



DISCUSSION FORUM ON
LIFE CYCLE ASSESSMENT

67th LCA Discussion Forum

Recent developments in indirect Land-Use Change (iLUC) modelling land use changes

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Background

*IPCC (2014), Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.
https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf

- 11% of global GHG emissions from LUC*
- Why do we have land use changes?
 - Because of increased demand for land
 - A change in demand for land \Rightarrow land-use changes
- Challenge
 - Ascribing the land use changes to its drivers
 - What is the role of energy/food/fibers?



Pangkalanbuun, Kalimantan, 3rd April 2014



Bukit Lawang, Sumatra, 10th November 2013

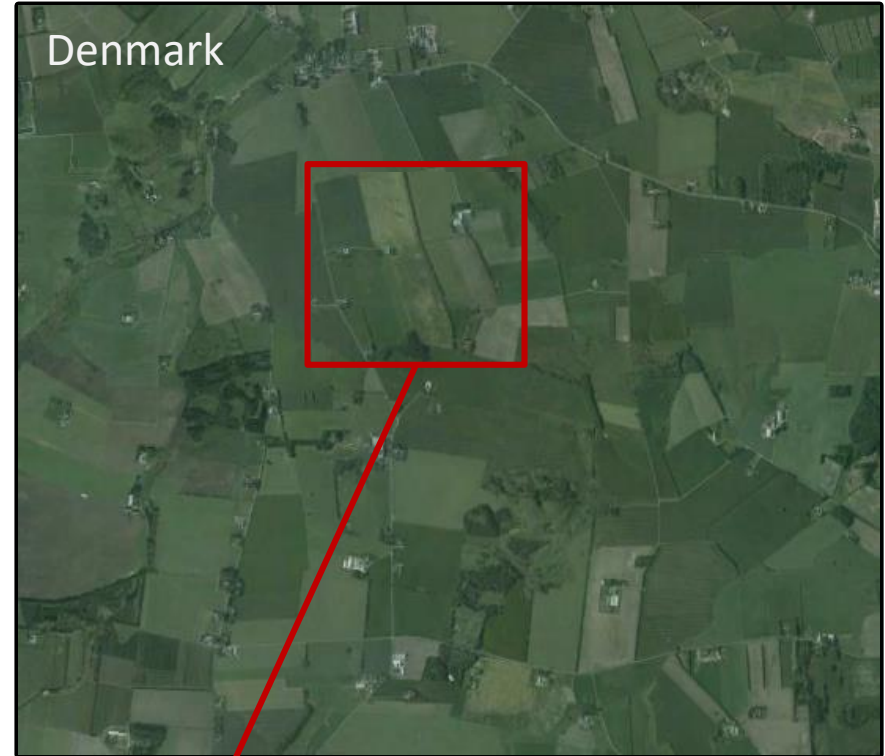


Perak, Malaysia, 21st April 2014

Direct and indirect Land-Use Changes



Land for displaced crops?

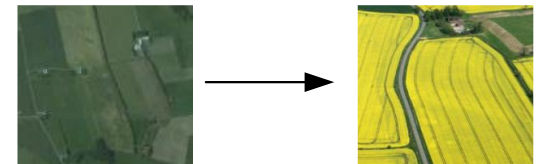


Somewhere else – at the frontier

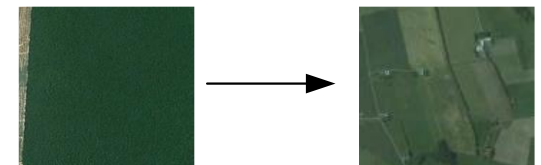
e.g. Brazil



Direct land use changes (**dLUC**)



Indirect land use changes (**iLUC**)

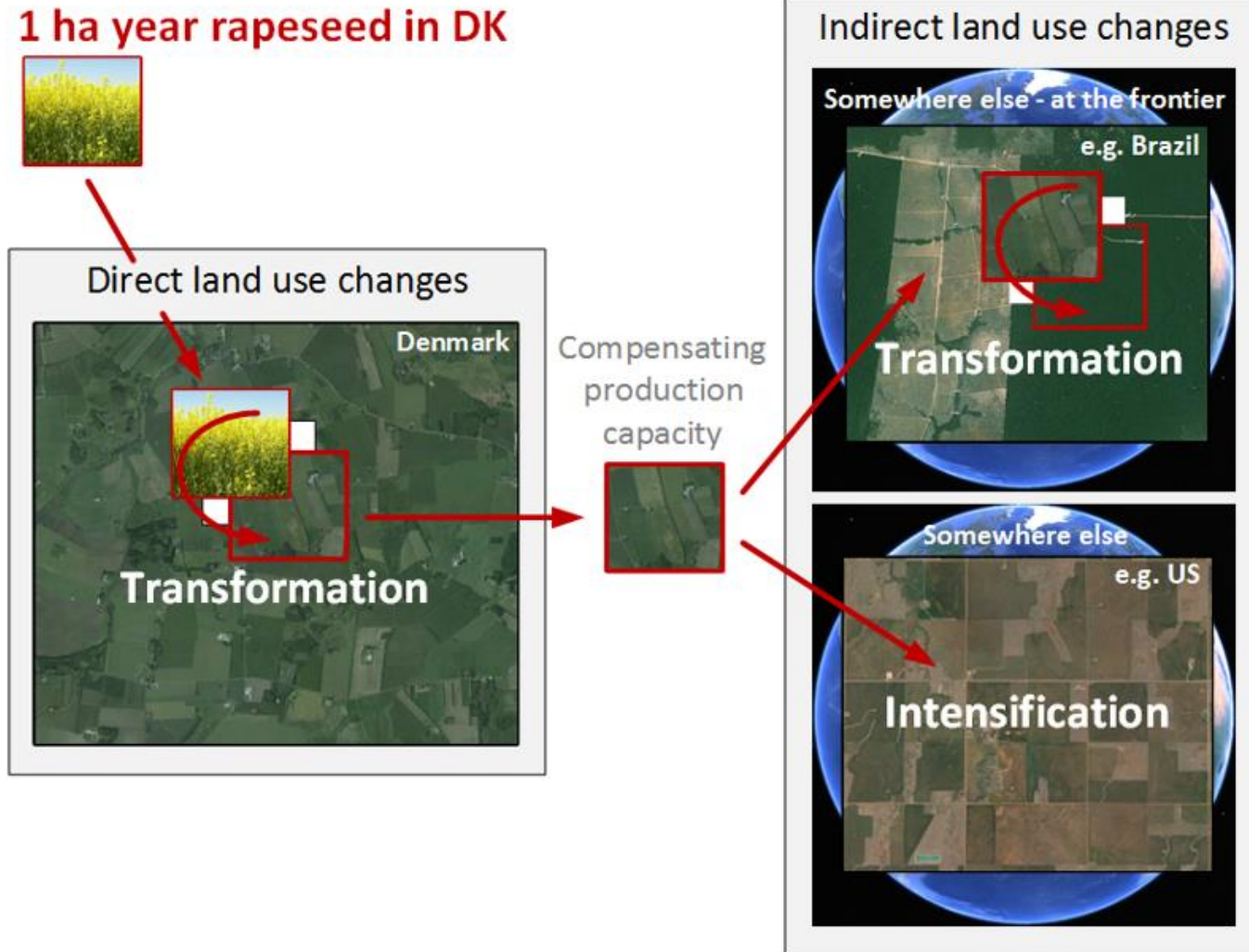


The model in five bullets

1. Land use changes are **caused** by the **demand** for land
2. There is a **market** for land i.e. for land's **capacity for growing biomass**
3. The market for land is **global**:
 - crops can be grown in different **regions**
 - biomasses are **substitutable** and are traded on the global market
4. Different markets for land can be distinguished: **arable, forest, range**
5. **Change** in demand for land **cause** (and/or):
 - Transformation of land
 - Intensification of land already in use
 - Crop displacement / reduced consumption

Methods

- iLUC = Transformation & Intensification



Methods

- iLUC = Transformation & Intensification

Land use changes

Output	Flow	Unit
Transformation	a_1	ha*year eq.
Resources inputs from nature		
Transformation from...	b_1	ha
Transformation to...	b_2	ha
Emissions		
e.g. CO ₂	$b_{3...}$	kg

Intensification

Output	Flow	Unit
Intensification	a_2	ha*year eq.
Inputs from technosphere		
Diesel for traction	c_1	MJ
N-Fertiliser, as N	c_2	kg
Emissions		
e.g. N ₂ O, CO ₂	$c_{3...}$	kg

Not included

Social effects

Output	Flow	Unit
Changes in consumption	a_3	ha*year eq.
Inputs		
n.a.	-	
Emissions		
n.a.	-	

Land market activity

Output	Flow	Unit
Land	$\sum (a_1:a_3)$	ha*year eq.
Inputs from technosphere		
Transformation	a_1	ha*year eq.
Intensification	a_2	ha*year eq.
Changes in consumption	a_3	ha*year eq.

Wheat LCA activity (1 ha yr)

Output	Flow	Unit
Wheat	7,296	kg
Inputs from technosphere		
Land	1.08	ha*year eq.
Diesel for traction	3,306	MJ
N-Fertiliser, as N	198	kg
P-Fertiliser, as P ₂ O ₅	46	kg
K-Fertiliser, as K ₂ O	84	kg
Emissions		
CO ₂ fossil (diesel combustion)	245	kg
N ₂ O	4.15	kg
Resources		
CO ₂ biogenic from air	11,370	kg

→ wheat

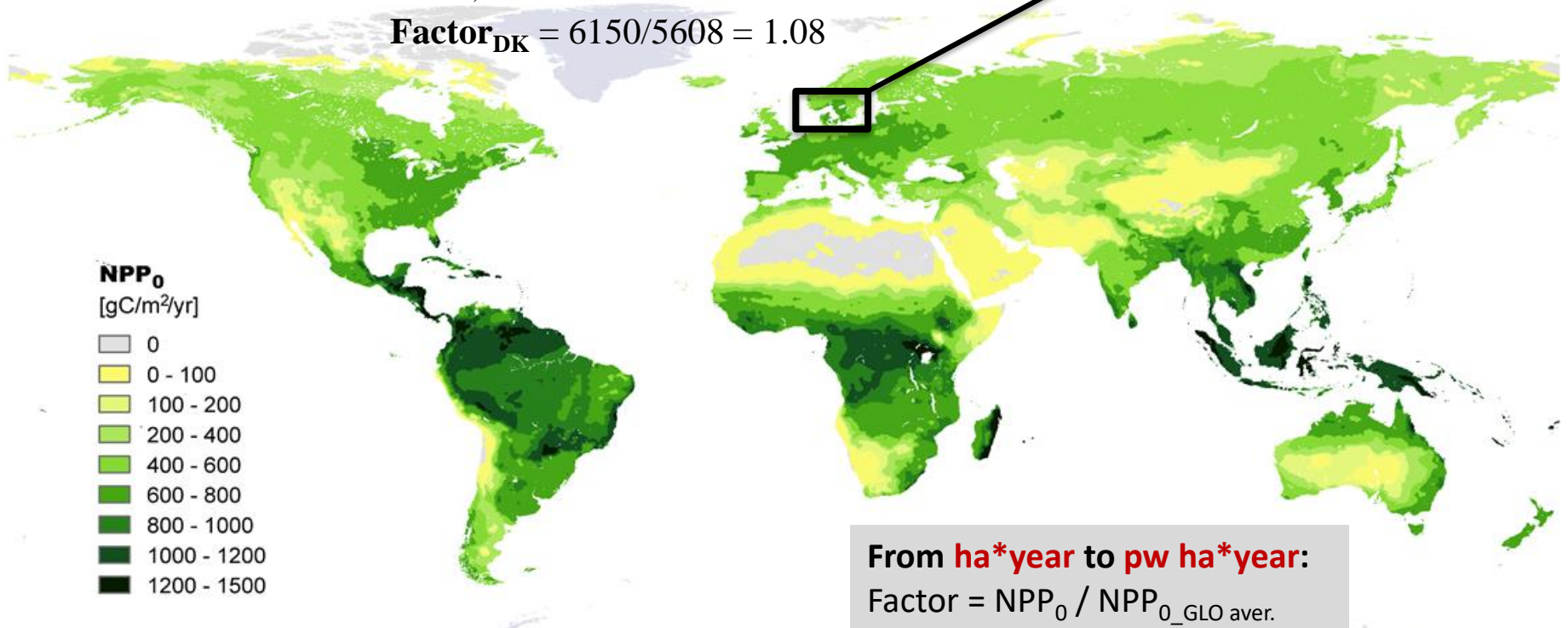
Global map of potential net primary production (NPP₀)

How can 1 ha yr in the Aalborg area be expressed as pw ha*year?

(GLO aver. arable is 5680 kg C ha⁻¹ year⁻¹)

$$\text{NPP}_{0,\text{DK}} = 6150 \text{ kg C ha}^{-1} \text{ year}^{-1}$$

$$\text{Factor}_{\text{DK}} = 6150/5680 = 1.08$$



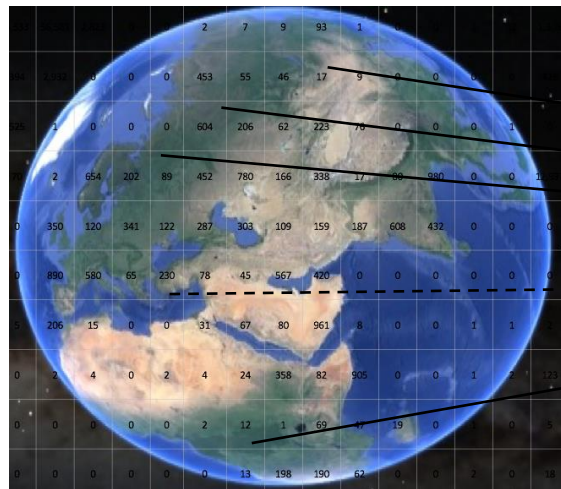
New developments

- Global model

Integration with



Supply of land

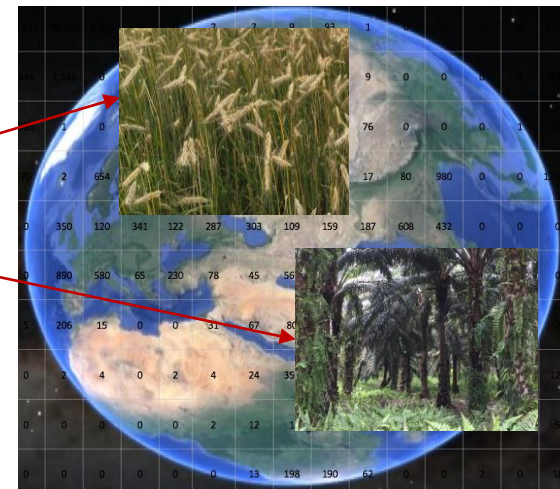


Input data

- Time-series for all crops, all countries of:
 - Area
 - Yield
 - Production
- 3 markets for land: Arable, forest, range



Use of land



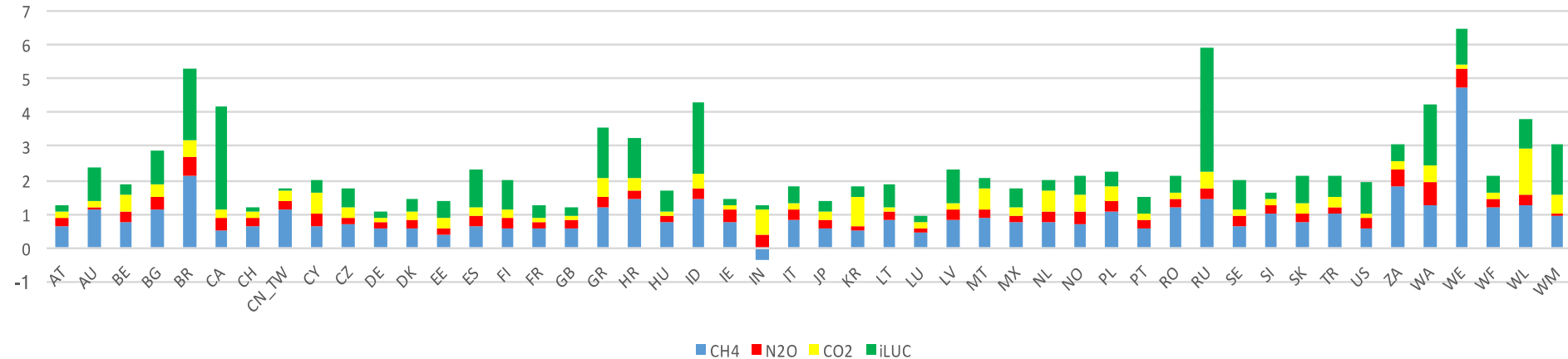
*Output of the model
(next slide...)*

Examples of results (1/2)

Raw milk and the impact of iLUC

- Exiobase v3, hybrid version inclusive iLUC

Raw milk, kg CO2e/kg



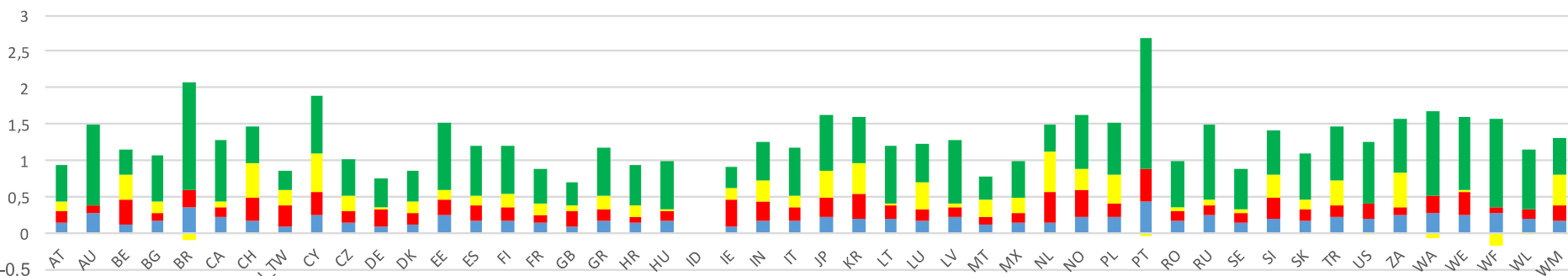
Examples of results (2/2)

Cereal and the impact of iLUC

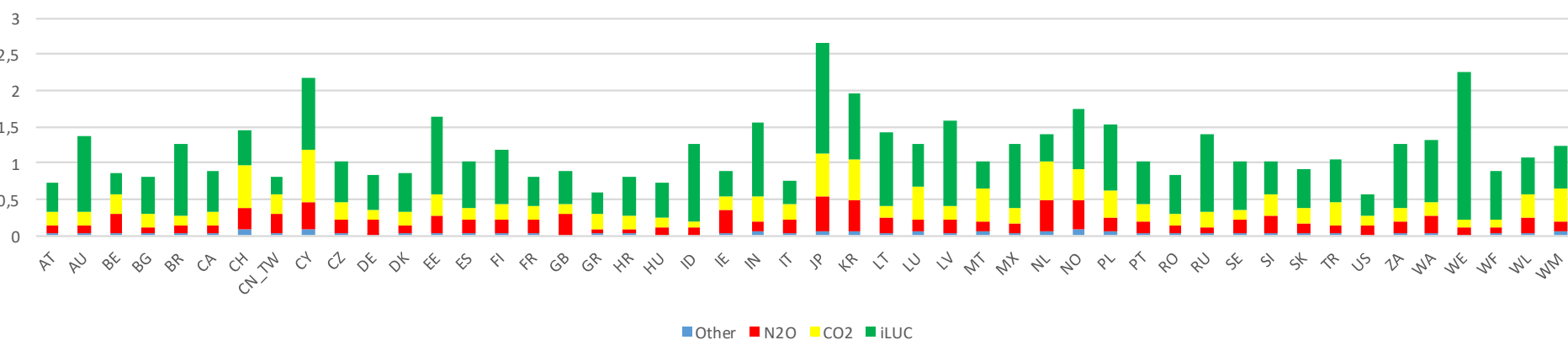
- Exiobase v3, hybrid version inclusive iLUC

Per kg dry matter

Wheat, kg CO2e/kg



Cereals, kg CO2e/kg



Other N2O CO2 iLUC

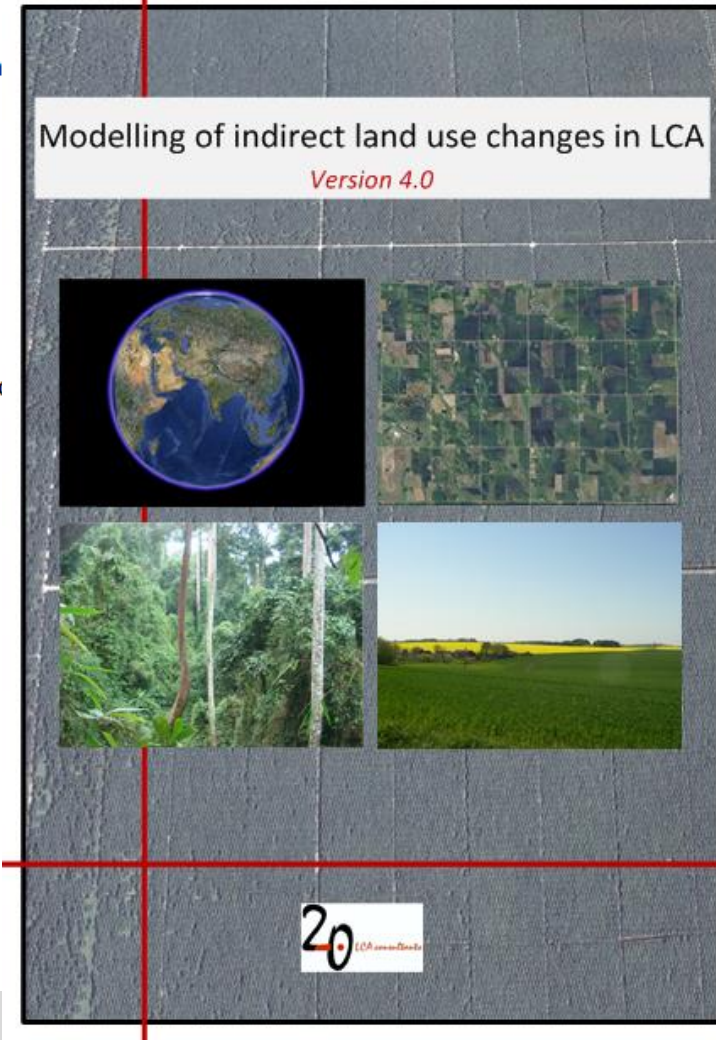
Members of the iLUC crowdfunded project

- Aalborg University, Department of Planning and Development, AAU (plan.aau.dk)
- Aarhus University, Department of Agroecology - Agricultural Systems and Sustainability (scitech)
- Arla Foods (arla.com)
- Asplan Viak (asplanviak.no)
- Concito (concito.dk)
- CSIRO (csiro.au)
- DuPont Nutrition and Health (dupont.com)
- DONG Energy (dong.dk)
- ecoinvent (ecoinvent.org)
- Mahidol University, Department of Civil and Environmental Engineering (<http://www.eg.mahidol>)
- IFP Energies nouvelles (<http://www.ifpen.fr/>)
- Miljögiraff (miljogiraff.se)
- National Agricultural Research Center, Japan (naro.affrc.go.jp)
- Niras (niras.dk)
- NSW Department of Primary Industries (<http://www.dpi.nsw.gov.au/>)
- PRé Consultants (<https://www.pre-sustainability.com/>)
- PT SMART (<https://www.smart-tbk.com>)
- Round Table on Sustainable Palm Oil, RSPO (rspo.org)
- Sustainability Consortium (sustainabilityconsortium.org)
- Swedish University of Agriculture Sciences, SLU (slu.se)
- TetraPak (tetrapak.com)
- Unilever (unilever.com)
- United Plantations Berhad (unitedplantations.com)
- University of Copenhagen, The Faculty of Life Sciences, LIFE (life.ku.dk)

More info at:

<https://lca-net.com/clubs/iluc/>

Schmidt J, Weidema B P, Brandão M (2015). A framework for modelling indirect land use changes in life cycle assessment. Journal of Cleaner Production 99:230-238



Examples of application

- **Vegetable oils** (palm, rapeseed, sunflower, peanut, soybean)
- **Milk** (Germany, Denmark, Sweden and United Kingdom)
- **Chicken**
- **Specialty food ingredients**
- **Canteens** (eco-labelled and conventional)
- **Nature conservation** in Kalimantan
- **Global food consumption**
- **Biofuels** (liquid and solid)
- **Electricity models**
- **Structural timber**
- **Aggregates**
- **Buildings**
- **Apparels**
- Corporate footprints for large, multinational companies, e.g. **Arla Foods**, **Novo Nordisk**, **Nordic Alcohol Monopoly**, and many others
- **Danish consumption footprint**
- **Municipal level production and consumption footprint**
- Global input-output table (the model is integrated in a special version of **Exiobase v3**)
- And many more...



All examples can be accessed here:

<https://lca-net.com/projects/show/indirect-land-use-change-model-iluc/>

Modelling of indirect land use changes in LCA

Version 4.0



*Thank you for
your attention*

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<https://lca-net.com/clubs/iluc/>

Occupation and transformation

- Accelerated deforestation

Effect of occupation (1 ha yr)

