Indirect land use changes (iLUC)

- Exercises with answers

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Exercise 1: The effect of time horizon (1 of 2)

- Case: biodiesel
  - Functional unit = 1 t biodiesel (~35 GJ) incl. combustion in engine
  - Land use: 1 ha yr needed to produce the biofuel
  - Process emissions (non-LUC emissions):
    - Biodiesel: 2.5 t CO_2/t biodiesel
    - Fossil alternative: 3 t CO_2/t
  - Carbon stock for land
    - C-stock before = 145 t/ha
    - C-stock cropland = 70 t/ha

Exercise 1: The effect of time horizon (2 of 2)

- **Question 1: emissions from change in C-stock**
  - Calculate CO_2-emissions for functional unit from land use change – induced by C-stock change
- **Question 2: Amortisation**
  - Calculate LUC-emissions using amortisation, use 20 and 100 years as amortisation period
- **Question 3: Carbon debt**
  - Calculate carbon debt (years)
- **Question 4: Accelerated deforestation**
  - Calculate LUC emissions (GWP) using the accelerated deforestation method for time horizons at 20, 100 and 500 years
  - N.B. Use excel sheet with GWP calculation

Exercise 2: Intensification

- Imagine you want to include intensification in your iLUC calculations
- From FAOSTAT you have downloaded:
- Calculate proportion between intensification (Δyield) and expansion (Δarea)

World production of wheat

Year	Area Harvested (Ha)	Production (tonnes)
2000	215,436,907	585,690,370
2001	214,611,026	589,832,114
2002	213,816,159	574,745,910
2003	207,698,892	560,127,922
2004	216,926,157	632,703,310
2005	219,742,875	626,866,195
2006	211,195,424	602,892,293
2007	216,706,677	612,601,092
2008	222,275,263	683,153,270
2009	224,389,208	686,794,645
2010	217,312,408	653,355,358
2011	220,385,285	704,080,283

Exercise 3: Intensification

- Assume that 1 t biodiesel can be produced via intensification with emissions at 2 t CO_2
- How can modelled intensification be fitted into the LUC model for
  - Amortisation
  - Carbon debt
  - Accelerated deforestation

Exercise 4: Intensification

- What is the fertiliser (kg N) required to produce additional 1 kg dm pasture grass when fertiliser level is
  - 0 kg N/ha yr
  - 50 kg N/ha yr
  - 100 kg N/ha yr
- Use the following data

Sun X, Luo N, Longhurst B and Luoet J (2008), Fertiliser Nitrogen and Factors Affecting Pasture Responses. The Open Agriculture Journal, 2008, 2, 35-42

N	0	150	175	300	350	450	525	600	700
Yield(dm)	**7.7**	**10.0**	**9.5**	**10.4**	**10.2**	**11.2**	**11.3**	**10.7**	**10.8**

Exercise 5: Evaluate and draft response paper on Finkbeiner (2013)

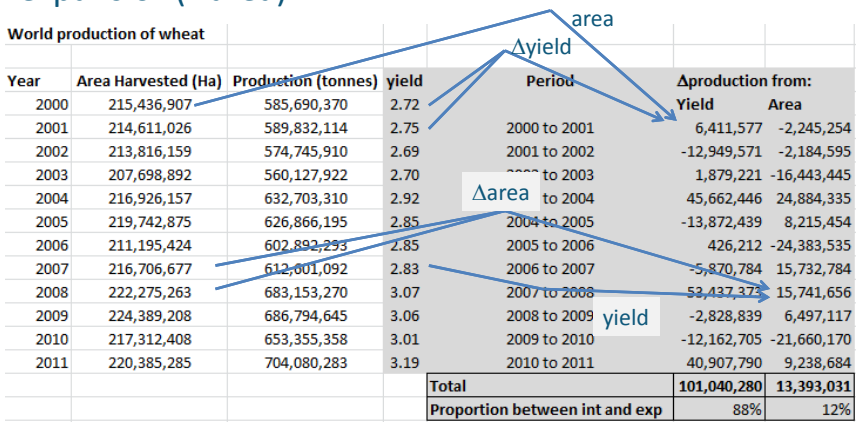
- Finkberiner (2013), iLUC within LCA - scientific robustness and consistency with standards
- http://www.fediol.eu/data/RZ_VDB_0030_Vorstudie_ENG_Komplett.pdf

Answers Exercise 1: The effect of time horizon

1. **CO2 from carbon stock change**
   - CO_2 = (145-70)*(44/12) = 275 t CO_2
2. **Amortisation**
   - 20 yr: 275/20 = 13.8 t CO_2 from LUC
   - 100 yr: 275/100 = 2.75 t CO_2 from LUC
3. **Carbon debt**
   - 275 t CO_2 / (3 t CO_2 /t – 2.5 t CO_2 /t) = 550 years
4. **Accelerated deforestation**
   - TH_{20}: (1 – 0.958) x 275 t CO_2 = 11.4 t CO_2 from LUC
   - TH_{100}: (1 – 0.992) x 275 t CO_2 = 2.1 t CO_2 from LUC
   - TH_{500}: (1 – 0.9985) x 275 t CO_2 = 0.41 t CO_2 from LUC

Answers Exercise 2: Intensification

- Calculate proportion between intensification (Δyield) and expansion (Δarea)



World production of wheat

Year	Area Harvested (Ha)	Production (tonnes)	yield	Period	Δproduction from: Yield	Area
2000	215,436,907	585,690,370	2.72			
2001	214,611,026	589,832,114	2.75	2000 to 2001	6,411,577	-2,245,254
2002	213,816,159	574,745,910	2.69	2001 to 2002	-12,949,571	-2,184,595
2003	207,698,892	560,127,922	2.70	[illegible] to 2003	1,879,221	-16,443,445
2004	216,926,157	632,703,310	2.92	[illegible] to 2004	45,662,446	24,884,335
2005	219,742,875	626,866,195	2.85	2004 to 2005	-13,872,439	8,215,454
2006	211,195,424	602,892,293	2.85	2005 to 2006	426,212	-24,383,535
2007	216,706,677	612,001,092	2.83	2006 to 2007	-5,870,784	15,732,784
2008	222,275,263	683,153,270	3.07	2007 to 2008	53,437,373	15,741,656
2009	224,389,208	686,794,645	3.06	2008 to 2009	-2,828,839	6,497,117
2010	217,312,408	653,355,358	3.01	2009 to 2010	-12,162,705	-21,660,170
2011	220,385,285	704,080,283	3.19	2010 to 2011	40,907,790	9,238,684
				Total	**101,040,280**	**13,393,031**
				Proportion between int and exp	88%	12%

Answers Exercise 3: Intensification

- Amortisation
  - Overlap between process emissions and intensification emissions
  - Lack of distinction between 'direct LUC' (on field) and iLUC (upstream)
- Carbon debt
  - LUC in unit year, and intensification in unit CO_2
- Accelerated deforestation
  - Can be implemented
  - Note that intensification emissions should not be treated as accelerated emissions

Answers Exercise 4: Intensification

- What is the fertiliser (kg N) required to produce additional 1 kg dm pasture grass when fertiliser level is
  - 0 kg N/ha yr: 0.083 kg N/kg dm pasture grass
  - 50 kg N/ha yr: 0.091 kg N/kg dm pasture grass
  - 100 kg N/ha yr: 0.100 kg N/kg dm pasture grass

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N	0	150	175	300	350	450	525	600	700
Yield(dm)	**7.7**	**10.0**	**9.5**	**10.4**	**10.2**	**11.2**	**11.3**	**10.7**	**10.8**

Dose-response function derived from yield-to-fertiliser function

N-level	100	Enter value: Current level of N-fertiliser (kg N ha-1)
y(N)	9.0	yield(t dm ha-1)
Slope	10.00	Δyield(kg dm ha-1) per ΔN-fert (kg N ha-1)