SETAC EUROPE 23RD ANNUAL MEETING

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LIFE CYCLE ASSESSMENT OF BIO-BASED ETHANOL PRODUCED FROM DIFFERENT AGRICULTURAL FEEDSTOCK

Ivan Muñoz[1], Karin Flury[2], Niels Jungbluth[2], Giles Rigarlsford[1], Llorenç Milà i Canals[1], Henry King[1]

[1]Safety and Environmental Assurance Centre, Unilever
[2] ESU-services GmbH

BACKGROUND
Bio-based products

- Increasing interest in bio-based raw materials, not only biofuels

- **Renewable ≠ sustainable** thus life cycle approach needed to assess potential benefits and tradeoffs

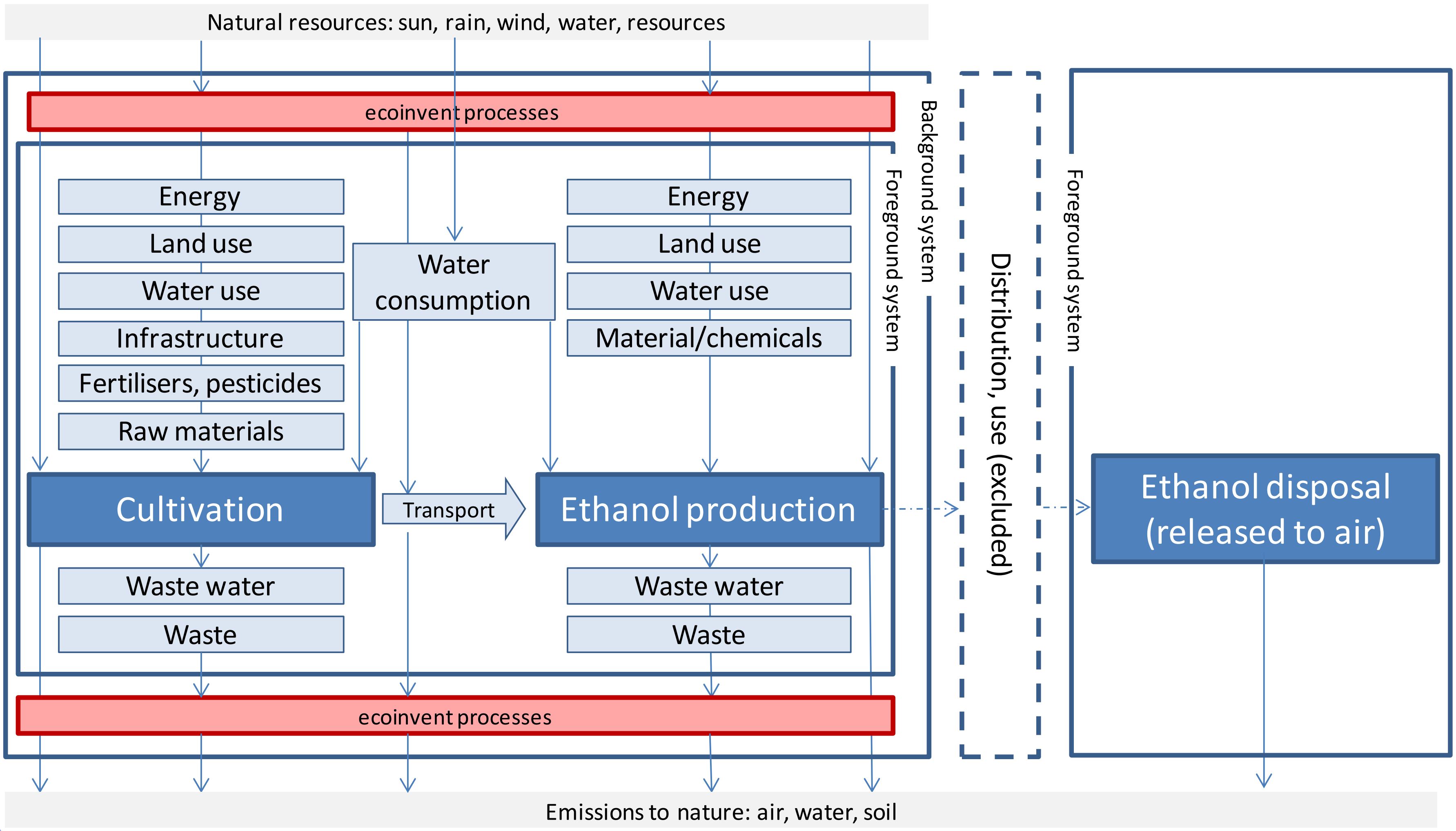
- Ethanol is a good example of bio-based product (Mature biotechnology, high volumes, variety of feedstock and uses…)

GOAL & SCOPE
Goal and biomass sources

- Goal:
  - Identify hotspots in the life cycle for different routes
  - Explore differences between alternative feedstock
  - Compare bio-based vs. petrochemical ethanol
- Countries and biomass resources chosen based on global production and data availability

Country	Feedstock
USA	Maize grain
USA	Maize stover
Brazil (North-East)	Sugarcane
Brazil (Centre-South)	Sugarcane
France	Sugar beet
France	Wheat

GOAL & SCOPE
System boundaries



GOAL AND SCOPE
Modelling choices, data sources

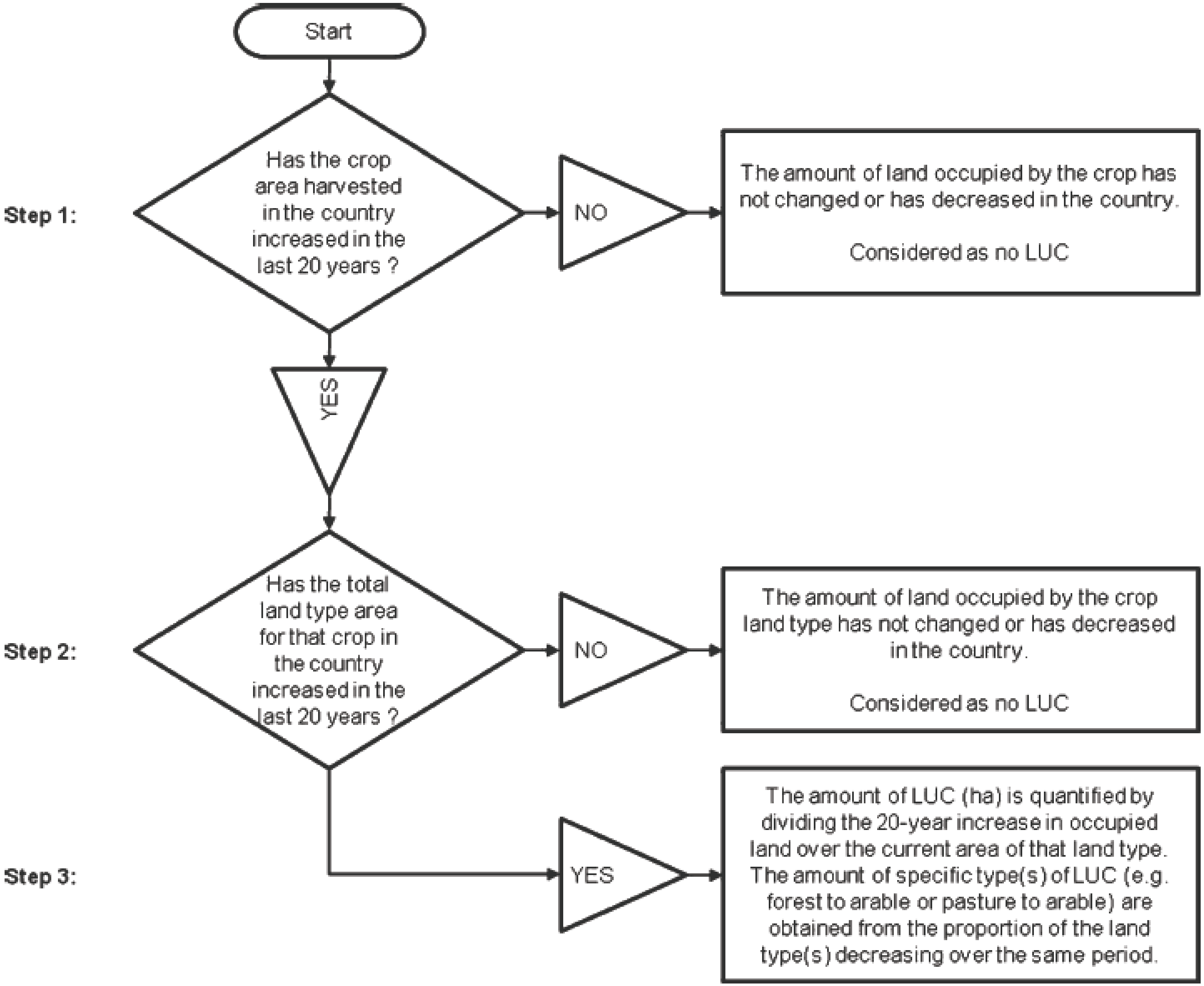
- Attributional LCA
- Economic allocation
  - Maize grain / stover
  - Ethanol mill
- Foreground system modelled with numerous literature sources
- Background system modelled with Ecoinvent 2.2

GOAL AND SCOPE
Impact assessment methods (midpoint)

- Climate change (GWP-100)
- Water footprint (Water Stress Index, Pfister's approach)
- Biodiversity and Ecosystem services (UNEP/SETAC Life Cycle Initiative)
  - Biodiversity damage potential (BDP)
  - Climate regulation potential (CRP)
  - Biotic production potential (BPP)
  - Freshwater regulation potential (FWRP)
  - Erosion regulation potential (ERP)
  - Water purification potential through physicochemical filtration (WPP-PCF)
  - Water purification potential through mechanical filtration (WPP-MF)

GOAL AND SCOPE

Land transformation (m^2*yr/ kg crop)



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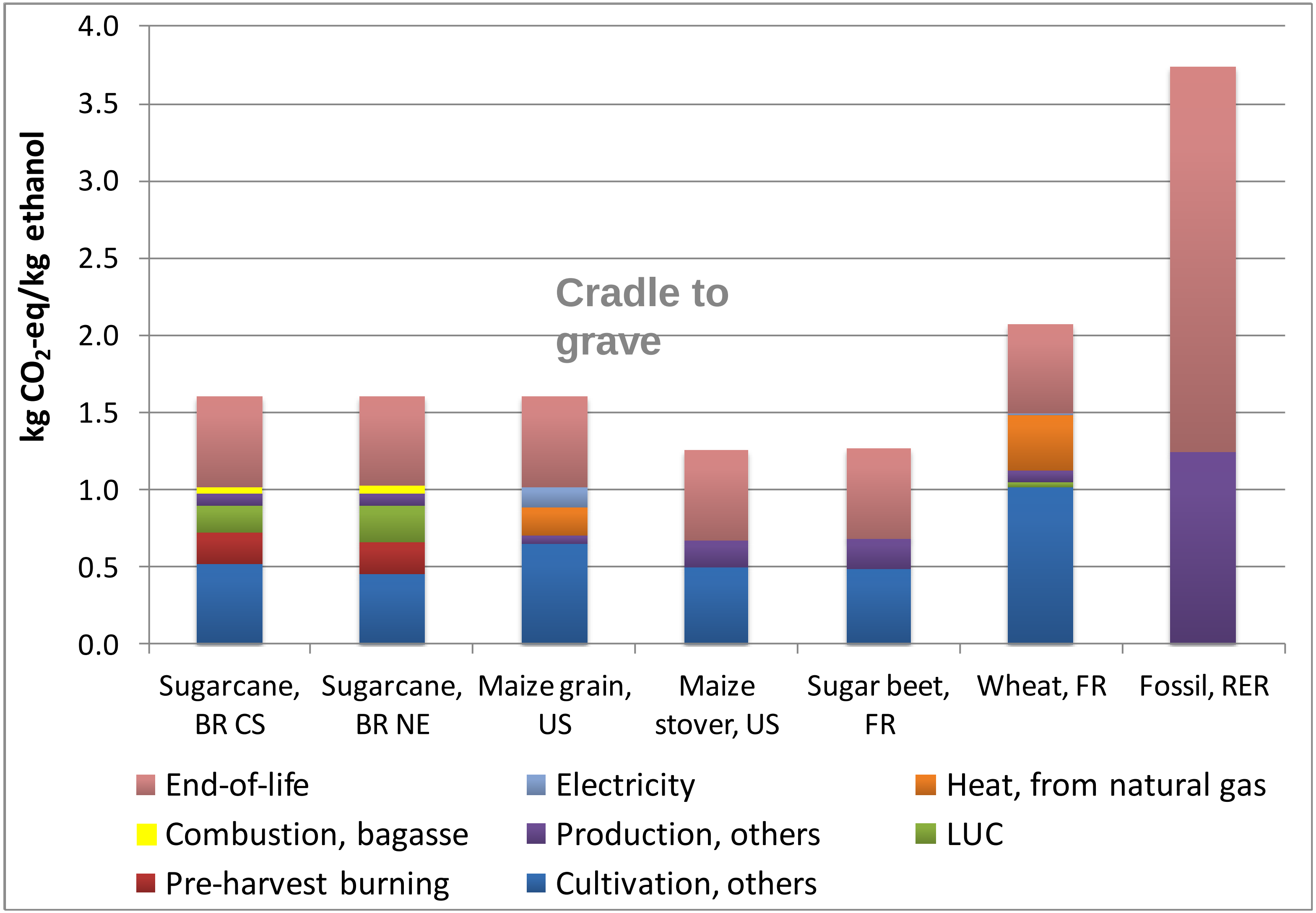
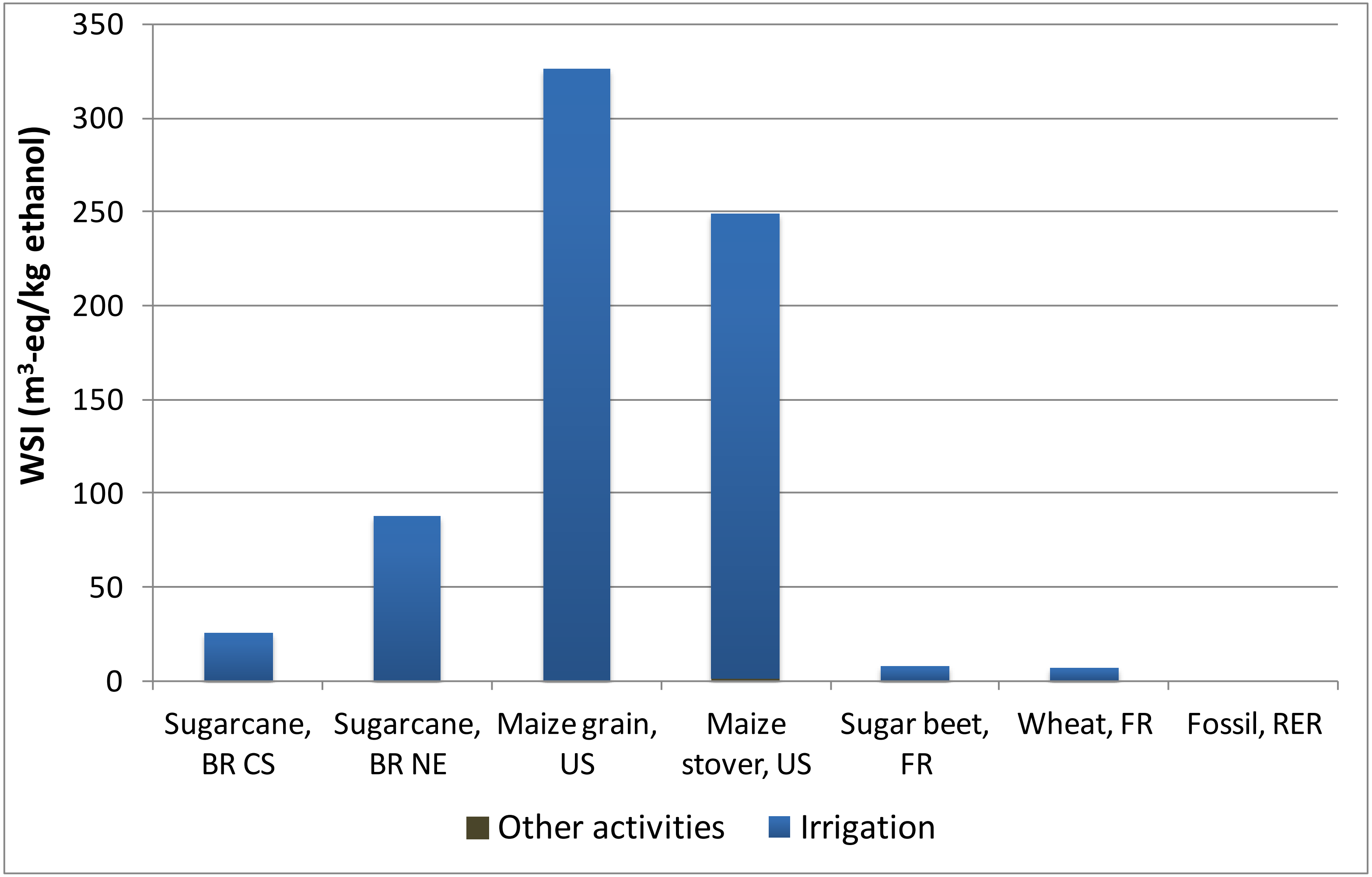
FAOSTAT

RESULTS
GHG emissions

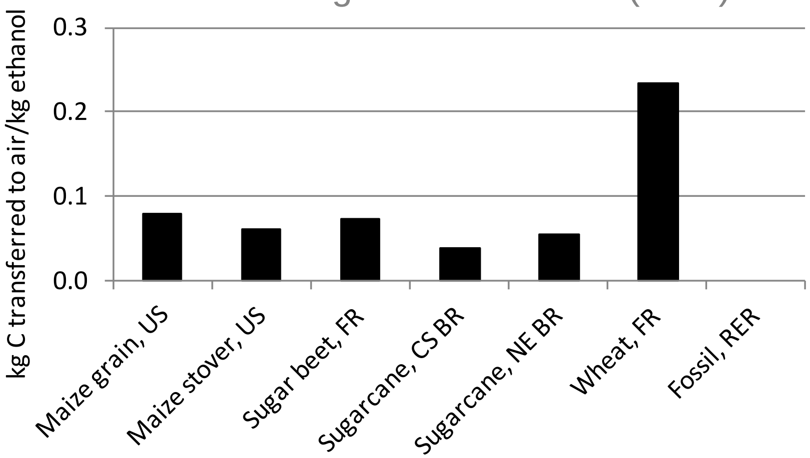


RESULTS
Water scarcity (WSI)

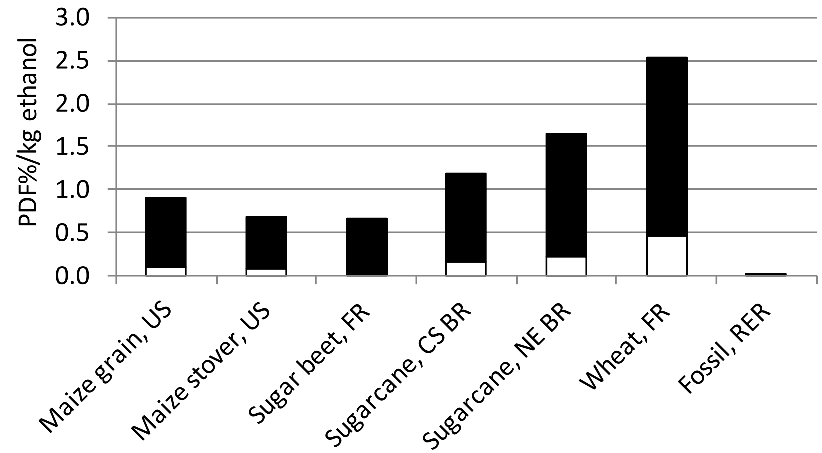


RESULTS
Biodiversity and ecosystem services

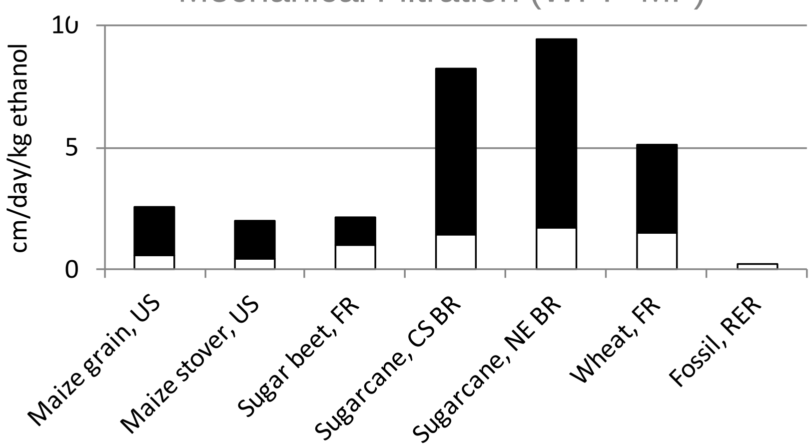
Carbon Regulation Potential (CRP)



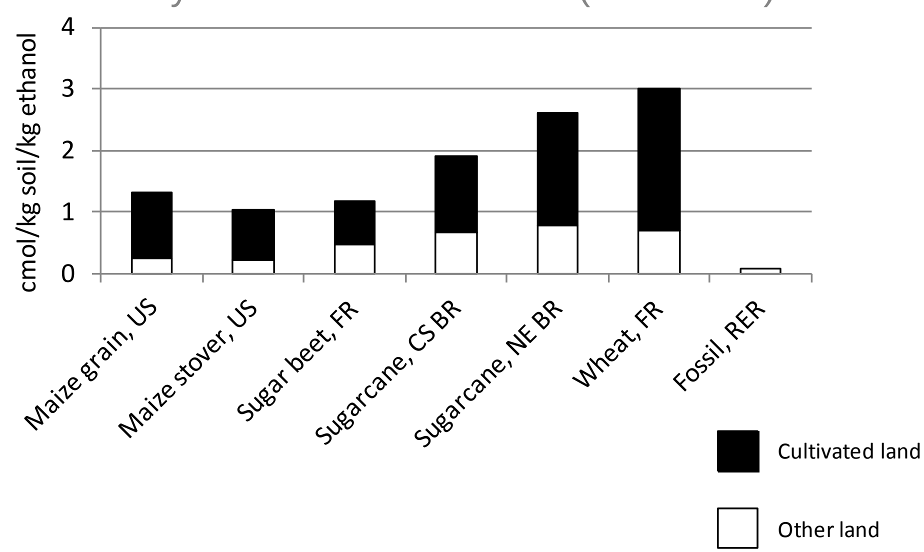
Biodiversity Damage Potential (BDP)



Water Purification Potential through Mechanical Filtration (WPP-MF)



Water Purification Potential through Physico-chemical Filtration (WPP-PCF)

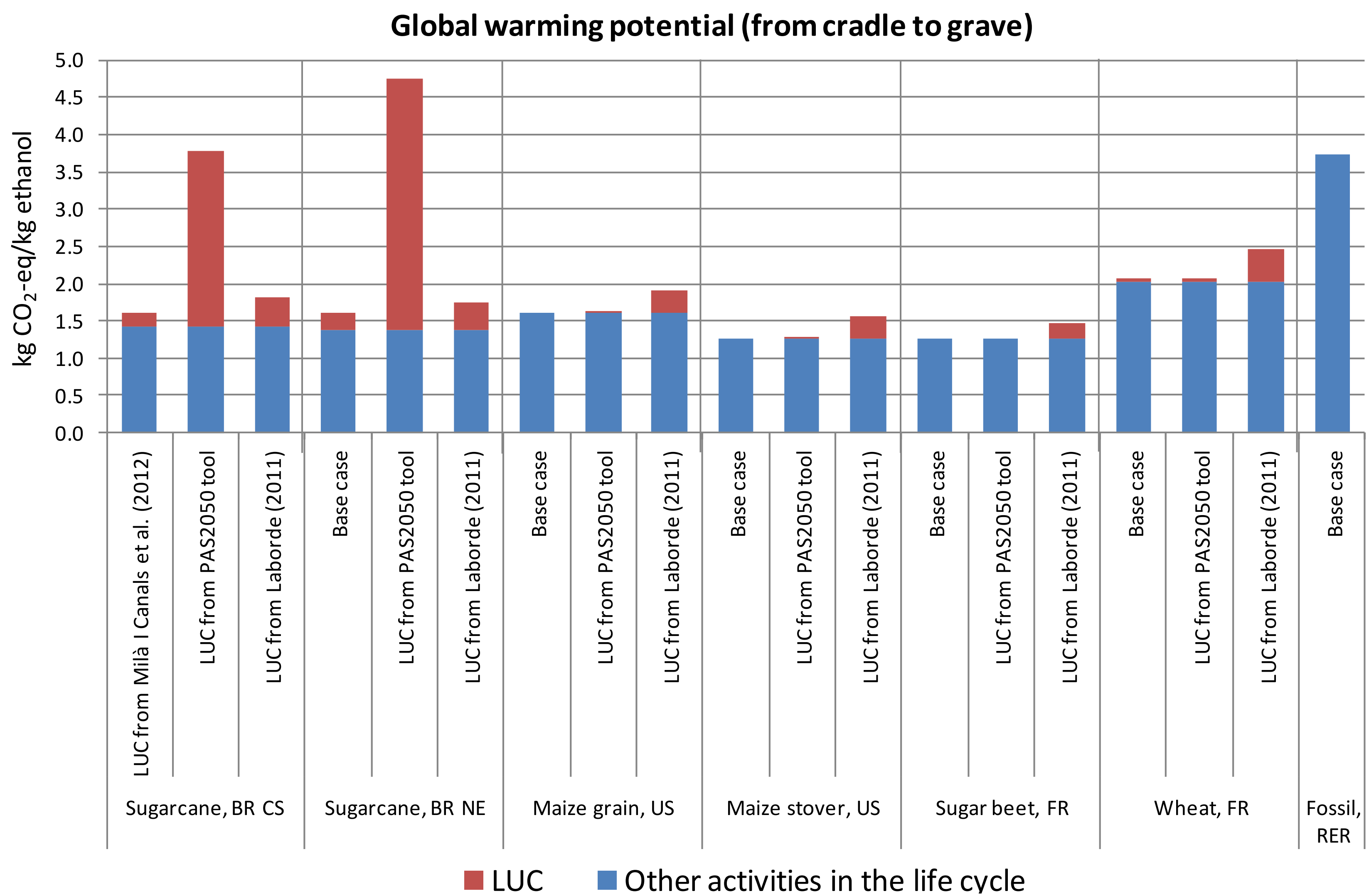


RESULTS
Sensitivity analysis: GHG and LUC

- Base case: Mila I Canals et al. (2013)
- PAS 2050 (2012) for horticultural products: similar in concept as base case
- Laborde (2011): General economic equilibrium modelling. Study on biofuel scenarios in EU 2020

- Milà i Canals et al.(2013) Land use impact assessment of margarine. Int J Life Cycle Assess, in press.
- BSI (2012) PAS 2050-1:2012 Assessment of life cycle greenhouse gas emissions from horticultural products, London, UK.
- Laborde D (2011) Assessing the Land Use Change Consequences of European Biofuel Policies. IFPRI for the European Commission.

RESULTS
Sensitivity analysis: GHG and LUC



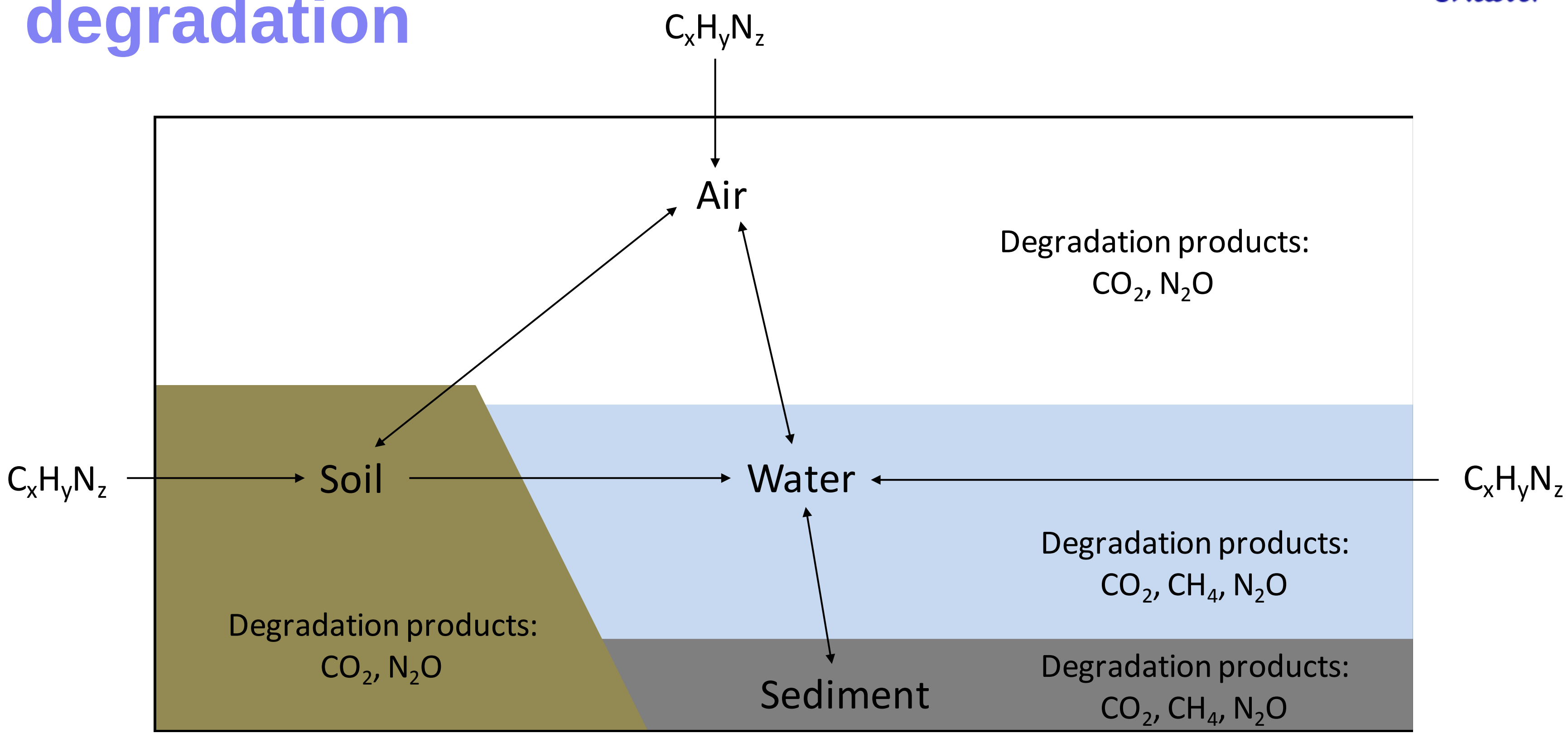
CONCLUSIONS

- High variability in impact of bio-based ethanol according to feedstock and region
- High yield per Ha seems to be a good indicator of lower impacts e.g. sugar beet
- Potential gains in GHG emissions when compared to fossil ethanol, but…
- Clear tradeoffs with impacts related to water, biodiversity and ecosystem services
- Need to harmonize approach to quantify LUC

REFERENCES

- Muñoz I, Flury K, Jungbluth N, Rigarlsford G, Milà i Canals L, King H. **Life Cycle Assessment of bio-based ethanol produced from different agricultural feedstocks**. *International Journal of Life Cycle Assessment*, submitted.
- Flury K, Jungbluth N, Frischknecht R, Muñoz I. **Recommendation for Life Cycle Inventory Analysis for Water Use and Consumption**. Working Paper, ESU Services. (http://www.esu-services.ch/fileadmin/download/flury-2012-water-LCI-recommendations.pdf)

APPENDIX
GHG emissions from ethanol degradation

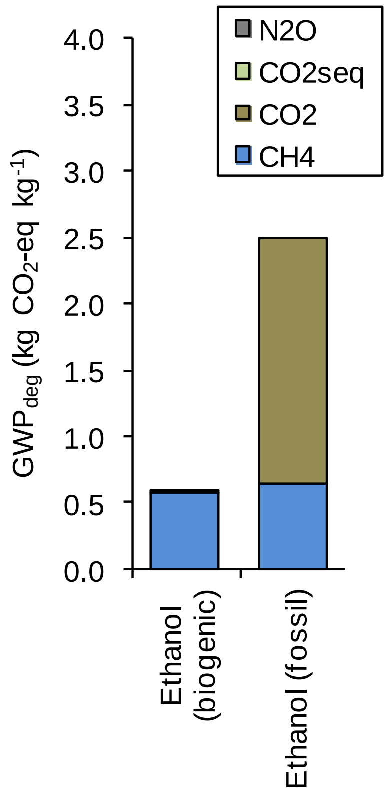


Muñoz I, Rigarlsford G, Milà i Canals L, King H. **Accounting for greenhouse-gas emissions from the degradation of chemicals in the environment**. Int J Life Cycle Assess, 18 (1): 252-262.

APPENDIX
GHG emissions from ethanol degradation

Fate modelling, USES-LCA 2.0 results

Degradation in:	Ethanol, to air
Air	43.87%
Water	55.75%
Sediment	0.00%
Soil	0.35%
Vegetation	0.00%
Leaching	0.00%
Burial	0.00%
Removal:	
Stratosphere	0.01%
Crop biomass	0.01%



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APPENDIX
Uncertainty analysis with Monte Carlo