Decision making on cropping systems adaptation to climate change

Jerzy Kozyra, Stelios Rozakis, Rafał Pudełko, Tomasz Żyłowski, Aleksandra Król
Institute of Soil Science and Plant Cultivation – State Research Institute (IUNG), POLAND

Budapest, 08.11.2018

Bioeconomy in the forefront of national policies
BIOEAST conference

This presentation was prepared in frame of long-term IUNG-PIB program Task 1.7

Institute of Soil Science
and Plant Cultivation
State Research Institute

BioEcon

Department
of Bioeconomy
and Systems Analysis

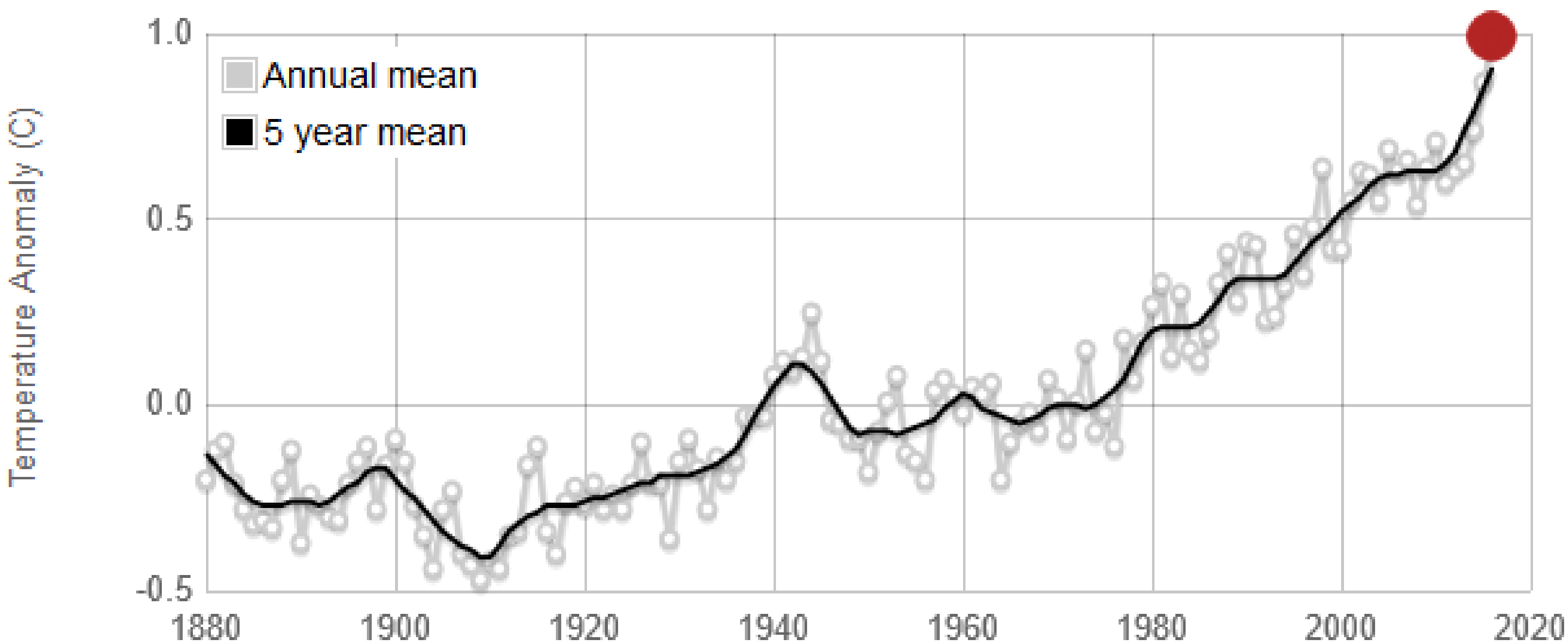
HR EXCELLENCE IN RESEARCH

Outline

1. Climate change; EU Bioeconomy Strategy; advantages of good design of agricultural cropping systems
2. Cereal crop yield gap in Europe - case study
3. Impact of CC on cereal yield in Europe
4. Management practices in face of climate change
5. Risk income analysis as a basis for decision making on cropping systems – willow vs triticale case study
6. Conclusions

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS).
Credit: NASA/GISS



2020 + 1.0°C

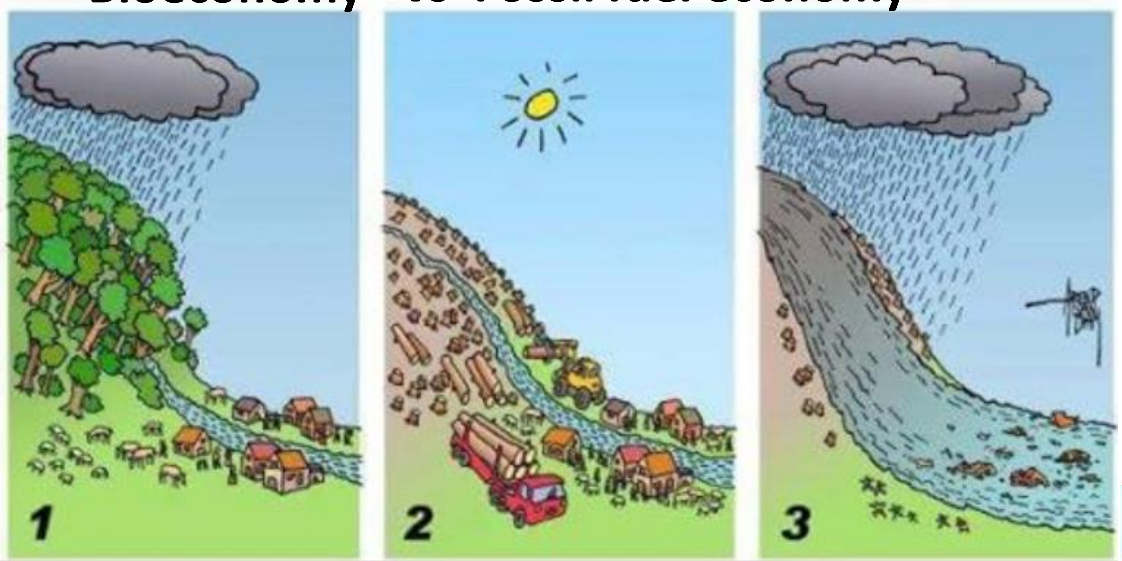
2060 + 1.8°C

2080 + 2.2°C

2100 + 2.6°C

https://climate.nasa.gov/vital-signs/global-temperature/

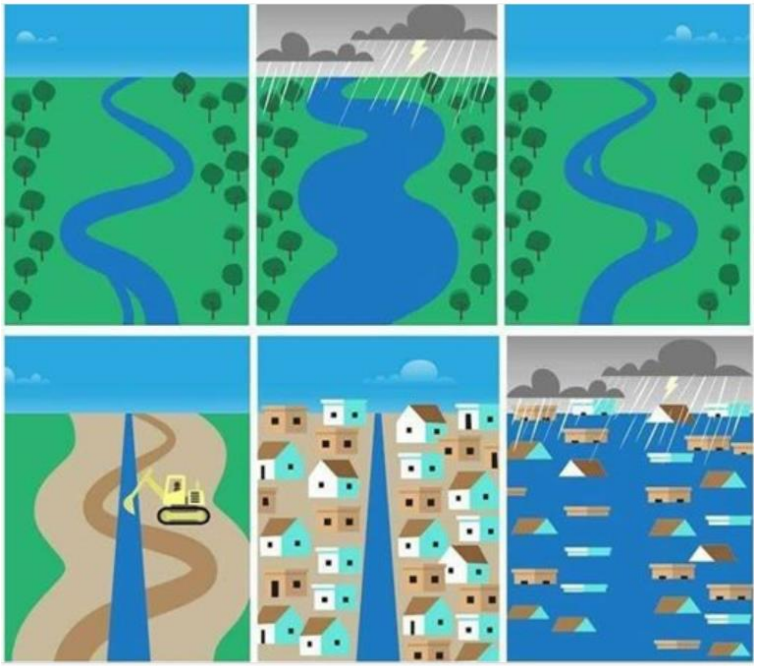
Bioeconomy vs Fossil fuel economy



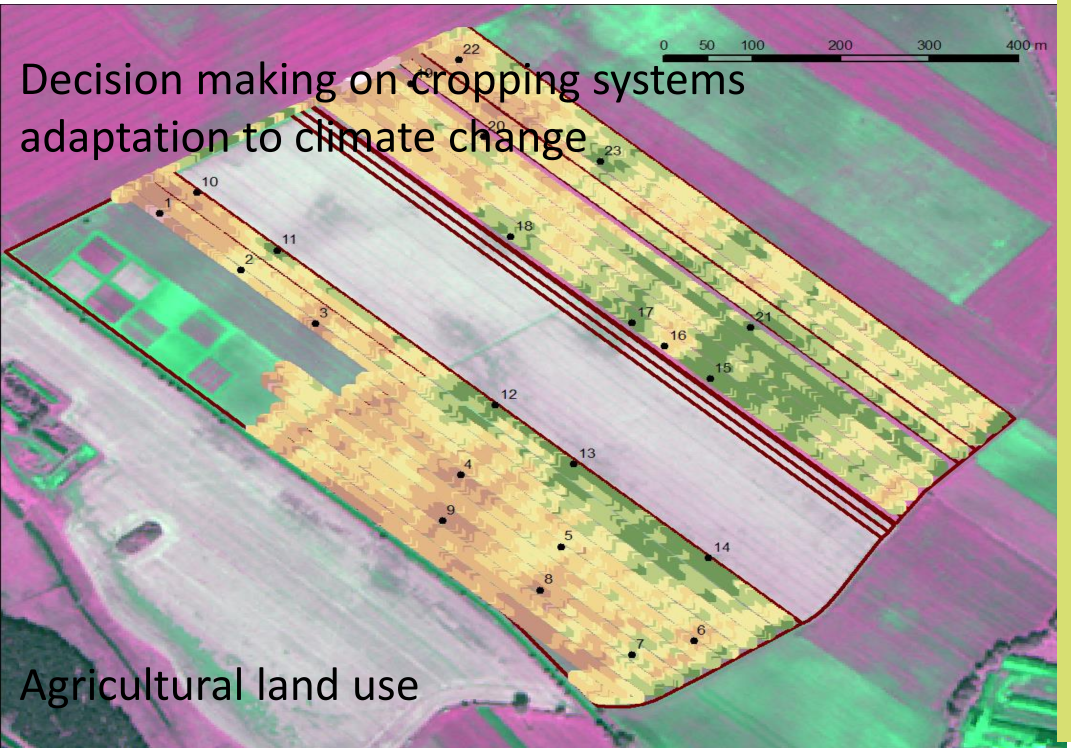
Jan Knap ▶ Zachranme lipana a pstruha potočního
23 października o 18:01

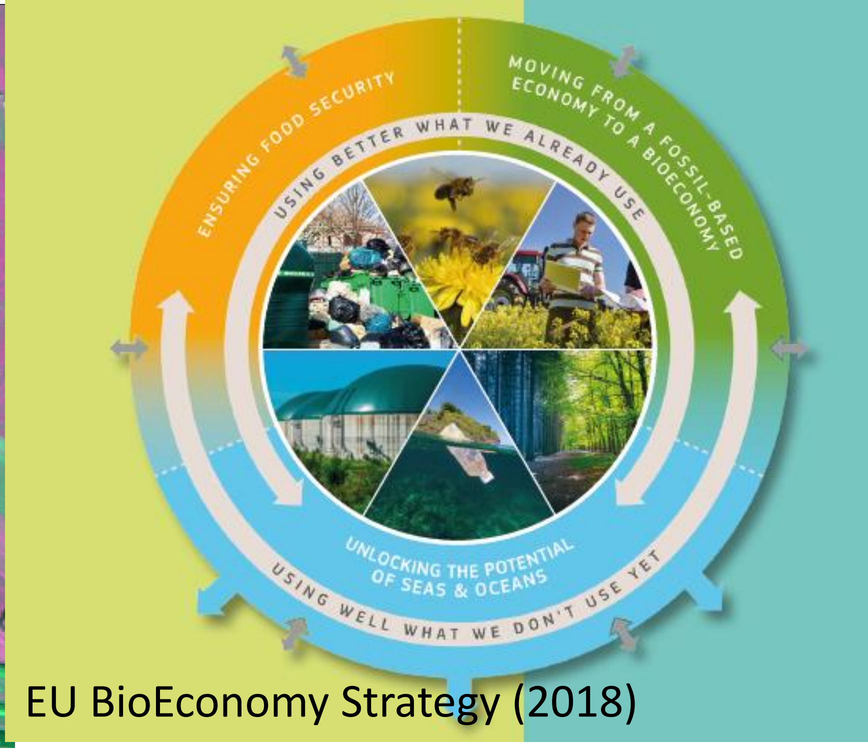
Bio-based economy

Fossil fuel Economy



Jan Knap ▶ Zachranme lipana a pstruha potočního
23 października o 18:01





EU BioEconomy Strategy (2018)

Use well what we don't use yet

Use better what we already use

Climate change adaptation concerning EU MS

1. The farmers' awareness of climate change
2. Water management in agriculture
3. Resilience of farming systems
4. Plant breeding for future climate
5. Livestock management

Well-designed agricultural systems: advantages

- Maintain and enhance soil fertility
- Enhanced crop growth
- Minimize spread of diseases
- Control weeds
- Increase soil cover
- Use resourses more effectively
- Reduce risk of crop failure
- Improve food and financial security
- Reduce GHG emissions

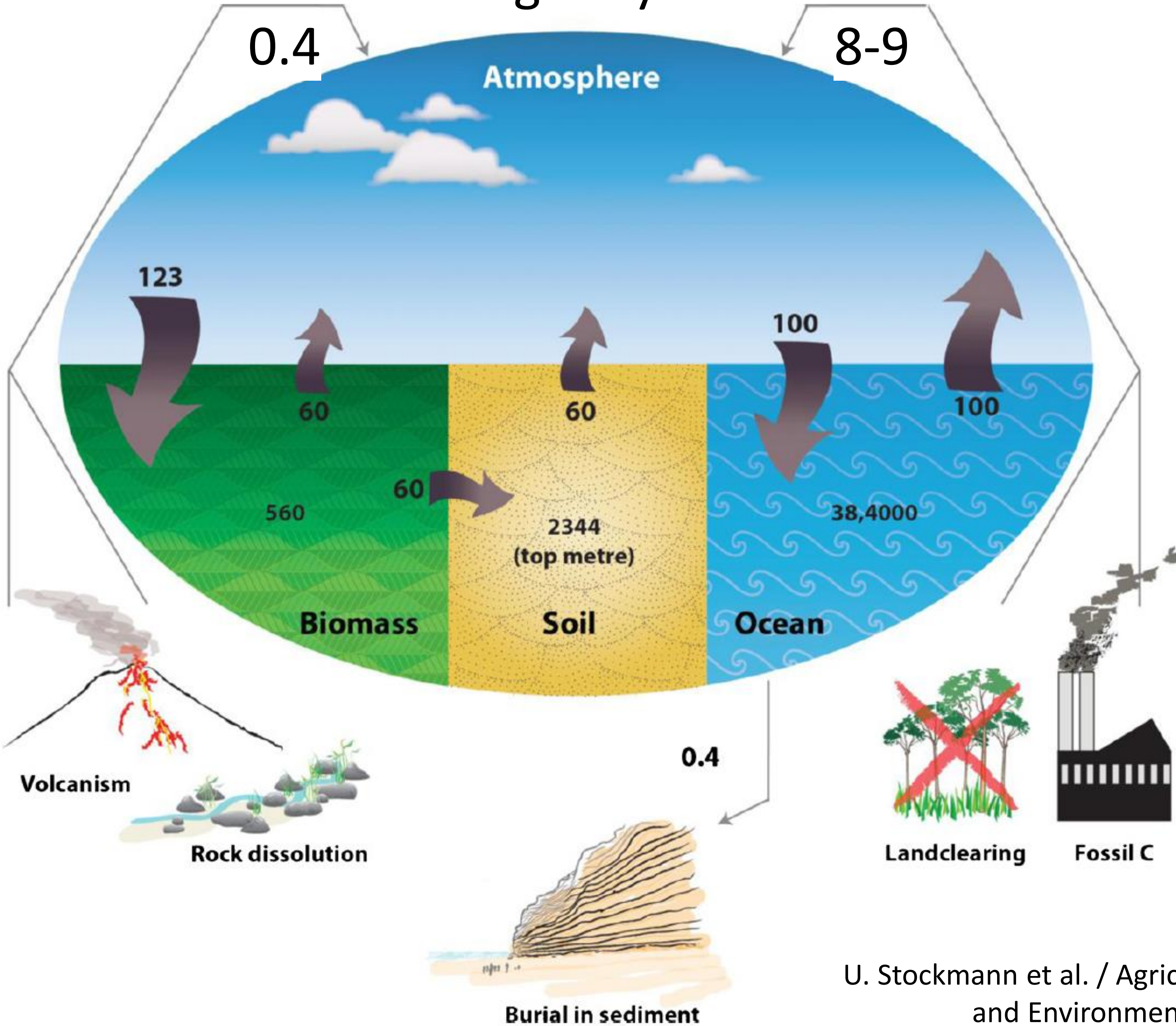
Institute of Soil Science
and Plant Cultivation
State Research Institute

BioEcon

Department
of Bioeconomy
and Systems Analysis

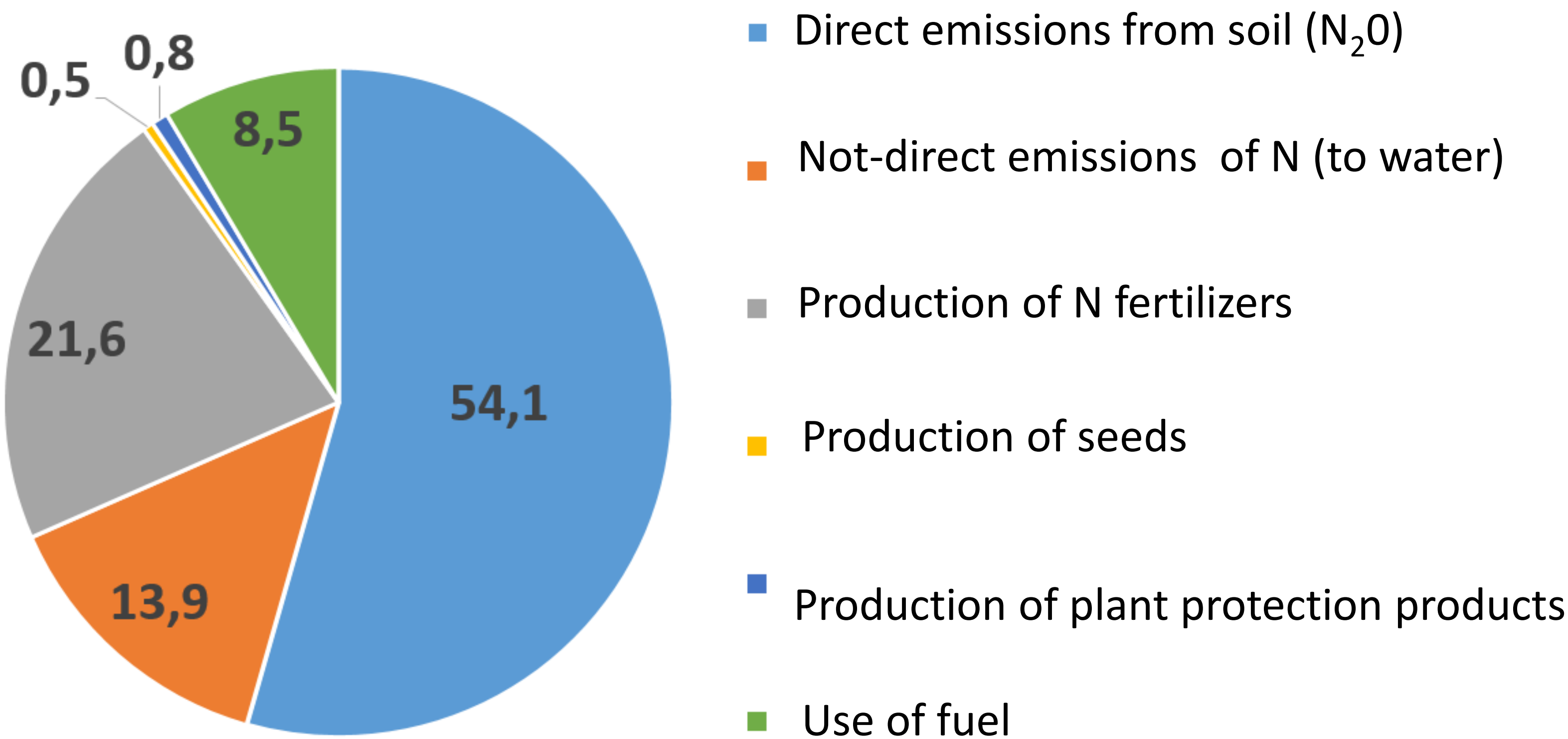
HR EXCELLENCE IN RESEARCH

Annual carbon streams between the atmosphere (billions of tons) and the most biologically active resources



U. Stockmann et al. / Agriculture, Ecosystems and Environment 164 (2013) 80-99

Sources of greenhouse gas emissions from maize cultivation in Poland (evaluation for 30 farms)



Source: Żyłowski T. ,Król A., Kozyra J., Ocena możliwości ograniczenia śladu węglowego w uprawie kukurydzy na ziarno, 2018, SERIA T.XX (4)

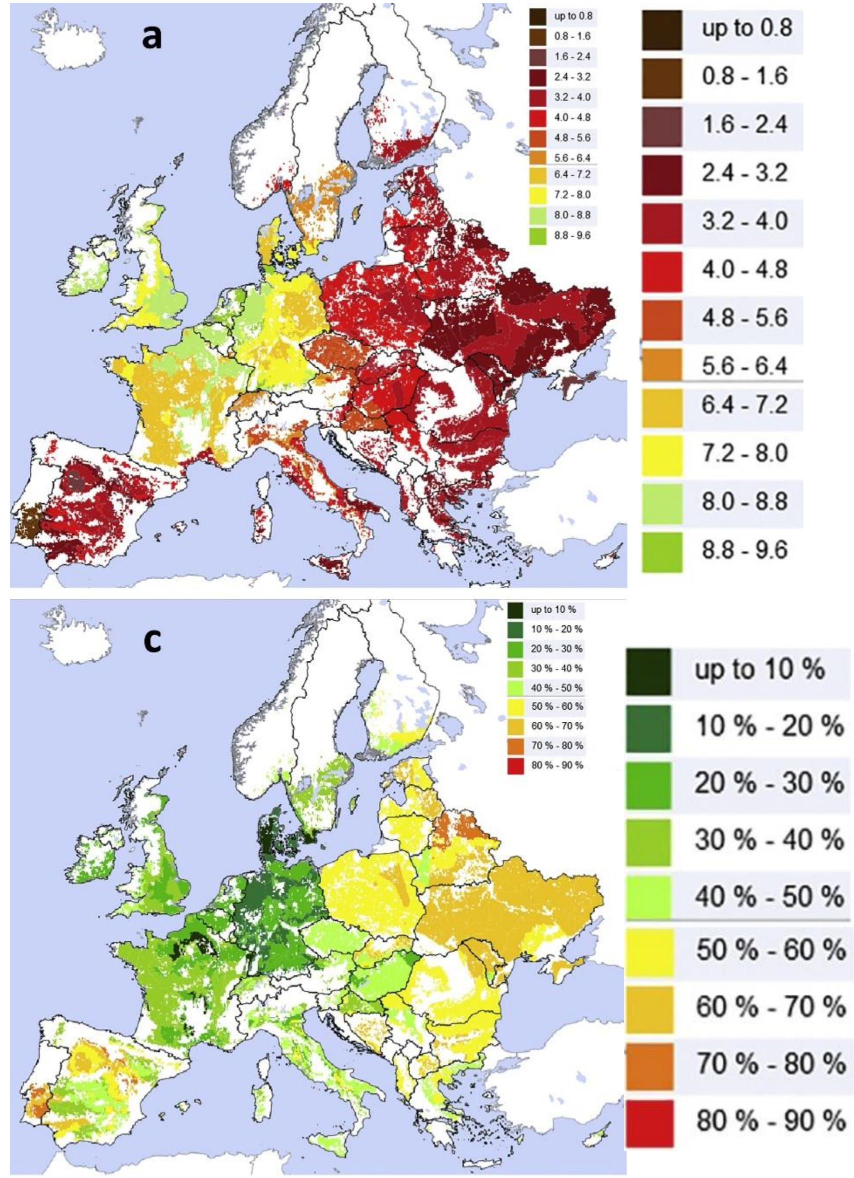
Contents lists available at ScienceDirect

European Journal of Agronomy

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

Cereal yield gaps across Europe

René Schils[a,*], Jørgen E. Olesen[b], Kurt-Christian Kersebaum[c], Bert Rijk[a], Michael Oberforster[d], Valery Kalyada[e], Maksim Khitrykau[e], Anne Gobin[f], Hristofor Kirchev[g], Vanya Manolova[g], Ivan Manolov[g], Mirek Trnka[h,i], Petr Hlavinka[i], Taru Palosuo[j], Pirjo Peltonen-Sainio[j], Lauri Jauhiainen[j], Josiane Lorgeou[k], Hélène Marrou[l], Nikos Danalatos[m], Sotirios Archontoulis[n], Nándor Fodor[o], John Spink[p], Pier Paolo Roggero[q], Simona Bassu[q], Antonio Pulina[q], Till Seehusen[r], Anne Kjersti Uhlen[r], Katarzyna Żyłowska[s], Anna Nieróbca[s], Jerzy Kozyra[s], João Vasco Silva[a], Benvindo Martins Maçãs[t], José Coutinho[t], Viorel Ion[u], Jozef Takáč[v], M. Inés Mínguez[w], Henrik Eckersten[x], Lilia Levy[y], Juan Manuel Herrera[y], Jürg Hiltbrunner[y], Oleksii Kryvobok[z], Oleksandr Kryvoshein[z], Roger Sylvester-Bradley[A], Daniel Kindred[A], Cairistiona F.E. Topp[B], Hendrik Boogaard[C], Hugo de Groot[C], Jan Peter Lesschen[D], Lenny van Bussel[a], Joost Wolf[a], Mink Zijlstra[a], Marloes P. van Loon[a], Martin K. van Ittersum[a]



Average crop yields (t ha-^{1}) and yield gaps of rainfed wheat in Europe

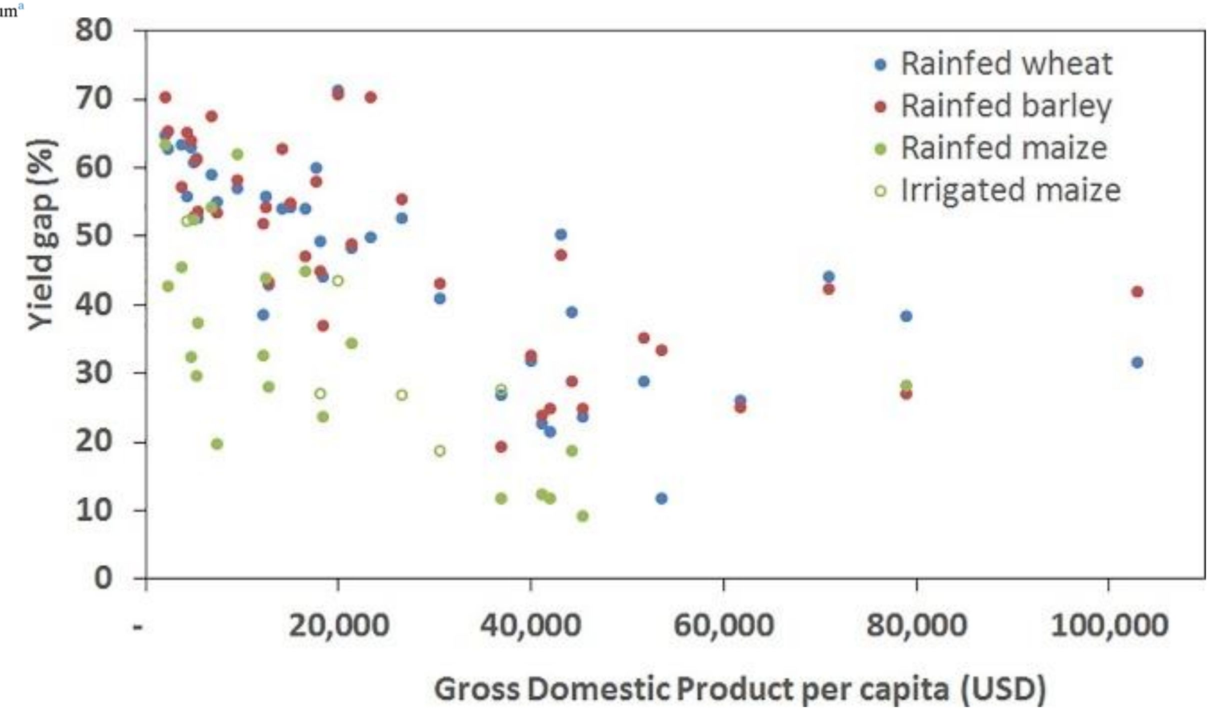
Contents lists available at ScienceDirect

European Journal of Agronomy

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

Cereal yield gaps across Europe

René Schils[a,*], Jørgen E. Olesen[b], Kurt-Christian Kersebaum[c], Bert Rijk[a], Michael Oberforster[d], Valery Kalyada[e], Maksim Khitrykau[e], Anne Gobin[f], Hristofor Kirchev[g], Vanya Manolova[g], Ivan Manolov[g], Mirek Trnka[h,i], Petr Hlavinka[i], Taru Palosuo[j], Pirjo Peltonen-Sainio[j], Lauri Jauhiainen[j], Josiane Lorgeou[k], Hélène Marrou[l], Nikos Danalatos[m], Sotirios Archontoulis[n], Nándor Fodor[o], John Spink[p], Pier Paolo Roggero[q], Simona Bassu[q], Antonio Pulina[q], Till Seehusen[r], Anne Kjersti Uhlen[r], Katarzyna Żyłowska[s], Anna Nieróbca[s], Jerzy Kozyra[s], João Vasco Silva[a], Benvindo Martins Maçãs[t], José Coutinho[t], Viorel Ion[u], Jozef Takáč[v], M. Inés Mínguez[w], Henrik Eckersten[x], Lilia Levy[y], Juan Manuel Herrera[y], Jürg Hiltbrunner[y], Oleksii Kryvobok[z], Oleksandr Kryvoshein[z], Roger Sylvester-Bradley[A], Daniel Kindred[A], Cairistiona F.E. Topp[B], Hendrik Boogaard[C], Hugo de Groot[C], Jan Peter Lesschen[D], Lenny van Bussel[a], Joost Wolf[a], Mink Zijlstra[a], Marloes P. van Loon[a], Martin K. van Ittersum[a]



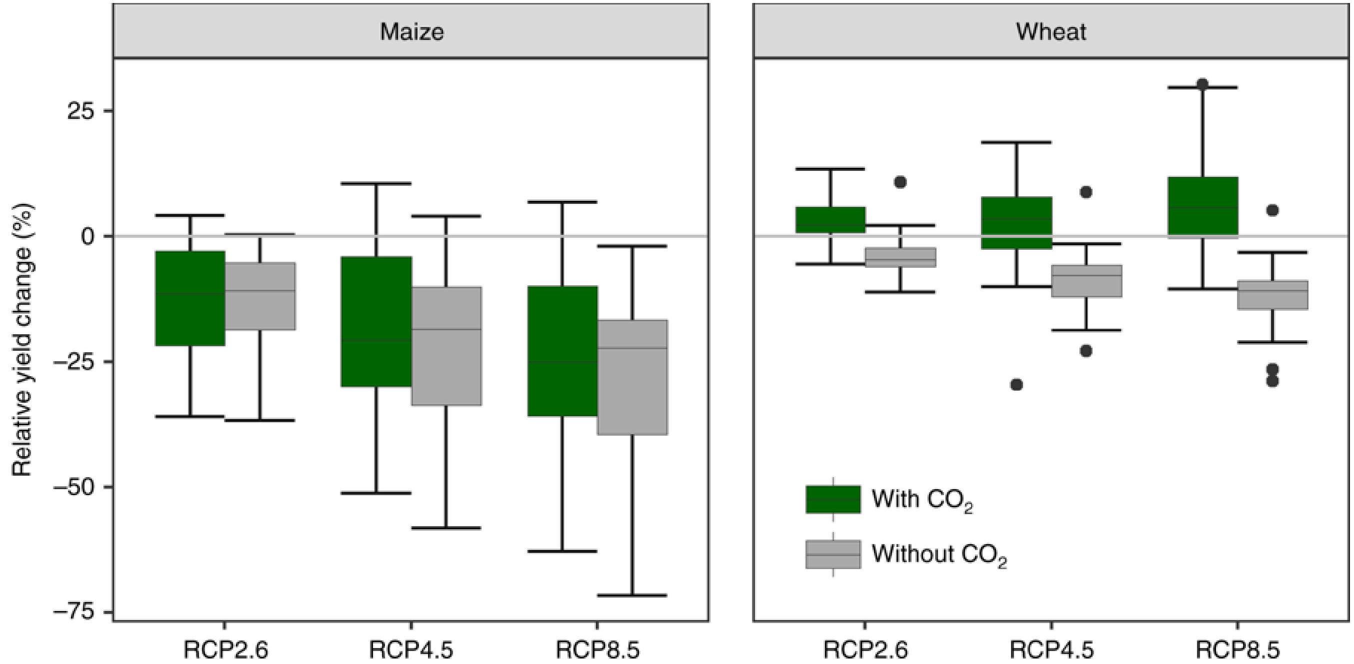
Relative yield gaps (%) in relations to national GDP (USD zapita)

ARTICLE

DOI: 10.1038/s41467-018-06525-2 OPEN

Diverging importance of drought stress for maize and winter wheat in Europe

Heidi Webber[1,2], Frank Ewert[1,2], Jørgen E. Olesen[3], Christoph Müller[4], Stefan Fronzek[5], Alex C. Ruane[6], Maryse Bourgault[7], Pierre Martre[8], Behnam Ababaei[8,9,10], Marco Bindi[11], Roberto Ferrise[11], Robert Finger[12], Nándor Fodor[13], Clara Gabaldón-Leal[14], Thomas Gaiser[2], Mohamed Jabloun[15], Kurt-Christian Kersebaum[1], Jon I. Lizaso[16], Ignacio J. Lorite[14], Loic Manceau[8], Marco Moriondo[17], Claas Nendel[1], Alfredo Rodríguez[16,18], Margarita Ruiz-Ramos[16], Mikhail A. Semenov[19], Stefan Siebert[20], Tommaso Stella[1], Pierre Stratonovitch[19], Giacomo Trombi[10] & Daniel Wallach[21]



Projected changes in European maize and wheat yield estimated for the period 2040-2069, compered to baseline (1981-2010)

sustainability

MDPI

Forthcoming Article

Evaluation of sustainability of maize cultivation in Poland. A Prospect Theory – PROMETHEE approach

Aleksandra Król , Jerzy Księżak , Elżbieta Kubińska and Stelios Rozakis

Ranking of agricultural practices in maize cultivation in Poland using multi-criteria evaluation by means of Prospect theory –PROMETHEE method

Criteria considered are: (1) expected gross margin (2) standard deviation of gross margin, (3) fuel consumption (4) labour use in hours, (5) soil moisture and (6) organic matter in soil.

Decision maker / Option	Small farm	Big farm	According to agricultural experts
Direct sowing	3	1	2
Reduced tillage	2	2	3
Traditional ploughing	1	3	1

IUNG Institute of Soil Science and Plant Cultivation State Research Institute

BioEcon

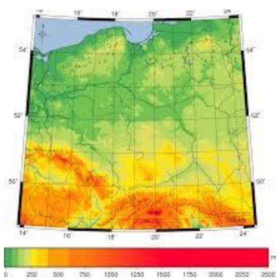
Department of Bioeconomy and Systems Analysis

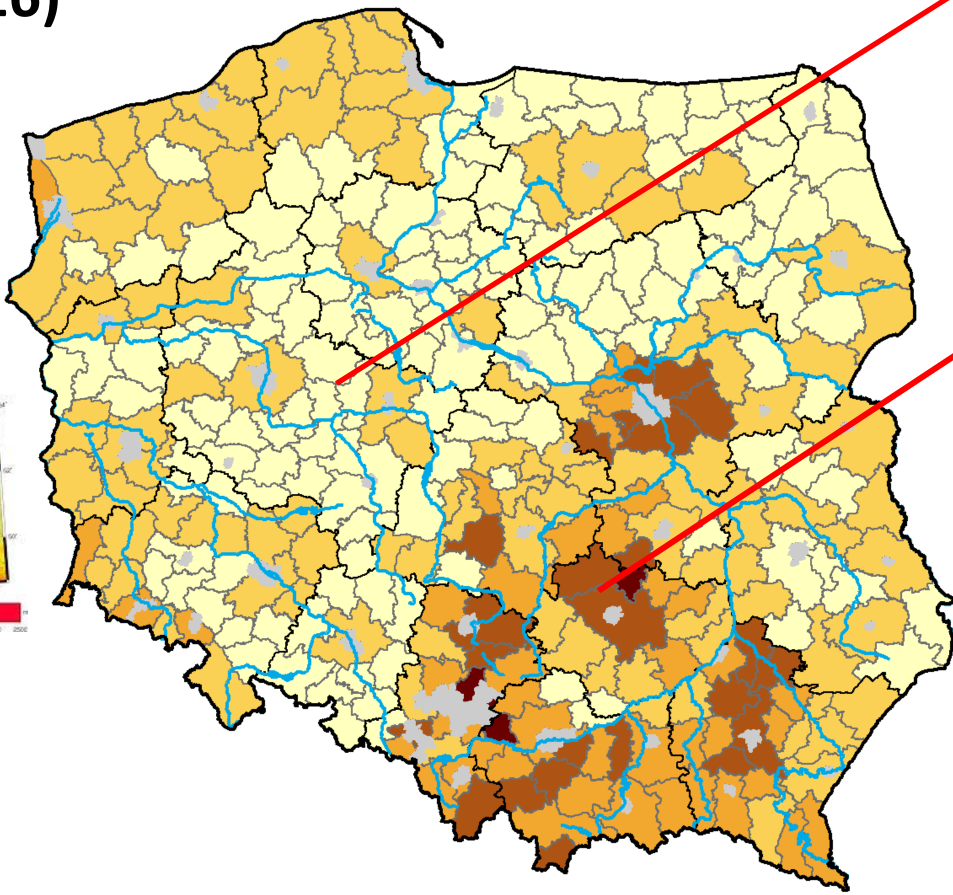
HR EXCELLENCE IN RESEARCH

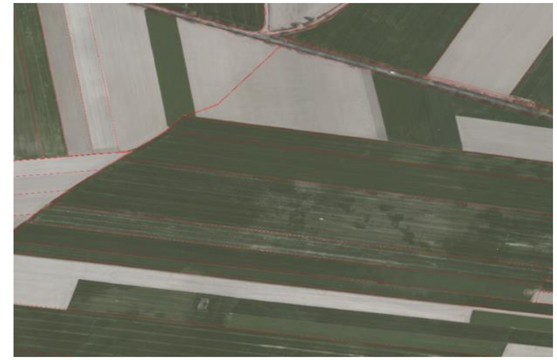
Reduced tillage

Conservation agriculture
Strip-till

Ratio of agricultural land not receiving EU Direct Payments (DP) to total agricultural land (2016)







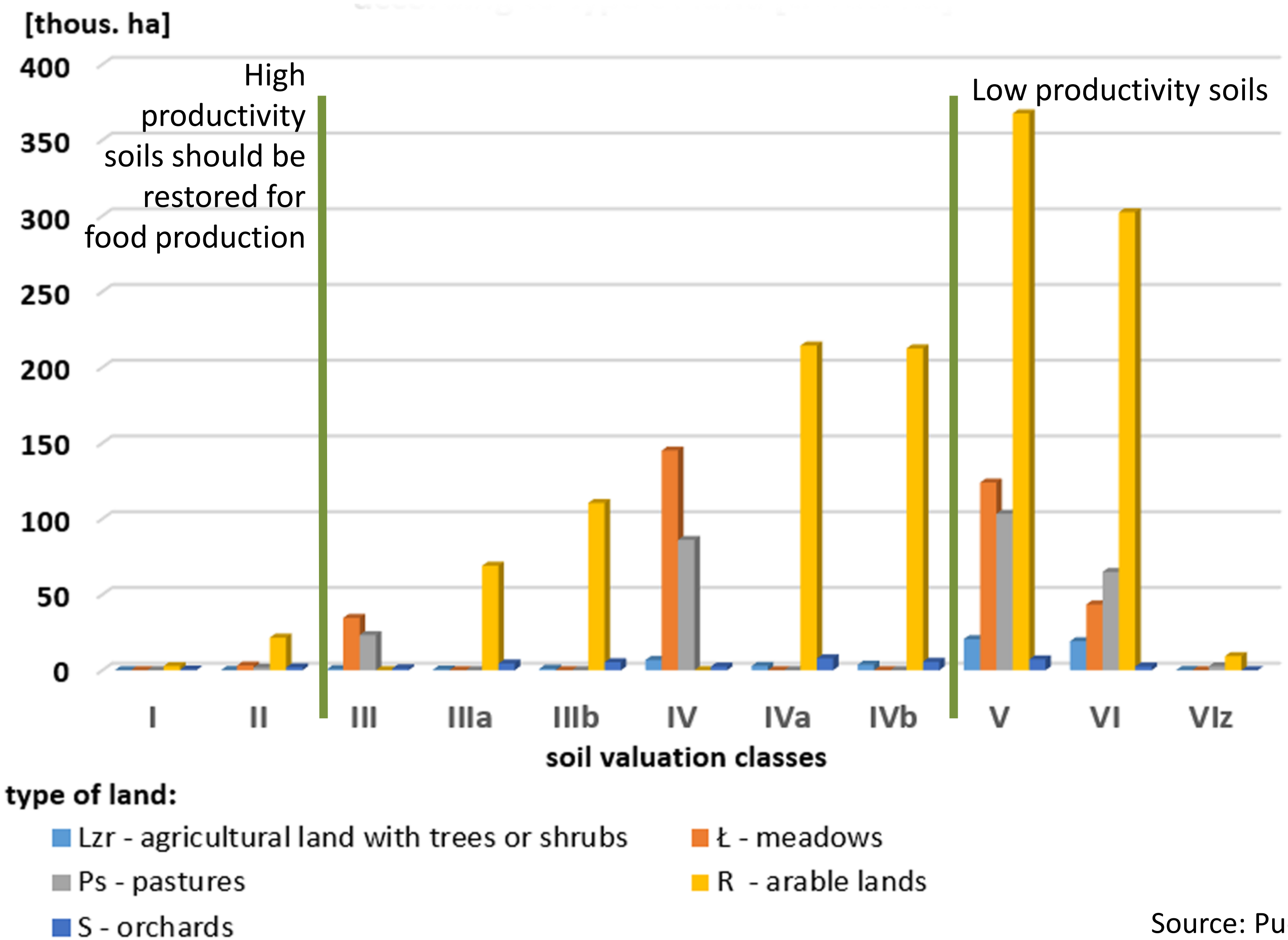
	0 - 0.10
	0.11 – 0.25
	0.26 – 0.50
	0.51 – 1.00
	1.01 – 2.73

14.4% agricultural land in Poland not paid by DP (2.03 mln ha)

Source: Pudełko et al. 2018

DOI: http://dx.doi.org/10.17951/pjss.2018.51.1.119

Share of agricultural land in Poland (2016) not receiving EU Direct Payments (DP) by type of soil productivity



Source: Pudełko et al. 2018

DOI: http://dx.doi.org/10.17951/pjss.2018.51.1.119

Institute of Soil Science and Plant Cultivation State Research Institute

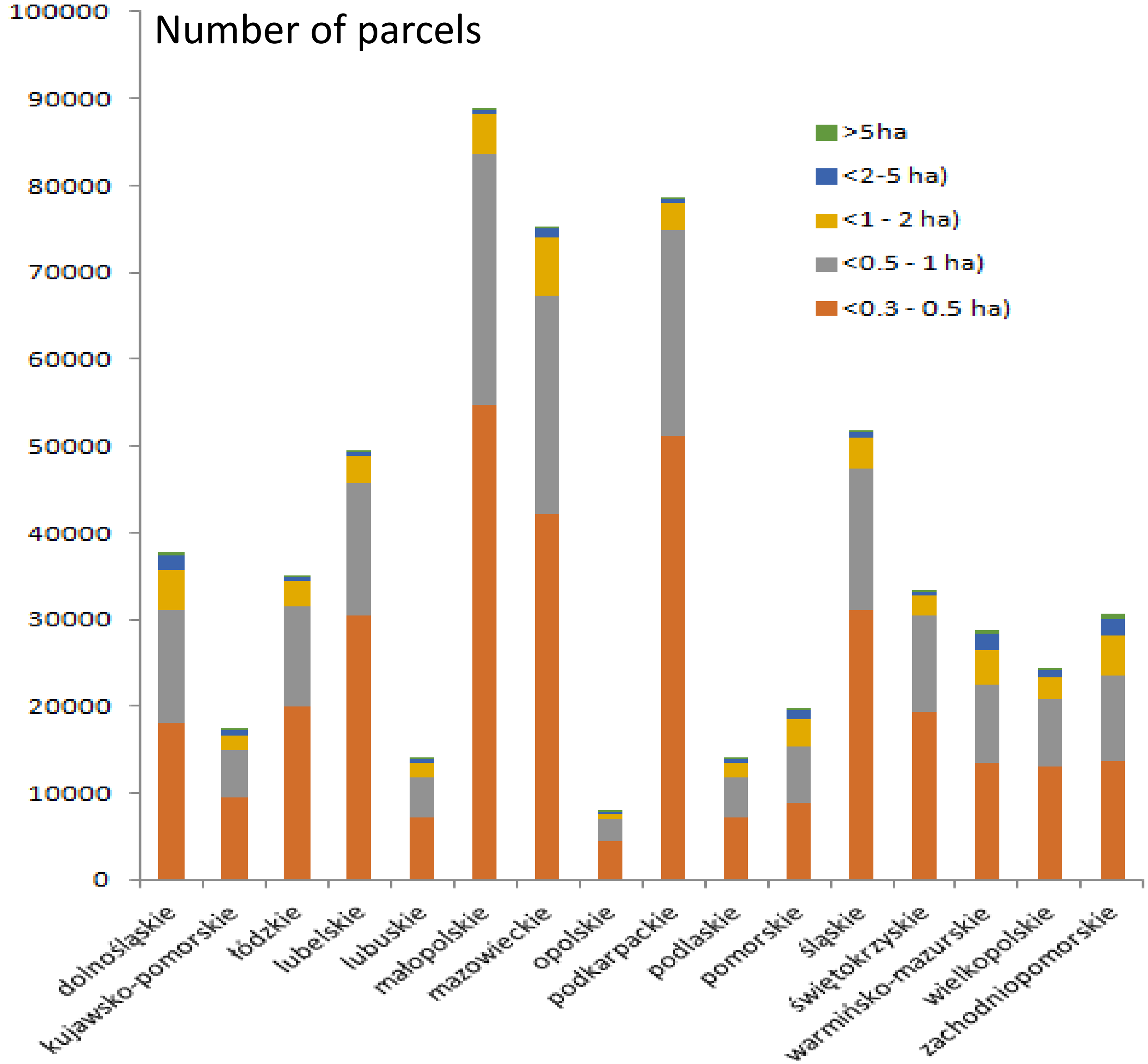
BioEcon

Department of Bioeconomy and Systems Analysis

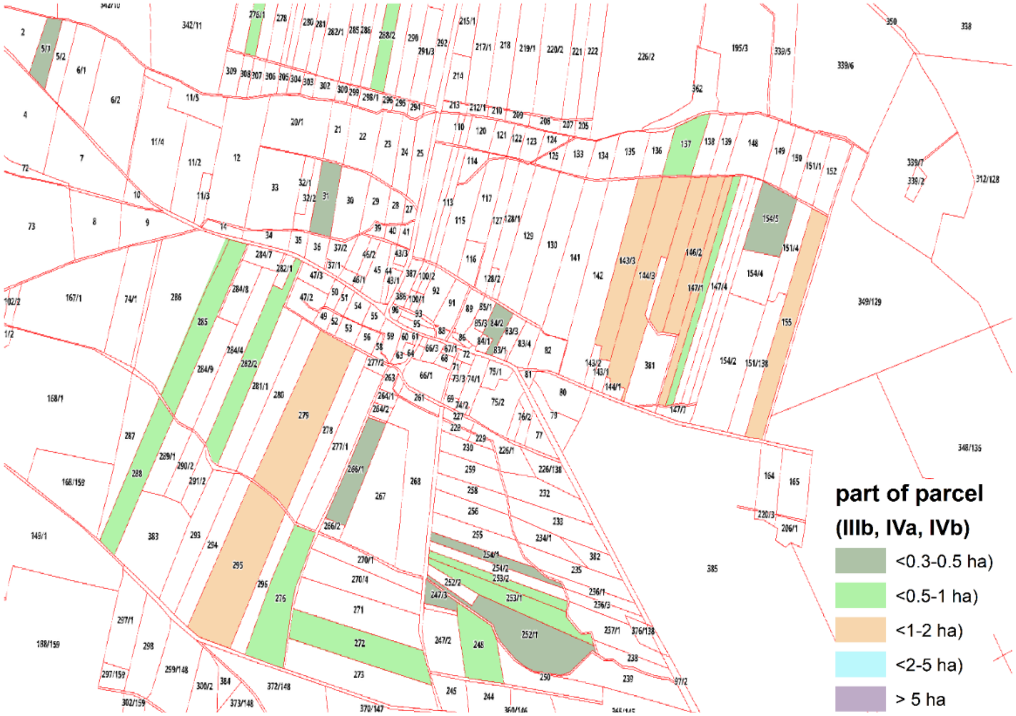
HR EXCELLENCE IN RESEARCH

Small size parcels prevail in unutilized land

Factors used for yield estimation	
Triticale	•Weather •Soil type •Parcel size
Willow	•Weather •Soil type •Parcel size •Management experience



Small size parcels prevail in unutilized land – example



Profitability of conventional versus energy SRC taking account of uncertainty

(SERF method: Faber et al. 2013)

Uncertainty factors		
triticale	Price	√
	Yield	√
willow	Cutting survival	√
	Time to maturity	?
	Variability mature yields	√
	price	Contract

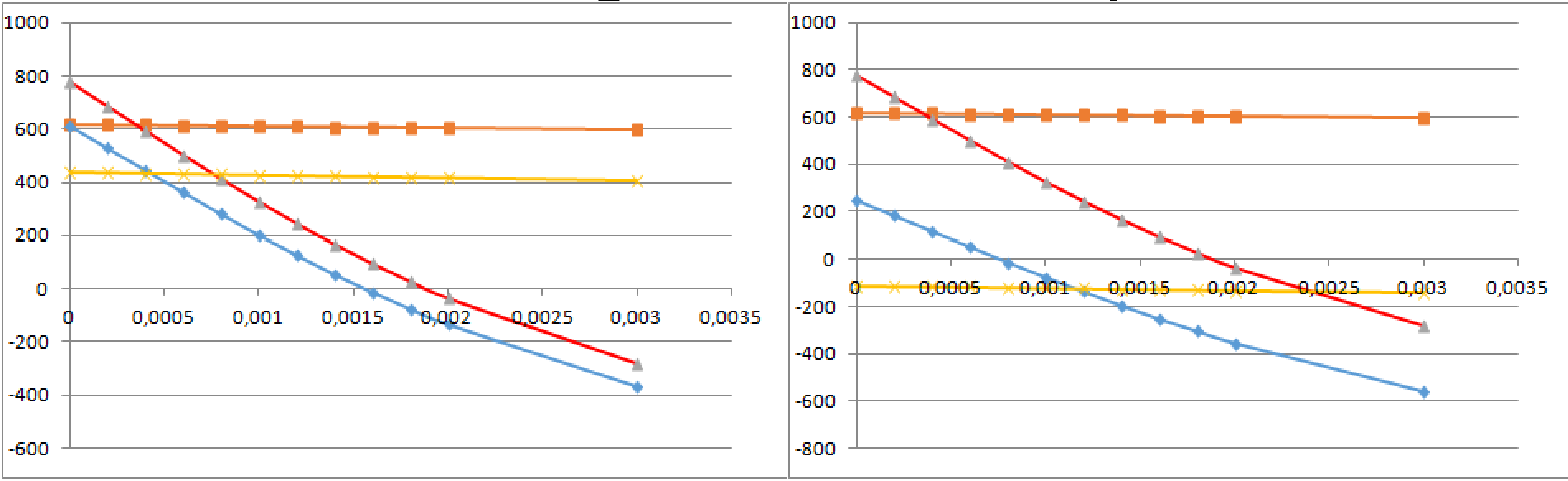
$$ExpYield = \sum_{i}^{n} freq_i \times PAYOFF_i$$

$$CE = -ln\left(\sum_{i}^{n} freq_i \times e^{-RAC \times PAYOFF_i}\right)/RAC$$

triticale per ha income			
frequency	price	yield	PLN payoff
1,36%	350	3,392	-1509,968
1,36%	350	4,24	-1232,46
1,36%	350	5,088	-954,952
5,30%	450	3,392	-1192,816
5,30%	450	4,24	-836,02
5,30%	450	5,088	-479,224
0,61%	550	3,392	-875,664
0,61%	550	4,24	-439,58
0,61%	550	5,088	-3,496
2,58%	650	3,392	-558,512
2,58%	650	4,24	-43,14
2,58%	650	5,088	472,232
8,33%	750	3,392	-241,36
8,33%	750	4,24	353,3
8,33%	750	5,088	947,96
15,00%	850	3,392	75,792
15,00%	850	4,24	749,74
15,00%	850	5,088	1423,688
0,15%	950	3,392	392,944
0,15%	950	4,24	1146,18
0,15%	950	5,088	1899,416
		expected value	236,17
		certainty equivalent	172

CE: the income a farmer would require to be indifferent to the potential result from the risky alternative

Profitability of conventional versus energy SRC taking account of uncertainty



<u>Horizontal axis</u>: Risk aversion coefficient (RAC close to 0 risk neutral, RAC > 0,001 risk averse)
<u>Vertical axis</u>: Certain equivalent income per hectare in PLN
Willow chips price in Poland fixed at 330 PLN per t

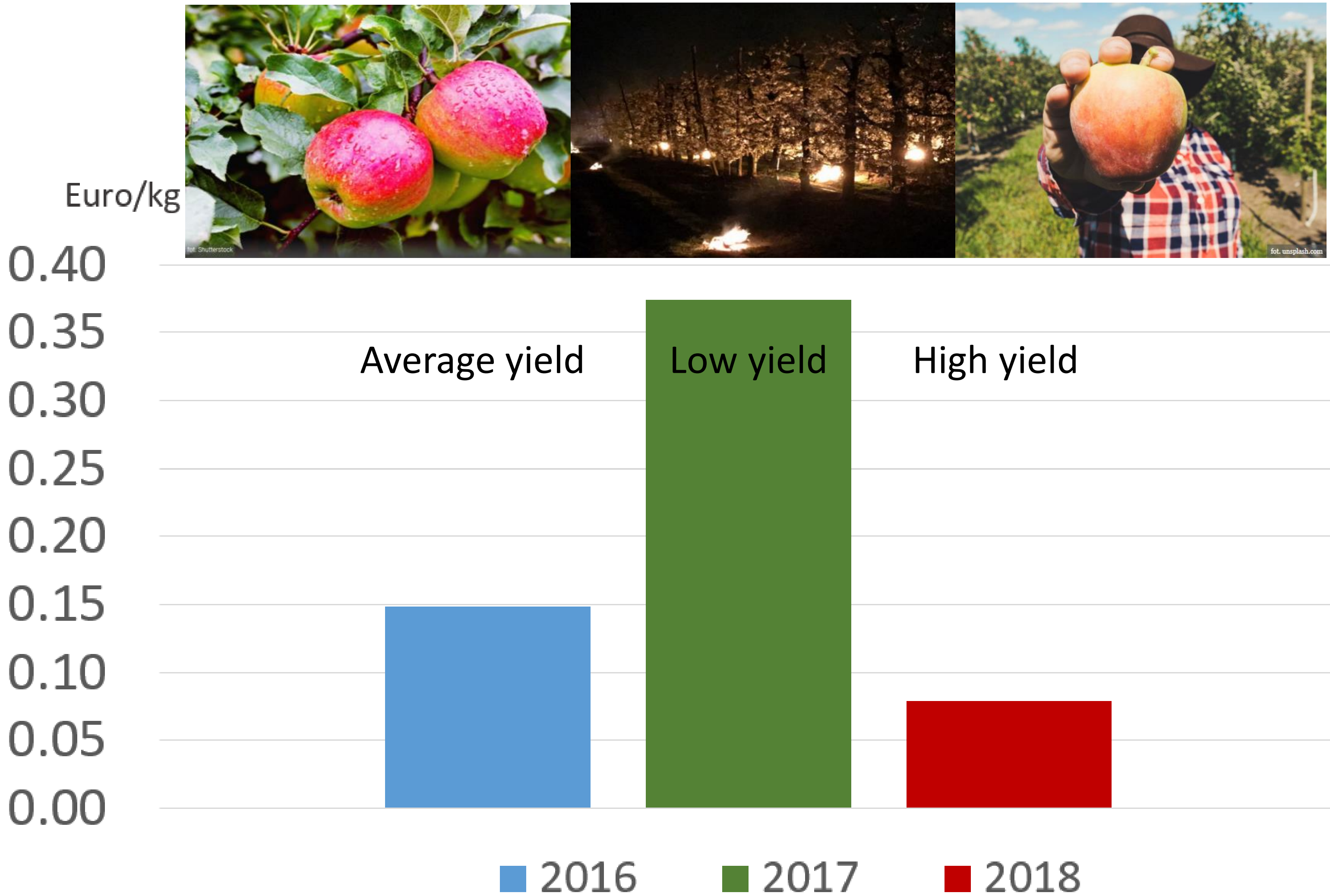
soil class IIIa and parcels >5ha — CE income willow > CE income triticale

soil class IIIa and parcels > 1-2ha — CE income willow > CE income triticale

soil class IIIa and parcels > 0.5-1ha — CE income willow negative **(graph to the right)**
CE income triticale positive (only for risk neutral farmers)

IUNG Institute of Soil Science and Plant Cultivation State Research Institute
BioEcon
Department of Bioeconomy and Systems Analysis
HR EXCELLENCE IN RESEARCH

Climate change is real but not always highlighted – purchase price for apple in Poland



Renewable and Sustainable Energy Reviews 100 (2019) 127–142

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

ELSEVIER

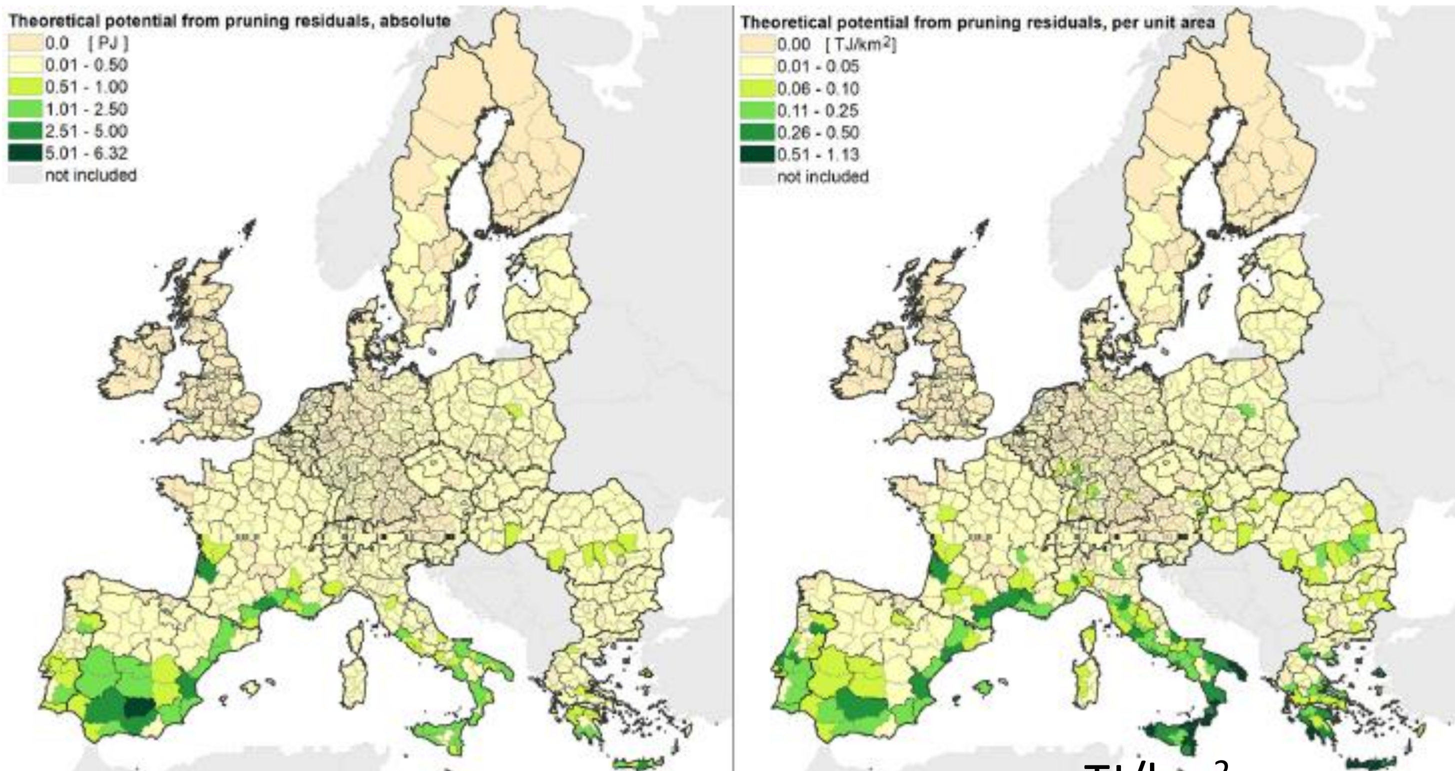
A spatial approach to bioeconomy: Quantifying the residual biomass potential in the EU-27

Lorie Hamelin[a,b,*], Magdalena Borzęcka[a], Małgorzata Kozak[a], Rafał Pudełko[a]

[a] Institute of Soil Science and Plant Cultivation, Department of Bioeconomy and System Analysis, Czartoryskich 8 Str., 24-100 Pulawy, Poland
[b] Department of Engineering of Biological Systems and Processes (LISBP), National Institute of Applied Sciences (INSA), INRA UMR792 and CNRS UMR5504, Federal University of Toulouse, 135 Avenue de Rangueil, F-31077 Toulouse, France

Check for updates

Residual potential for agri-industrial residue



PJ

TJ/km^2

Renewable and Sustainable Energy Reviews 100 (2019) 127–142

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

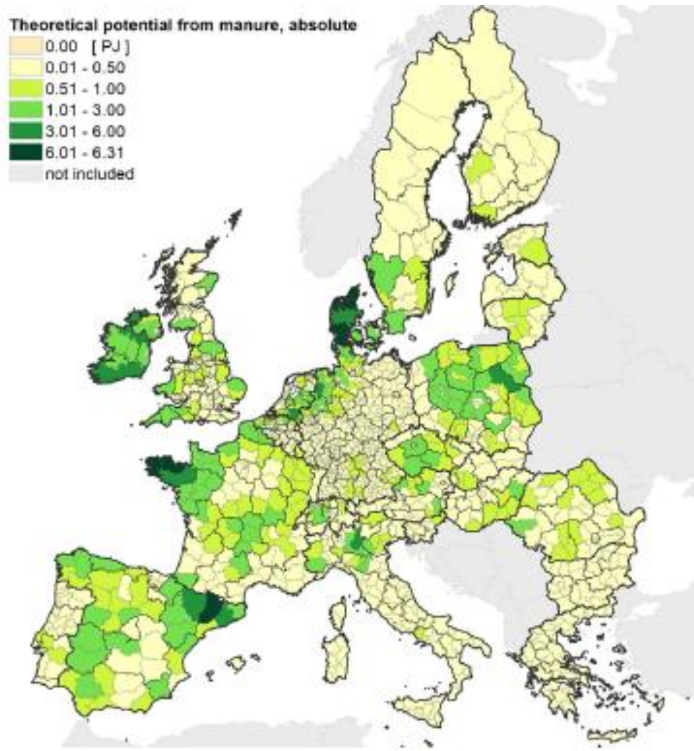
journal homepage: www.elsevier.com/locate/rser

A spatial approach to bioeconomy: Quantifying the residual biomass potential in the EU-27

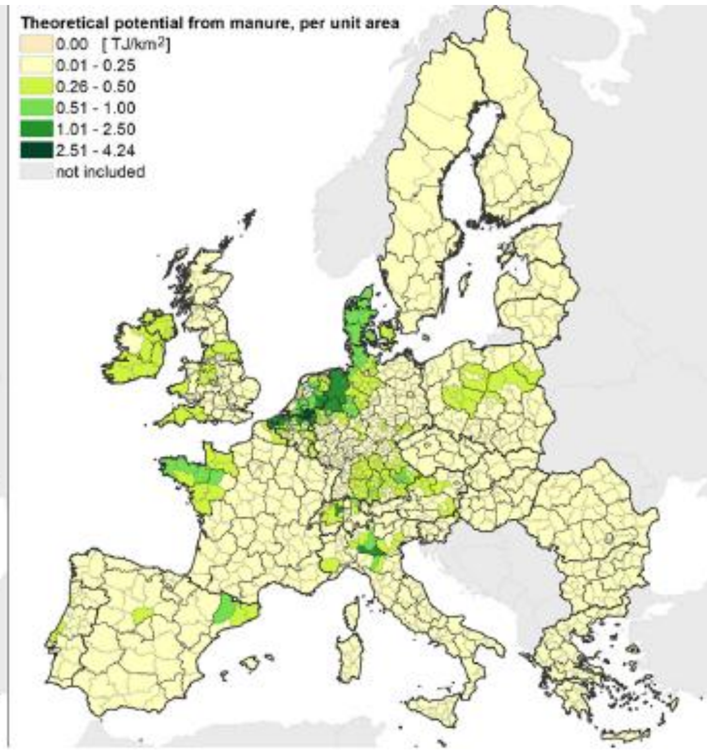
Lorie Hamelin[a,b,*], Magdalena Borzęcka[a], Małgorzata Kozak[a], Rafał Pudełko[a]

[a] Institute of Soil Science and Plant Cultivation, Department of Bioeconomy and System Analysis, Czartoryskich 8 Str., 24-100 Pulawy, Poland
[b] Department of Engineering of Biological Systems and Processes (LISBP), National Institute of Applied Sciences (INSA), INRA UMR792 and CNRS UMR5504, Federal University of Toulouse, 135 Avenue de Rangueil, F-31077 Toulouse, France

Residual potential for manure



PJ



TJ/km^2

Conclusions

1. The yield gap is strongly related to GDP and it is higher in eastern than western European countries
2. Special focus in adaptation of agricultural systems should be given to land use of unutilised agricultural land, low quality soil use, existing agricultural practices and farm structure
3. Risk analysis should be taken into account as a tool in evaluation of cropping systems in climate change adaptation
4. Spatial approach should be considered in case of sustainable use of resources in agri sector