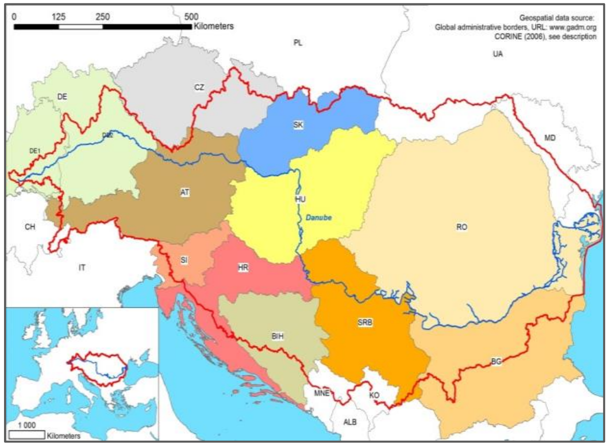
Potential of Agricultural Production in the Danube Region



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23rd CONFERENCE
WORKING COMMUNITY OF THE DANUBE REGIONS

CASEE
Central and South Eastern Europe

Content

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- Background
- Agro-ecological conditions of the Danube region
- Current production
- Additional potentials
  - Yield gap and intensification
  - Diet gap and diet changes
- Implications for food security, soils & environment

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Background

Can we feed the world?

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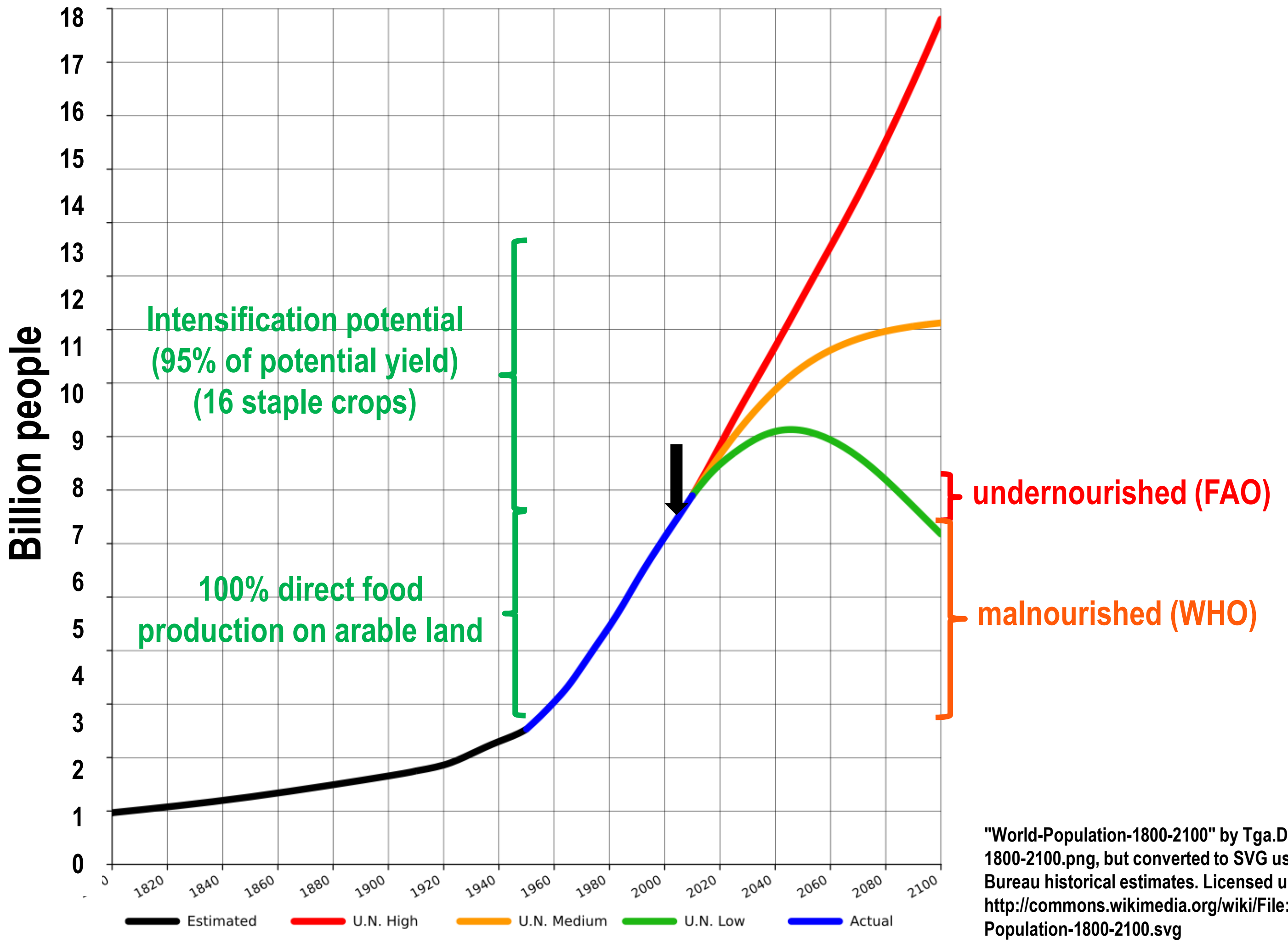
"World-Population-1800-2100" by Tga.D based on Aetheling's work - based on file:World-Population-1800-2100.png, but converted to SVG using original data from U.N. 2010 projections and US Census Bureau historical estimates. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:World-Population-1800-2100.svg#/media/File:World-Population-1800-2100.svg



Reducing losses (100%) along the food chain could potentially double the number of people that can be nourished

"World-Population-1800-2100" by Tga.D based on Aetheling's work - based on file:World-Population-1800-2100.png, but converted to SVG using original data from U.N. 2010 projections and US Census Bureau historical estimates. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:World-Population-1800-2100.svg#/media/File:World-Population-1800-2100.svg

Planetary bounderies for a safe operating space for humanity

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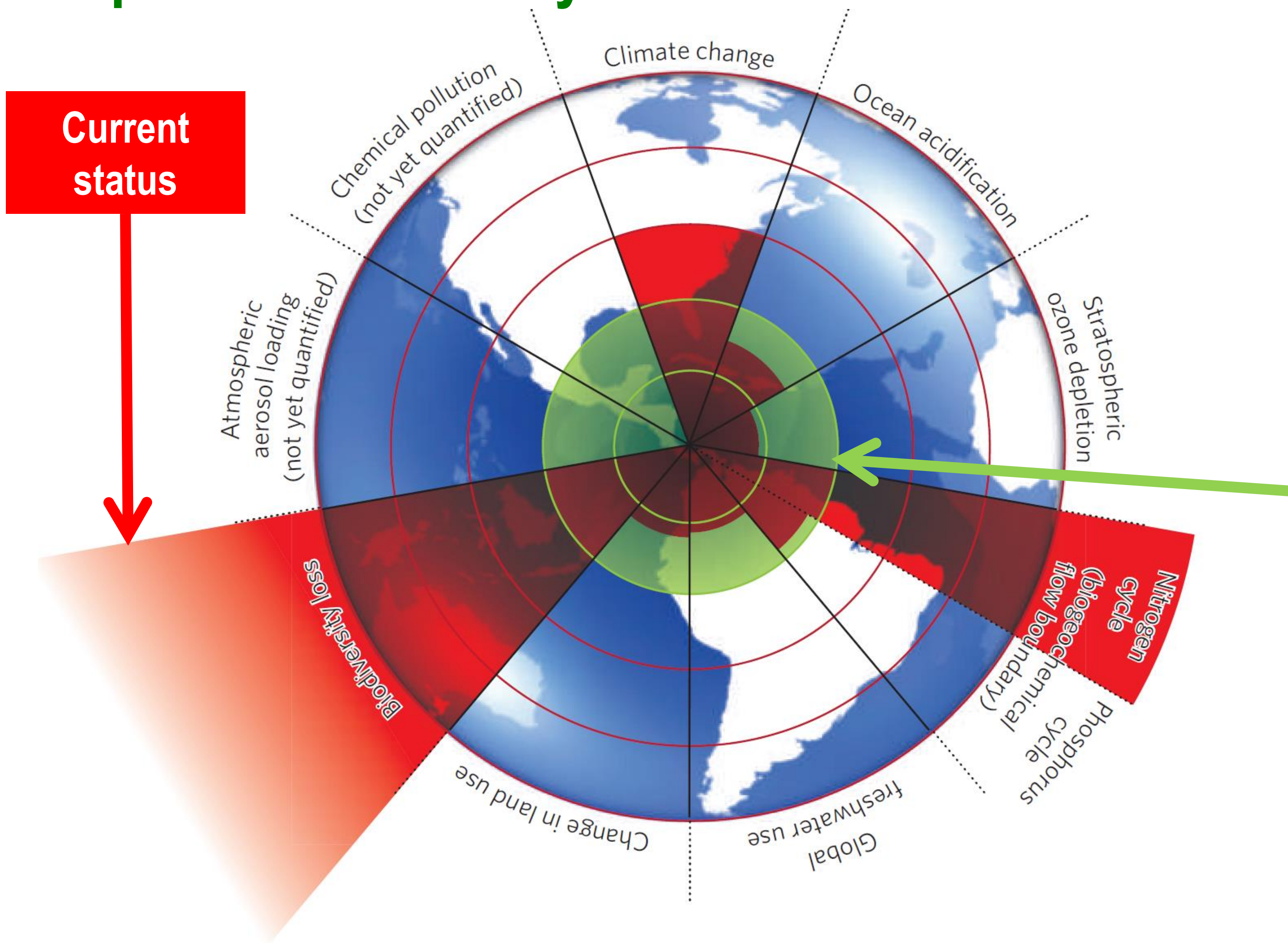
Rockström et al (2009), Nature 461: 472-475



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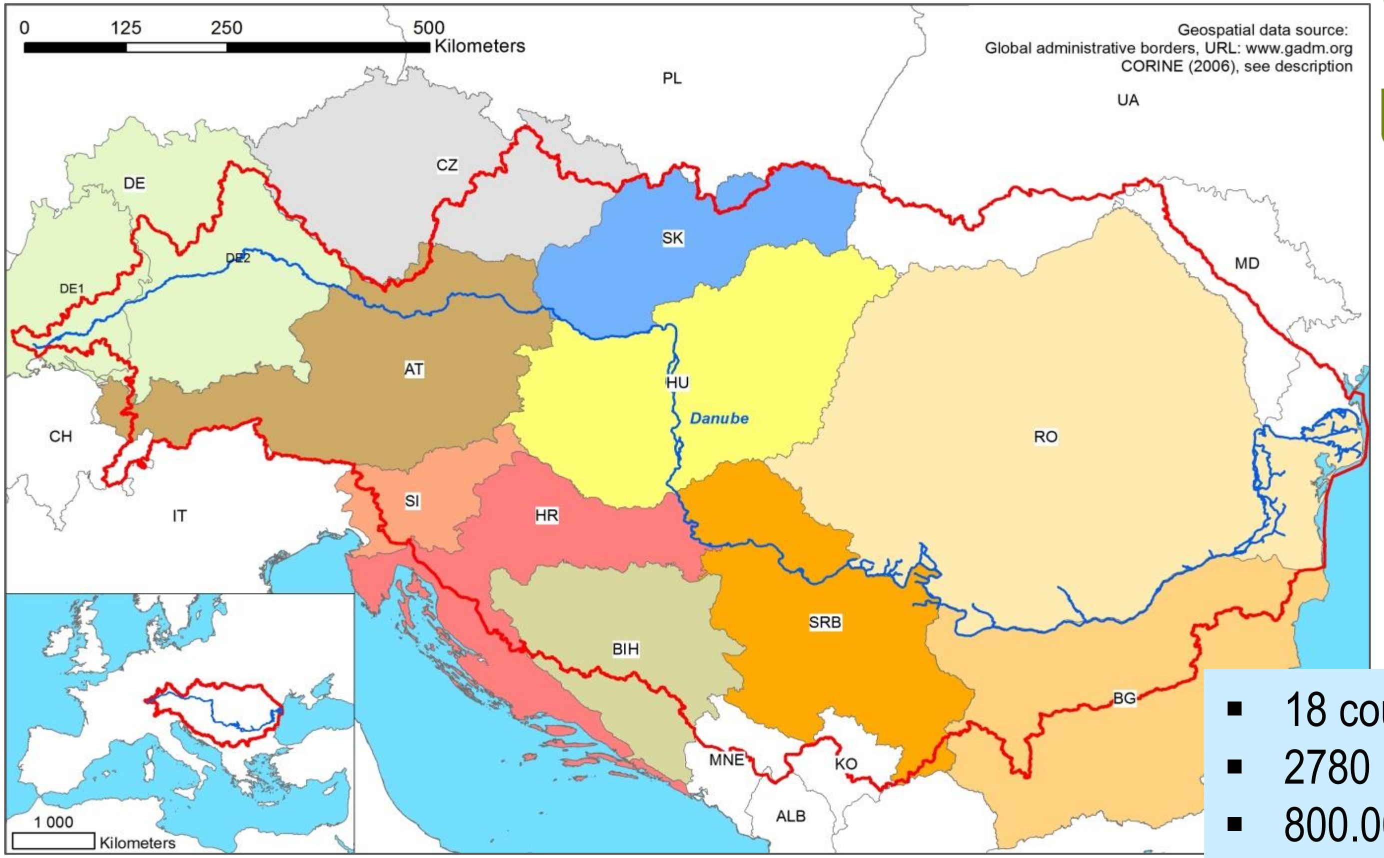
Agroecological conditions in the Danube region

The Danube region



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Source: Rittler (2016)

- 18 countries
- 2780 km
- 800.000 km^2
- >25 x 10^6 ha arable land (25% of arable land in EU)
- 81 Mio people (11% of Europeans)

Annual precipitation in the Danube region

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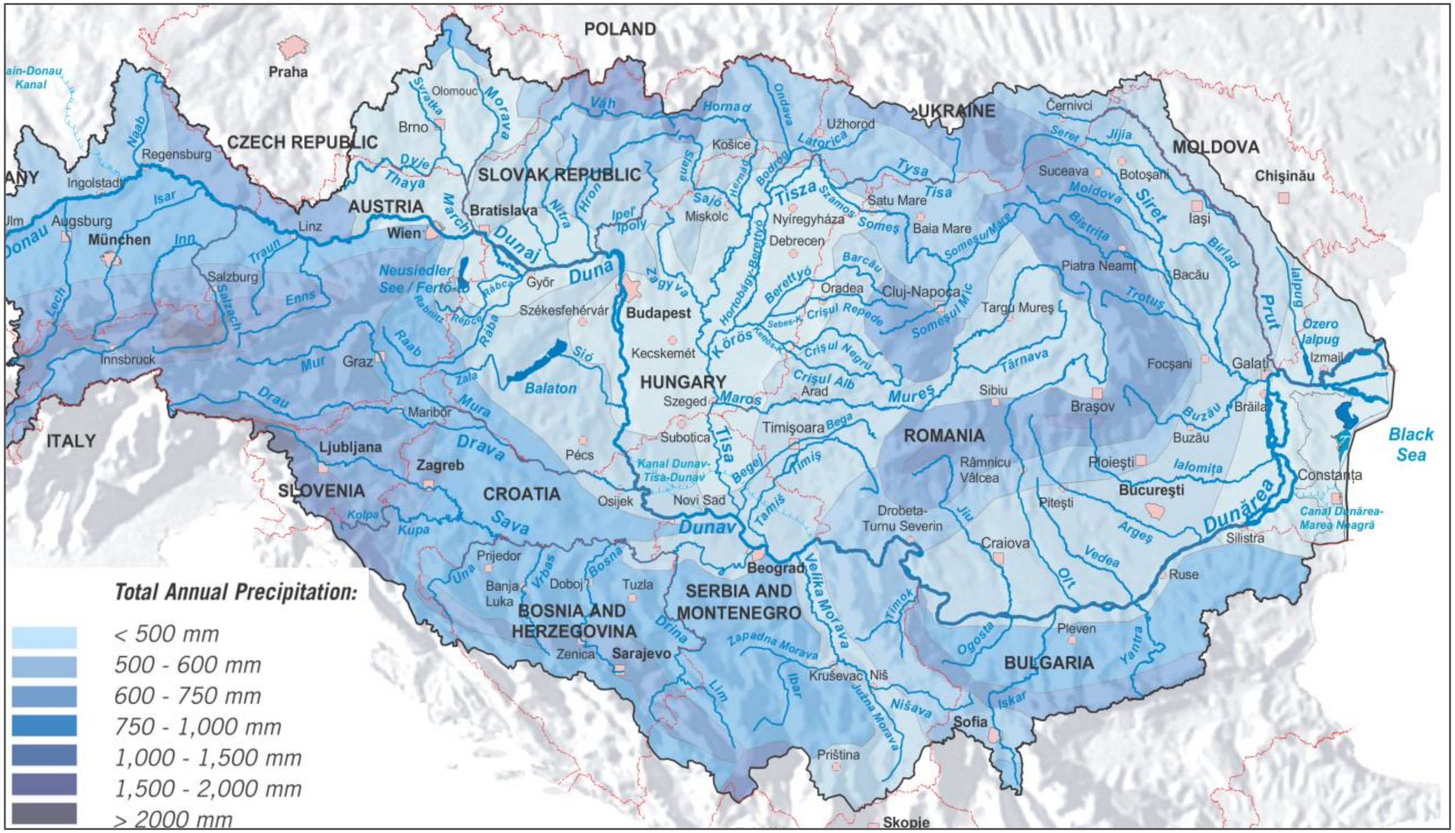
Source: Rittler (2016)

Precipitation map of the Danube basin (source: ICPDR, 2015). Most of the arable land is characterised by a mean annual precipitation from 500 – 600 mm/y.



Soils of the Danube region

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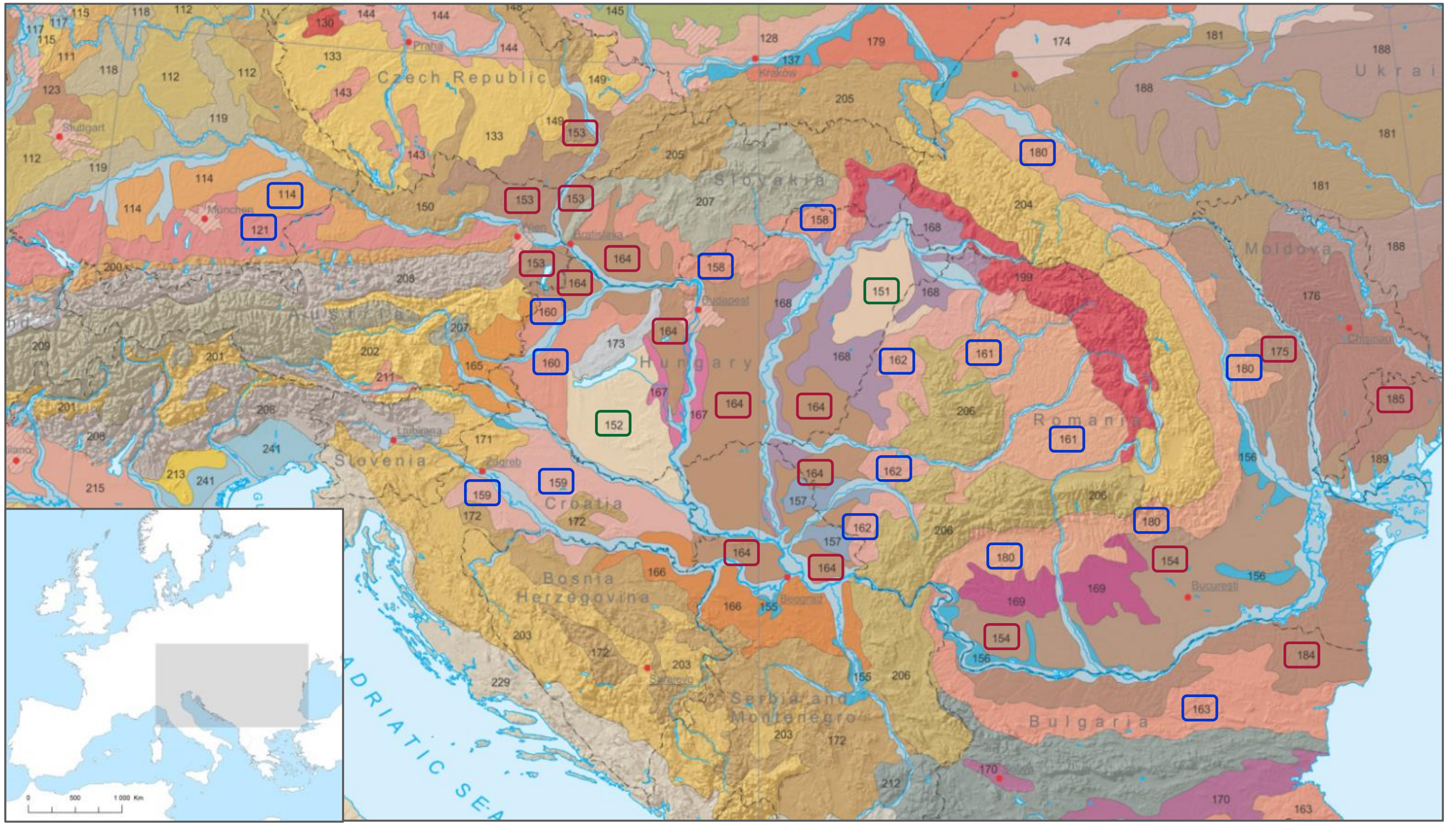
Soil map of the Danube basin according to *World Reference Base (WRB)* (FAO, 2006) (map source: BGR, 2005)

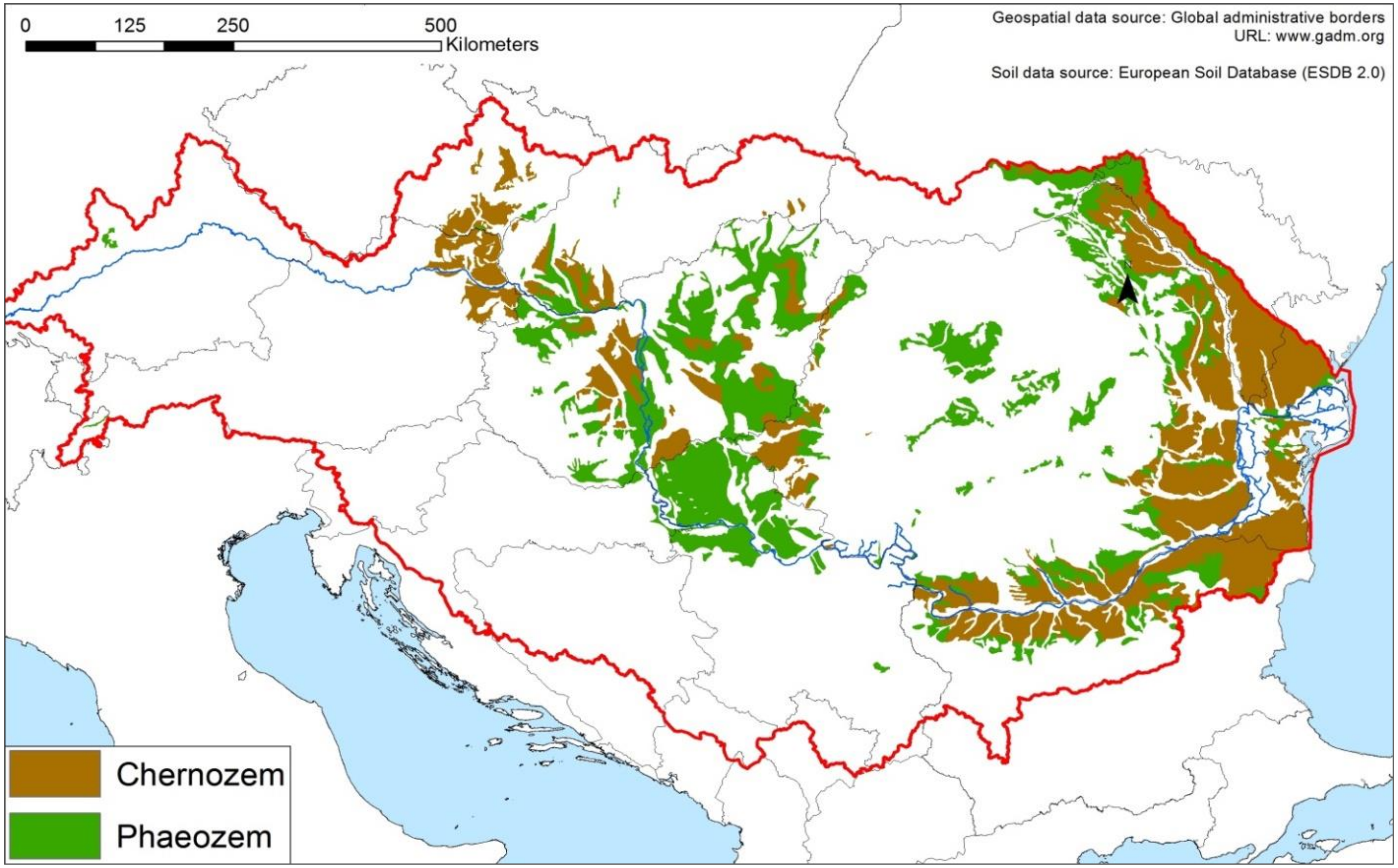
Source: Rittler (2016)



- Arenosols, Chernozems
- Chernozems, Phaeozems
- Luvisols, Luvic Phaeozems

Soils of the Danube region

Distribution of Chernozems and Phaeozems (FAO, 2006) in the Danube basin (red boundary line) (data source: EC, 2003). Large parts of the arable area in the Danube basin are characterised by the two closely related soil groups.



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Source: Rittler (2016)

Soils of the Danube region

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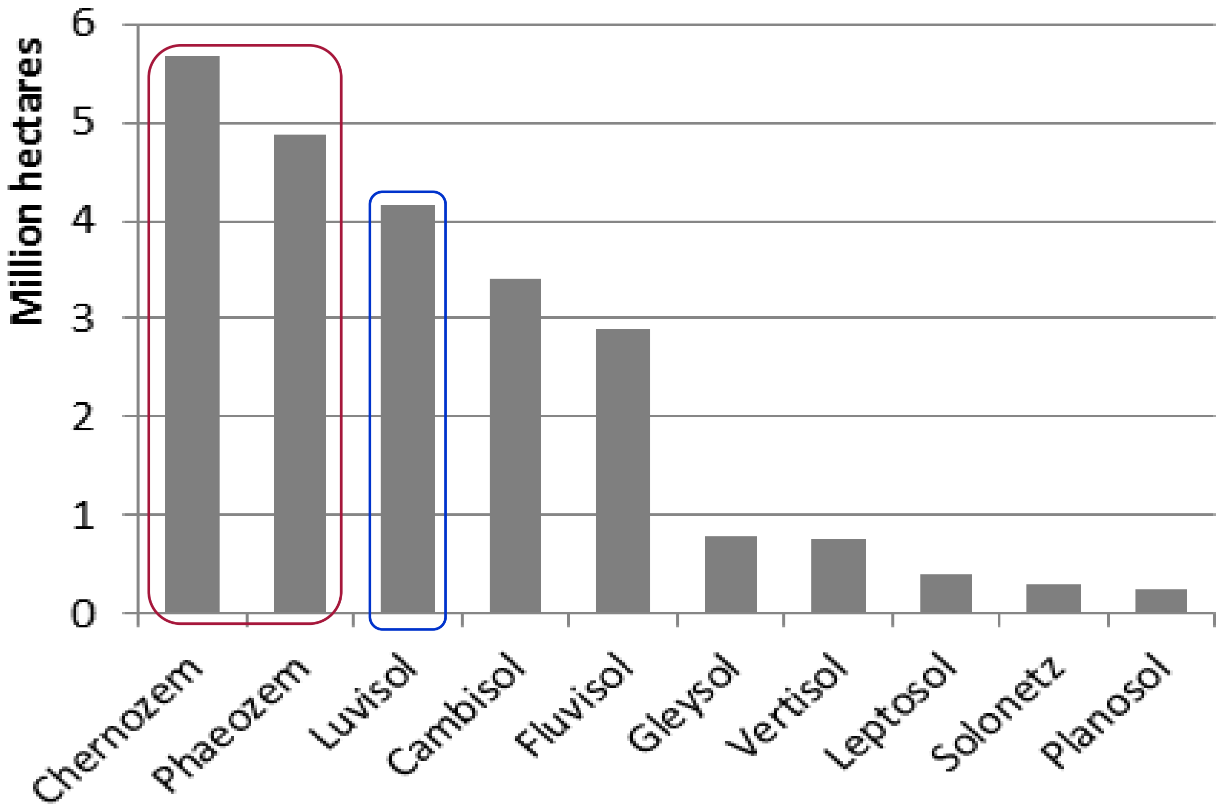
Source: Rittler (2016)

Acreages of different soil groups in the Danube basin (data source: EEA(a), 2014). Numbers derive from intersection of ESDB data with the CORINE arable land class.



Landuse pattern in the Danube region

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Source: Rittler (2016)

Land cover map of the Danube basin in 2006 (CORINE; EEA, 2014)

Land suitability pattern in the Danube region

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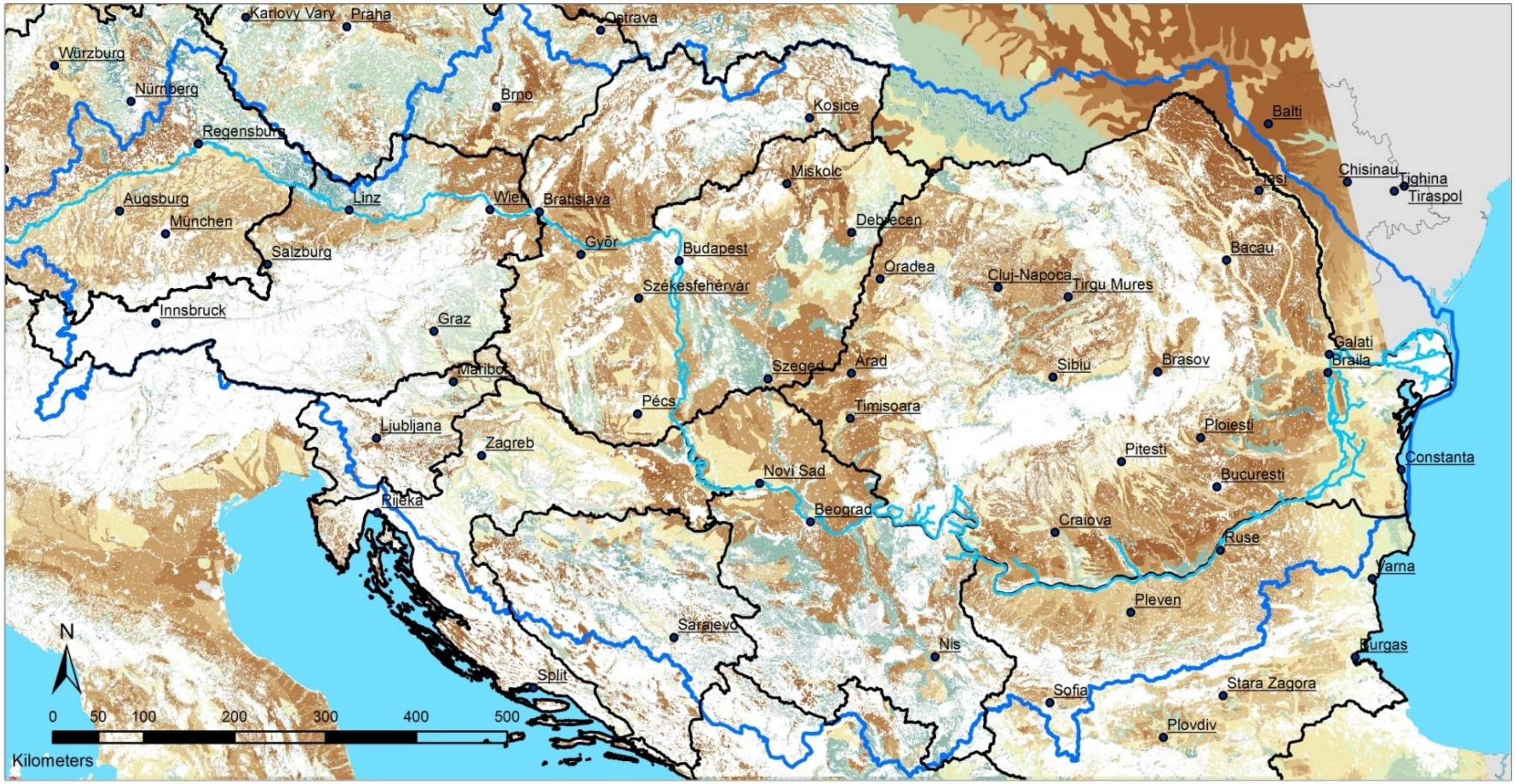
Agricultural land suitability for the period of 1981-2010. The agricultural suitability represents for each pixel the maximum suitability value of the considered 16 plants (coloured in brown-blue; scoring rank from 0 - 100). The model contains climate, soil and topography properties. The GLUES assessment is overlaid by a CORINE mask indicating an agricultural land cover (data source: glues.ufz.de and EEA)

Source: Rittler (2016)



Land suitability pattern in the Danube region

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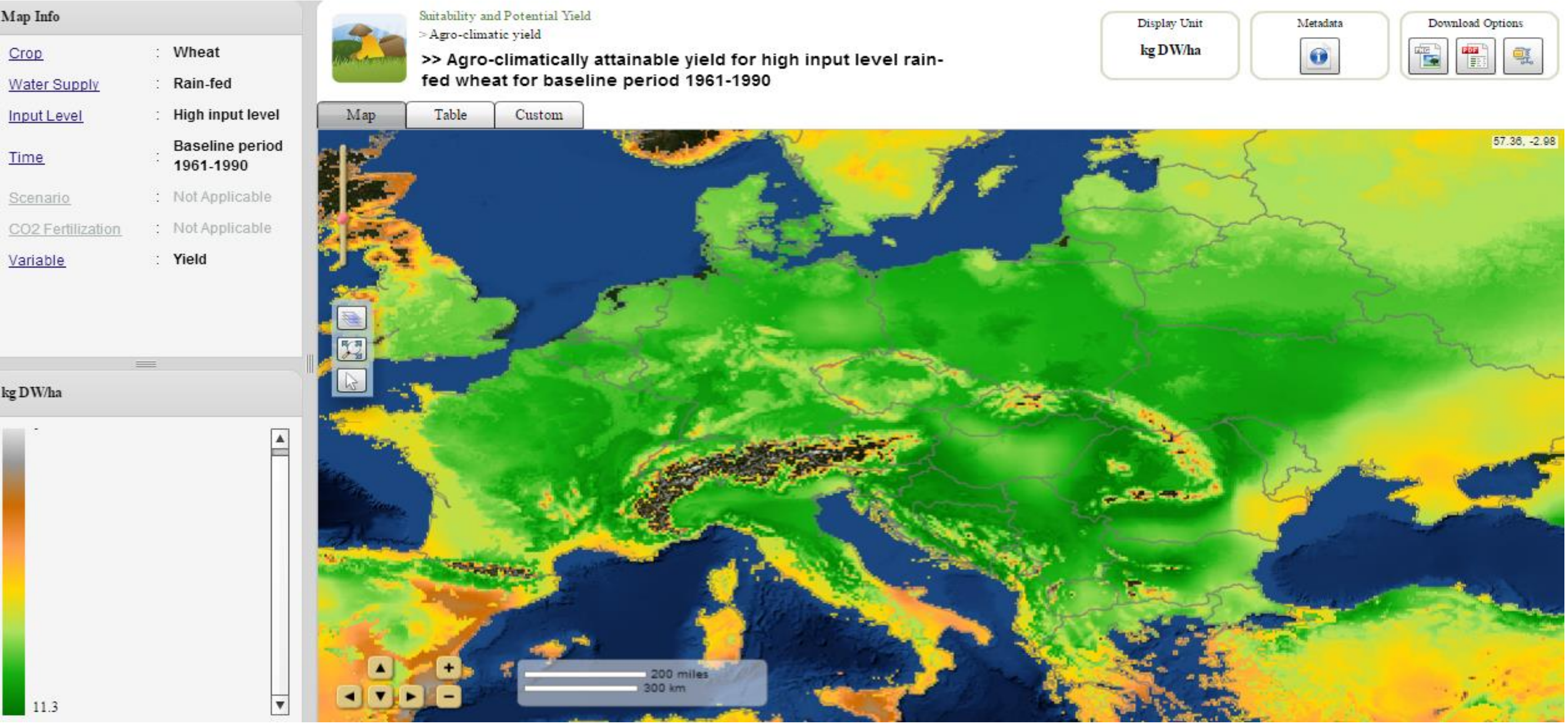
Agro-climatically attainable yield for high input level rain-fed wheat for baseline period 1961-1990 from the GAEZ-Model (Global Agro-Ecological Zones). Dark green regions indicate highest yield potentials for wheat. The highest yield potentials is found in Western HU and HR, where also highest number of growing days (240-269) are recorded (link to homepage: www. http://gaez.fao.org/).



Source: Rittler (2016)

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Current Production

Agricultural production in the Danube region

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Source: Rittler (2016)

Selected land use and production patterns in the Danube region. Mean production quantities derive from the product of mean yields (2000-2012) and the acreages in 2009.

	Crop production		Food delivery		
	Hectares (x 10^6)	Tonnes (x 10^6)	Gcal (x 10^6)	Supplied people/year* (x 10^6)	Proteins (x 10^6 tonnes)
Arable area	26.38				
Grain maize	5.83	28.5			
Barley	1.99	7.5			
Wheat					
Mean wheat production quantity of the 'Diet shift model'	6.69	25.12	68.6	55.3	2.05
Mean wheat production quantity in the study area of the 'Intensification model'	2.63 **(40%)**	9.11	24.9	20.0	7.45

average energy demand per person: 3400 kcal/day

Could feed 55 Mio. people

Could feed 20 Mio. people

Agricultural production in the Danube region

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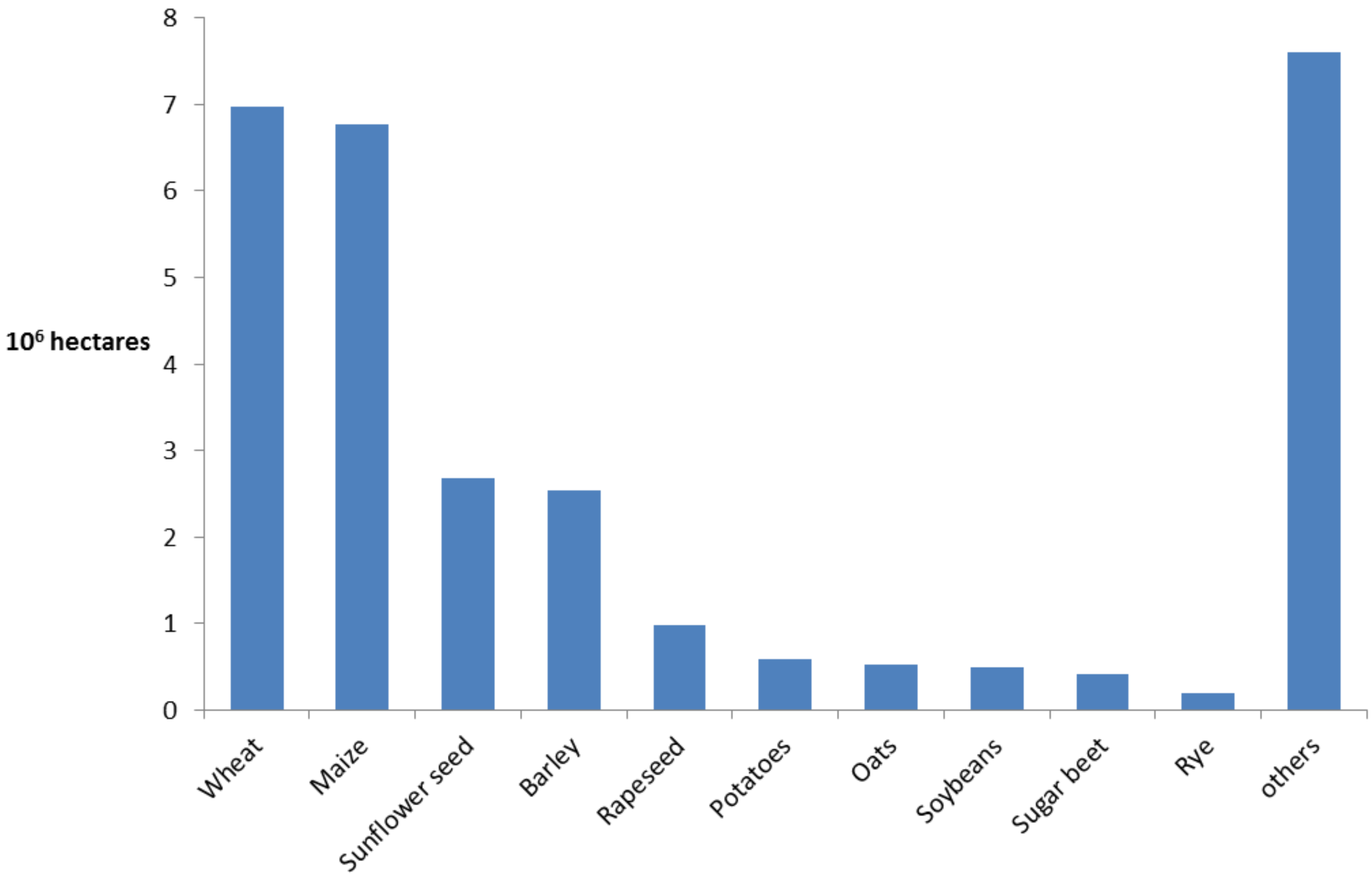
Source: Rittler (2016)



Agricultural production in the Danube region

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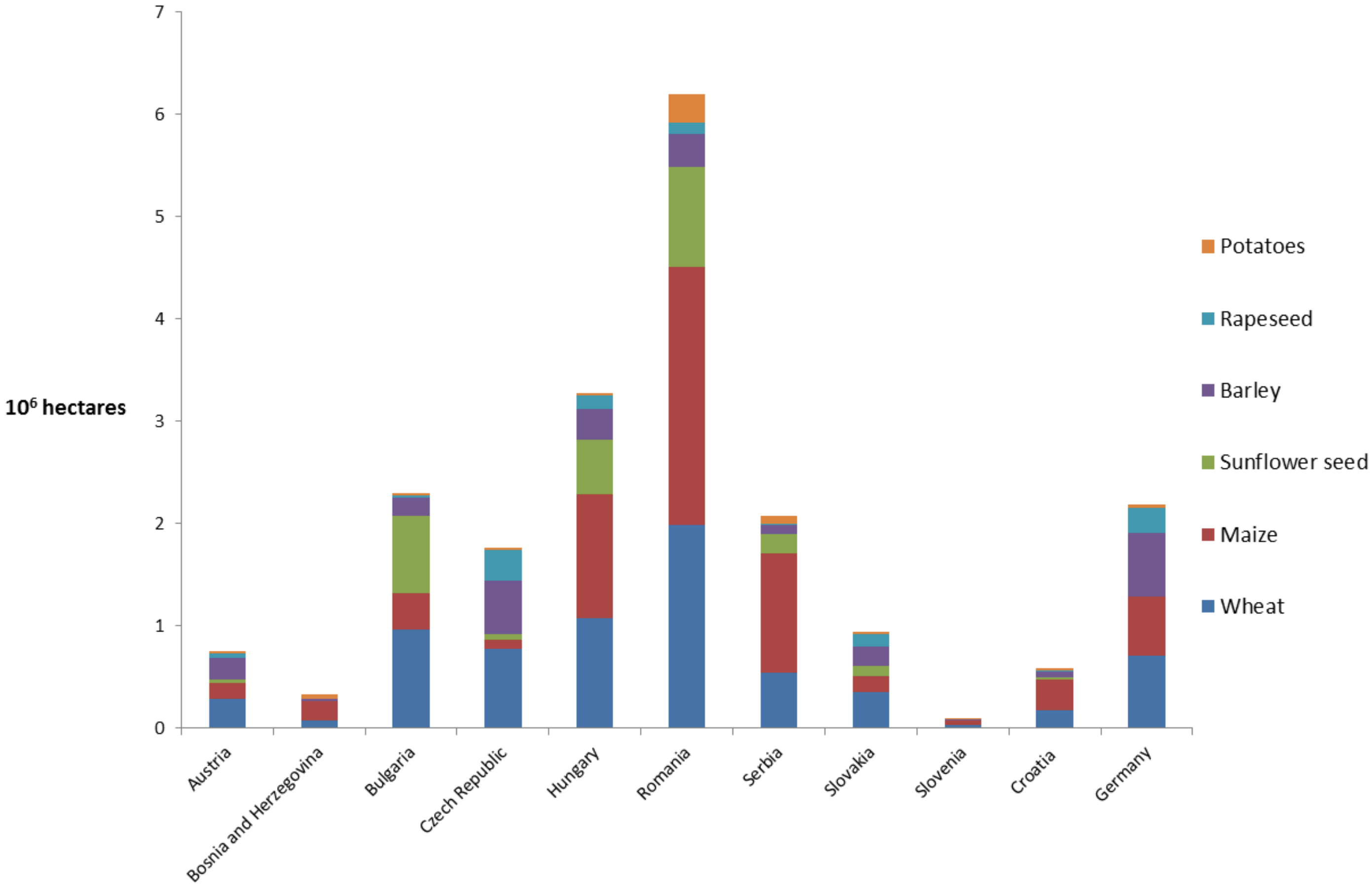
Source: Rittler (2016)



Agricultural production in the Danube region

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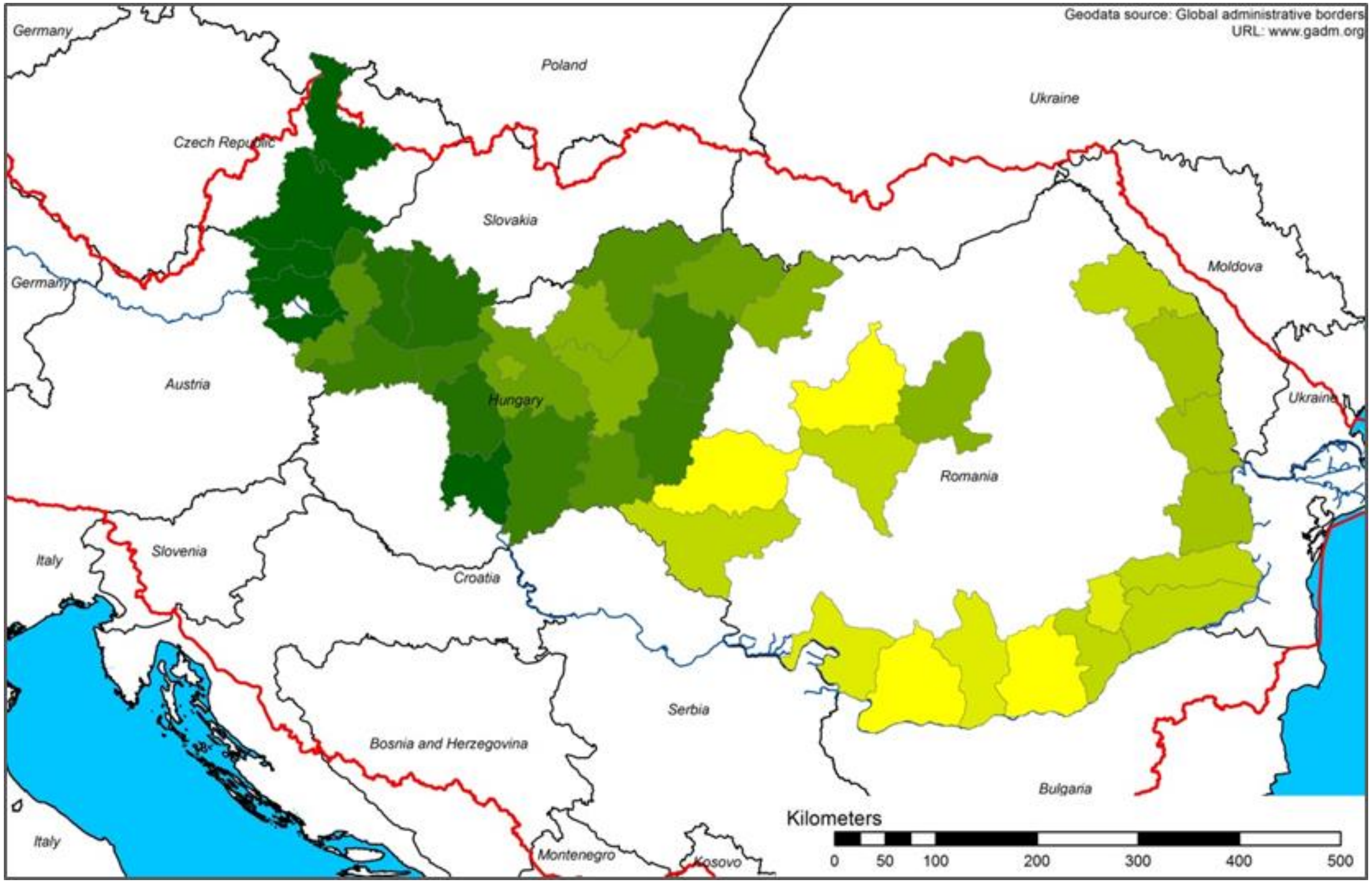
Source: Rittler (2016)

Mean wheat yields for the period (2000 – 2012) in the Danube basin



Mean wheat yields 2000-2012

in kg/ha

- 4500 - 5400
- 4300 - 4400
- 4000 - 4200
- 3800 - 3900
- 3500 - 3700
- 3200 - 3400
- 2900 - 3100
- 2700 - 2800
- 2500 - 2600
- 2200 - 2400

Agricultural production in the Danube region

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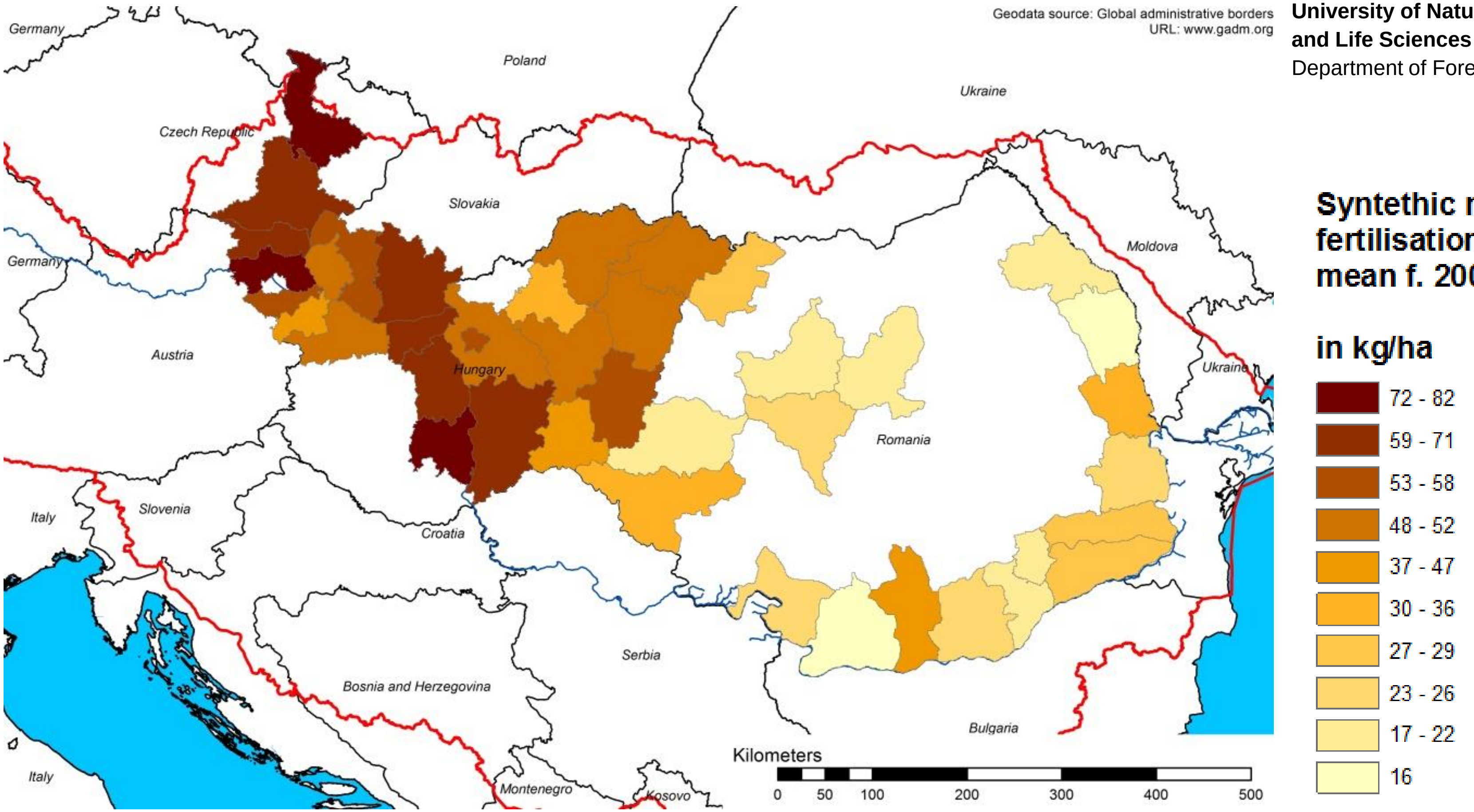
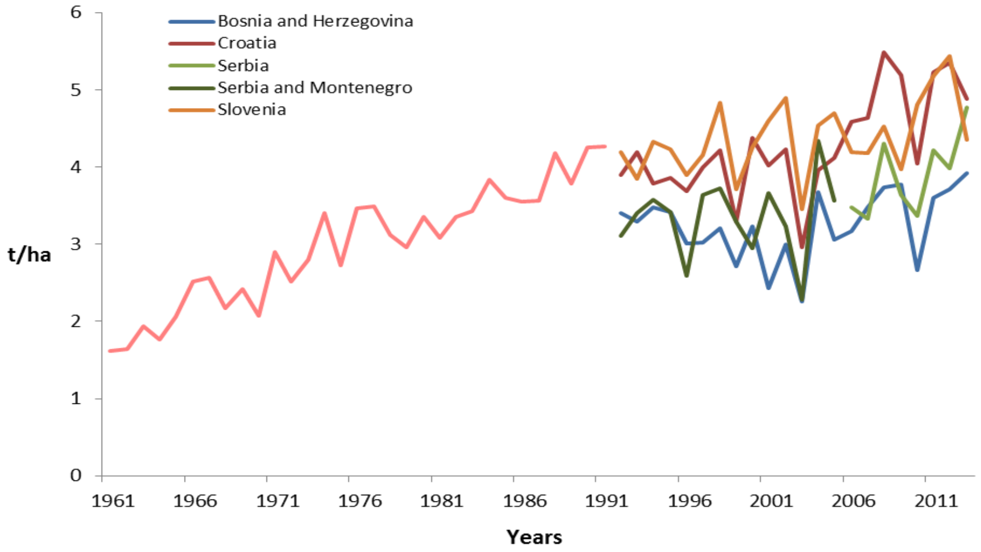
Source: Rittler (2016)

Mean fertilisation rates of synthetic nitrogen fertilisers (2000 – 2012) in the Danube basin



Agricultural production in the Danube region



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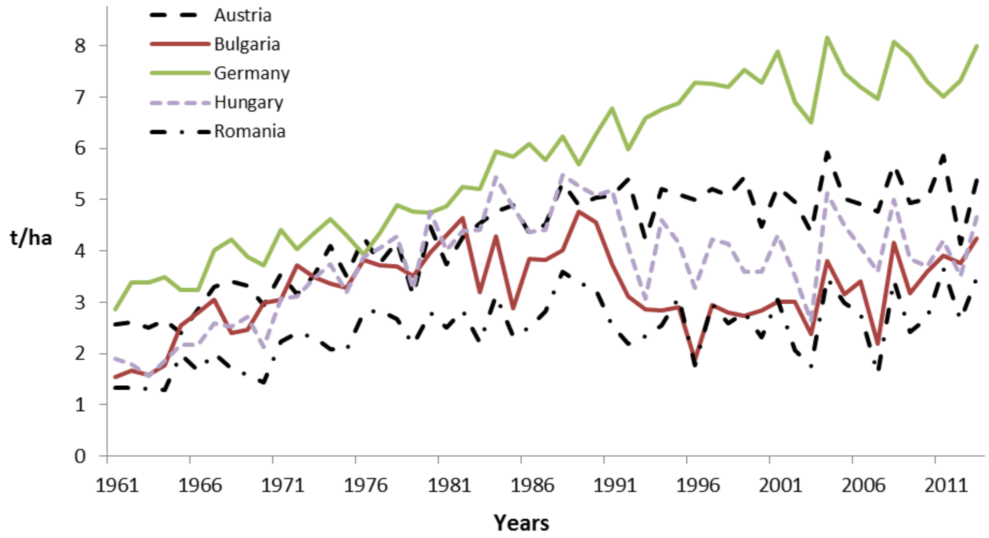
Source: Rittler (2016)

Historical wheat yields of selected countries in the Danube basin (data source: FAO, 2015)



Agricultural production in the Danube region

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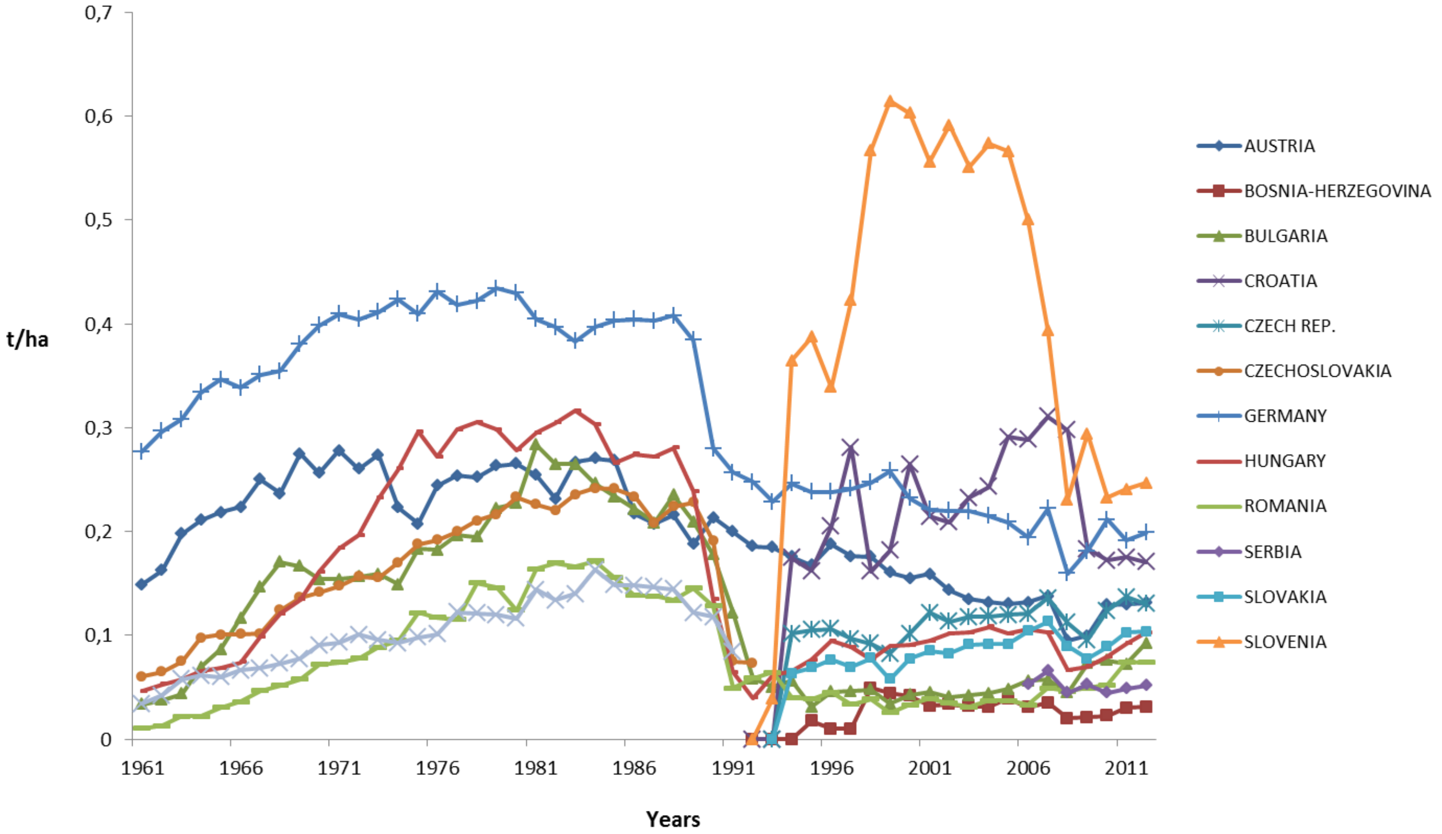
Source: Rittler (2016)

Consumption of synthetic nitrogenous fertilisers per arable land since 1960 (data source: FAO, 2015)



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Additional Potentials:

Yield gap & intensification

Closing the yield gap – intensification?

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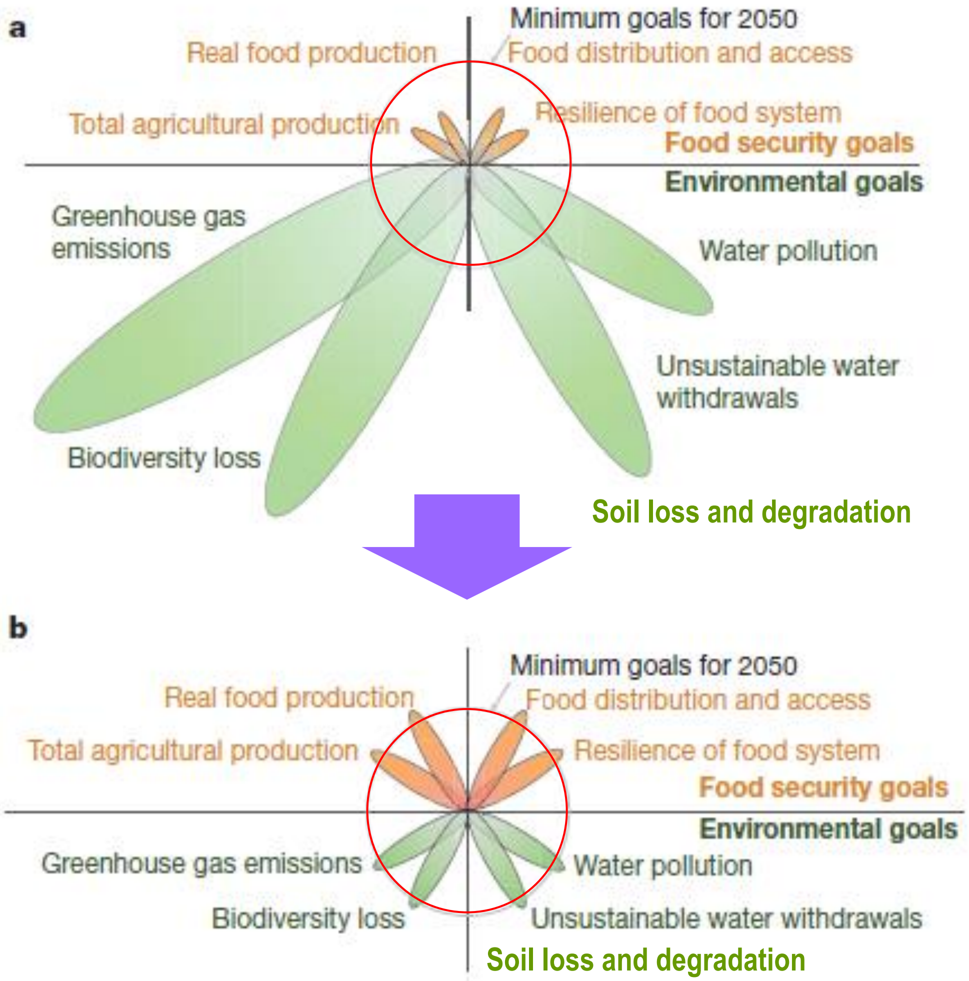
Foley et al. (2011): Nature 476:337-342



Meeting goals for food security and environmental sustainability by 2050. Here we qualitatively illustrate a subset of the goals agriculture must meet in the coming decades. At the top, we outline four key food security goals: increasing total agricultural production, increasing the supply of food (recognizing that agricultural yields are not always equivalent to food),improving the distribution of and access to food, and increasing the resilience of the whole food system. At the bottom, we illustrate four key environmental goals agriculture must also meet: reducing greenhouse gas emissions from agriculture and land use, reducing biodiversity loss, phasing out unsustainable water withdrawals, and curtailing air and water pollution from agriculture. Panel a sketches out a qualitative assessment of how current agricultural systems may be measured against these criteria compared to goals set for 2050. Panel b illustrates a hypothetical situation in which we meet all of these goals by 2050.

Mineral N input versus wheat yield

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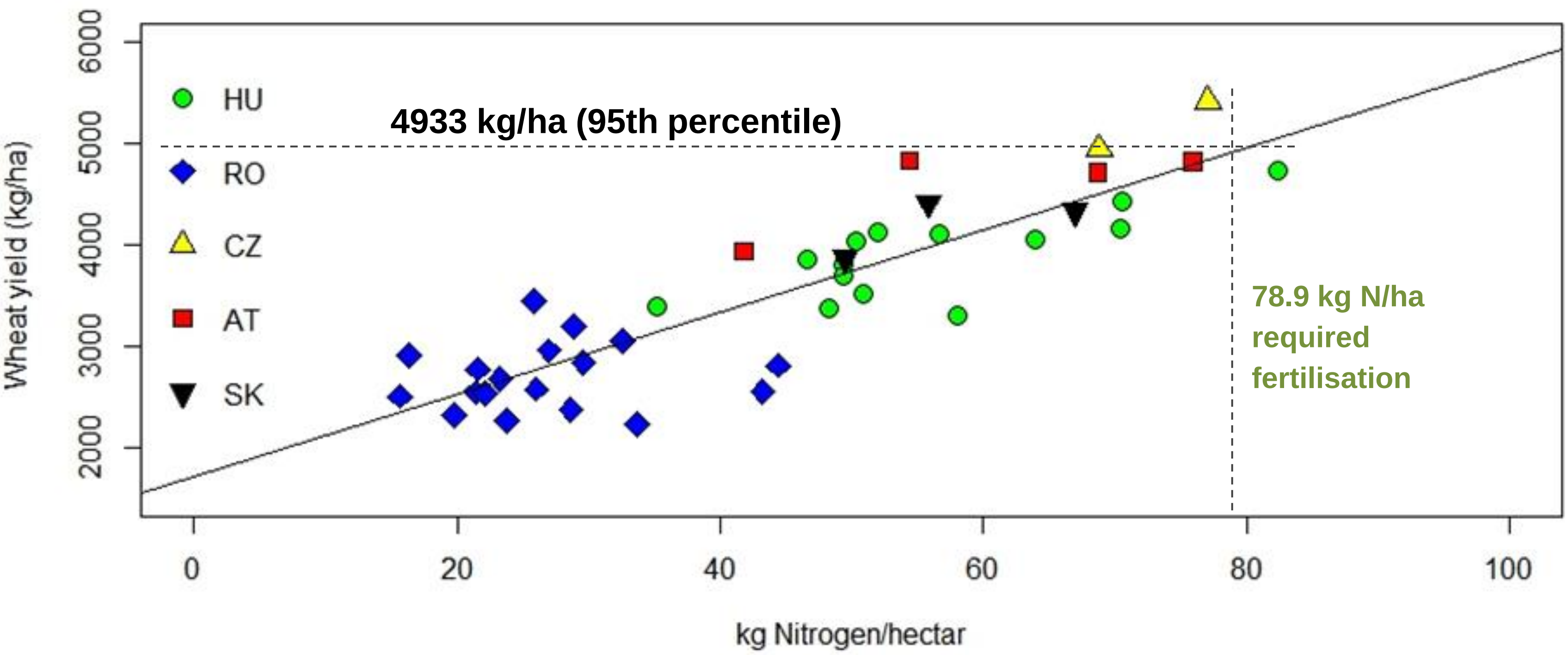
Source: Rittler (2016)

Correlation between mean fertilisation rates and mean wheat yield (2000 – 2012) in 41 NUTS 3 regions in the Danube basin (data source: Appendix I, section i). The horizontal dashed line represents the attainable yield level or yield potential (4933 kg/ha) defined as the 95th percentile. The corresponding synthetic nitrogen fertilisation required is marked by the vertical dashed line (78.9 kg N/ha)



Intensification scenario

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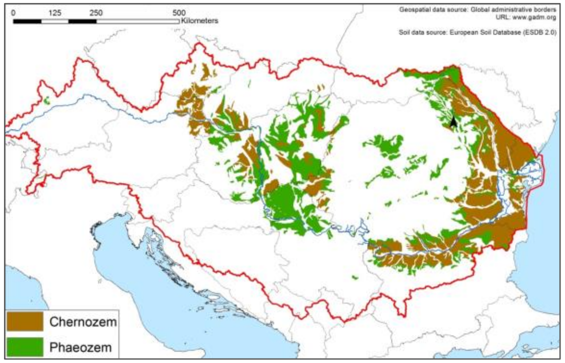
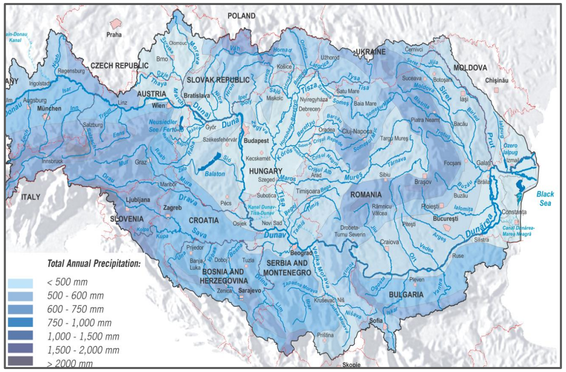
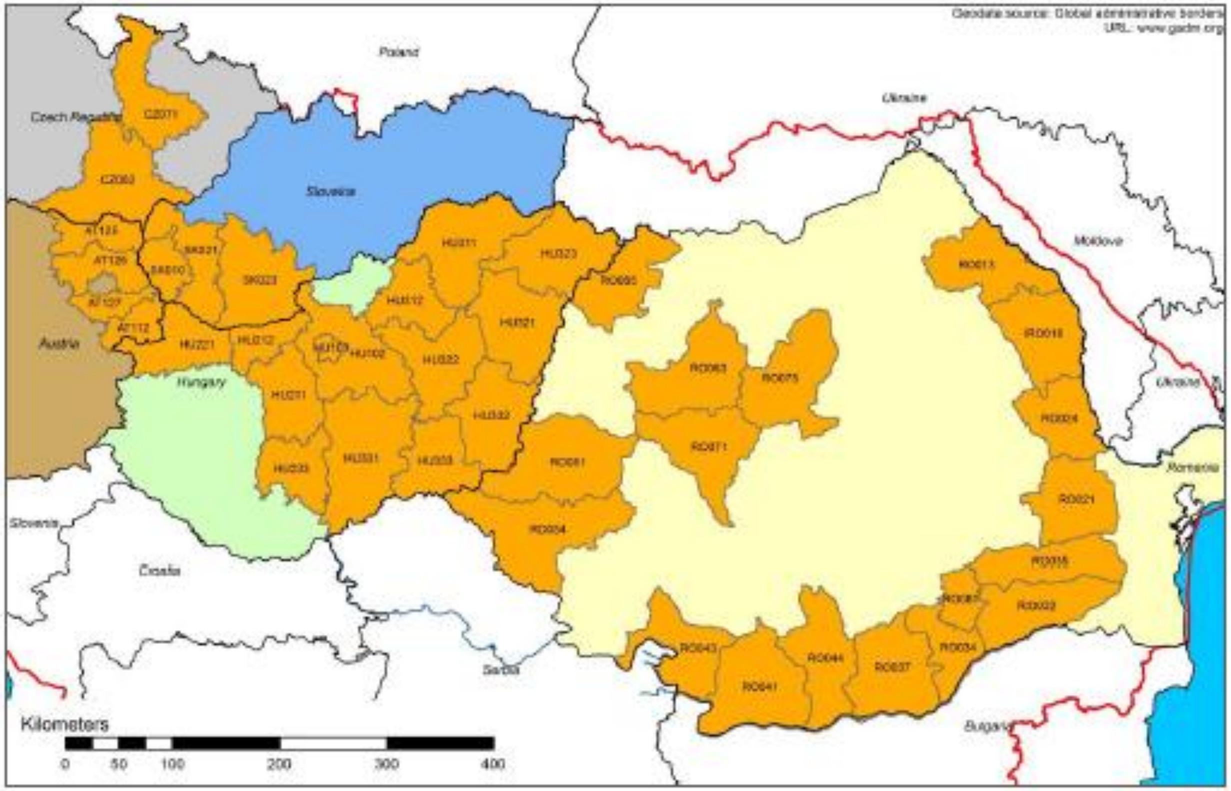
Source: Rittler (2016)

Selected NUTS regions for the intensification scenario







Spatial pattern of yield gaps

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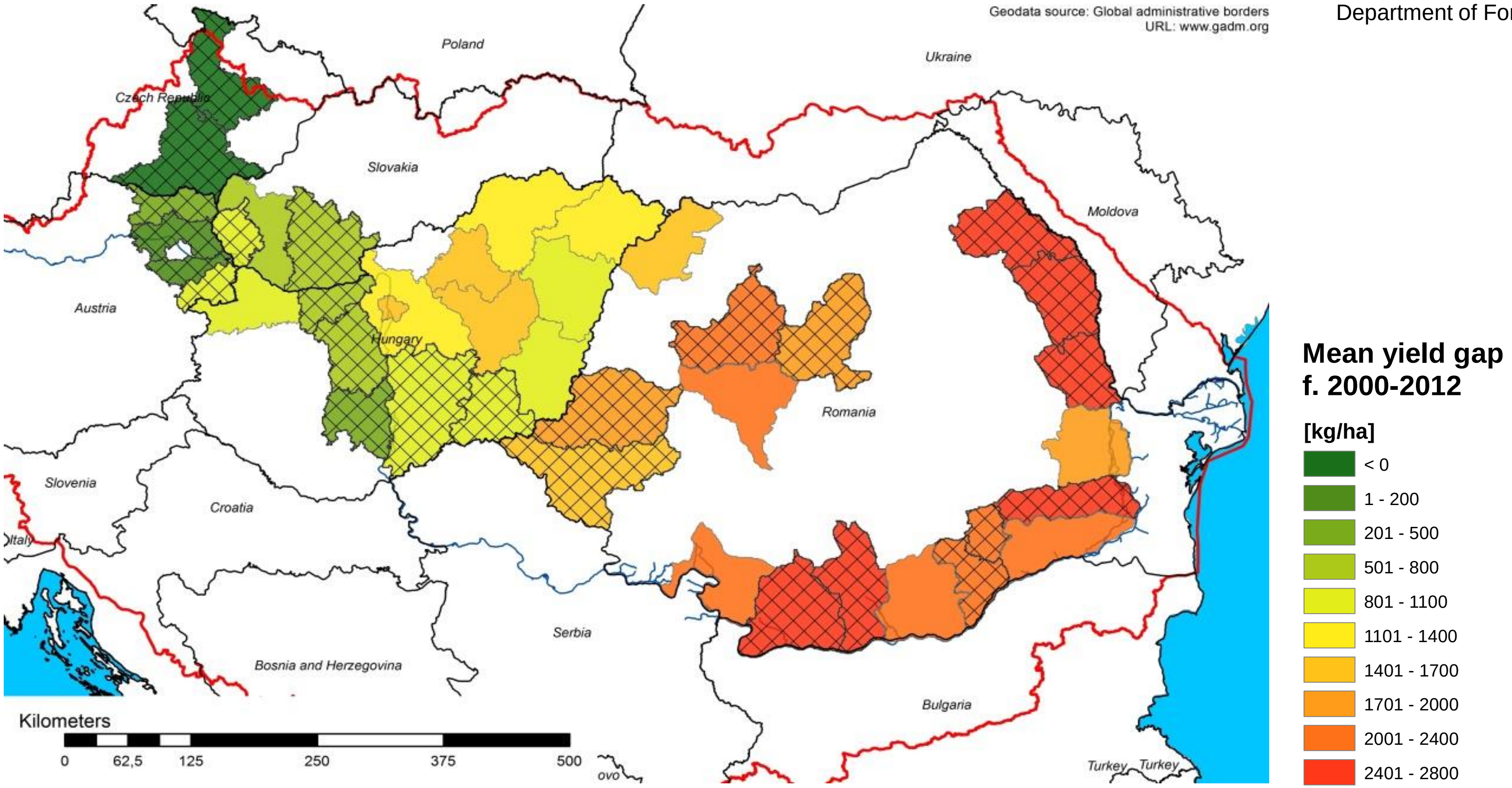
Source: Rittler (2016)

Yield gaps and integration of nitrate levels in groundwater into the yield gap assessment. Shaded areas mark regions where more than 10 % of the groundwater monitoring stations exceed 50 mg/l



Environmental constraints of intensification

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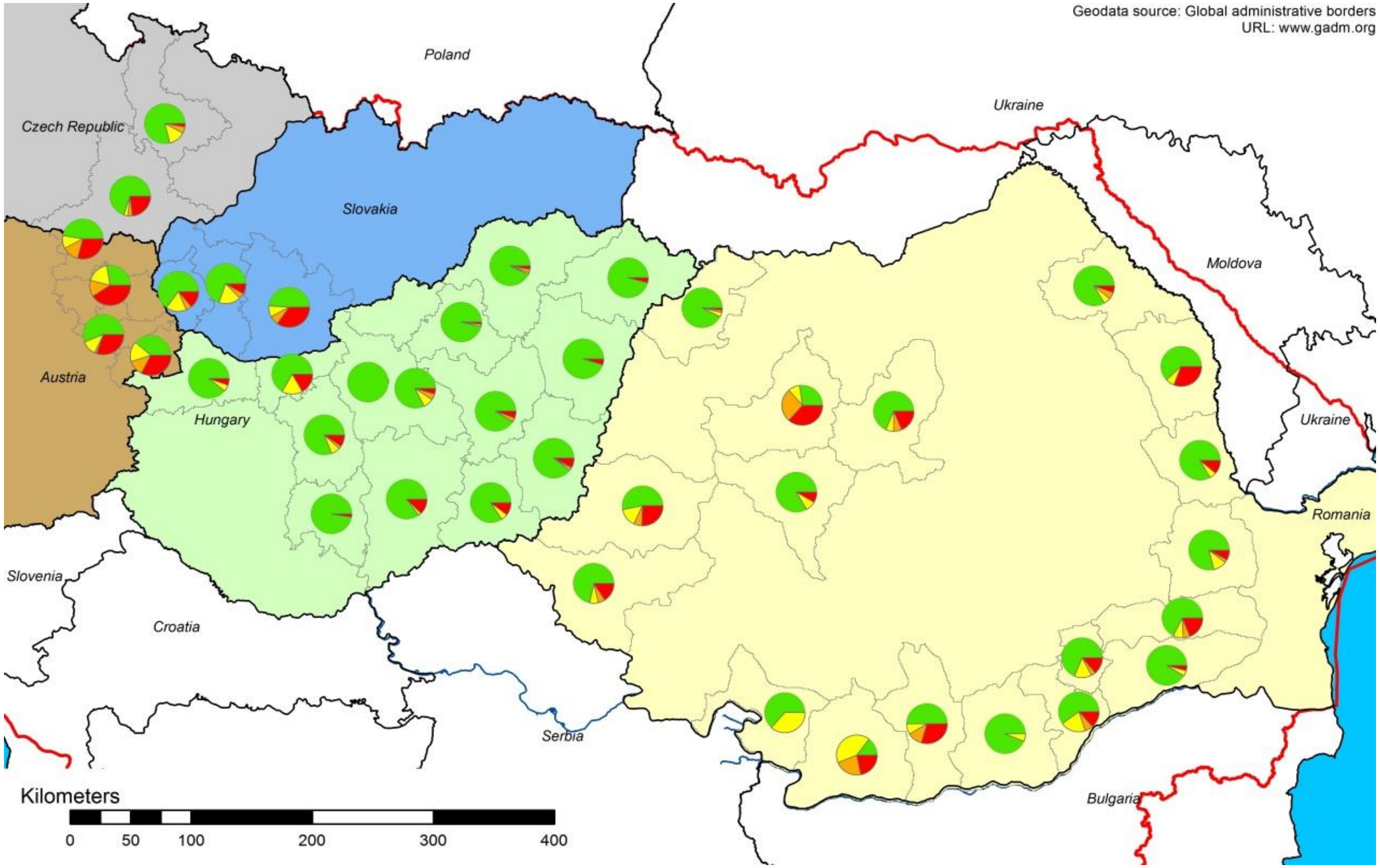
Source: Rittler (2016)

Mean nitrate concentrations in groundwater monitoring stations in the Danube region



Mean nitrate concentration [mg/l]

- 0 - 24.99
- 25 - 39.99
- 40 - 50
- > 50

Intensification scenario

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Source: Rittler (2016)

Additional production quantity, energy and protein supply of the "unlimited" Intensification scenario and for excluding NUTS 3 areas with >10% share of monitoring stations exceeding nitrate levels of 50 mg/l

Unlimited Intensification	Crop production		Food delivery			
	Hectares $x\ 10^6$	Tonnes $x\ 10^6$	Gcal $x\ 10^6$	Supplied people/year* $x\ 10^6$ (41 regions)	Supplied people/year* $x\ 10^6$ (16 regions)	Proteins $x\ 10^6$ tonnes
Total arable area	10.31					
Total wheat acreage	2.63					
Included regions	41					
Additional production quantity						
Attainable yield (t/ha)		3.89	10.6	8.54	1.46	0.32
closing yield gap by 75%		2.92	7.98	6.43	1.09	0.24
closing yield gap by 50%		1.95	5.32	4.29	0.73	0.16

Current production could feed 20 Mio. people

**average energy demand assumed per person: 3400 kcal/day*

41 regions | 16 regions

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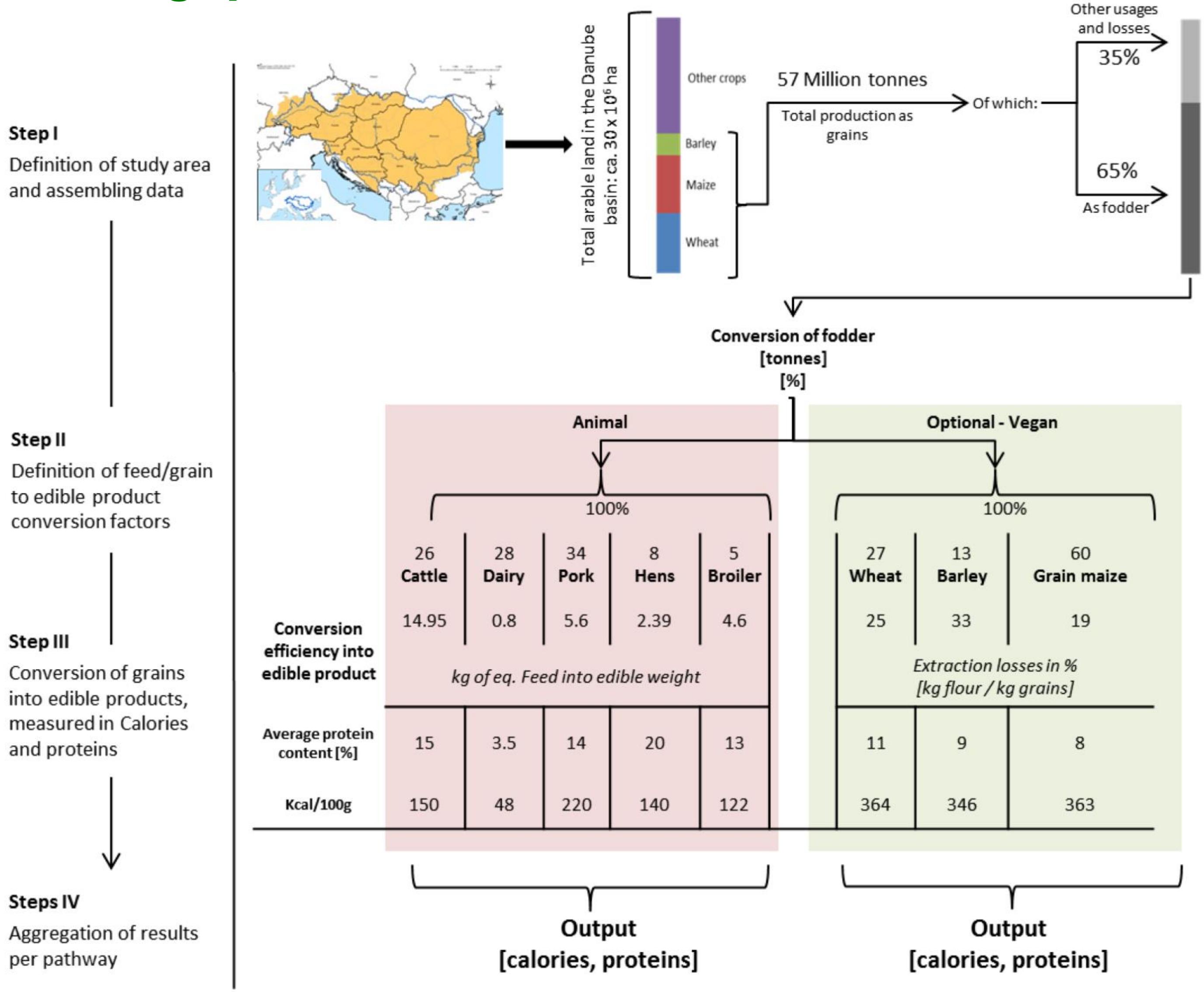
Additional Potentials:
Diet gap & diet changes

Diet gap scenario



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Source: Rittler (2016)

The 'Diet shift model' (starting from left upper corner, Step I). The model shows two different scenarios (boxes in red and green) of the usage of harvested grains in the Danube region. It contains a comparison of the conversion efficiency, measured in calories and proteins, from crops into edible products between animal end-product and plant end-products (Step III).

Diet gap scenario

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Source: Rittler (2016)

Results of the 'Diet shift model'. Scenario 'Animal' contains the nutritive value of animal end-product which results from feeding fodder crops such as grain maize, wheat and barley derived from the Danube region. Scenario 'Vegan' assumes that all fodder crops from scenario 'Animal' would be consumed directly by humans (in form plant end-product).

Edible end products:	Animal calories	Vegan calories	Calorie gap	Animal proteins	Vegan proteins	Protein gap
Unit:	x 10^6 Giga calories			x 10^6 tonnes		
Results:	15.4	104	89.0	1.18	2.63	1.45
Supplying people (1):	12.4	84.1	71.7	Not applicable (2)		

(1) Calorie consumption per person/day: 3400 kcal

(2) Recommended uptakes refer more to the quality of proteins measured in the content of individual amino acids

Comparison of scenarios

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Summary table of the model results for a comparative analysis. As the models operate in different proportions of the Danube basin), comparability increases if results are related to unit land. A shift from production of fodder wheat on 2.54 x 10^6 ha can contribute in a larger extent to food supply in the Danube region than intensification (and closing yield gaps) of wheat production.

		Unit		*Intensification*	*Diet shift*
Reference production**	Acreage of wheat/ Acreage of fodder wheat*	*Hectares*	x 10^6	2.63	2.54***
	Production of wheat/ Fodder use of wheat	*Tonnes*	x 10^6	9.11	10.1
Results of models	Additional production/ Additional availability	*Giga calories*	x 10^6	10.6	23.7
	Additional calorie supply per unit land in the study region	*Giga calories/hectare*		4.03	9.33
	Additional calorie supply for people		x 10^6	8.54	19.1

*refers for *Intensification* to an mean yield of 2000-2012 and the wheat acreage of 2012 and for *Diet shift* to an mean yield of 2000-2009 and the food balance data of circa 2009.
**for the calculation of the fodder wheat acreage see at chapter 4.4 and Appendix III, chapter 3
****fodder wheat acreage: From the production of fodder wheat per region (Appendix III, chapter 3) I calculated by mean wheat yields the acreage of fodder wheat.*

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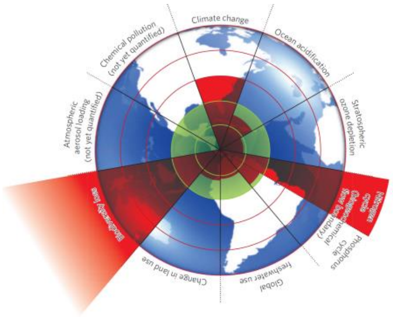
Implications for food security, soils & environment

Limitations of the intensification scenario



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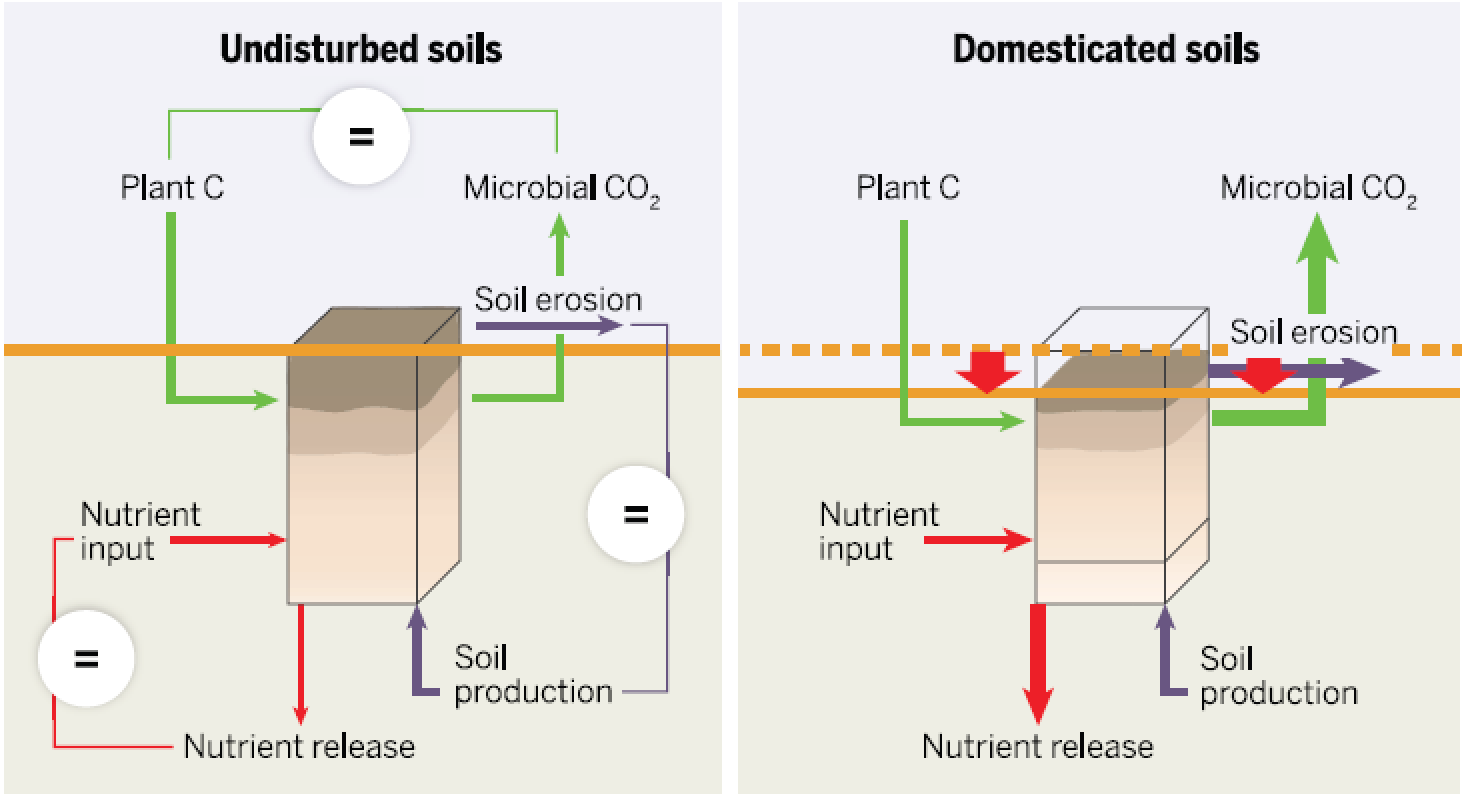
Amundson et al. (2015): Science. 348: 647

Soil Sustainability = Steady State



Implications of closing the diet gap

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Westhoek et al. (2014), Global Environmental Change 26: 196-205

Halving the production of meat, eggs and dairy production in Europe……

……40% reduction in nitrogen emissions
……25-40% reduction in greenhouse gas emissions
……23% per capita decrease in cropland use for food production
……enhance human health (40% reduction of intake of saturated fat)
……soymeal use reduced by 75%
……nitrogen use efficiency in food system would increase from 18% to 41-47%

Implications of closing the diet gap

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West et al (2010), PNAS 107: 19645-19648

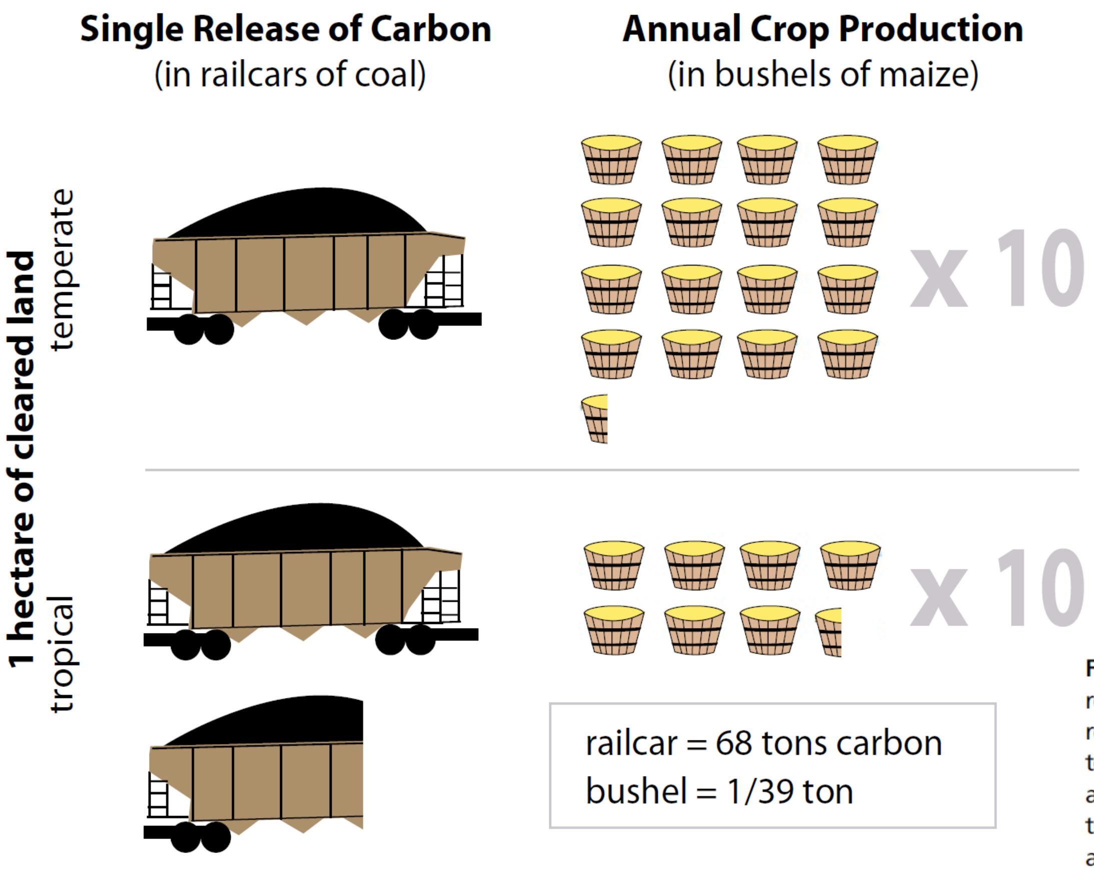

Fig. 4. Tradeoffs of carbon and crop production in temperate and tropical regions. Each hectare of land cleared for cropland in the temperate region releases an average of 63 tons of carbon and annually produces an average of 3.8 tons of dry crops. In contrast, a hectare of cleared land in the tropics releases an average of 120 tons of carbon and annually produces 1.7 tons of dry crops. The tradeoff varies depending on type of ecosystem cleared, soil type, crops planted, and crop management practices. We assumed that the coal was 75% carbon, making a standard railcar of coal equivalent to 68 tons of carbon. Dry yields were adjusted to account for the 11% water content in harvested maize grain.

Implications of closing the diet gap

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HMI = Human Health = Environmental Health = Soil Health