Seminar, Brussels, 3.5.2011

An Analysis of iLUC and Biofuels - Regional quantification of climate-relevant land use change (LUC) and options for combating it

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BZL Kommunikation und Projektsteuerung GmbH

What are indirect effects of biofuels?

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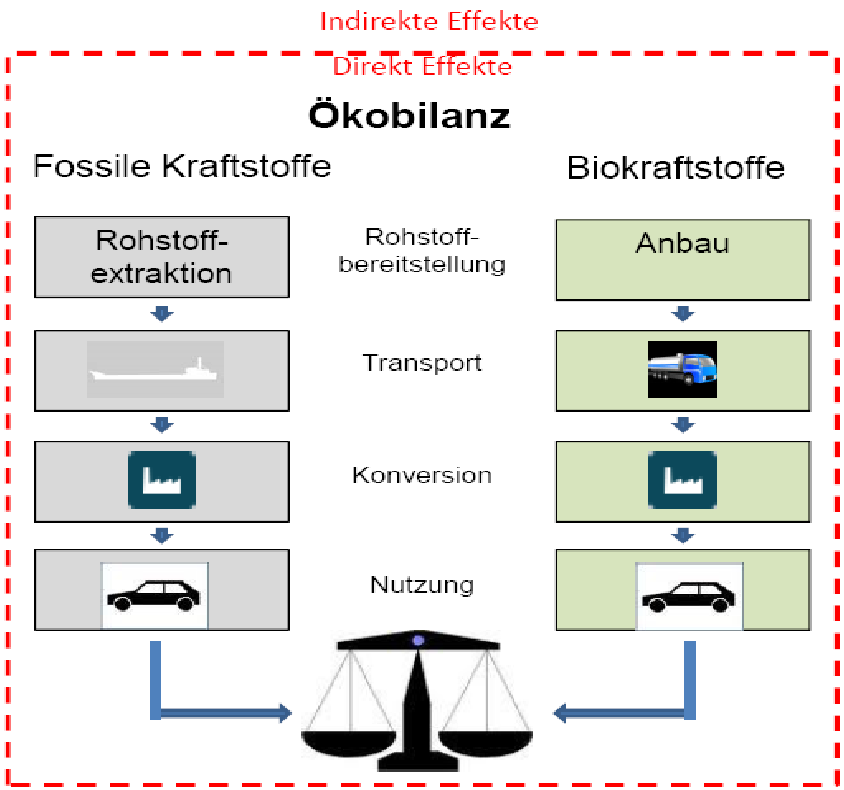
With today's methodology of LCA only the direct environmental impacts of products and processes are recorded and evaluated.
Indirect effects are not yet included.

Führt die höhere Biokraftstoff-produktion zu geringerer Produktion von:
- OPEC-Öl?
- Tiefseeöl?
- EOR (Enhanced Oil Recovery)?
- Teersand-Oil?
- CTL (Coal-to Liquid)?
- GTL (Gas-to-Liquid)?
- Ölschiefer?



Führt die höhere Biokraftproduktion zu indirekten Landnutzungs-änderungen (iLUC): zu einer Ausweitung der landwirtschaftlichen Nutzfläche und dadurch zu Abholzung von Waldflächen? Oder zu einer verbesserten Landnutzung durch die Regeneration von degradierten Flächen? Oder zu einem Rückgang der Viehzucht durch höhere Futtermittelpreise?

Pieprzyk, TUD, 2011

Example for indirect effects

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Indirect effects – e.g. ethanol production in the U.S.

- The ethanol production **increasese** the demand for corn.
- The increased demand for corn can lead to **several effects**:
  - Farmers in the United States **increase the productivity** OR
  - Farmers in the United States to **change the crop rotation** OR
  - Farmers in the United States are **expanding the area planted** OR
  - Farmers in the U.S. grow **more corn than soybeans**.
  - The U.S. soybean **exports go down** and the world soybean **prices become higher**.
  - Thus, the area sown to soybeans in **Brazil will be expanded** in the Amazon region; **ergo iLUC!**

Pieprzyk, TUD, 2011

Forest loss by iLUC

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Countries with the highest forest loss worldwide

Land	LUC, 1995 – 2007 in Mio. ha/a	LUC, Waldverluste 1995 – 2001 % / a	LUC, Waldverluste 2001 – 2007 % / a
Brasilien	- 2,9	-0,55%	-0,65%
Indonesien	- 1,9	-1,84%	-2,07%
Sudan	- 0,6	-0,82%	-0,86%
Burma	- 0,5	-1,31%	-1,43%
Sambia	- 0,4	-0,98%	-1,04%
Tansania	- 0,4	-1,08%	-1,04%
Nigeria	- 0,4	-2,94%	-3,56%
Kongo	- 0,4	-0,36%	-0,24%
Zimbabwe	- 0,3	-1,59%	-1,75%
Mexiko	- 0,3	-0,50%	-0,40%
Venezuela	- 0,3	-0,58%	-0,60%
Bolivien	- 0,3	-0,45%	-0,46%
Australien	- 0,2	-0,18%	-0,12%

Lywood W.J. (Ensus Ltd, Yarm/UK): Natural vegetation changes resulting from changes in land requirements for increased biofuel production. ILUC-Paper 3, Draft for Discussion, June 2009

Data basis for calculation

Carbon stock (in vegetation and soil) for different land uses, in Mg C / ha

Land use	"CS" carbon stock	Land use	"CS" carbon stock
"Rain forest", **default**	300 Mg C/ha	Grassland, **default**	100 Mg C/ha
"Rain forest", Asia, soil = 0	205 Mg C/ha	"Bush", Africa	90 Mg C/ha
"Rain forest", Asia, peatland	970 Mg C/ha	"Woody cerrado", South America	75 Mg C/ha
"Rain forest", Amazon	265 Mg C/ha	"Grassy cerrado", South America	65 Mg C/ha
"Forest", **default**	150 Mg C/ha	"Savanna" wet	130 Mg C/ha
"Forest" North America	140 Mg C/ha	"Grassland" tropical	75 Mg C/ha
"Forest" Europe	130 Mg C/ha	"Grassland" temperate	70 Mg C/ha
Plantation	110 – 130 Mg C/ha	"Pasture" temperate, minimal	40 Mg C/ha
Wetland	100 Mg C/ha	"Cropland" annual harvest, default	55 Mg C/ha
		"Cropland" annual harvest, soil = 40	45 Mg C/ha
		"Cropland" annual harvest, minimal	30 Mg C/ha

Lahl 2010

State of Research

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Econometric models to calculate agricultural iLUC effects

- The **methodology** for the evaluation of indirect effects is still in an early research stage.
- In recent years, **econometric models** of agriculture have been refined to calculate iLUC effects. These include computational models such as GTAP, Purdue University, IMPACT IFPRI (International Food Policy Research Institute) and CAPRI, University of Bonn, trying to capture and quantify the iLUC effect at the global level.
- The econometric models calculate the impact of increased demand on the price and the agricultural land use
- The first study about iLUC by Searchinger et al. was published in 2008, calculating the global indirect land use effects of the increasing U.S. ethanol production.

Pieprzyk, TUD, 2011

iLUC factors

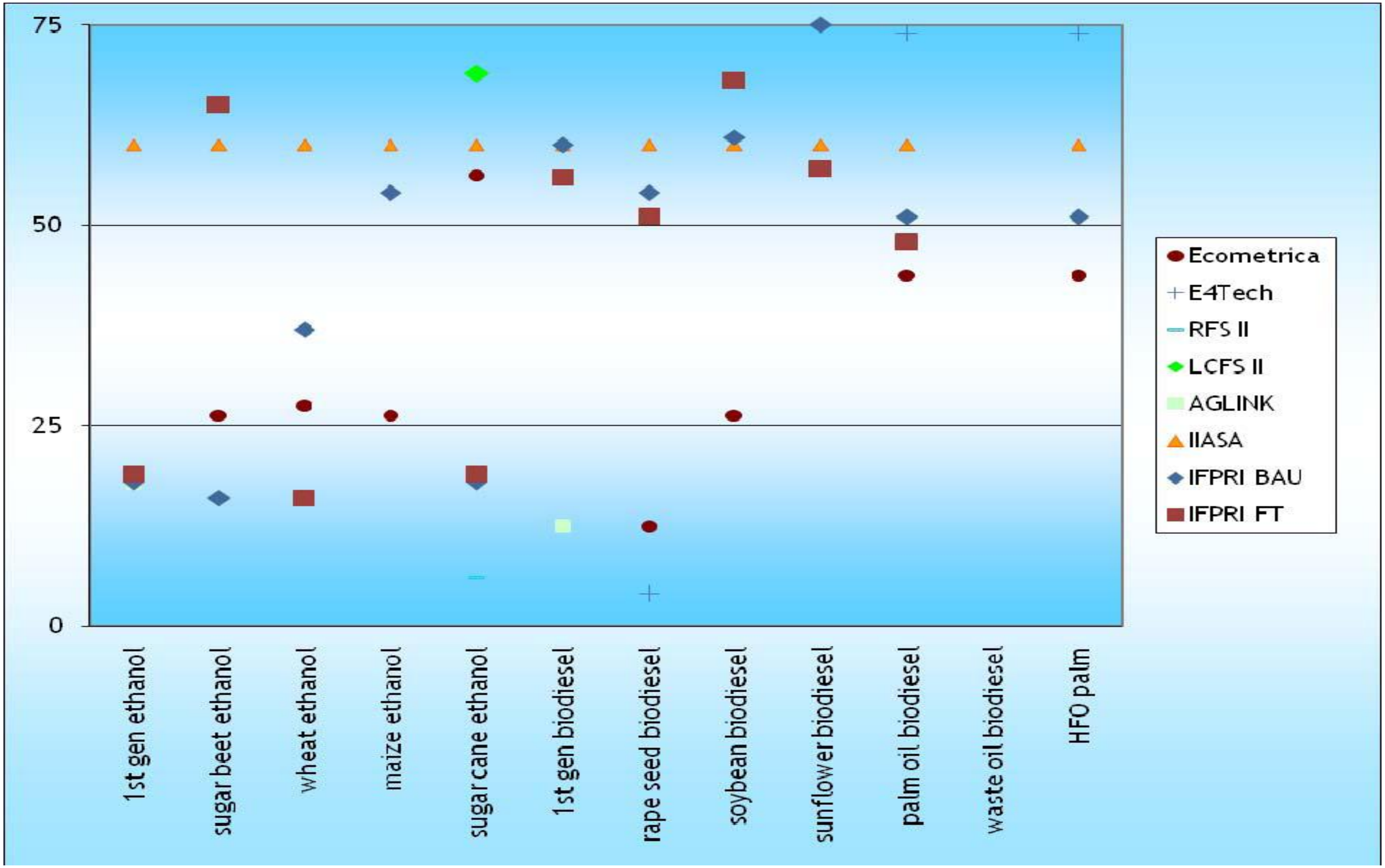
Published estimates of iLUC emissions induced by expansion of corn ethanol in the US and EU

Study	Target year	Shock size (10^6 m^3)	ILUC factor (g CO_{2eq}/MJ)	Range (g CO_{2eq}/MJ)
Searchinger et al. (2008)	2016	56	104	20–200[a]
Hertel et al.(2010)	2001[b]	50	27	15–90[c]
Dumortier et al.(2009)	2018/19	30	n/a	21–118[d]
	2012	7.5	81	62–104[e]
USEPA (2010)	2017	14	58	43–76[e]
	2022	10	34	25–45[e]
Al Riffai et al. (2010)	2020[f]	0.47	36	36–53[g]
Tyner et al.(2010)	2015	7.6	14	14–18[h]

a Calculated from reported sensitivity results.
b Based on the GTAP-6 2001 database, adjusted for 10% greater corn yield in 2010.
c Based on a combination of high and low values for various economic model parameters.
d Based on evaluating alternative model assumptions.
e 95% CI around mean considering only the uncertainty in satellite data analysis and carbon accounting.
f Based on the GTAP-7 2004 database, using the model to project out to 2020.
g Effect of additional 10^6 GJ after meeting 5.6% mandate. Higher value is for greater trade liberalisation.
h Based on 2006 data constructed from 2001 GTAP database. Low value includes yield and population growth.

iLUC factors

iLUC factors for biofuels according to various studies [g CO_{2eq}/MJ]



Croezen H.J., Bergsma G.C., Otten M.B.J., van Valkengoed M.P.J.: Biofuels: Indirect land use change and climate impact. Delft, CE Delft, June 2010

Uncertainties of iLUC rating

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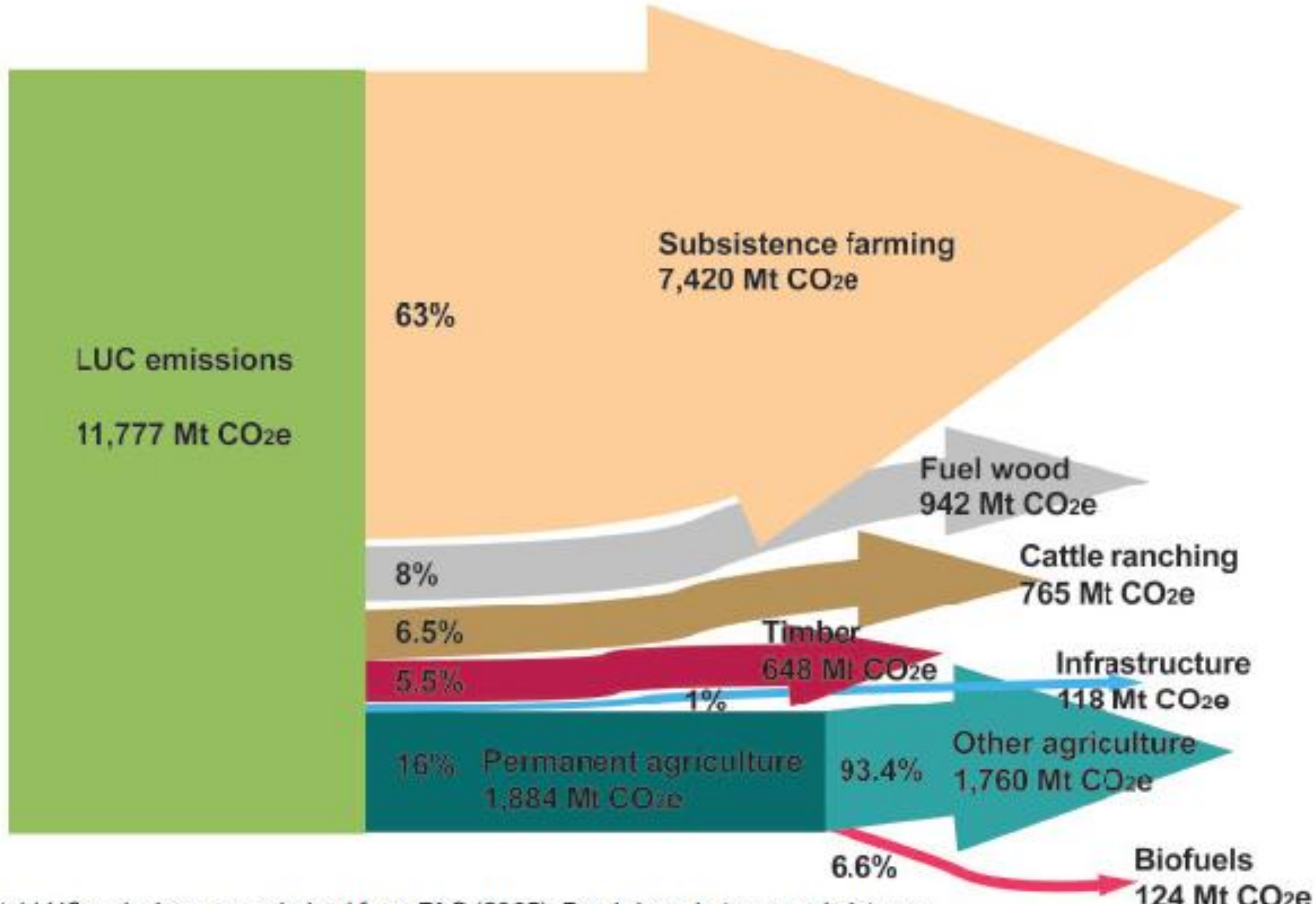
Multiple causes of land use change in the tropics



Total LUC emissions were derived from FAO (2005). Breakdown between subsistence farming, fuel wood, cattle ranching, timber and permament agriculture were taken from FAO (1980). The contribution of biofuels was based on the proportion of commercial agricultural output allocated to biofuels over the period 2000 - 2005.

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Uncertainties of iLUC rating

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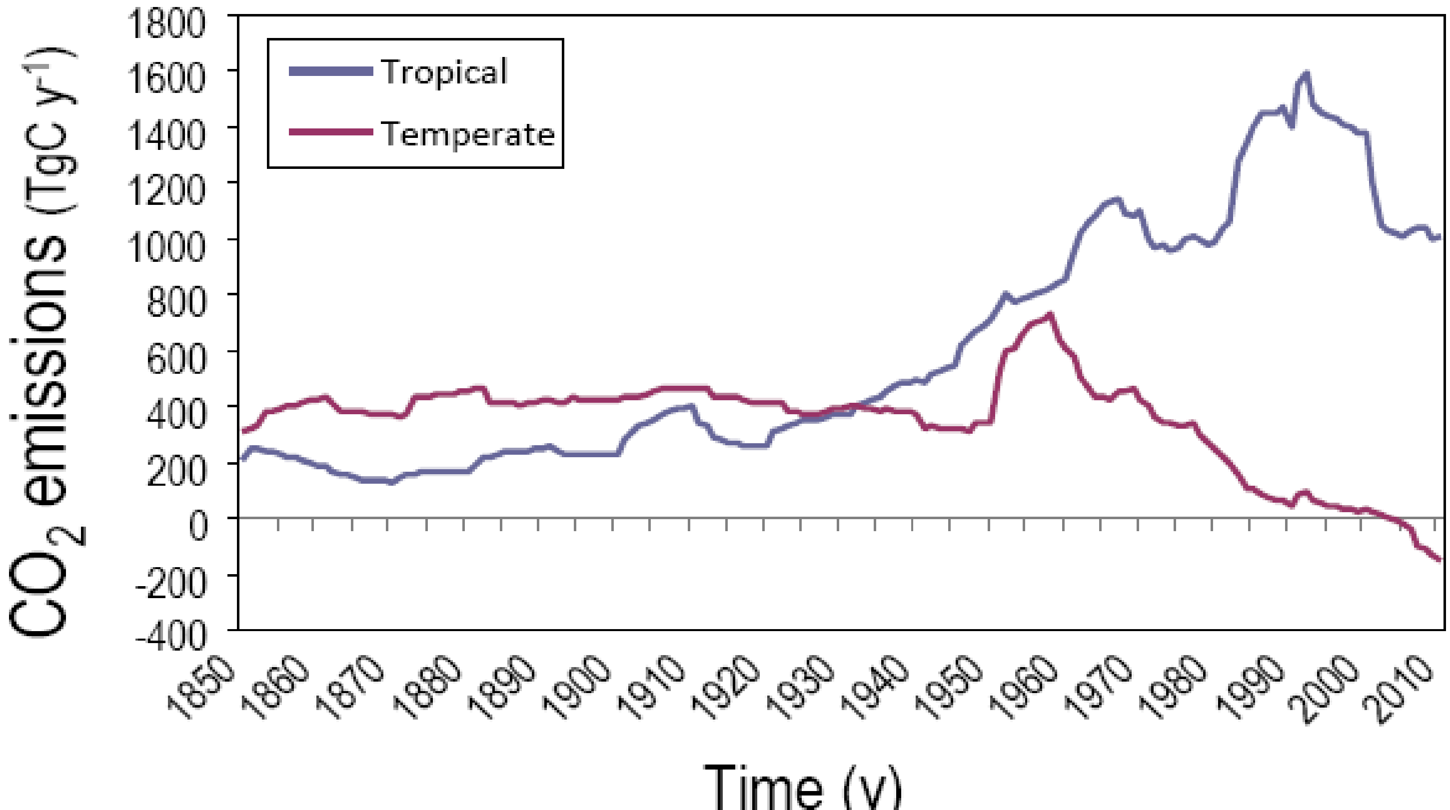
CO_2 emissions from deforestation in different climate zones



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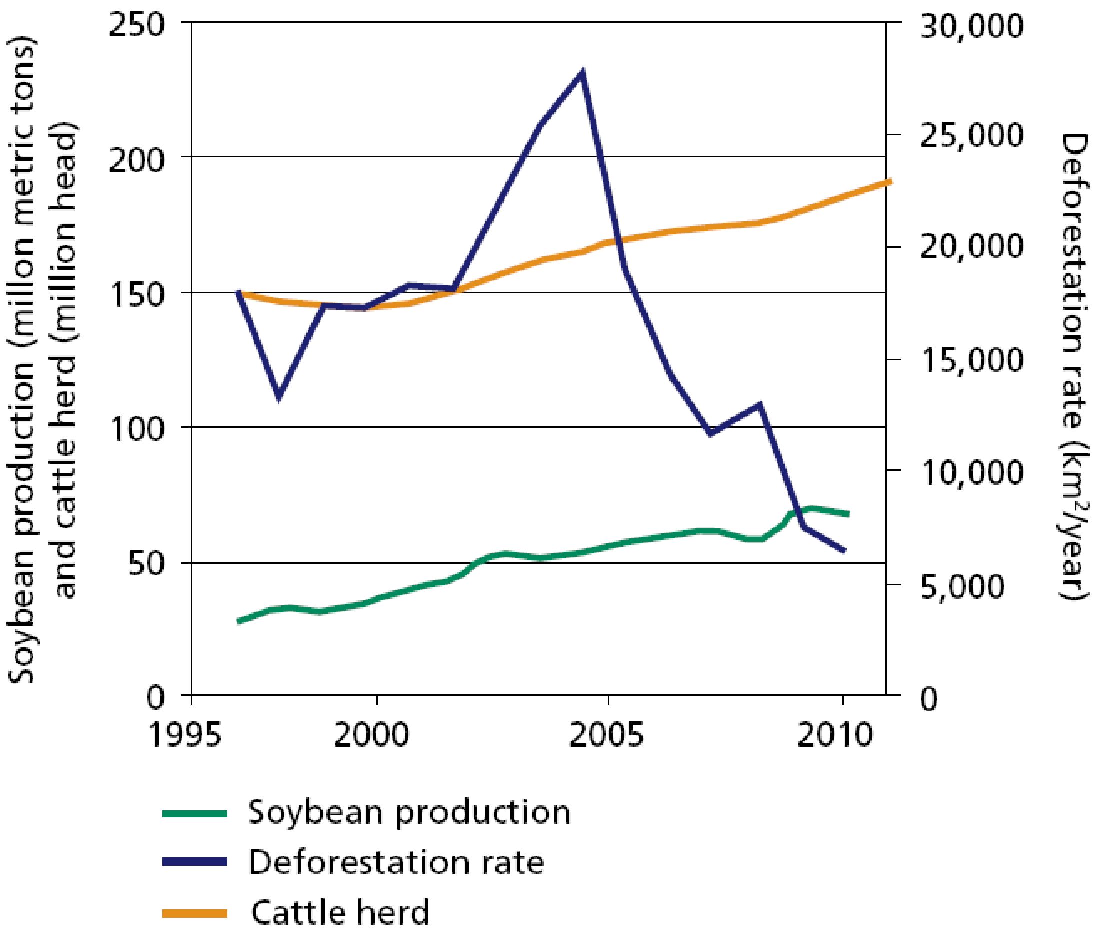
Uncertainties of iLUC rating

Deforestation, cattle herd and soybean production in Brazil



Sources: USDA Foreign Agriculture Service, PDS Online (*http://www.fas.usda.gov/psdonline/psdHome.aspx*); Brazilian National Space Research Institute (INPE) (*http://www.obt.inpe.br/prodes/index.html*).

Both cattle and soybean production have continued to increase steadily in Brazil in the past several years—even as deforestation rates have dropped to record low levels.

Pieprzyk, TUD, 2011

Uncertainties of iLUC rating

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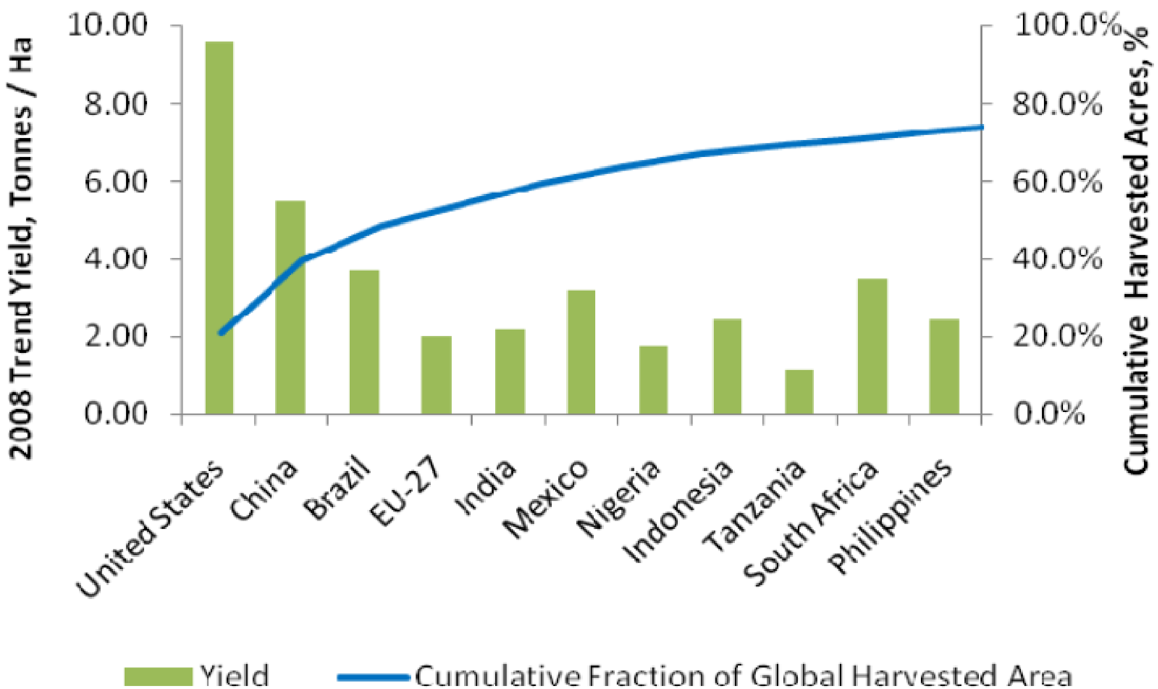
Soybean yields in 2008 in different countries



Pieprzyk, TUD, 2011

Interim Conclusion

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- There are relevant LUC / iLUC effects.
- But very large differences between countries.
- Global agricultural models vary considerably.
- High legal risk of using them for regulative purposes.
- Deterministic models at the global level are even less appropriate.
- Incentive effects of iLUC global factors are doubtful because of all the regions are averaged, "one size fits all".

What to do?

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Regional model approach

- Better baseline data.
- 90% of agricultural production remain in the region.
- ... the key to understanding the iLUC effects can not be looking at global econometric or even deterministic model of agriculture, but in each of the decisions and decision-making structures in the regions or countries.
- Incentive effects are differentiated.

Design of a regional model

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The model‘s calculation method consists of five steps:

- Step 1 - Identifying LUC
- Step 2 - Determination of CO_2 emission from LUC
- Step 3 - Determination of the biofuel sector's share of CO_2 emissions from LUC
- Step 4 - Determination of CO_2 emissions from the biofuel sector from iLUC (over dLUC)
- Step 5 - Options for allocation of emissions iLUC

Details:

http://www.bdbe.de/downloads/PDF/iLUC/iLUC_Studie_Lahl_engl.pdf

Model Calculations

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Case A: Mid-sized tropical country / Palm oil

Case A	Medium-size country 30% tropical forest Palm oil diesel fuel	Relevant input figures, all: CS^{RF} = 265 Mg C, CS^{Sa} = 130 Mg C, Δ Agr = 8 million Mg GE (GE = grain unit)			ILUC in g CO_{2eq}/MJ
A 1	In the reference year rainforest is converted at today's common level of **0.5%** for the production of agricultural product x, which was previously grown on other land. **Biofuel industry is a key driver for this development.**	LUC^R	=	75 000 ha	**37**
		ΔAgr_{fuel}	=	3.5 million Mg GE	
		$Agr_{fuel, energy}$	=	3.05 E+11 MJ	
A 2	In the reference year rainforest is converted at today's common level of **0.05%** for the production of agricultural product x, which was previously grown on other land. **Biofuel industry is a key driver for this development.**	LUC^R	=	7 500 ha	**3.7**
		ΔAgr_{fuel}	=	3.5 million Mg GE	
		$Agr_{fuel, energy}$	=	3.05 E+11 MJ	
A 3	In the reference year rainforest is converted at today's common level of **0.01%** for the production of agricultural product x, which was previously grown on other land. **Biofuel industry is a key driver for this development.**	LUC^R	=	1 500 ha	**0.7**
		ΔAgr_{fuel}	=	3.5 million Mg GE	
		$Agr_{fuel, energy}$	=	3.05 E+11 MJ	
A 4	In the reference year rainforest is converted at today's common level of **0.1%** for the production of agricultural product x, which was previously grown on other land. **Biofuels industry** shows much less increase, as it **is not the key driver of this development.**	LUC^R	=	15 000 ha	**0.4**
		ΔAgr_{fuel}	=	0.1 million Mg GE	
		$Agr_{fuel, energy}$	=	1.57 E+11 MJ	

Model Calculations

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Case B - Large tropical country / Soy & sugar cane

Case B	Large tropical country 35% of the land is tropical forest	Relevant input figures, all: CS^{RF} = 265 Mg C, CS^{GLtrop} = 75 Mg C **Δ Agr = 150 million Mg GE** (GE = grain unit)			ILUC in g CO_{2eq}/MJ
B 1	**Worst case bioethanol:** In the reference year **0.17%** of rainforest is converted. Livestock farming is replaced by sugar cane cultivation. **Bioethanol production is a major reason for this.**	LUC^R	=	714 000 ha	**159**
		$\Delta\ Agr_{fuel}$	=	29 million Mg GE	
		$Agr_{fuel,\ energy}$	=	4.23 E+11 MJ	
B 2	**Bioethanol:** In the reference year **0.17%** of rainforest is converted. Livestock farming is replaced by sugar cane cultivation. **Bioethanol production is not a major reason for this.**	LUC^R	=	714 000 ha	**22**
		$\Delta\ Agr_{fuel}$	=	3.5 million Mg GE	
		$Agr_{fuel,\ energy}$	=	3.76 E+11 MJ	
B 3	**Soybean oil diesel fuel:** In the reference year **0.17%** rainforest is converted to grassland. Pasture is replaced by soybean cultivation. **Soybean oil-diesel shows no big increase.**	LUC^R	=	714 000 ha	**44**
		$\Delta\ Agr_{fuel}$	=	3.1 million Mg GE	
		$Agr_{fuel,\ energy}$	=	2.81 E+10 MJ	
B 4	**Soybean oil diesel fuel:** In the reference year **0.17%** rainforest is converted to grassland. Pasture is replaced by soybean cultivation. **Soybean oil-diesel shows a large increase.**	LUC^R	=	714 000 ha	**39**
		$\Delta\ Agr_{fuel}$	=	78 million Mg GE	
		$Agr_{fuel,\ energy}$	=	7.98 E+11 MJ	
B 5	**Worst case soybean oil diesel fuel:** In the reference year **0.60%** rainforest is converted to grassland. Pasture is replaced by soybean cultivation. **Soybean oil-diesel shows a large increase.**	LUC^R	=	2 520 000 ha	**136**
		$\Delta\ Agr_{fuel}$	=	78 million Mg GE	
		$Agr_{fuel,\ energy}$	=	7.98 E+11 MJ	

Model Calculations

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Case C - Land in temperate climate zone / grain & oilseed rape

Case C	Country in temperate climate zone	Relevant input figures, all: **CS^{Cl} = 45 Mg C,** **Δ Agr = 3 million Mg GE** (GE = grain unit) **Δ Agr_{fuel} = 0.6 million Mg GE**	ILUC in g CO_{2eq}/MJ
C 1	**Bioethanol:** **0.01%** of the forest is converted to the benefit of arable land. **Grain farming has a share in producing bioethanol.**	LUC^R = 1 000 ha CS^F = 130 Mg C $Agr_{fuel, energy}$ = 1.71 E+10 MJ	**1.8**
C 2	**Bioethanol:** **Low percentage** of land is converted from grassland to arable land. **Grain farming has a share in producing bioethanol.**	LUC^R = 1 000 ha CS^F = 70 Mg C $Agr_{fuel, energy}$ = 1.71 E+10 MJ	**0.5**
C 3	**Bioethanol:** **Higher percentage** of land is converted from grassland to arable land. **Grain farming has a share in producing bioethanol.**	LUC^R = 25 000 ha CS^F = 70 Mg C $Agr_{fuel, energy}$ = 1.71 E+10 MJ	**13.0**
C 4	**Rapeseed oil biodiesel:** **Large areas** of grassland are converted into arable land. **Rapeseed for bioethanol extraction is the key driver.**	LUC^R = 60 000 ha CS^F = 70 Mg C $Agr_{fuel, energy}$ = 1.72 E+11 MJ	**1.9**

Conclusion model calculations

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- **The analytical model provides reproducible results**, it is transparent in its calculation method and deflected in such a way that „good governance“ based on land use issues is „rewarded“.
- Restrictions:
  - Carbon content in vegetation and soils
  - iLUC effects between countries
  - Scope for yield increases
  - Correction factors
  - Cross-border supply chain
- Overall, it can be found, despite the criticisms and limitations shown, that the model presented here would, in principle, be suitable to capture regional iLUC effects and to determine a „regional iLUC factor“.

Policy Analysis

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Different options for controlling indirect Land Use Change (iLUC]

- Solutions at the root
  - Equal treatment of all agricultural sectors through a comprehensive scheme dLUC
  - Land use planning
  - Completing an international convention on land protection
- Temporary solutions
  - No action
  - Transitional solution „needs to tighten EE“
  - Interim solution „Additional Bonus“
  - Transitional solution „Black List“
  - Interim solution „Bilateral Treaties“
  - Interim solution „Introduction of a regional iLUC factor“
  - Transitional solution „Introduction of a global iLUC factor“
  - Imposing a temporary solution „iLUC model“

Policy Analysis

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- False solutions are dangerous
- Biomass for climate change policy for the next years, an ever-increasing importance.
- Without a significant increase in biomass production, the 2-degree target is not reachable.
- Therefore, a real problem solving is required.
- Therefore, long-term dLUC regulations for all agricultural sectors
- Temporary solutions for the transition required.
  - Biofuel industry can act as an icebreaker.

Conclusion Policy Analysis

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- The study concludes that Land Use Change (LUC) - the conversion of natural forests, grazing land or waste land into arable land - in some regions of the world remains a major concern, not only for climate protection.
- Global models for iLUC e.g. determined on econometric calculations are not sufficiently resilient and show marked differences in results.
- Regional models have on the opposite advantages.
- Adding an option to the RE Directive is recommended: the EU Commission should be given the ability to calculate and define a regional iLUC factor for a country given defined political conditions. These conditions include, in particular, a documented and long-term refusal of a country to agree with the EU to a bilateral agreement as the solution to the problem.
- **Overall a combination of activities made up of a medium to long-term international solution and short-term interim solutions through various "bilateral agreements" supported by a regional iLUC model is recommended.**

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Thank you for your attention!

Vielen Dank

für Ihre Aufmerksamkeit!

BACKUP

Key Factors affecting the Biomass Potential

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Issue/effect	Importance
Supply potential of biomass	
Improvement agricultural management	***
Choice of crops	***
Food demands and human diet	***
Use of degraded land	***
Competition for water	***
Use of agricultural/forestry by-products	**
Protected area expansion	**
Water use efficiency	**
Climate change	**
Alternative protein chains	**
Demand for biomaterials	*
Demand potential of biomass	
Bio-energy demand versus supply	**
Cost of biomass supply	**
Learning in energy conversion	**
Market mechanism food-feed-fuel	**

A. Faaji, 8. Int. Congress on Biofuel, Berlin 2011

Biomass for Climate Protection

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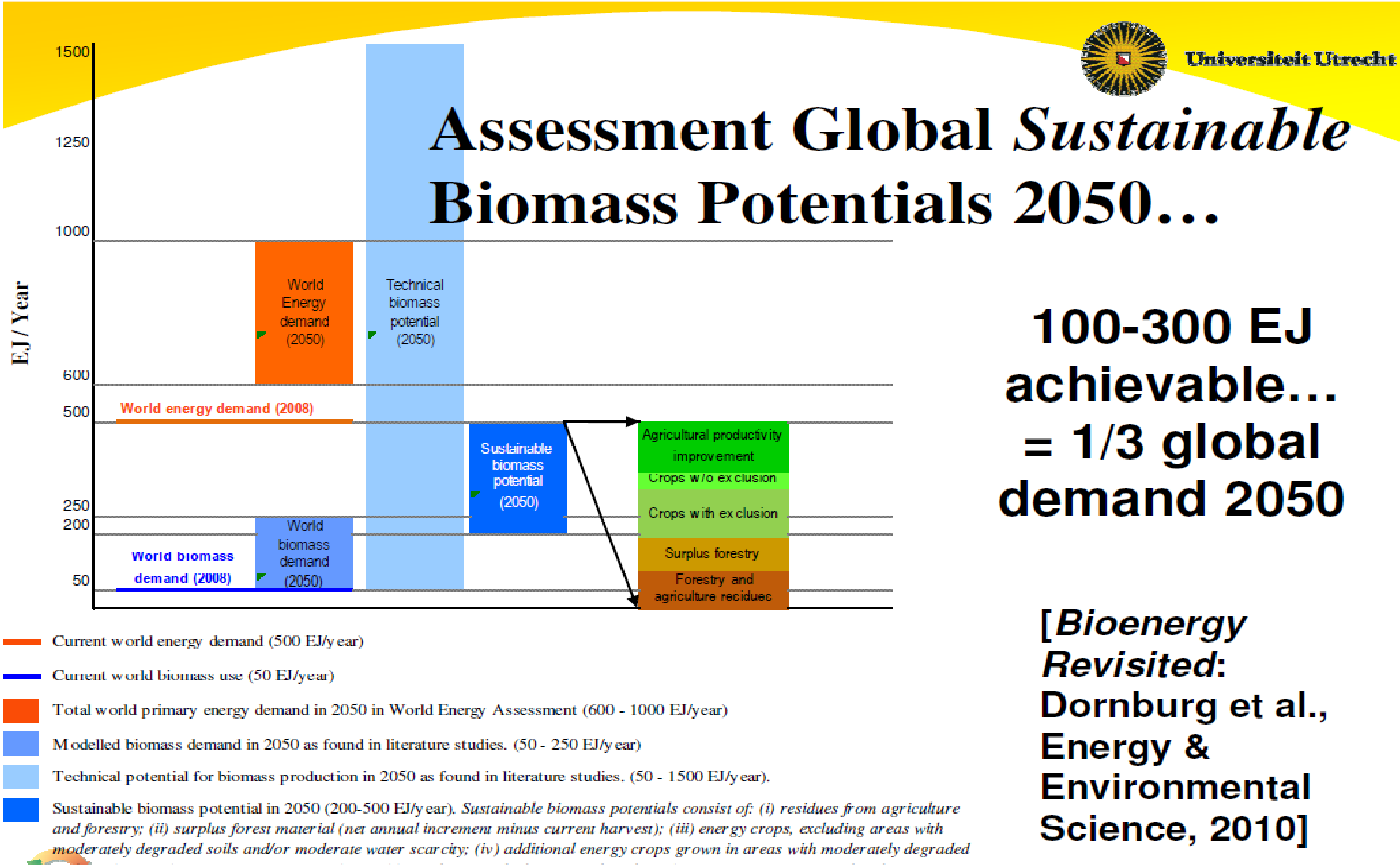

100-300 EJ achievable… = 1/3 global demand 2050

[*Bioenergy Revisited*: Dornburg et al., Energy & Environmental Science, 2010]

A. Faaji, 8. Int. Congress on Biofuel, Berlin 2011