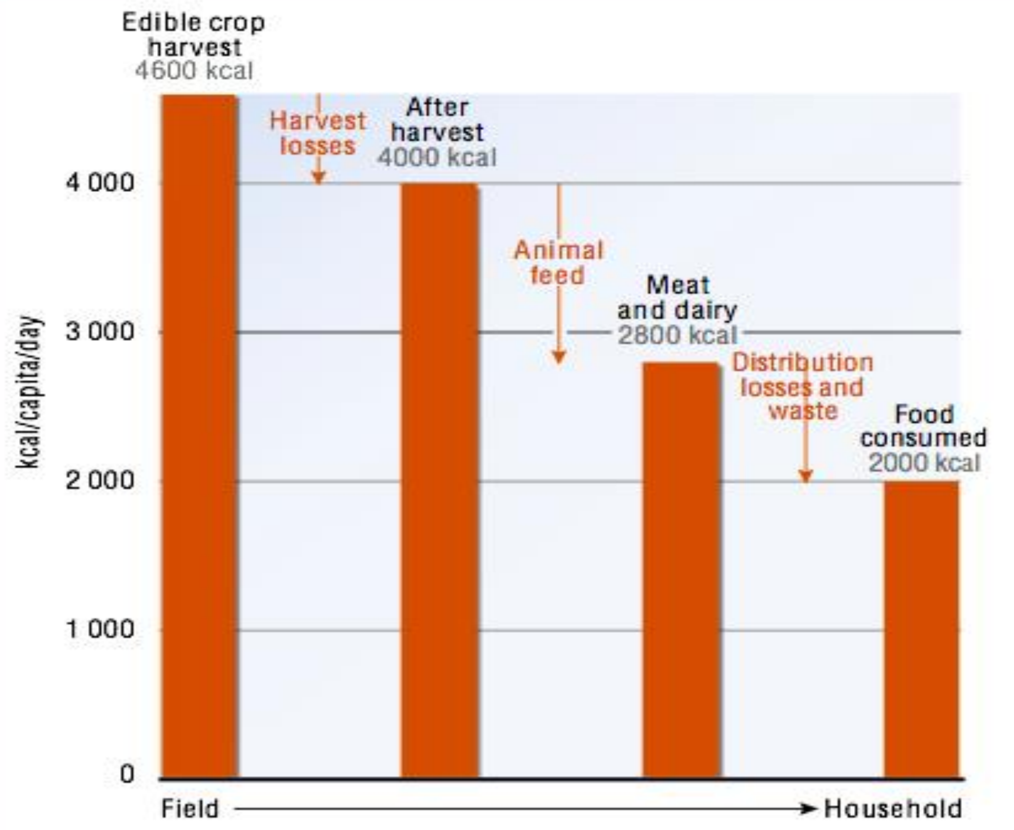


Figure 9a-b: The makeup of total food waste[11]
Source: Lundqvist et al., Godfray

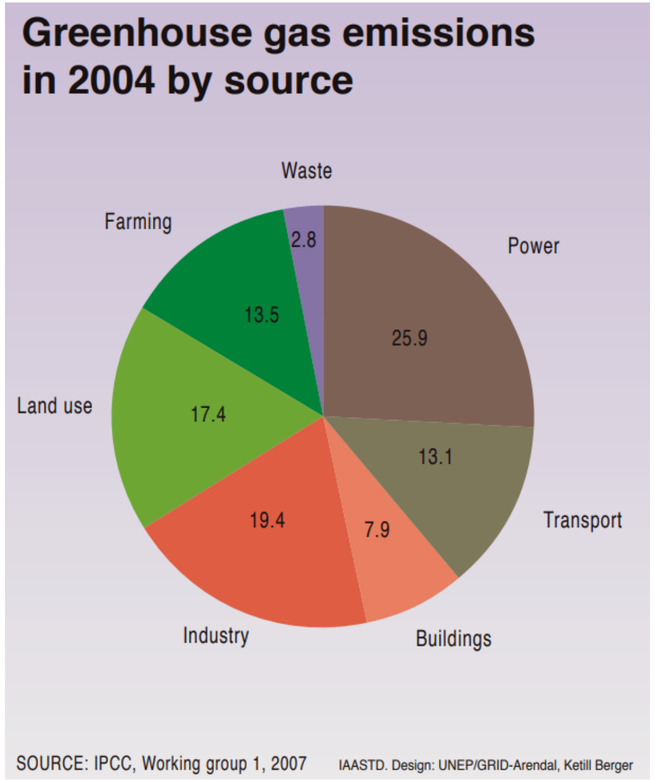
The natural ressources and environment…

What is the environmental footprint of food production?

Food production is the largest cause of global environmental change

- Agriculture occupies about 40% of global land
- Food production is responsible for up to 30% of global greenhouse-gas emissions
- Food production consumes 70% of global freshwater
- Conversion of natural ecosystems to croplands and pastures is the largest factor causing species to be threatened with extinction
- Overuse and misuse of nitrogen and phosphorus causes eutrophication and dead zones in lakes and coastal zones
- Overfishing of the oceans (more than 30% overfished)
- Chemical pollution of the environment

Willett et al. 2019



Global external costs of agriculture (in Million US$)

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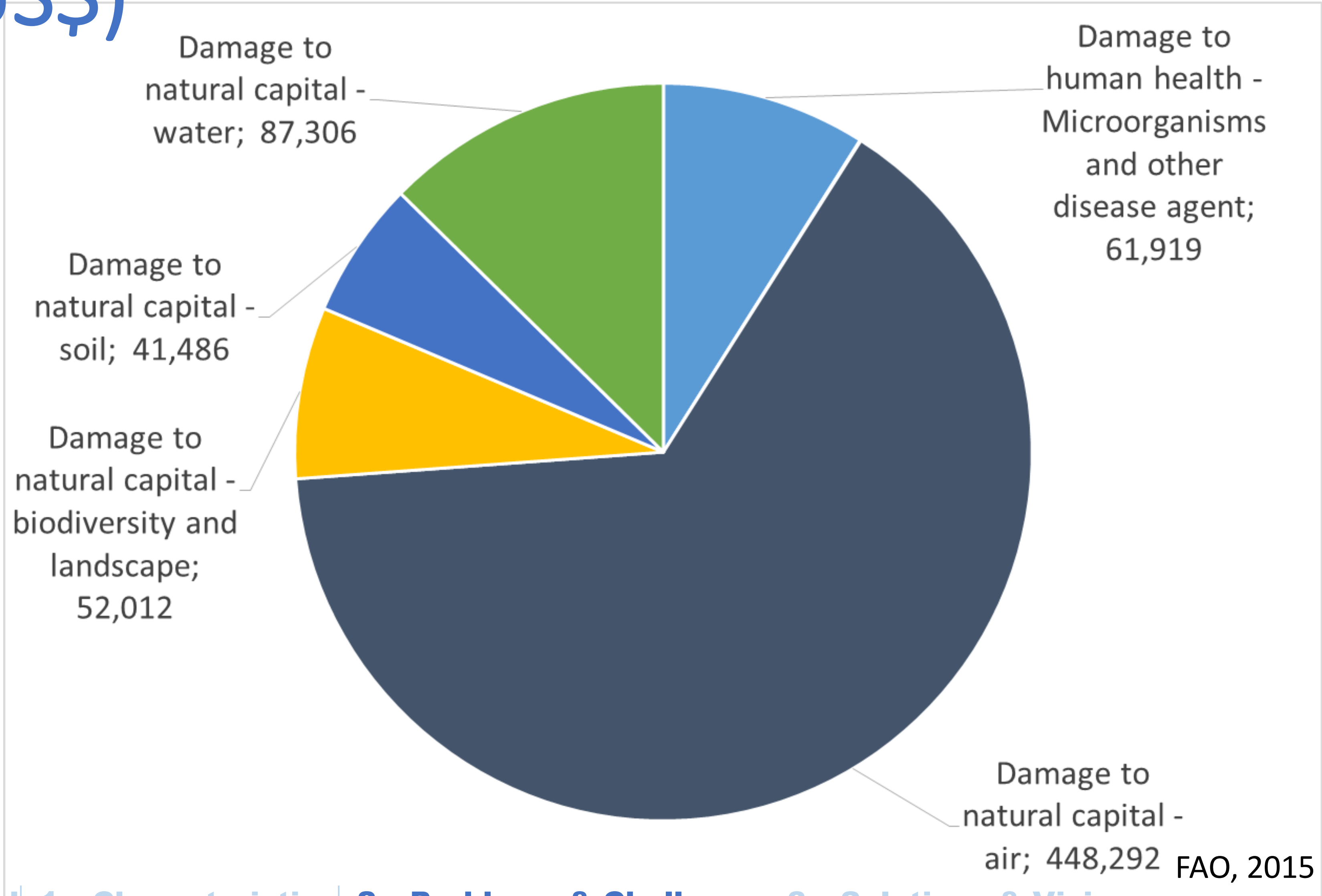

FAO, 2015

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Animal husbandry causes 18% of global GHG emissions (Steinfeld et al., 2006)

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"Please eat less meat. Meat is a very carbon intensive commodity."

Rajendra Pachauri, Chair IPPC, Nobel Laureate 2007

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Environmental effects per serving of food produced

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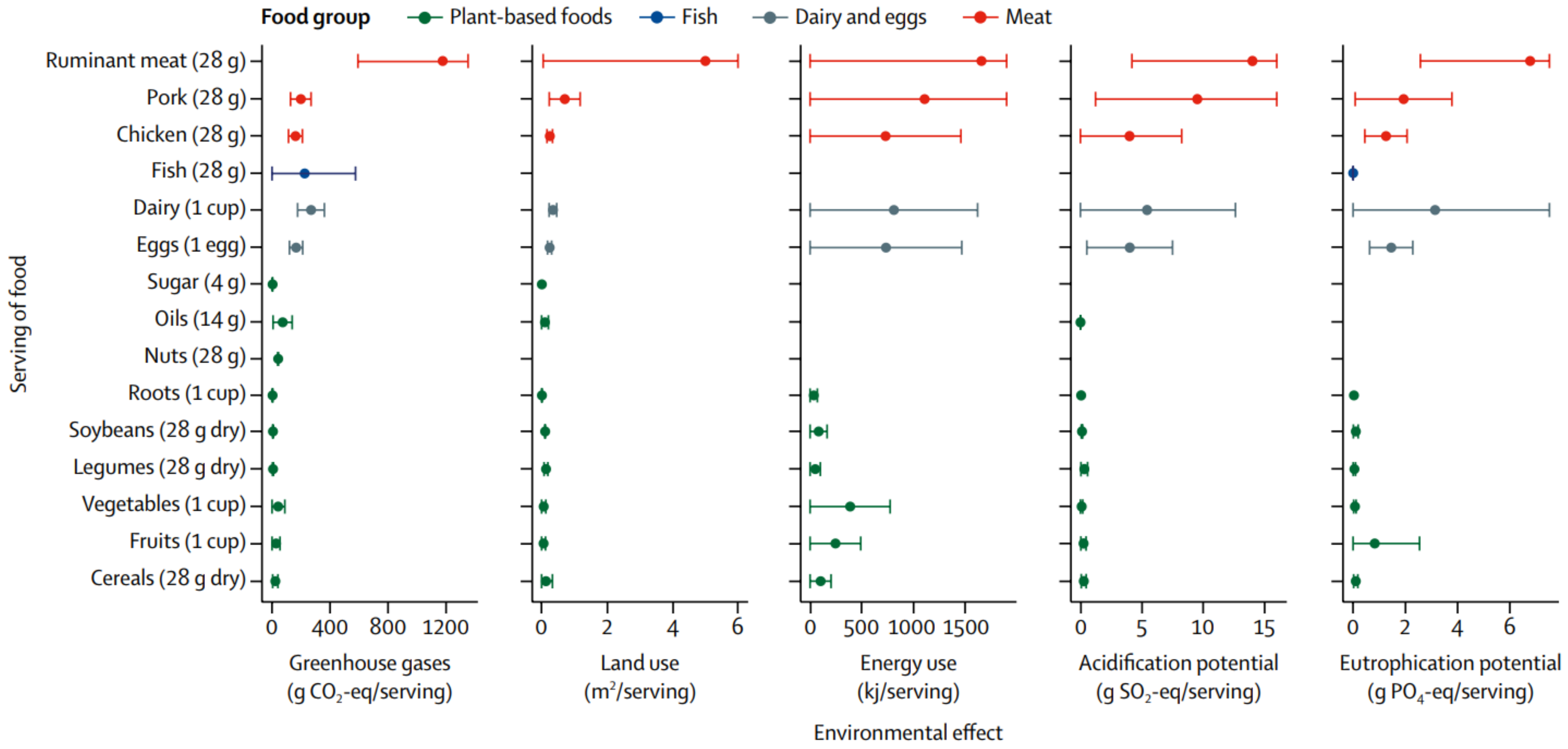

Willett et al. 2019

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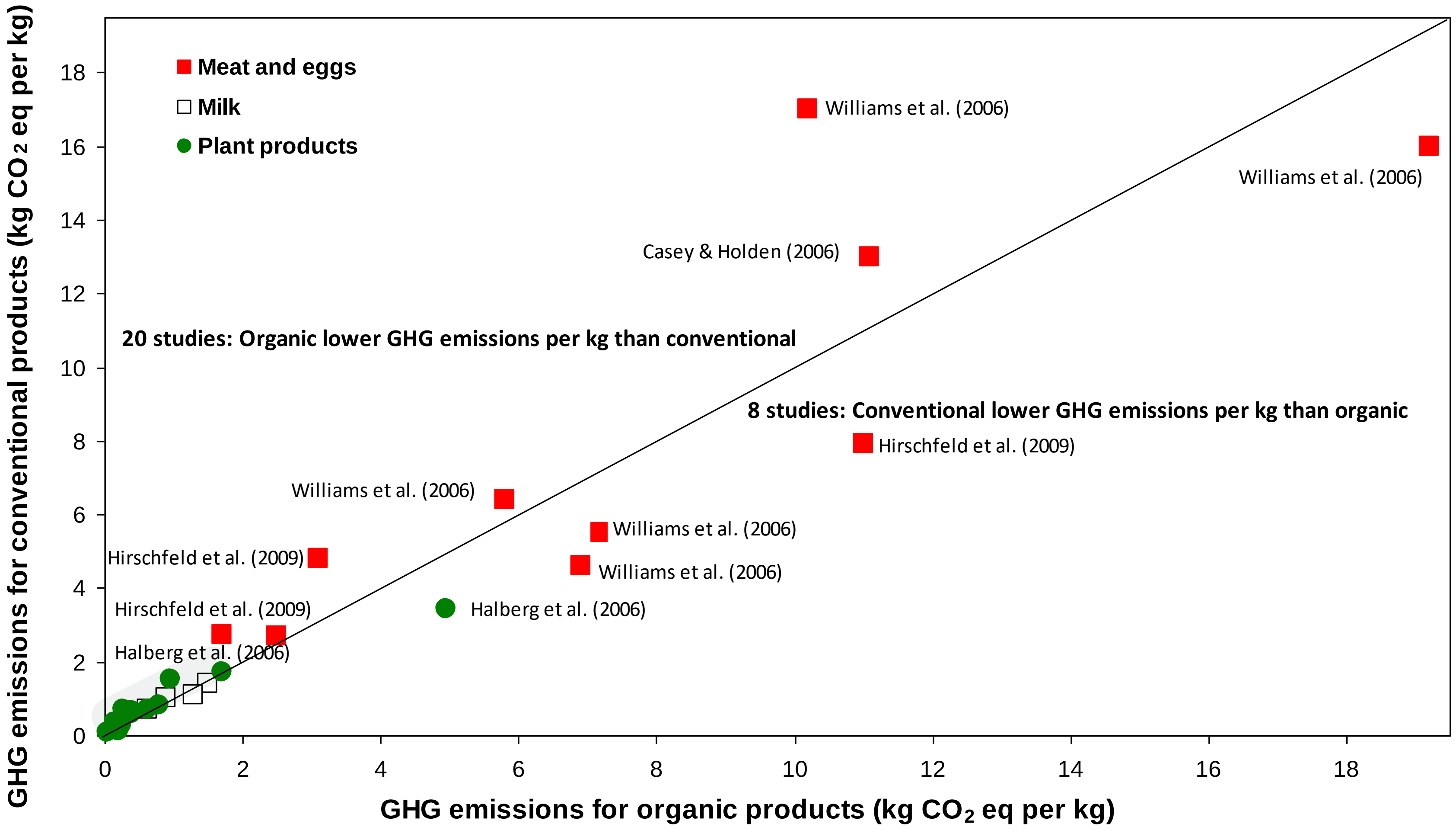
Climate relevance of animal products



Knudsen et al. 2011

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18% of global GHG emissions is caused by livestock

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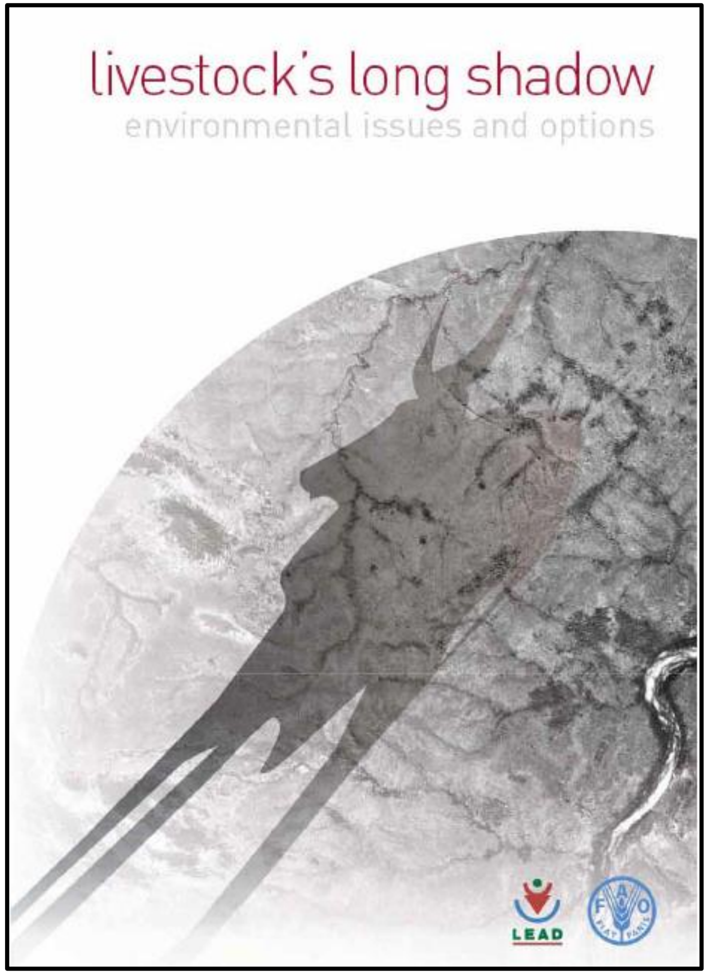

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http://www.fao.org/3/a-a0701e.pdf

Soils under threat…

Soil – key ressource in agriculture

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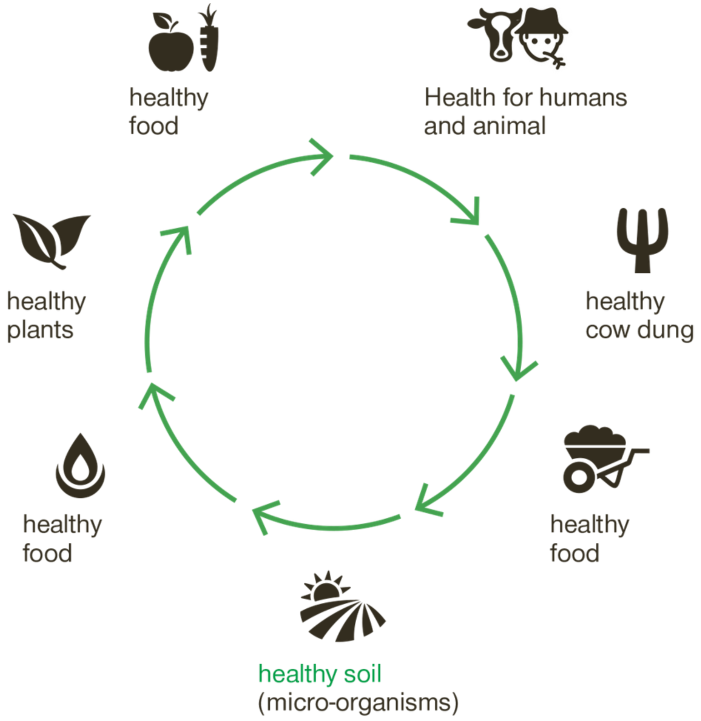
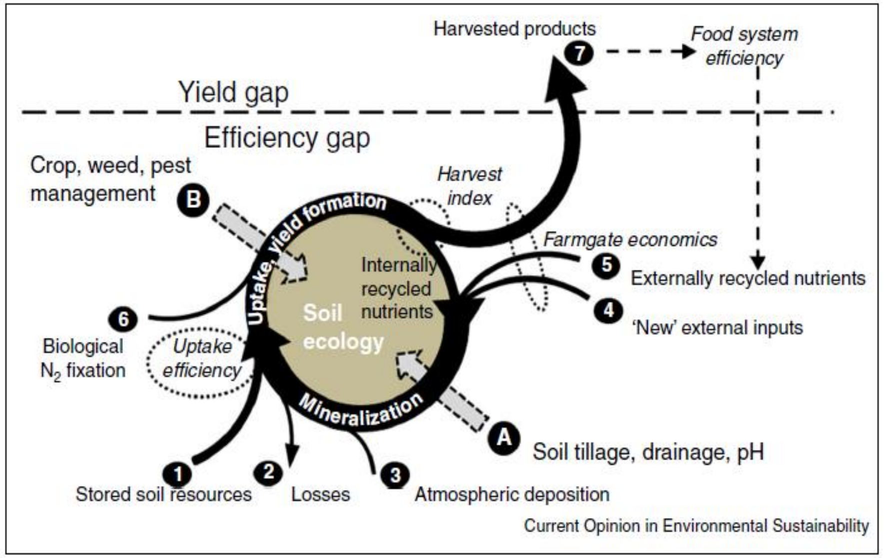


https://www.thinglink.com/scene/649976274629951488



Nordwijk and Brussard. 2015, Curr Op Environ Sus

Soil – key ressource in agriculture

- Approximately 99% of the world's food is supplied by terrestrial systems (Orgiazzi et al., 2016).
- At present, there is 2,000 m2 of arable land available for each person, half of which is used for animal feed and energy production (GIZ, 2015).
- By 2050, an estimated 9 billion people will be living on the planet, with supplies directly (vegetable food) or indirectly (food of animal origin) dependent on intact soils.

Alberto Orgiazzi u. a.: Europäische Kommission (Hg.): Global Soil Biodiversity Atlas (Luxemburg 2016), : http://esdac.jrc.ec.europa.eu/public_path/JRC_global_soilbio_atlas_online.pdf; zuletzt ab-gerufen am 09.08.2016.

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(Soil-based) agriculture worldwide

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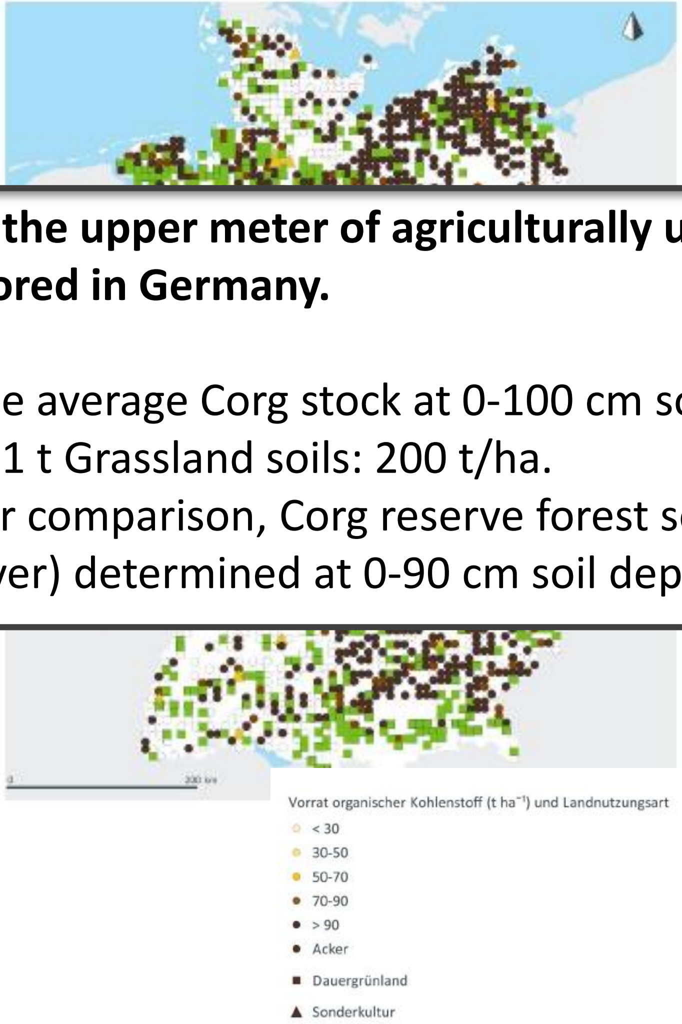
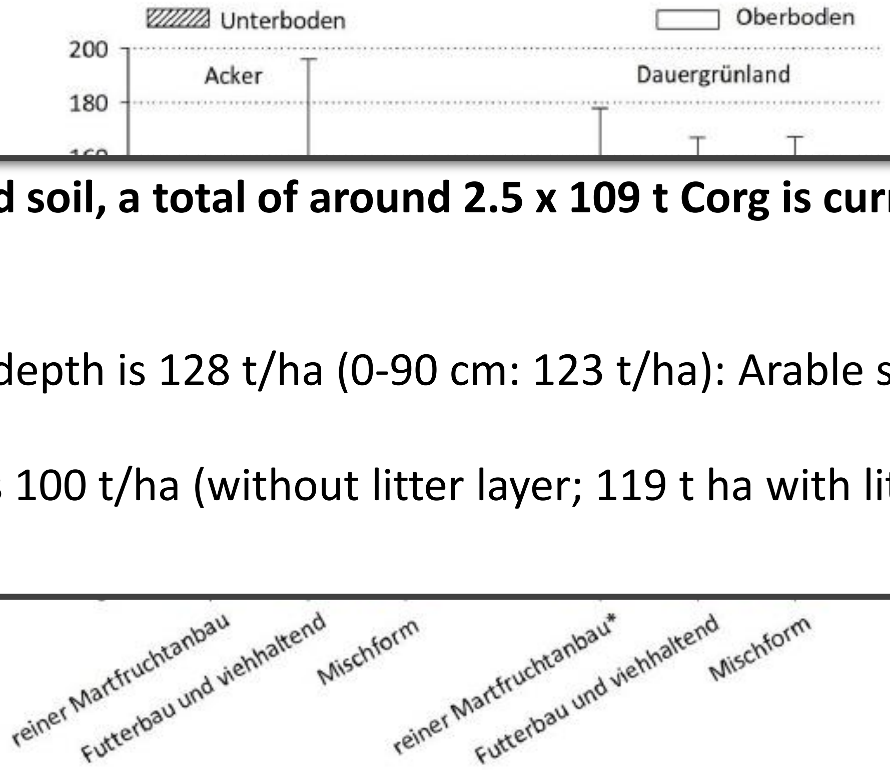
Table 6: Agricultural land use in the last four decades

	Area (M km²)					Change 2000s/1960s	
	1961-70	1971-80	1981-90	1991-00	2001-03	%	M km²
1. World							
Agricultural land	45.38	46.51	47.94	49.49	49.80	10	4.4
Arable land	13.01	13.35	13.79	13.97	14.03	8	1.0
Permanent crops	0.91	0.99	1.10	1.30	1.38	51	0.50
Permanent pasture	31.46	32.18	33.05	34.23	34.39	9	2.9
Forest and Woodland[a]	43.52	42.91	42.87	42.12	0.00	-3	-1.4
Other Land[a]	41.50	40.98	39.59	38.68	0.00	-7	-2.8
Non-arable and -permanent[b]	0.00	0.00	0.00	114.72	114.63	-0.08	-0.1
2. Developed countries							
Agricultural land	18.85	18.82	18.69	18.58	18.24	-3	-0.6
Arable land	6.46	6.48	6.51	6.32	6.10	-6	-0.4
Permanent crops	0.32	0.31	0.30	0.30	0.30	-7	-0.02
Permanent pasture	12.06	12.03	11.88	11.96	11.85	-2	-0.2
Forest and Woodland[a]	19.94	19.93	20.09	19.36	0.00	-3	-0.6
Other Land[a]	15.64	15.68	15.65	16.04	0.00	3	0.4
Non-arable and -permanent[b]	0.00	0.00	0.00	47.46	47.61	0.33	0.15
3. Developing countries							
Agricultural land	26.53	27.69	29.25	30.91	31.56	19	5.0
Arable land	6.55	6.87	7.30	7.65	7.94	21	1.4
Permanent crops	0.59	0.67	0.80	1.00	1.08	84	0.49
Permanent pasture	19.40	20.15	21.18	22.27	22.54	16	3.1
Forest and Woodland[a]	23.58	22.98	22.78	22.75	0.00	-4	-0.8
Other Land[a]	25.86	25.31	23.94	22.64	0.00	-13	-3.2
Non-arable and permanent[b]	0.00	0.00	0.00	67.27	67.02	-0.36	-0.25

Source: FAOSTAT; data archive – land use, accessed 30.05.2007 [a] until 1994; [b] from 1995 onwards

German soil survey for agriculture (D)





In the upper meter of agriculturally used soil, a total of around 2.5 x 109 t Corg is currently stored in Germany.

The average Corg stock at 0-100 cm soil depth is 128 t/ha (0-90 cm: 123 t/ha): Arable soils: 101 t Grassland soils: 200 t/ha.
For comparison, Corg reserve forest soils 100 t/ha (without litter layer; 119 t ha with litter layer) determined at 0-90 cm soil depth.

THÜNEN

Jakobs et al. Thünen Report, 2018

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Soil condition survey for agriculture (D)

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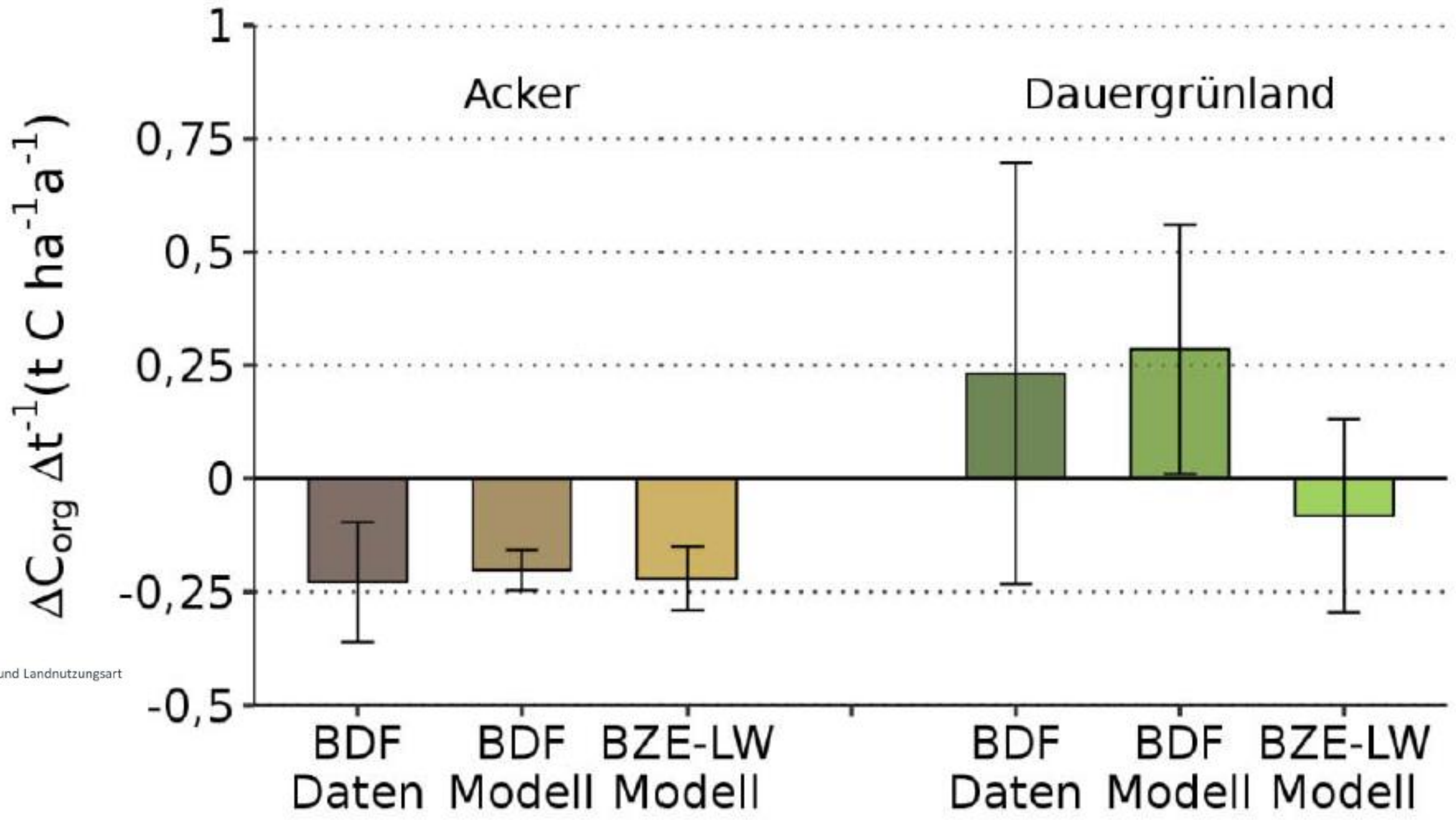

Vorrat organischer Kohlenstoff (t ha^{-1}) und Landnutzungsart
- < 30
- 30-50
- 50-70
- 70-90
- > 90
- Acker
- Dauergrünland
- Sonderkultur

THÜNEN

Jakobs et al. Thünen Report, 2018

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Vicious cycle of humus loss - Decrease in crop yield - Food insecurity

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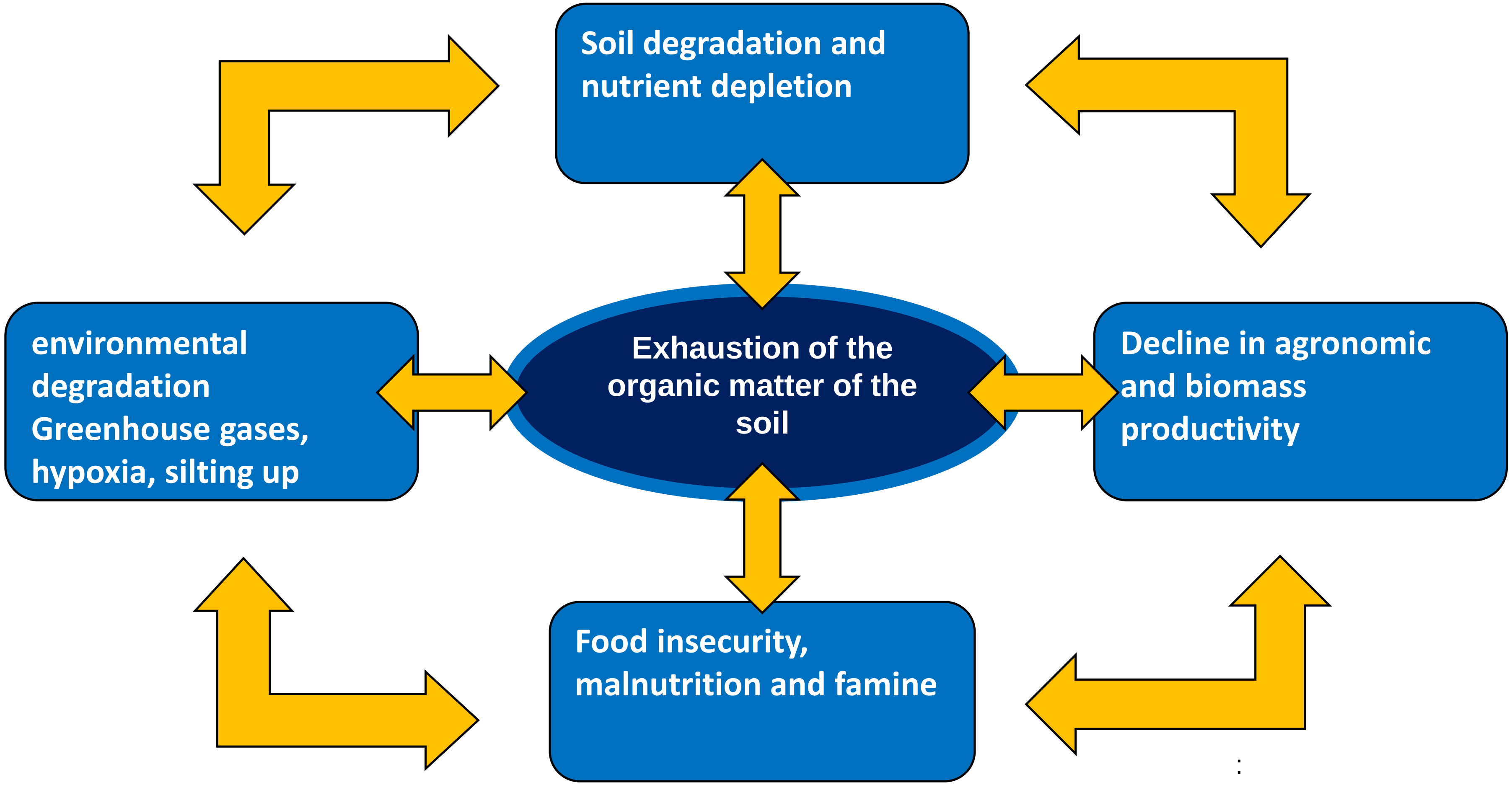

:
Lal R. *(2004) Soil carbon sequestration impacts on global climate change and food security. Science*

Terrestrial stages of the global carbon cycle are of special importance in the mitigation and adaptation efforts to climate change

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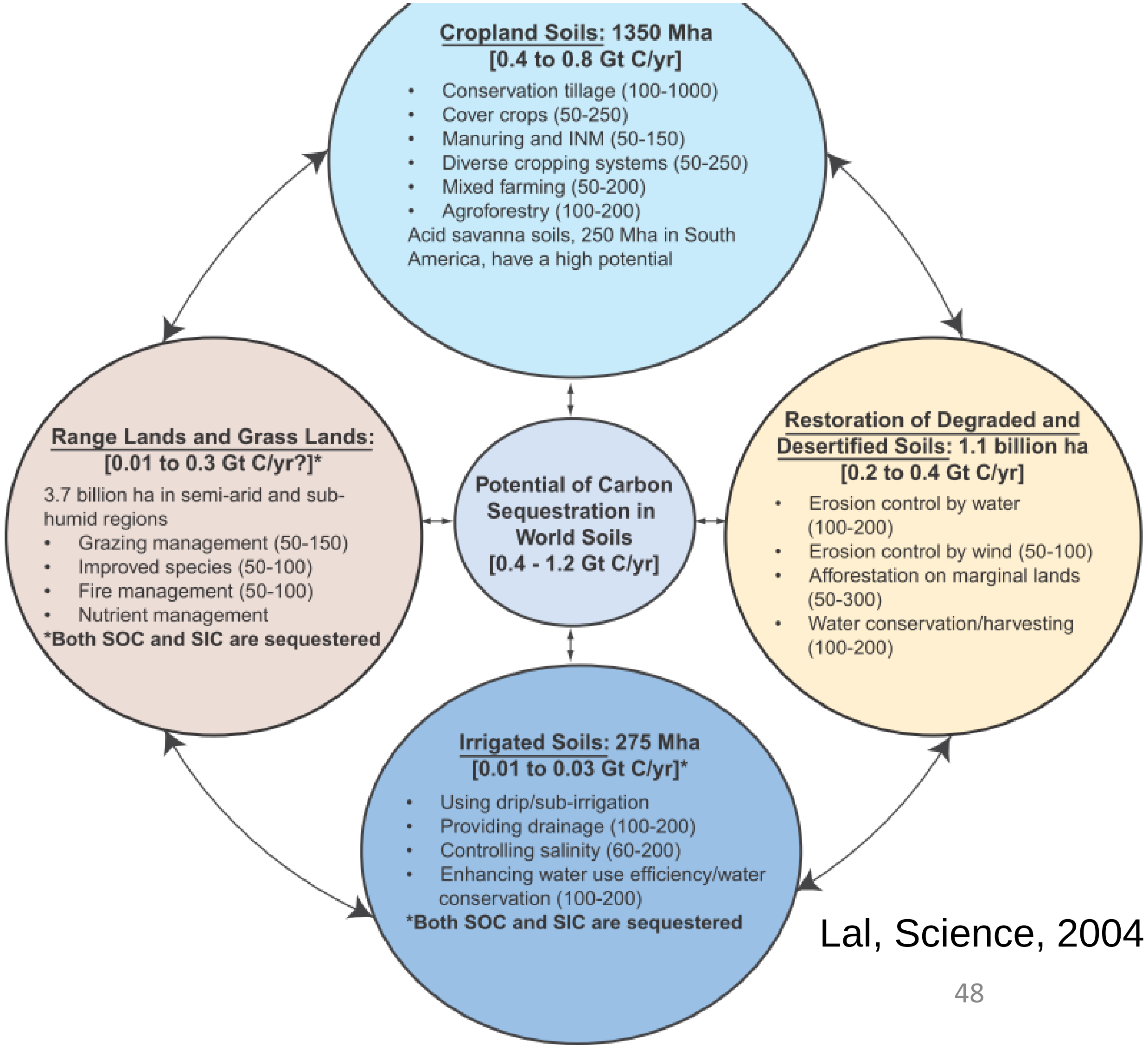
- Soil organic carbon (SOC) pool is twice as big as atmospheric C pool
- historic losses since 1850 are estimated in 78 ± 12Pg CO2 on a global basis
- Emitted fossil fuel combustion 270 ± 30 Pg CO2 *(Lal, 2004)*
- there is a large potential to recover the C historically lost *(Smith et al. 2008)*



Lal, Science, 2004

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...consequences of inappropriate soil and land use

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To waste, to destroy our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them amplified and developed.

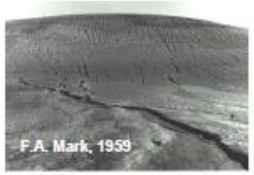
—*Theodore Roosevelt, U.S. President, 1907.*

A nation that destroys its soils destroys itself.

—*Franklin Roosevelt, U.S. President, 1937.*

A-D: Pictorial sequence of a conservation success story initiated during the 1930s in the Coon Valley Watershed in Wisconsin.

Find out more at: http://www.nrcs.usda.gov/about/history/



Soil sealing

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Land taken up by building and transport projects at the cost of agricultural land in Germany

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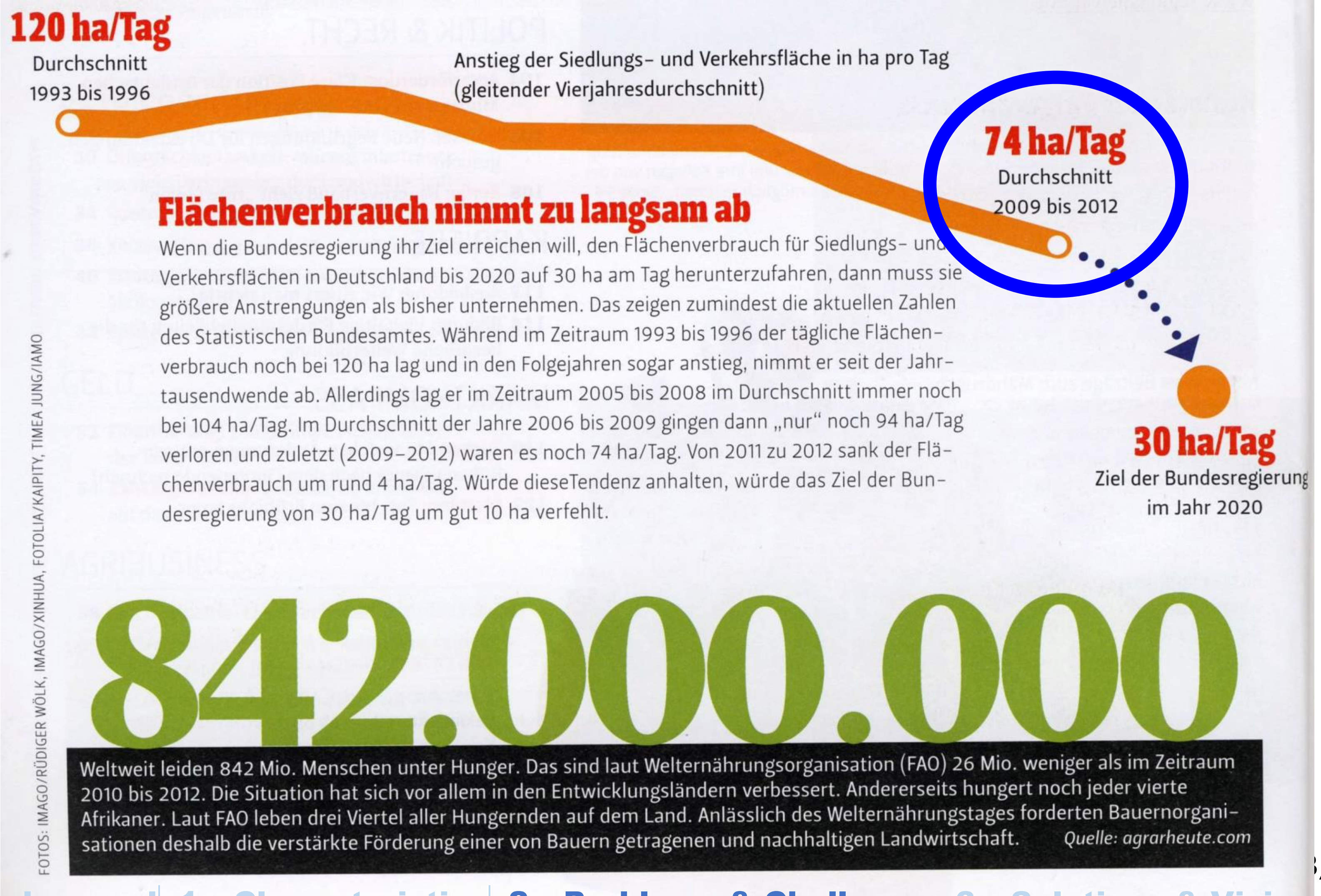

Flächenverbrauch nimmt zu langsam ab

Wenn die Bundesregierung ihr Ziel erreichen will, den Flächenverbrauch für Siedlungs- und Verkehrsflächen in Deutschland bis 2020 auf 30 ha am Tag herunterzufahren, dann muss sie größere Anstrengungen als bisher unternehmen. Das zeigen zumindest die aktuellen Zahlen des Statistischen Bundesamtes. Während im Zeitraum 1993 bis 1996 der tägliche Flächenverbrauch noch bei 120 ha lag und in den Folgejahren sogar anstieg, nimmt er seit der Jahrtausendwende ab. Allerdings lag er im Zeitraum 2005 bis 2008 im Durchschnitt immer noch bei 104 ha/Tag. Im Durchschnitt der Jahre 2006 bis 2009 gingen dann „nur" noch 94 ha/Tag verloren und zuletzt (2009–2012) waren es noch 74 ha/Tag. Von 2011 zu 2012 sank der Flächenverbrauch um rund 4 ha/Tag. Würde dieseTendenz anhalten, würde das Ziel der Bundesregierung von 30 ha/Tag um gut 10 ha verfehlt.

842.000.000

Weltweit leiden 842 Mio. Menschen unter Hunger. Das sind laut Welternährungsorganisation (FAO) 26 Mio. weniger als im Zeitraum 2010 bis 2012. Die Situation hat sich vor allem in den Entwicklungsländern verbessert. Andererseits hungert noch jeder vierte Afrikaner. Laut FAO leben drei Viertel aller Hungernden auf dem Land. Anlässlich des Welternährungstages forderten Bauernorganisationen deshalb die verstärkte Förderung einer von Bauern getragenen und nachhaltigen Landwirtschaft. *Quelle: agrarheute.com*

FOTOS: IMAGO/RÜDIGER WÖLK, IMAGO/XINHUA, FOTOLIA/KAIPITY, TIMEA JUNG/IAMO

, S. 6

Social justice and equity…

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Do we have enough food for all?

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Population growth per capita 2016

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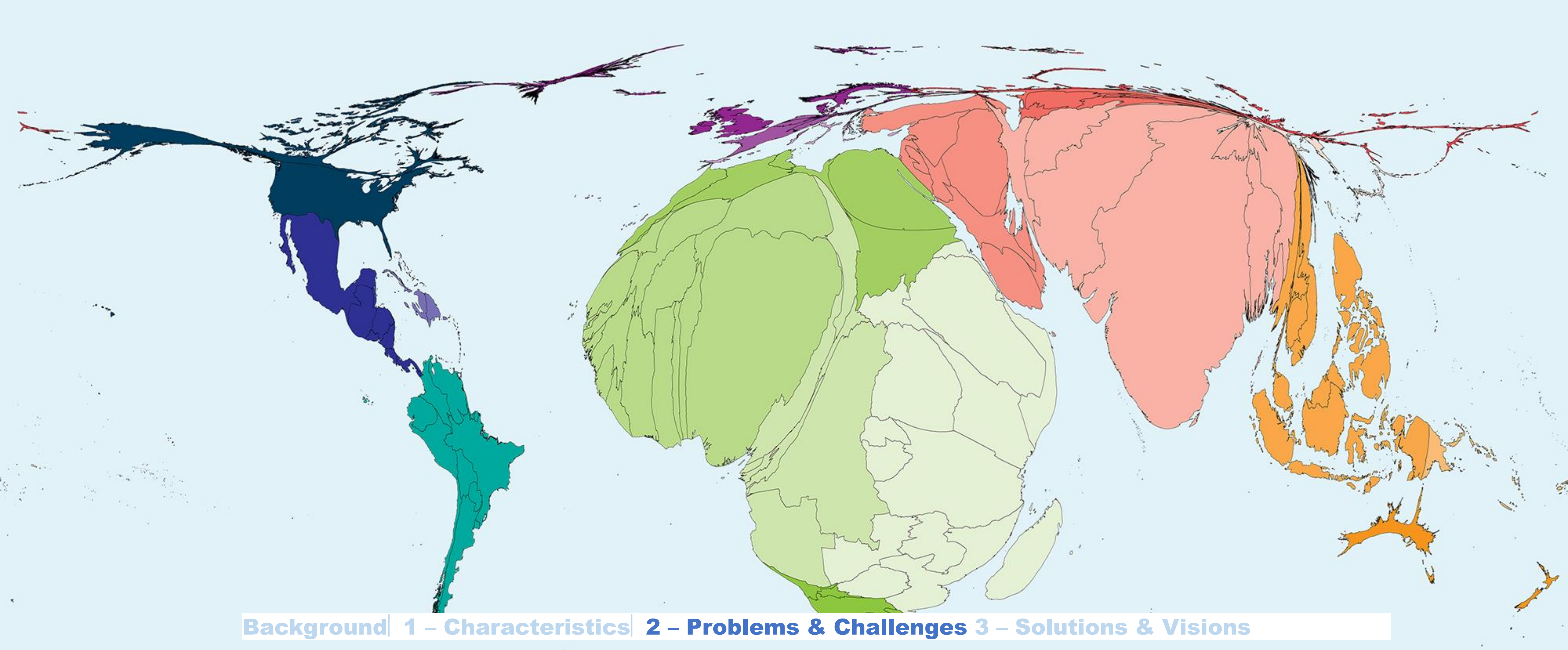
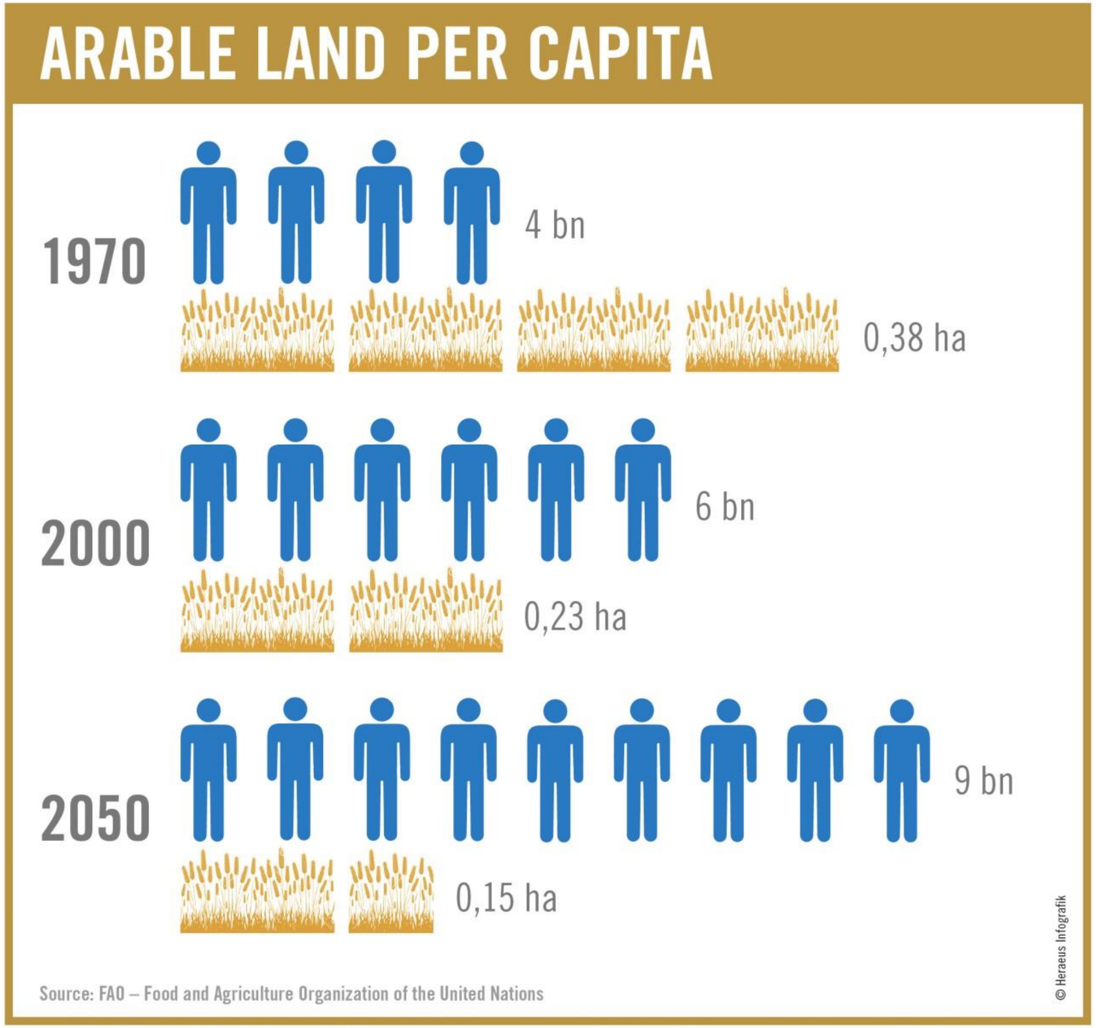
Map based on data from the United World Population Prospects, 2017 Revision. All estimates are based on the 'medium variant' (the middle of a range of estimated populations) projections.



Arable land per capita is shrinking worldwide



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Per capita arable land shrinking worldwide

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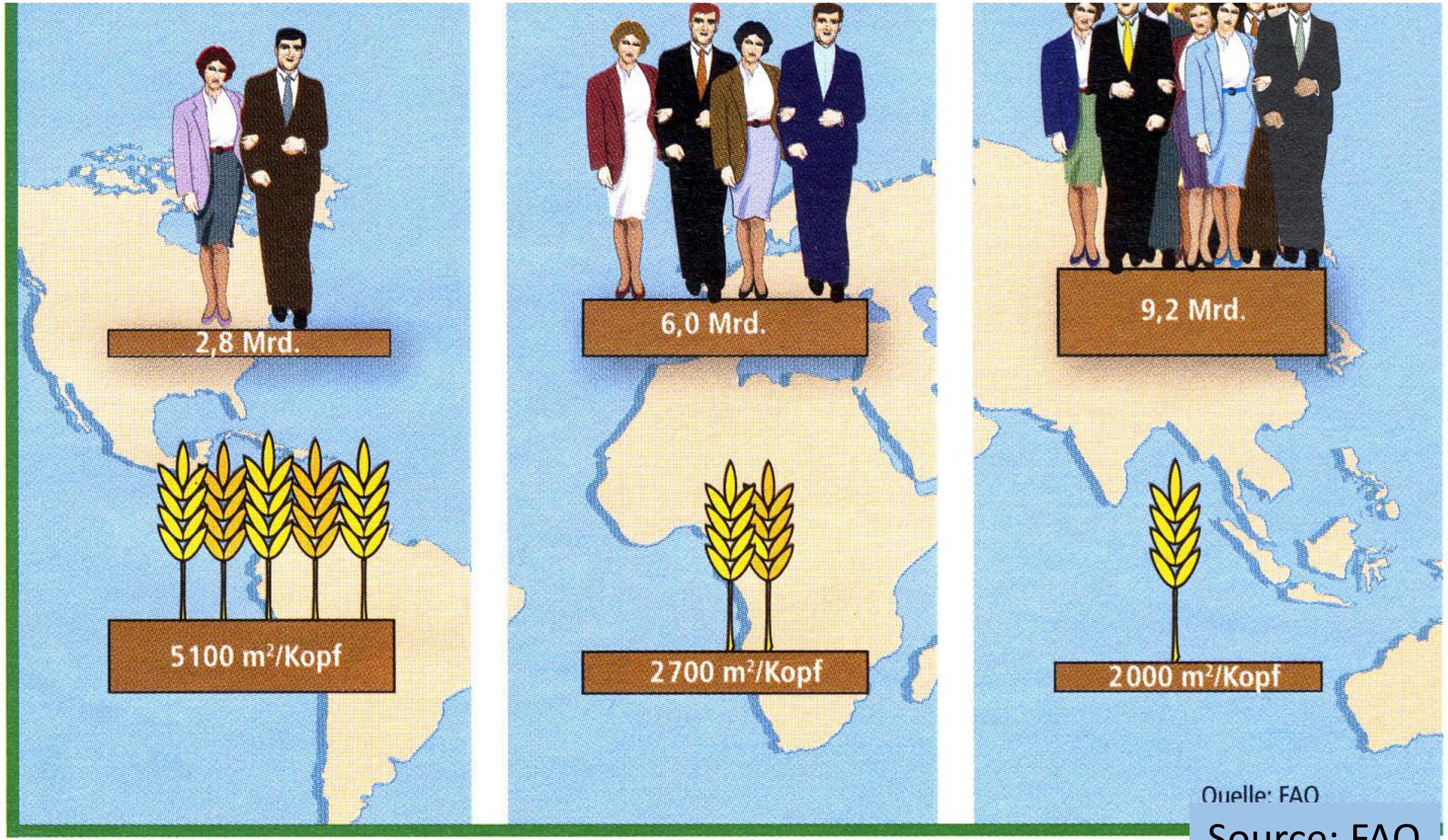

Source: FAO

Die Ackerfläche pro Kopf sinkt dramatisch. In 2050 wird sie in weiteren Regionen der Erde nicht mehr reichen, um die Menschen dort satt zu machen.

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Forecasted yield increase to feed a growing world population

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Year	Cereal Yield / Mg ha^{-1}	Total Production / 10^6 Mg
2005	3.27	2240
2025 a.	3.60	2780
b.	4.40	3629
2050 a.	4.30	3255
b.	6.00	4553

a = without dietary change
b = with change to preference for meat-based (animal-based) diet

- 45% more yield until 2050 necessary with constant nutrition
- 103% additional yield by 2050 necessary for predominantly "animal-based" nutrition

Lal, 2010

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Causes of food insecurity

- Access to food is more important than availability (= absolute quantity produced by farmers).
- Why do people not have access?
- Poverty, debt, bankruptcy, expropriation;
- Unequal distribution;
- Unattractive prices, rural exodus;
- Political turmoil, democratic deficits.

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Causes of food insecurity

- We feed 21.7 billion farm animals (1.5 billion cattle and buffalo), which will continue to increase without changing eating habits.
- The feeding of cereals to livestock consumes 7 times more cultivated land per kilocalorie.
- Significantly more than 30% of all food ends up in waste or spoilage at storage sites or during transport.
- A tank full of agro-diesel from an off-road vehicle can feed a person for a year.

Agro– Food for Thought

1. Characteristics of current food and farming systems, focus Germany

2. Problems & challenges

3. **Solutions & visions**

Sustainable Development Goals (SDGs):17 Goals for a Sustainable World

http://www.un.org/sustainabledevelopment/sustainable-development-goals/

The Lancet Commissions

Food in the Anthropocene: the EAT–*Lancet* Commission on healthy diets from sustainable food systems

Walter Willett, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, David Tilman, Fabrice DeClerck, Amanda Wood, Malin Jonell, Michael Clark, Line J Gordon, Jessica Fanzo, Corinna Hawkes, Rami Zurayk, Juan A Rivera, Wim De Vries, Lindiwe Majele Sibanda, Ashkan Afshin, Abhishek Chaudhary, Mario Herrero, Rina Agustina, Francesco Branca, Anna Lartey, Shenggen Fan, Beatrice Crona, Elizabeth Fox, Victoria Bignet, Max Troell, Therese Lindahl, Sudhvir Singh, Sarah E Cornell, K Srinath Reddy, Sunita Narain, Sania Nishtar, Christopher J L Murray

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How to solve the problems regarding the sustainability of our food production?

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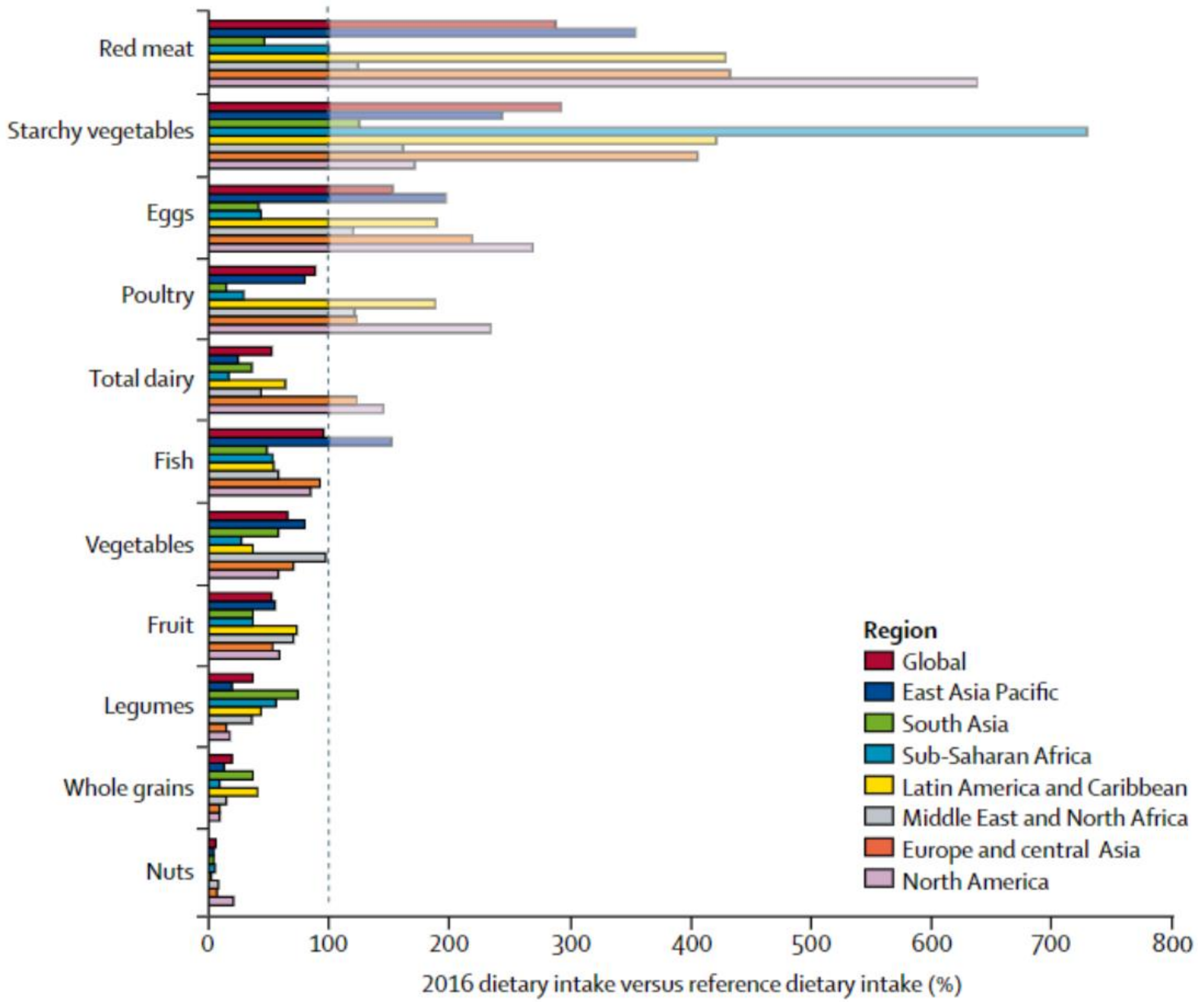

Transformation to healthy diets by 2050 will require substantial dietary shifts

- Consumption of unhealthy foods such as red meat and sugar must be reduced by >50%.
- Consumption of healthy foods such as nuts, fruit, vegetables and legumes must increase by >100%.

Willett et al. 2019

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Projections of global emissions to keep global warming to well below 2°C, aiming for 1.5°C

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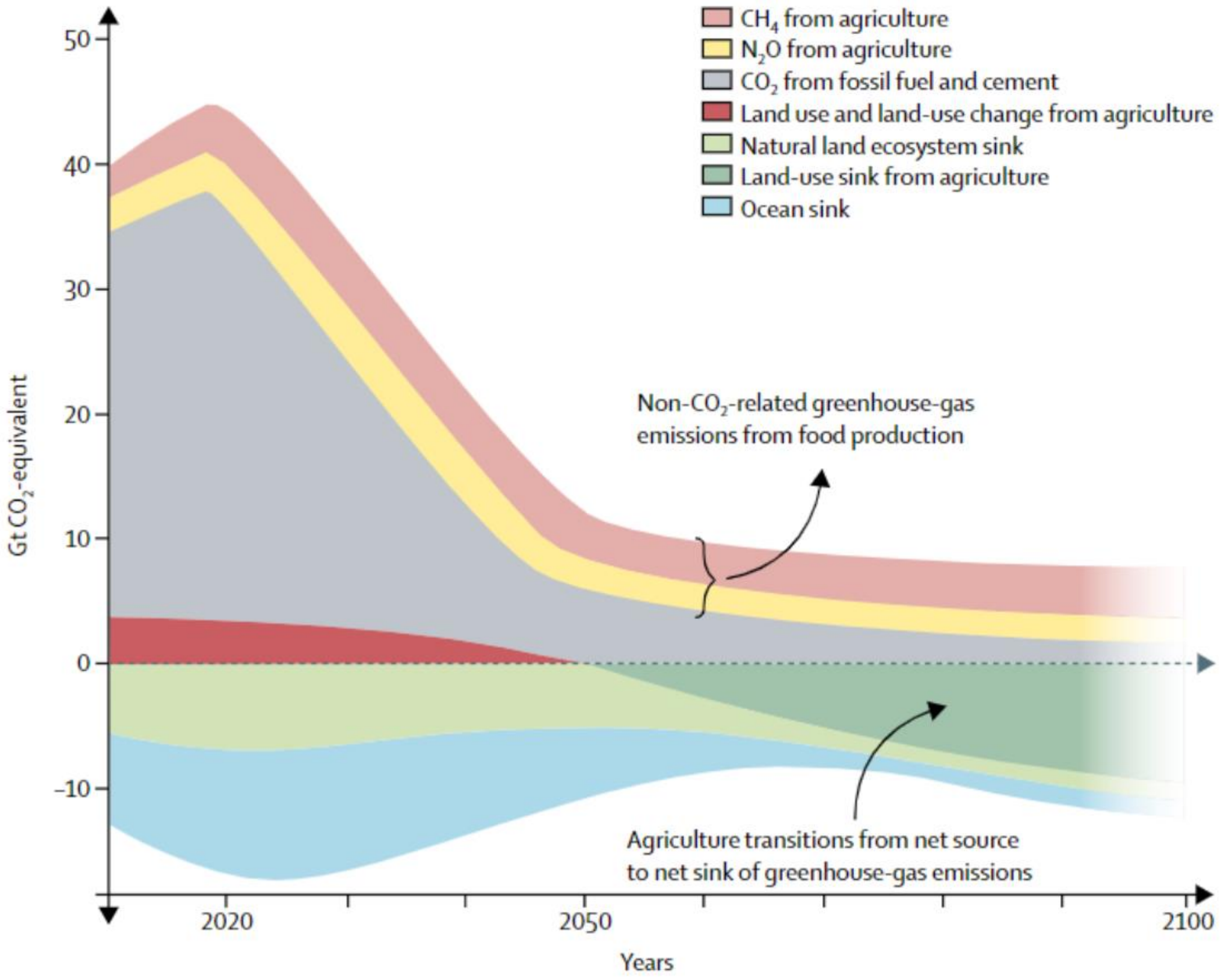

How to solve the problems regarding the sustainability of our food production?

A sustainable food production for about 10 billion people should:

- use no additional land
- safeguard existing biodiversity
- reduce water consumption and manage water responsible
- reduce nitrogen and phosphorus pollution
- produce no CO2 emissions and keep CH4 and N2O emissions at the same level

Willett et al. 2019

How to solve the problems regarding the sustainability of our food production?

Transformation to sustainable food production by 2050 will require

- at least a 75% reduction of yield gaps
- global redistribution of nitrogen and phosphorus fertiliser use
- recycling of phosphorus
- radical improvements in efficiency of fertiliser and water use
- rapid implementation of agricultural mitigation options to reduce greenhouse-gas emissions
- adoption of land management practices that shift agriculture from a carbon source to sink

Willett et al. 2019

Political framework

- Environmental legislation.
- Ecological and social standards in the WTO.
- Remove false incentives in agricultural policy.
- Public money for public goods.
- Carbon taxes and carbon offsets mechanisms for agriculture.
- Fairtrade and eco-labels.

Copenhagen House of Food: Changing diets in public meals

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Organic conversion in the saucepan

What is done differently in the kitchen?

1) Less meat – different meat
2) More vegetables – greens in season
3) More potatoes – better potatoes
4) Fruit in season- fruit alone is not enough
5) More or different use of bread and grains
6) Beware of the sweet and expensive.
7) Composition of the menus - Difference between everyday and feast.
8) Old housekeeping virtues - Rational kitchen operation (less waste)
9) Critical use of full-and semi-manufactures,more ingredients
10) Find the weak point, one or more of the above

Anya Hultberg & Betina Bergmann Madsen

Anya Hultberg & Betina Bergmann Madsen

Implementation of agro-ecological and organic food and farming systems across farm, landscape and food system scale

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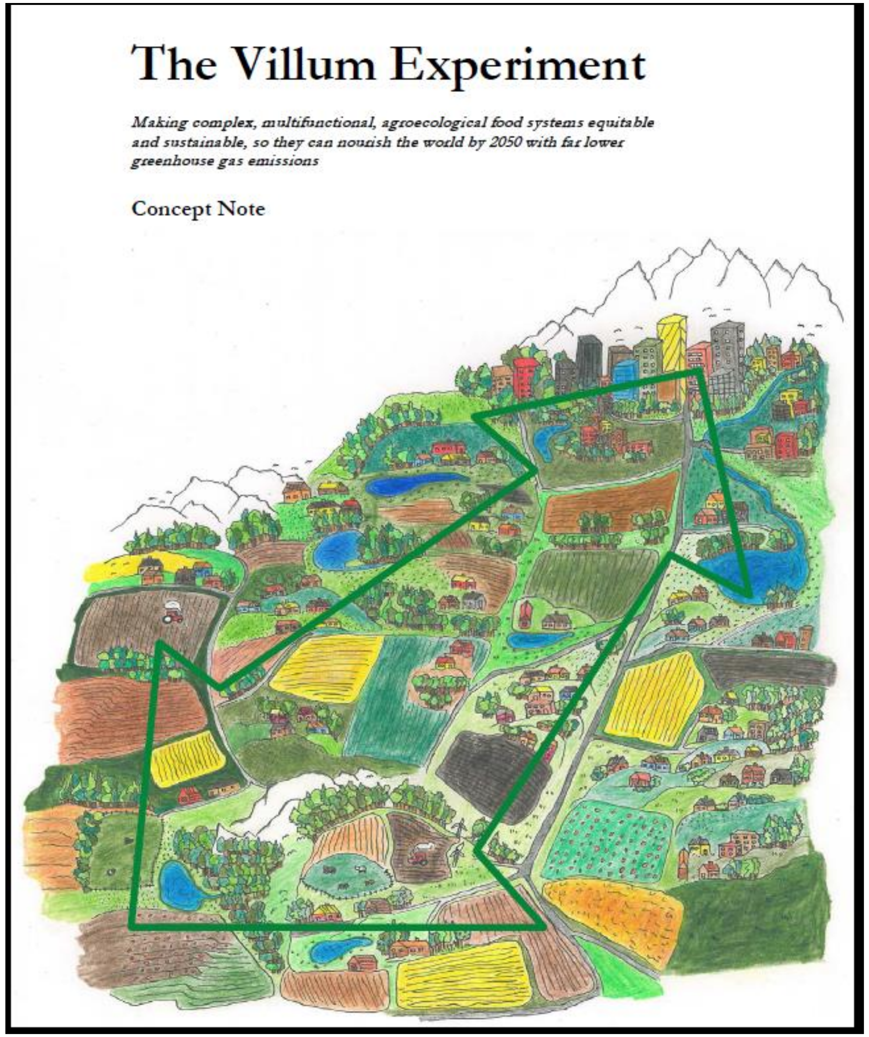
The Villum Experiment

Making complex, multifunctional, agroecological food systems equitable and sustainable, so they can nourish the world by 2050 with far lower greenhouse gas emissions

Concept Note

Making complex, multifunctional, agroecological food systems equitable and sustainable, so they can nourish the world by 2050 with far lower greenhouse gas emissions

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Which agricultural systems are sustainable and socially equitable to feed the world in 2050 with significantly reduced greenhouse gas emissions?

Green revolution 2.0 ?

Organic Farming?

Regenerative Production?

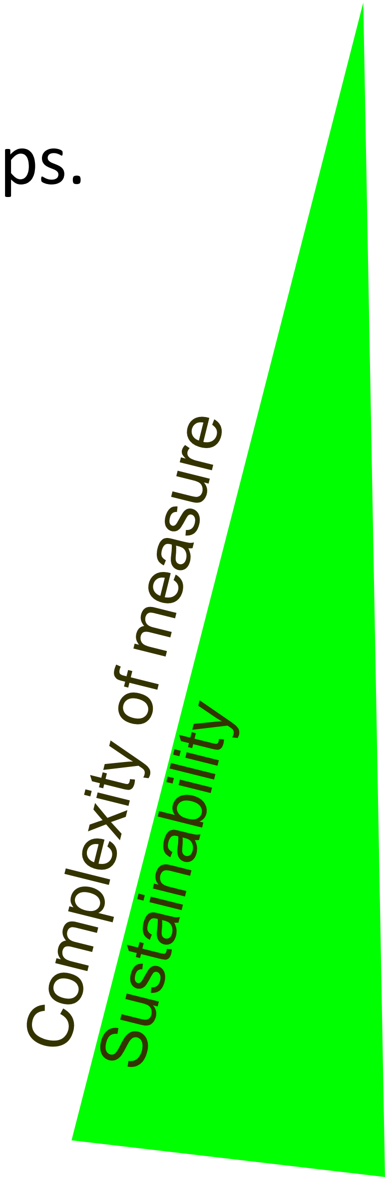
Intensivication?

Integrated Production?

Agroecology (La Via Campesina) ?

Different approaches to sustainability

- Improved technologies like minimum/ no tillage or GMO crops.
- Integrated Production (IP, IPM).
- Low Input Agriculture (LIA) or Precision Farming.
- Low External Input Sustainable Agriculture (LEISA).
- Organic Farming
- Organic plus innovative elements of low till, precision farming and LEISA.
- Organic (successional) agroforestry systems



Can organic farming feed 9 billion people?

No,

at present 1 billion people suffer from malnutrition or starve to death (every 7th person).

Why should 2% organic farmers be able to do what 98% conventional and subsistence farmers cannot?

Can today's agriculture feed 9 billion people?

Yes,

Today agriculture produces food 7.5 to 11 billion people

- whether conventional, integrated or biological plays a subordinate role!

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Soil-based climate impacts of organic agriculture

Klimaschutz

Bodenkohlenstoff (Organische Bodensubstanz)	**Bodenbürtige Lachgasemissionen**	**Bodenbürtige Methanemissionen**
- **Organische C-Gehalte im Boden** (SOC in %) - **Organische C-Vorräte im Boden** (C t/ha) - **C-Speicherung im Boden** (C kg/ha x Jahr)	- **Kumulierte N2O-Emissionen** (kg N2O-N/ha x Jahr)	- **Kumulierte CH4-Emissionen** (kg CH4-C/ha x Jahr)

Contents lists available at ScienceDirect

Science of the Total Environment

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

ELSEVIER

Greenhouse gas fluxes from agricultural soils under organic and non-organic management — A global meta-analysis

CrossMark

Colin Skinner [a], Andreas Gattinger [a,*], Adrian Muller [a], Paul Mäder [a], Andreas Fließbach [a], Matthias Stolze [a], Reiner Ruser [b], Urs Niggli [a]

[a] *Research Institute of Organic Agriculture (FiBL), Ackerstrasse 21, 5070 Frick, Switzerland*
[b] *Fertilisation and Soil Matter Dynamics (340i), Institute of Crop Science, University of Hohenheim, Fruwirthstraße 20, 70599 Stuttgart, Germany*

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Global meta-analysis on N_2O emissions from soils under organic and conventional management

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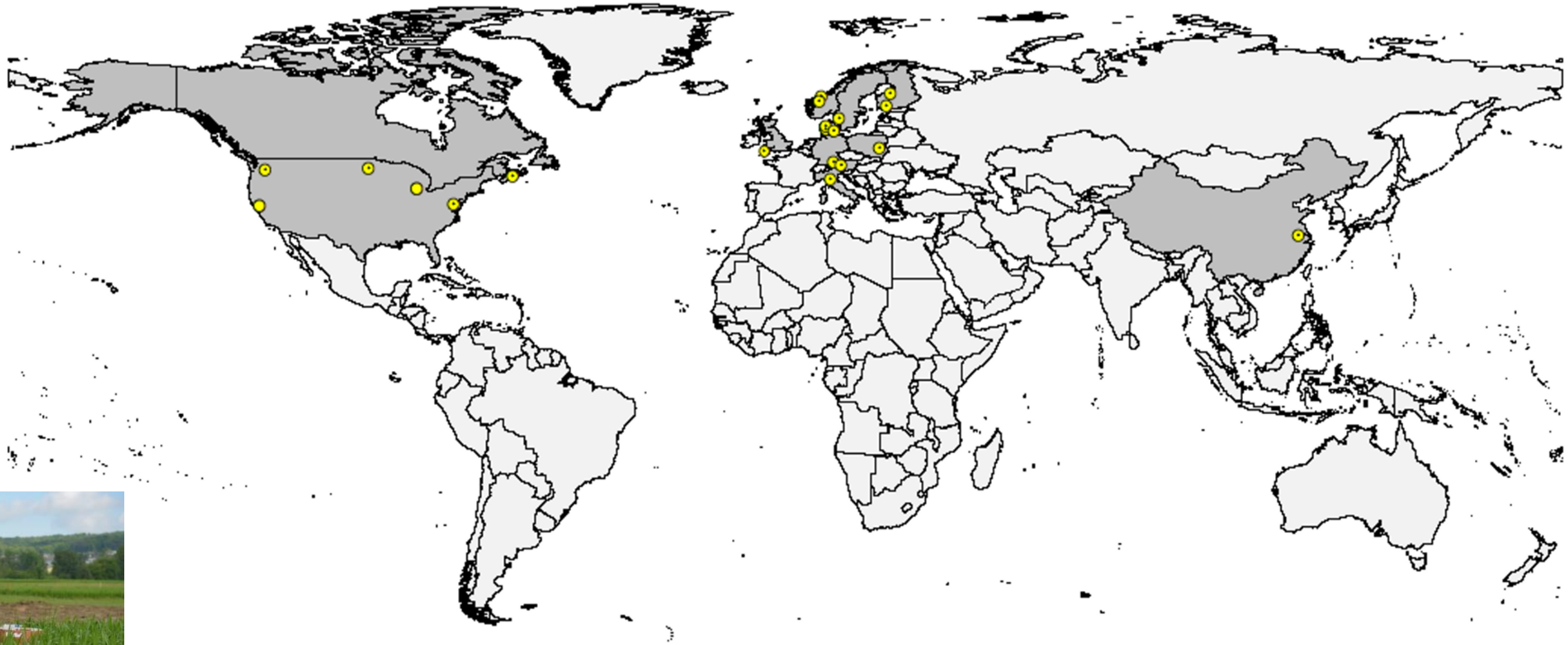

18 farming system comparison studies, 98 comparative pairs

Skinner, Gattinger et al. STOTEN, 2014

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Less area-scaled N_2O emissions from organically managed soils

	Area-scaled GWP[d] N_2O emissions ($kg\ CO_2$ eq. $ha^{-1}\ a^{-1}$)				
land-use	MD	CI[b]	P	studies	comp.[c]
all (annual)[f]	-492	160	0.00	12	70
arable	-497	162	0.00	11	67
grassland	-1091	2531	0.40	2	3
rice-paddies	-646	1040	0.22	1	3

[b] ± 95%confidence interval (CI), [c] comparisons,
[d] Greenhouse Warming Potential (GWP)
[f] all annual measurements excl. rice

ca. 500 kg ha-1 yr-1 less CO_2 eq. as N_2O from organically managed soils

Skinner, Gattinger et al. STOTEN, 2014

N_2O emissions after 34 years of contrasting management in maize cropping

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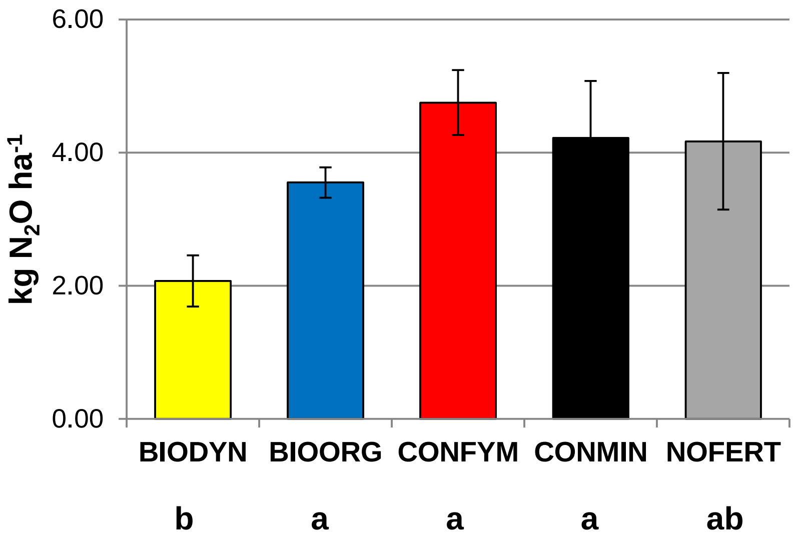
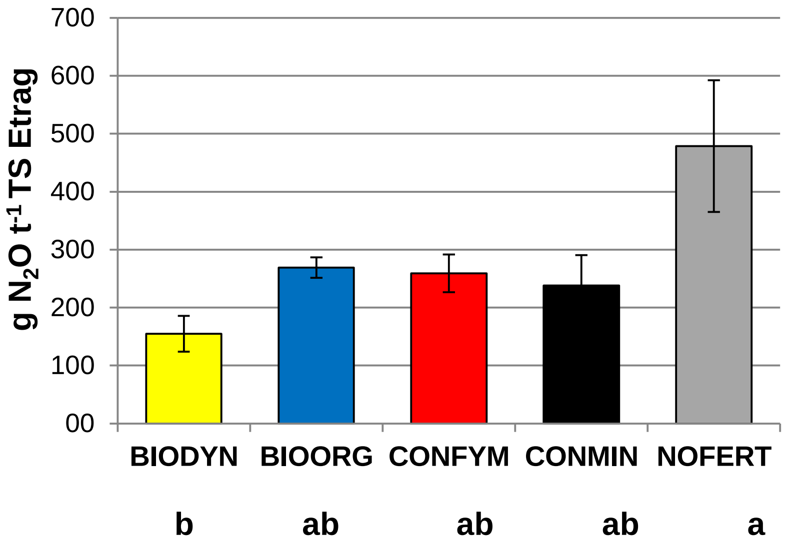
- No fertilisation (= extensification) no option for N_2O mitigation
- Lowest area- and yield-scaled N_2O emissions in BIODYN



N input: 139 182 335 170 0

Area-scaled N_2O in maize



Yield-scaled N_2O in maize

Contents lists available at SciVerse ScienceDirect

Agriculture, Ecosystems and Environment

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

Managing soil carbon for climate change mitigation and adaptation in Mediterranean cropping systems: A meta-analysis

Eduardo Aguilera[a,*], Luis Lassaletta[b,c], Andreas Gattinger[d], Benjamín S. Gimeno[e]

[a] *Universidad Pablo de Olavide, Ctra. de Utrera, km. 1, 41013 Sevilla, Spain*
[b] *UPMC/CNRS, UMR Sisyphe, 4, Place Jussieu, 75005 Paris, France*
[c] *Department of Ecology, Universidad Complutense de Madrid, c/José Antonio Novais, s/n, 28040 Madrid, Spain*
[d] *Research Institute of Organic Agriculture, Ackerstrasse, CH-5070 Frick, Switzerland*
[e] *Ecotoxicology of Air Pollution, CIEMAT, Avda. Complutense 22, 28040 Madrid, Spain*

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Comparison of SOC change and C sequestration under a number of recommended management practices (RMPs) with neighboring conventional plots under Mediterranean climate (174 data sets from 79 references).

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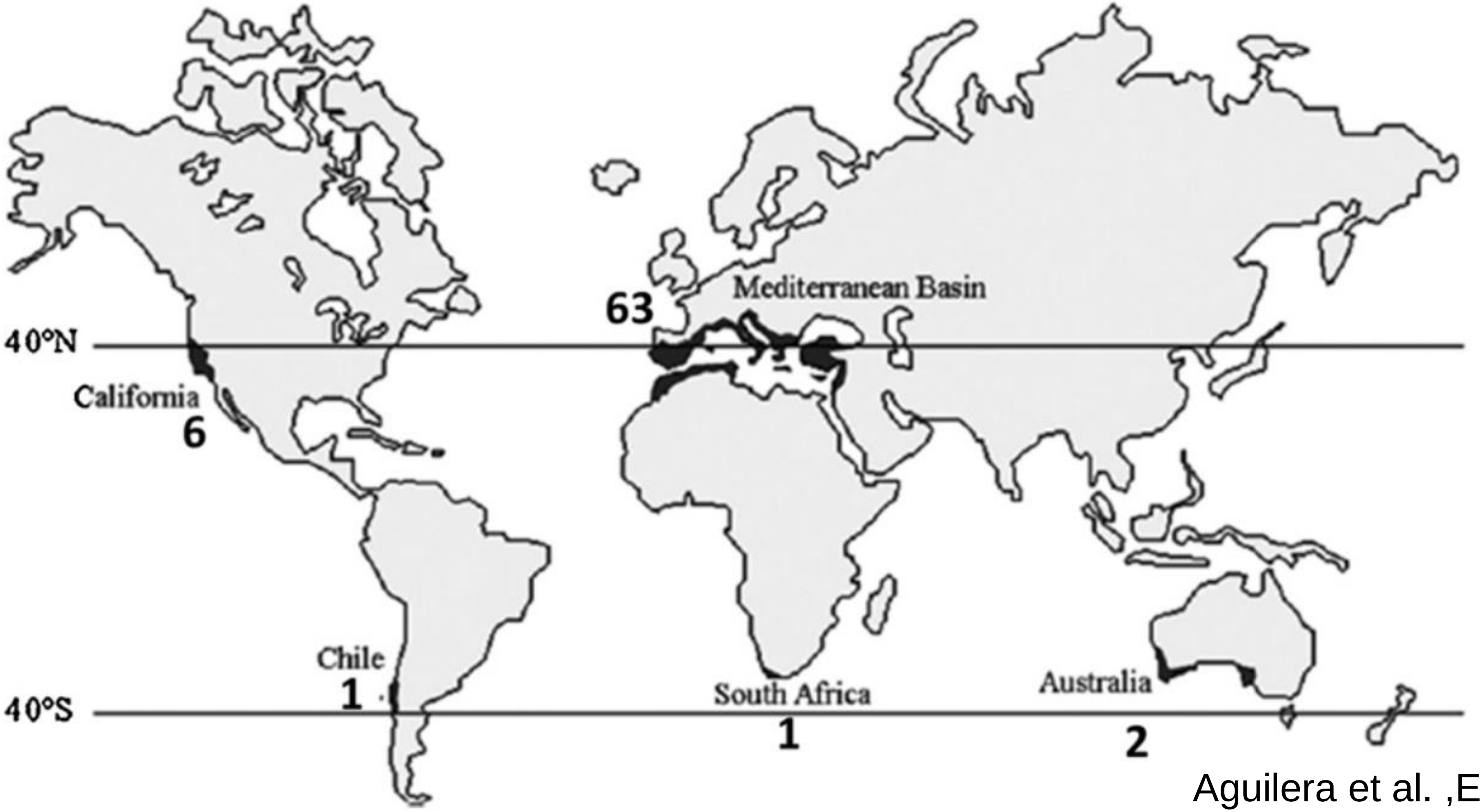

Aguilera et al. ,Elsevier, 2013

Chair of Organic Farming

Effect of different recommended management practices (RMPs) on C sequestration rate, compared to conventional management.

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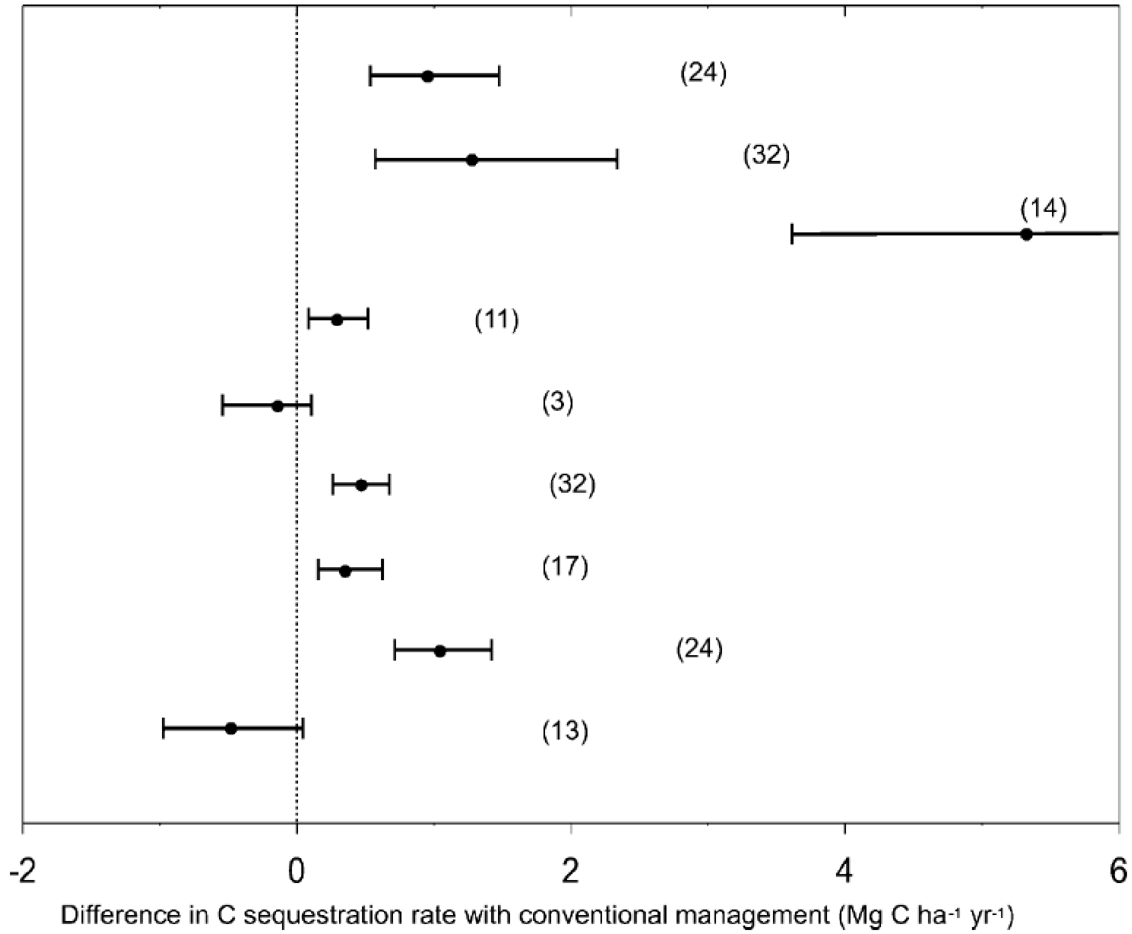

Organic management

Organic amendments

Land treatment

Cover crops

Slurry

No tillage

Reduced tillage

combined management practices

unfertilized

Aguilera et al. ,AGEE, 2013

PNAS

Enhanced top soil carbon stocks under organic farming

Andreas Gattinger[a,1], Adrian Muller[a], Matthias Haeni[a,b], Colin Skinner[a], Andreas Fliessbach[a], Nina Buchmann[b], Paul Mäder[a], Matthias Stolze[a], Pete Smith[c], Nadia El-Hage Scialabba[d], and Urs Niggli[a]

[a]Research Institute of Organic Agriculture, 5070 Frick, Switzerland; [b]Institute of Agricultural Sciences, Eidgenössische Technische Hochschule Zurich, 8092 Zurich, Switzerland; [c]Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen AB24 3UU, Scotland; and [d]Natural Resources Management and Environment Department, Food and Agriculture Organization of the United Nations, 00153 Rome, Italy

Edited by William H. Schlesinger, Cary Institute of Ecosystem Studies, Millbrook, NY, and approved August 13, 2012 (received for review June 5, 2012)

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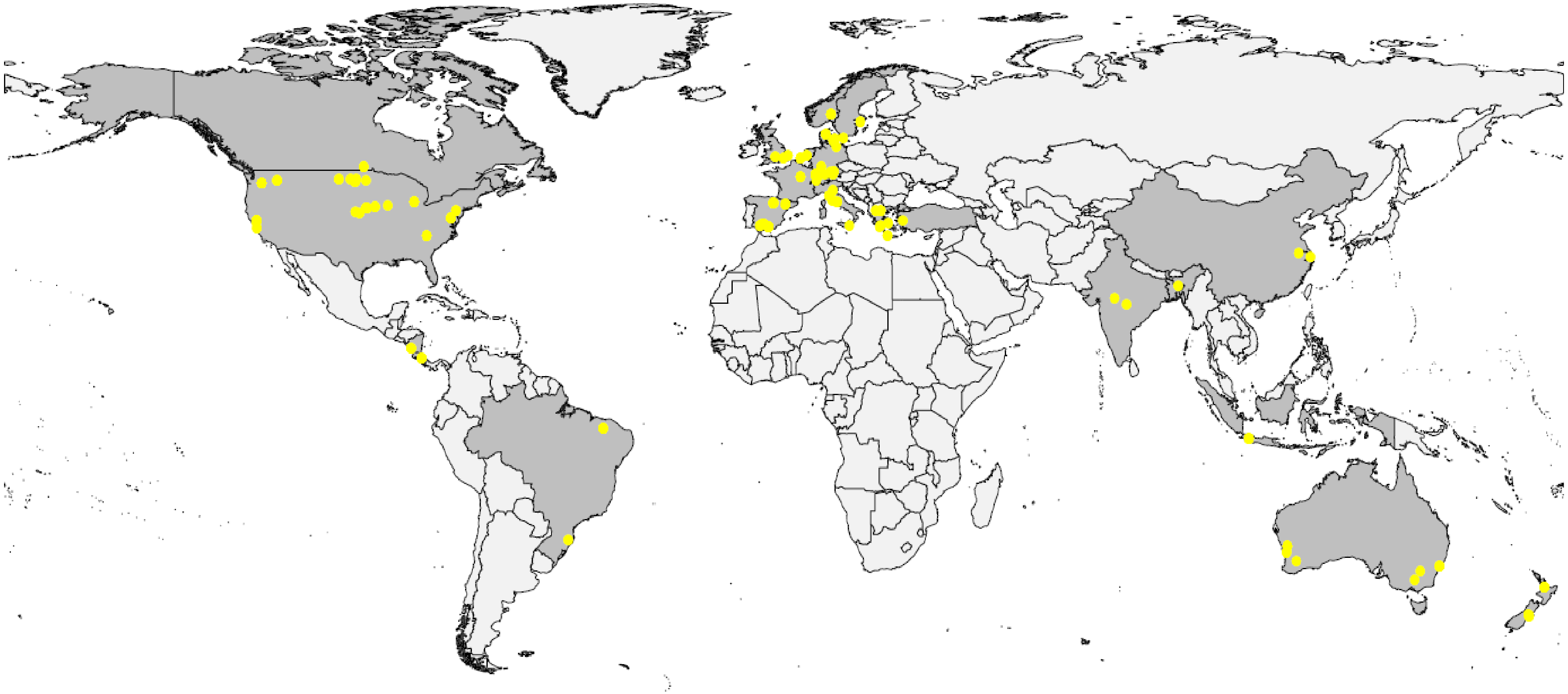
Geographic distribution of the system comparisons for meta-analysis

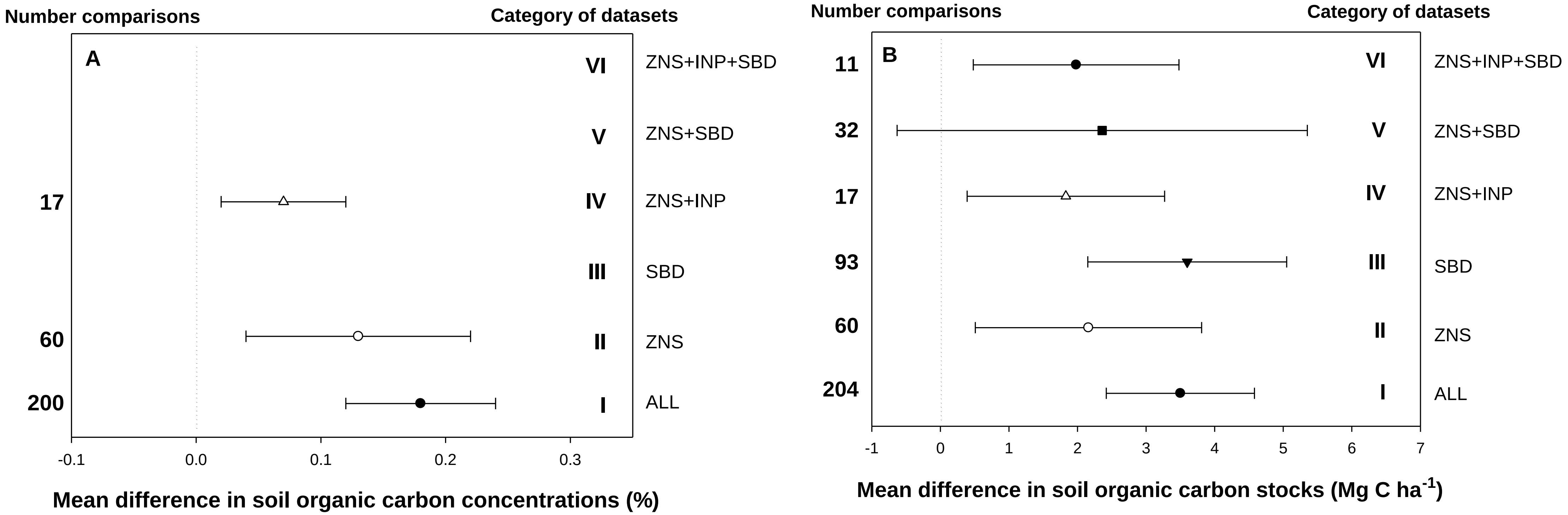
JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

74 studies globally with up to 211 paired comparisons



Gattinger et al., PNAS, 2012

Higher soil organic carbon concentrations (%) and stocks (t ha^{-1}) under organic farming management.



Gattinger et al., PNAS, 2012

Is carbon sequestration possible within organic farming systems?

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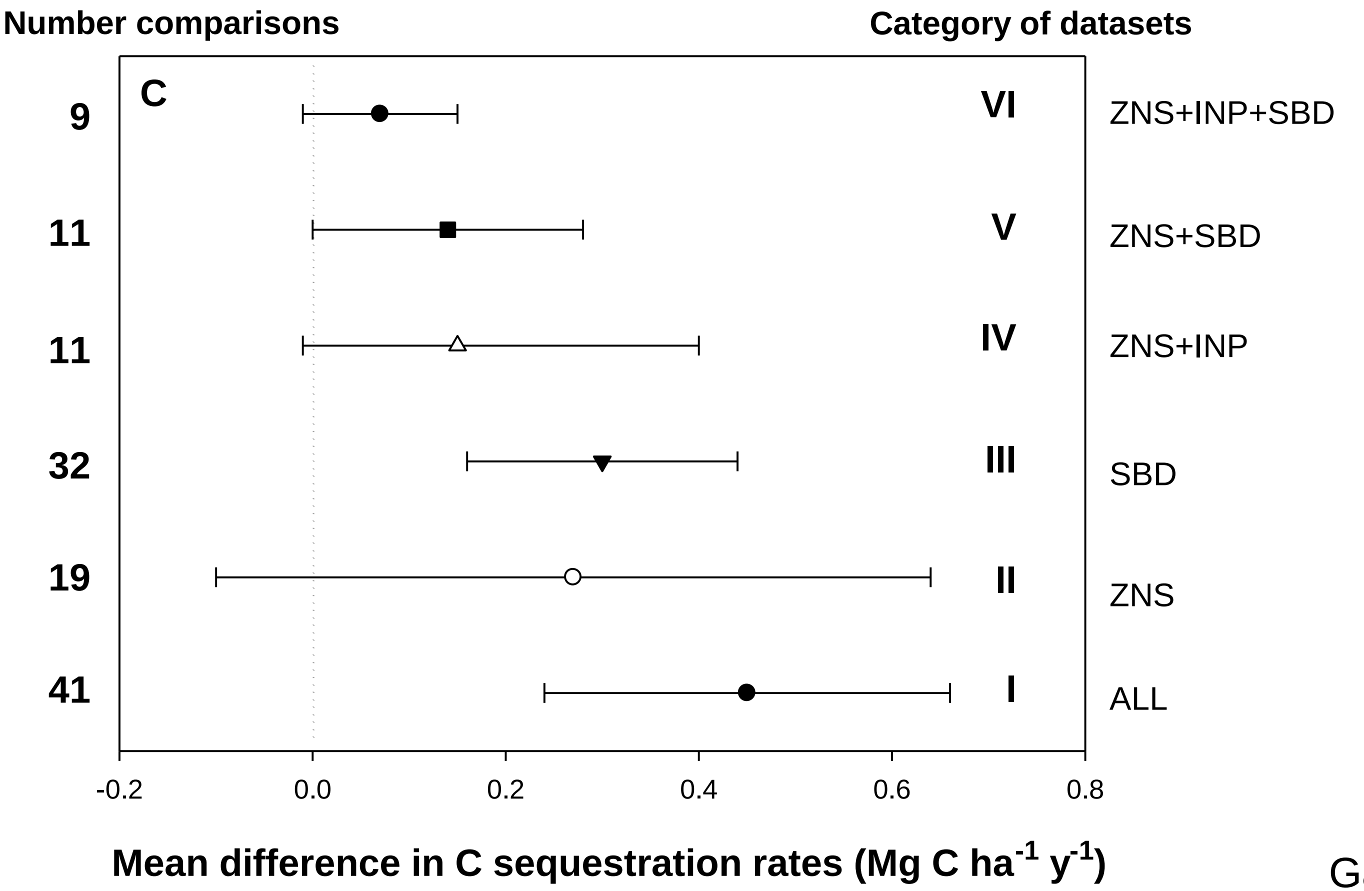


Yes, it is possible. Net sequestration of 450 kg C ha^{-1} y^{-1} (= 1.7 Mg CO_2 eq ha^{-1} y^{-1}) for all organic systems; the potential is lower for for zero net input systems (< 1.O ELU ha^{-1}): 70 – 270 kg C ha^{-1} y^{-1}.

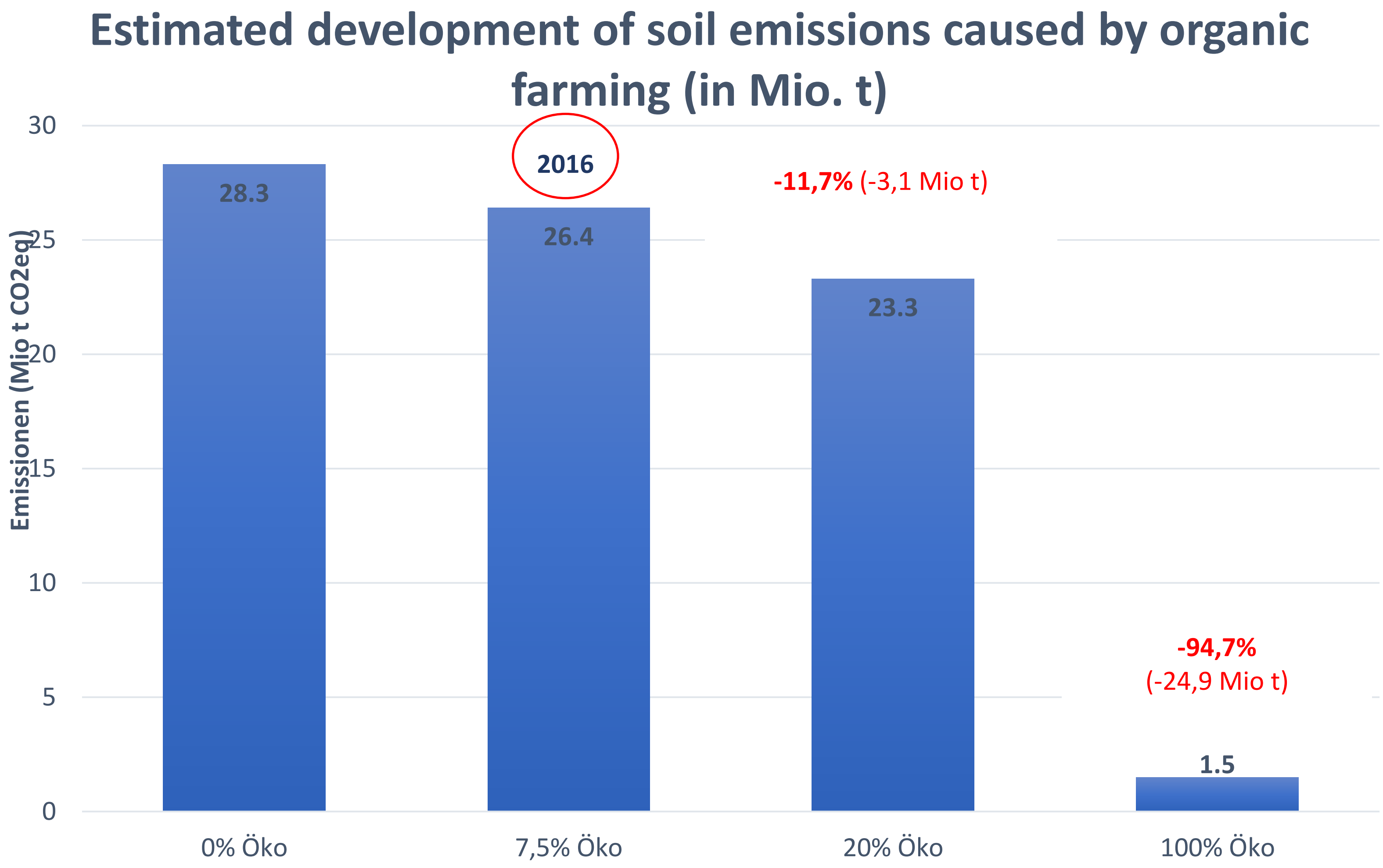
Gattinger et al., PNAS, 2012

Soil and climate protection through conversion to organic farming

- C Sequestrierung: -0.99 t CO_2 eq./ha (= 270 kg C for «closed» systems)
- N_2O Minderung: -0.49 t CO_2 eq./ha
- CH_4 Minderung: -0.03 t CO_2 eq./ha

Meta studies reveal a GHG mitigation potential of **1.51 t CO_2/ha*year** in soil-plant systems

What does it mean for German agriculture?

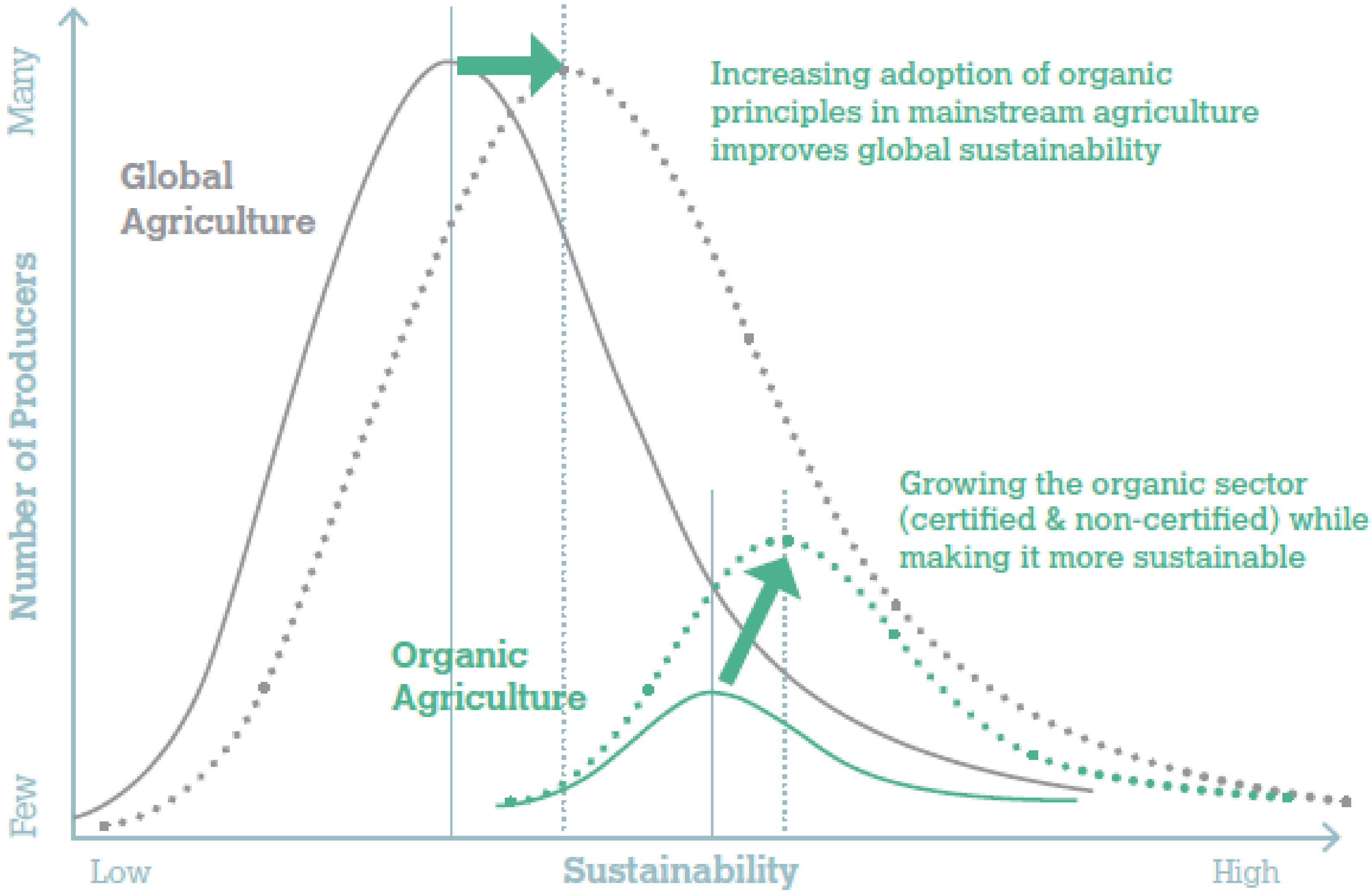


100% Öko: z.B. -4.7 Mio t Einsparung durch N-Düngerherstellung nicht mit einberechnet

Climate adaptation through SOC

- Improves physical, chemical and biological quality of the soil (Lal et al.,2011)
- These improvements are crucial for sustaining and enhancing crop productivity in a context where climatic conditions become more extreme
- Many adaptation measures, such as those that reduce soil erosion, conserve soil moisture or diversify crop rotations also promote SOC storage (Smith and Olesen,2010)

Agriculture as part of a globalised food system: Ecologisation as a goal (bio-economy model)



IFOAM 2016

Eco-functional intensification to bridge efficiency and yield gaps

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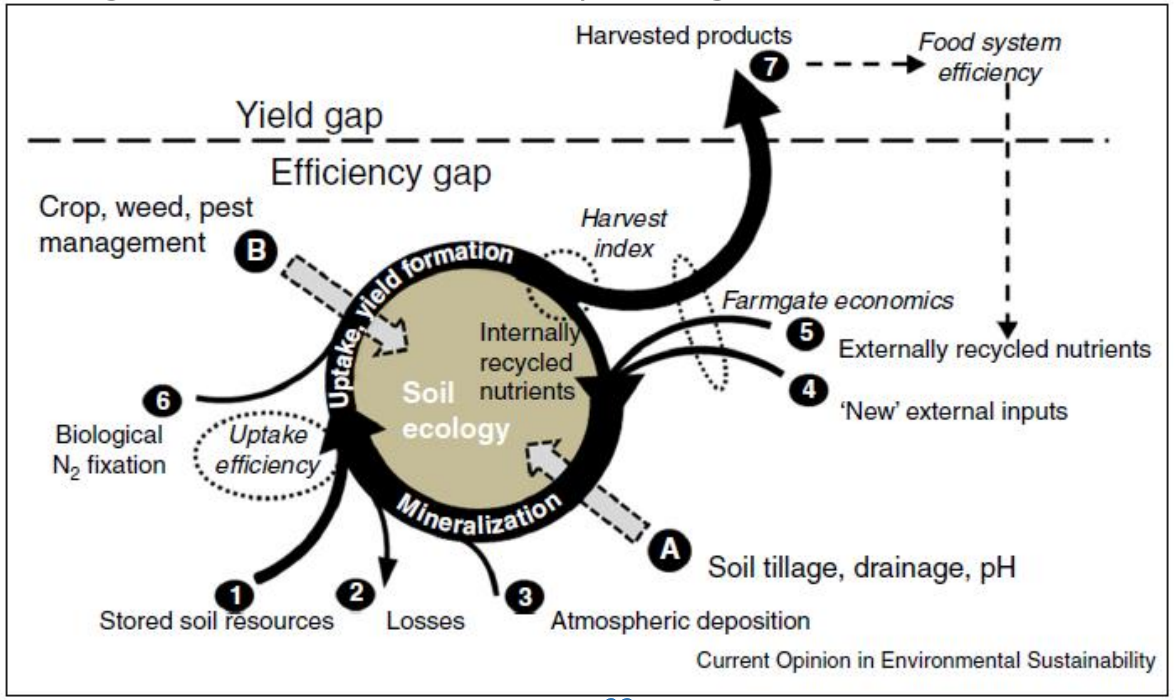
Ecofunctional intensification according to best practice to close yield and efficiency gaps

Putting the soil at the centre of cultivation and using and promoting its processes and ecosystem services in a targeted manner, thus replacing synthetic inputs (fertilisers, PPPs).



Nordwijk and Brussard. 2015, Curr Op Environ Sus

Take nature as an example….

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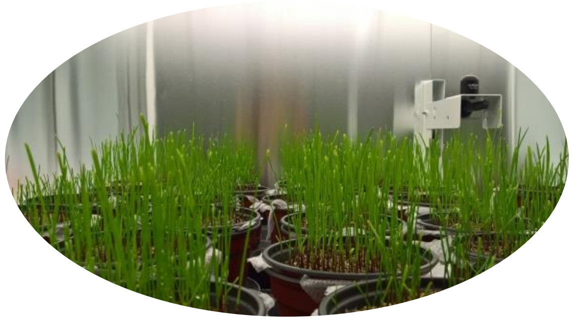
Innovations on stable-field-farm-landscape level

Innovations

→ Arable land / grassland



→ countryside

Large potentials through improved (temporal/spatial) integration of livestock and plant production

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)

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

...from humus build-up to stable agricultural and food systems: Agricultural systems ecology

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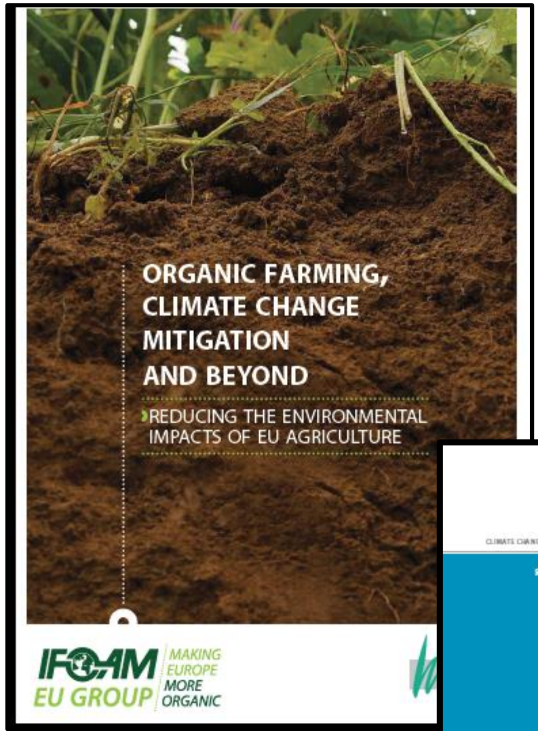

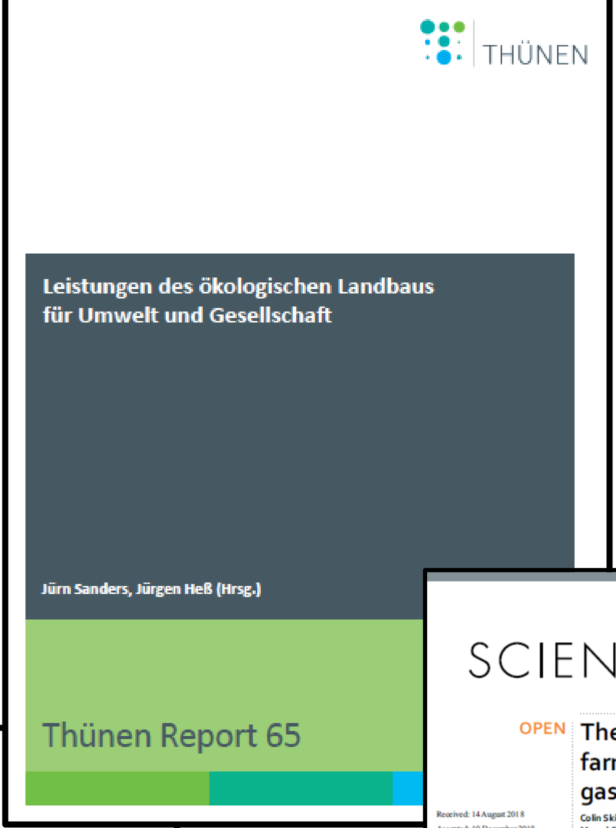

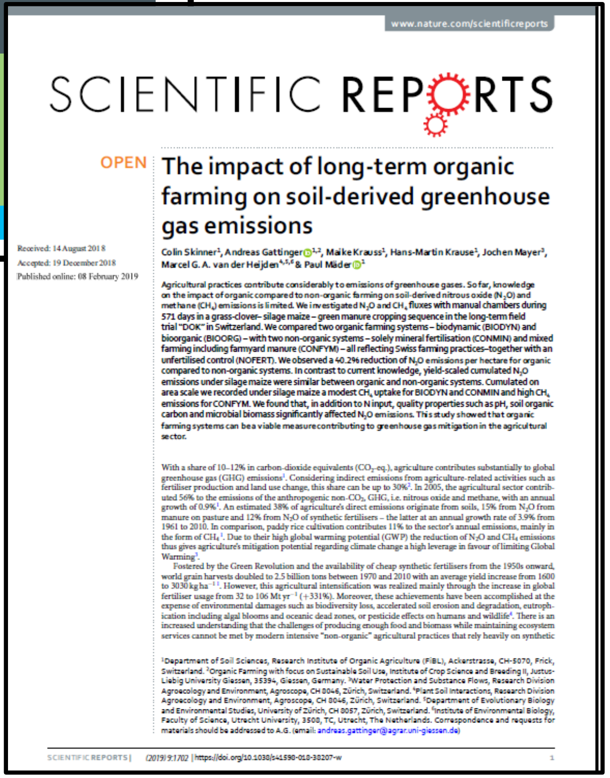

www.nature.com/scientificreports

SCIENTIFIC REPORTS

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The impact of long-term organic farming on soil-derived greenhouse gas emissions

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Accepted: 19 December 2018
Published online: 08 February 2019

Colin Skinner[1], Andreas Gattinger[1,2], Maike Krauss[1], Hans-Martin Krause[1], Jochen Mayer[3], Marcel G. A. van der Heijden[4,5,6] & Paul Mäder[1]

Agricultural practices contribute considerably to emissions of greenhouse gases. So far, knowledge on the impact of organic compared to non-organic farming on soil-derived nitrous oxide (N_2O) and methane (CH_4) emissions is limited. We investigated N_2O and CH_4 fluxes with manual chambers during 571 days in a grass-clover– silage maize – green manure cropping sequence in the long-term field trial "DOK" in Switzerland. We compared two organic farming systems – biodynamic (BIODYN) and bioorganic (BIOORG) – with two non-organic systems – solely mineral fertilisation (CONMIN) and mixed farming including farmyard manure (CONFYM) – all reflecting Swiss farming practices–together with an unfertilised control (NOFERT). We observed a 40.2% reduction of N_2O emissions per hectare for organic compared to non-organic systems. In contrast to current knowledge, yield-scaled cumulated N_2O emissions under silage maize were similar between organic and non-organic systems. Cumulated on area scale we recorded under silage maize a modest CH_4 uptake for BIODYN and CONMIN and high CH_4 emissions for CONFYM. We found that, in addition to N input, quality properties such as pH, soil organic carbon and microbial biomass significantly affected N_2O emissions. This study showed that organic farming systems can be a viable measure contributing to greenhouse gas mitigation in the agricultural sector.

With a share of 10–12% in carbon-dioxide equivalents (CO_2-eq.), agriculture contributes substantially to global greenhouse gas (GHG) emissions[1]. Considering indirect emissions from agriculture-related activities such as fertiliser production and land use change, this share can be up to 30%[2]. In 2005, the agricultural sector contributed 56% to the emissions of the anthropogenic non-CO_2, GHG, i.e. nitrous oxide and methane, with an annual growth of 0.9%[1]. An estimated 38% of agriculture's direct emissions originate from soils, 15% from N_2O from manure on pasture and 12% from N_2O of synthetic fertilisers – the latter at an annual growth rate of 3.9% from 1961 to 2010. In comparison, paddy rice cultivation contributes 11% to the sector's annual emissions, mainly in the form of CH_4[1]. Due to their high global warming potential (GWP) the reduction of N_2O and CH_4 emissions thus gives agriculture's mitigation potential regarding climate change a high leverage in favour of limiting Global Warming[3].

Fostered by the Green Revolution and the availability of cheap synthetic fertilisers from the 1950s onward, world grain harvests doubled to 2.5 billion tons between 1970 and 2010 with an average yield increase from 1600 to 3030 kg ha^{-1}[1]. However, this agricultural intensification was realized mainly through the increase in global fertiliser usage from 32 to 106 Mt yr^{-1} (+331%). Moreover, these achievements have been accomplished at the expense of environmental damages such as biodiversity loss, accelerated soil erosion and degradation, eutrophication including algal blooms and oceanic dead zones, or pesticide effects on humans and wildlife[4]. There is an increased understanding that the challenges of producing enough food and biomass while maintaining ecosystem services cannot be met by modern intensive "non-organic" agricultural practices that rely heavily on synthetic

[1]Department of Soil Sciences, Research Institute of Organic Agriculture (FiBL), Ackerstrasse, CH-5070, Frick, Switzerland. [2]Organic Farming with focus on Sustainable Soil Use, Institute of Crop Science and Breeding II, Justus-Liebig University Giessen, 35394, Giessen, Germany. [3]Water Protection and Substance Flows, Research Division Agroecology and Environment, Agroscope, CH 8046, Zürich, Switzerland. [4]Plant Soil Interactions, Research Division Agroecology and Environment, Agroscope, CH 8046, Zürich, Switzerland. [5]Department of Evolutionary Biology and Environmental Studies, University of Zürich, CH 8057, Zürich, Switzerland. [6]Institute of Environmental Biology, Faculty of Science, Utrecht University, 3508, TC, Utrecht, The Netherlands. Correspondence and requests for materials should be addressed to A.G. (email: andreas.gattinger@agrar.uni-giessen.de)

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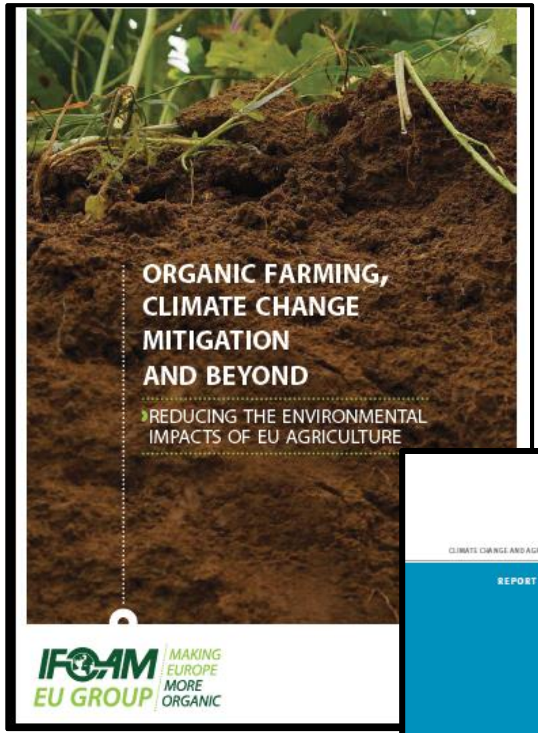

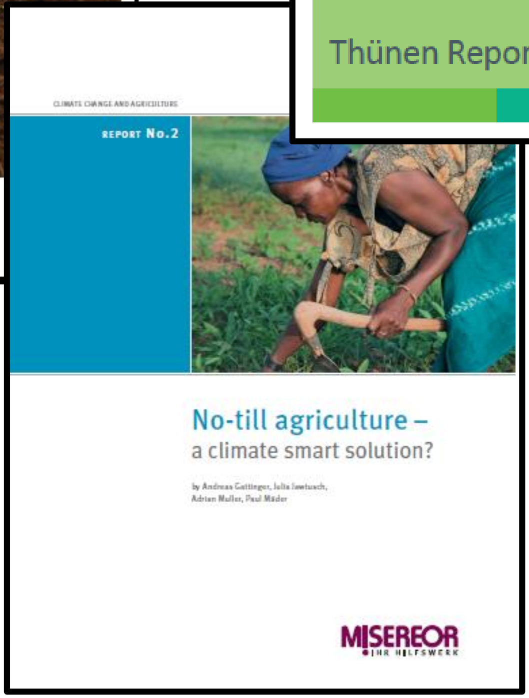


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The impact of long-term organic farming on soil-derived greenhouse gas emissions

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Colin Skinner[1], Andreas Gattinger[1,2], Maike Krauss[1], Hans-Martin Krause[1], Jochen Mayer[3], Marcel G. A. van der Heijden[4,5,6] & Paul Mäder[1]

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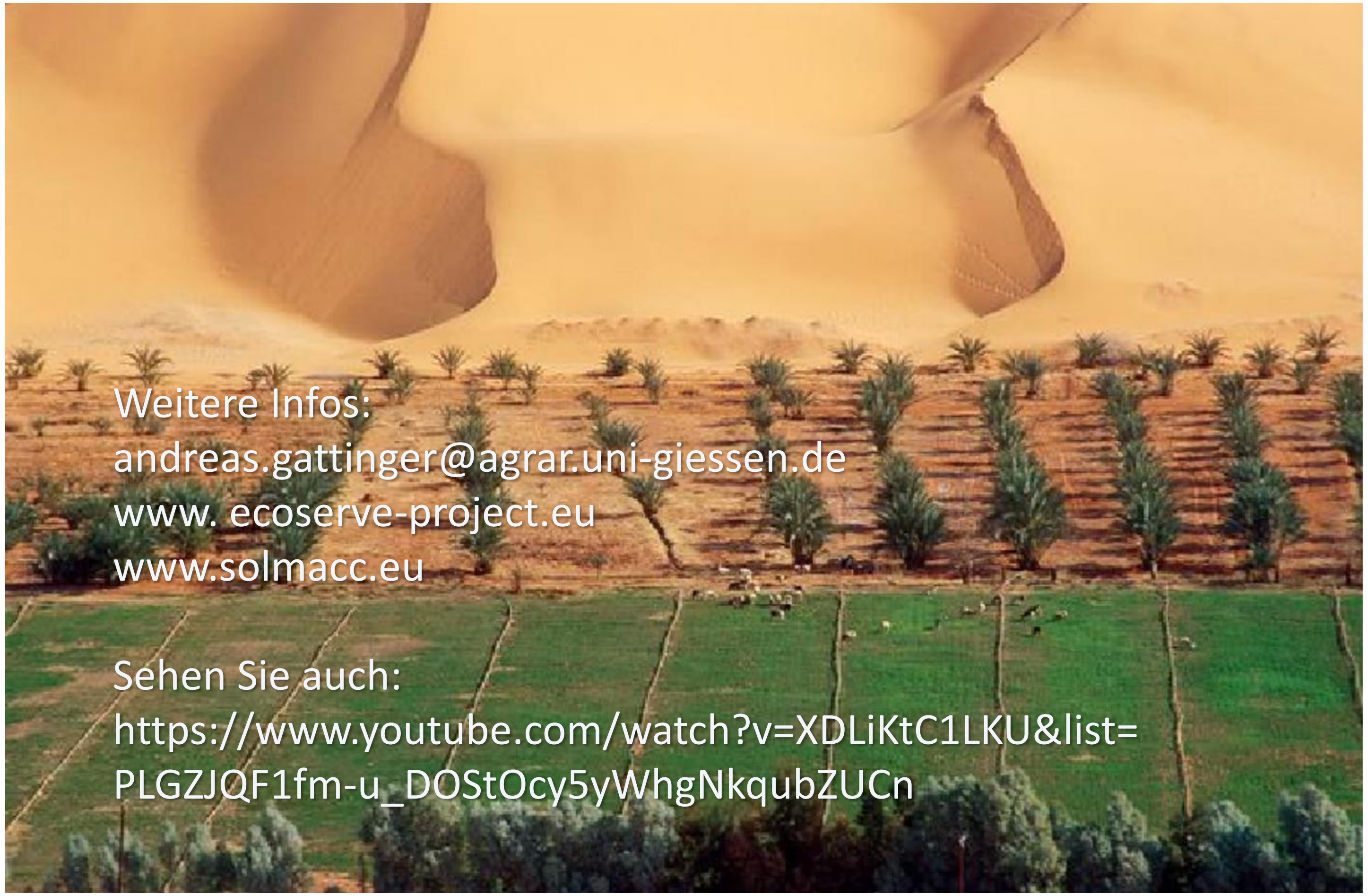

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