What if land use aspects are included in GHG balance of livestock production systems?

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Background information

- A major issue currently not fully resolved in LCA regarding livestock impacts is **land use**. This is actualized by the increased demand for food products worldwide and the emerging demand for biofuels.

Food demand

Source: FAO 2006

	2000	2050
Cereals (10^9 tons)	2.1	3
Meat (10^6 tons)	228	459
Milk (10^6 tons)	475	883

Biofuel demand

World ethanol production tripled (2000-2007), double again in 2017 to reach 127 billion L a year.
Biodiesel production (2007-2017): 11 - 24 billion L a year
Source: OECD_FAO, 2008

Background information

- The occupation of land for livestock production has two implications on GHG emissions: land-use change (LUC) and land opportunity cost (LOC).

  Land use change potentially results from an increased demand for food products as a result of growing population and rising incomes.

  The opportunity cost of land, i.e., the value of land for **alternative** uses e.g. forestry: what is the best way of using land to get the same amount of output **at least GHG cost**?

Background information

- GHG emissions inventory for agricultural products currently, however, in most cases does not include CO_2 implications of land use.

Product (conventional)	kg CO_2e/kg	**m^2a/kg**	Source
Livestock feed			
Barley	0.70	2.0	LCAfood.DK
Wheat	0.74	1.5	LCAfood.DK
Soy meal	0.62	3.6	Dalgaard et al.,2008
Livestock product (live weight)			
Beef	11.6	18	LCAfood.DK
Pork	2.3	6.8	LCAfood.DK
Chicken	1.7	3.6	LCAfood.DK
Milk	1.01	1.5	LCAfood.DK

Background information

- Biofuels: US corn ethanol g CO_2e/MJ energy in fuel

Feedstock carbon uptake credit

CO_2 -62

+24

+40

+71

∑ = +74

Carbon emissions from LUC +104

∑ = +177

∑ = +135

+4

+15

+72

∑ = +92

Searchinger et al. (2008)

Use of U.S. croplands for biofuels increases GHG emissions through emissions from LUC. Science 319 (5867), 1238-1240 (841 citations G Scholar 17 Sept 2010)

Objective

- to address the question '**how** and **what if** land use aspects are included in GHG balance of livestock production systems',

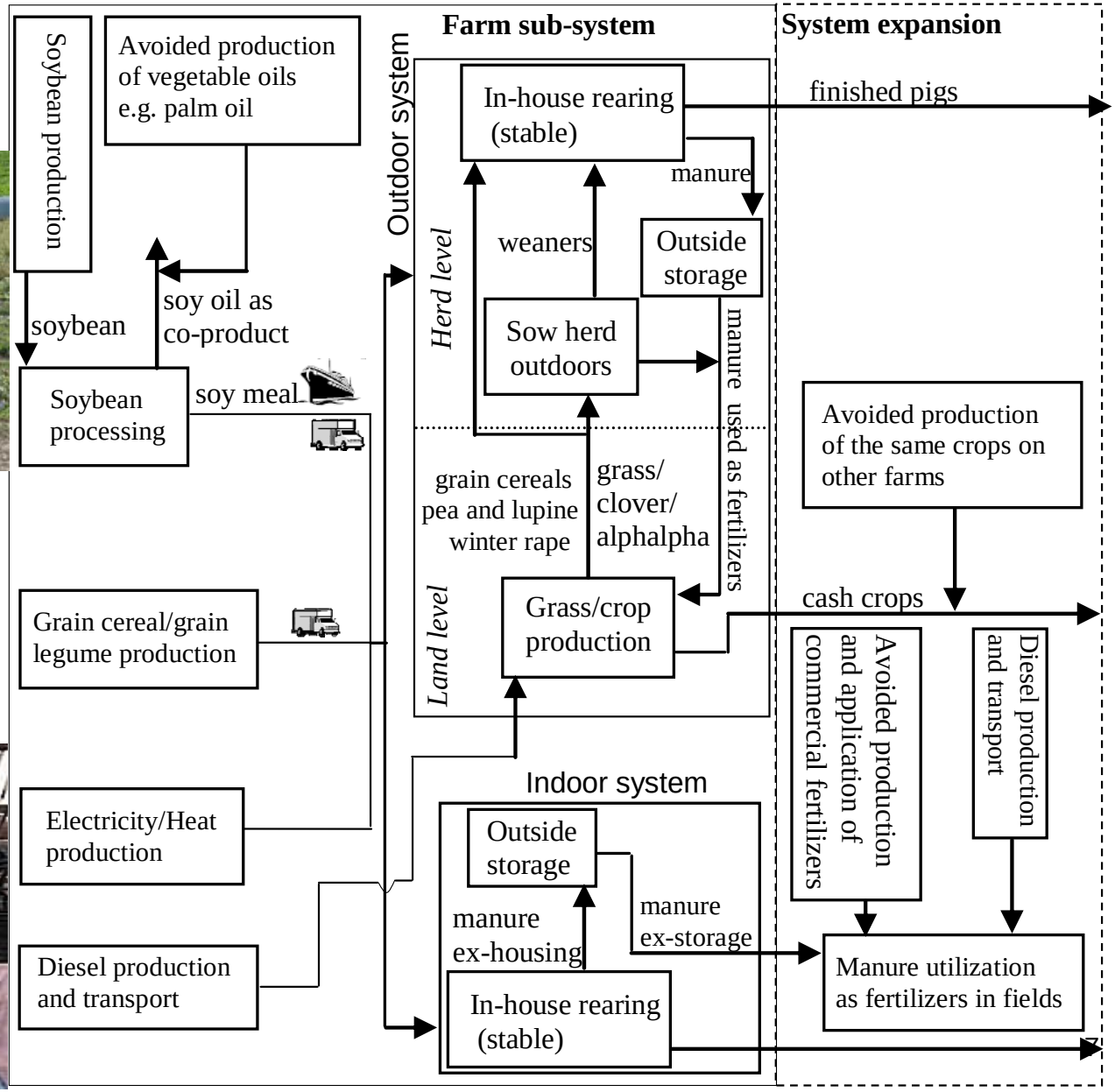
  We compare pork production in an indoor system versus an outdoor one using a life cycle approach.

  -The conventional indoor pig production system: defined in Dalgaard et al., (2007).

  -The outdoor system: organic prod. system, the sow herd kept on grassland with access to small huts, fattening pigs in indoor facilities (Halberg et al., 2010).

Materials and methodology

System boundary



Materials and methodology

	Outdoor (organic)		Indoor (conventional)		
		land use m^2a		land use m^2a	manure exp
Inputs					
Bought-in feed kg					
Grain cereals	1826	**5897**	2390	**3466**	
Soy meal	257	**1264**	540	**1917**	
Home-grown feed		**4221**			
Direct energy use					
Electricity kWh	186		229		
Heat MJ	0		239		
Diesel (traction) MJ	1167		169		-11.3
Outputs kg					
Live pigs	1000		1000		
Cash crops	153	-590			
Manure N			38.7		-29
Manure P			8.4		-8.4
On-farm emissions kg					
CH_4	40.0		42.7		
N_2O	1.9		1.4		-0.5

Materials and methodology

- **Fact**

  A common source of protein in livestock feed is **soy meal, which** comes mainly from Latin America.

  One of the main causes of **deforestation** in Latin America is the expansion of soybean growing areas (WWF, 2004).

  Deforestation is a large source of carbon emissions.

- **Argument**

  The production of 1 kg **extra** soy meal generates an extra land requirement of # 3.6 m^2a. It is reasonable to translate from this land use into CO_2 emissions, assuming that soybean expansion occurs *at the expense of forest.*

Materials and methodology

- **Fact**

  Other bought-in feeds (cereals from global sources) and home-grown feeds (local cereals and forage) also have land requirement. The link between "land occupation" and GHG emissions is not as well established as the link between LUC and GHG emissions.

Argument

What is the opportunity cost of growing cereal crops or rearing livestock on land considering alternative uses of land for maximum carbon storage e.g. forestry?

Materials and methodology

- It has been a challenge to develop an acceptable method for assessing the impacts of land use and land use change (LUC)
- Searchinger's study used a worldwide agricultural model to account for GHG emissions from LUC.

  Assumption: when forest conversion takes place, all carbon in vegetation, ongoing carbon sequestration that would take place each year if forest is not cleared, plus a portion of soil carbon are lost; If LUC is from forest to cropland, this portion is **25%**.

  • Murty et al. (2002): the effect of LUC from forest to pasture on soil carbon is insignificant (i.e. **0%** soil C lost).

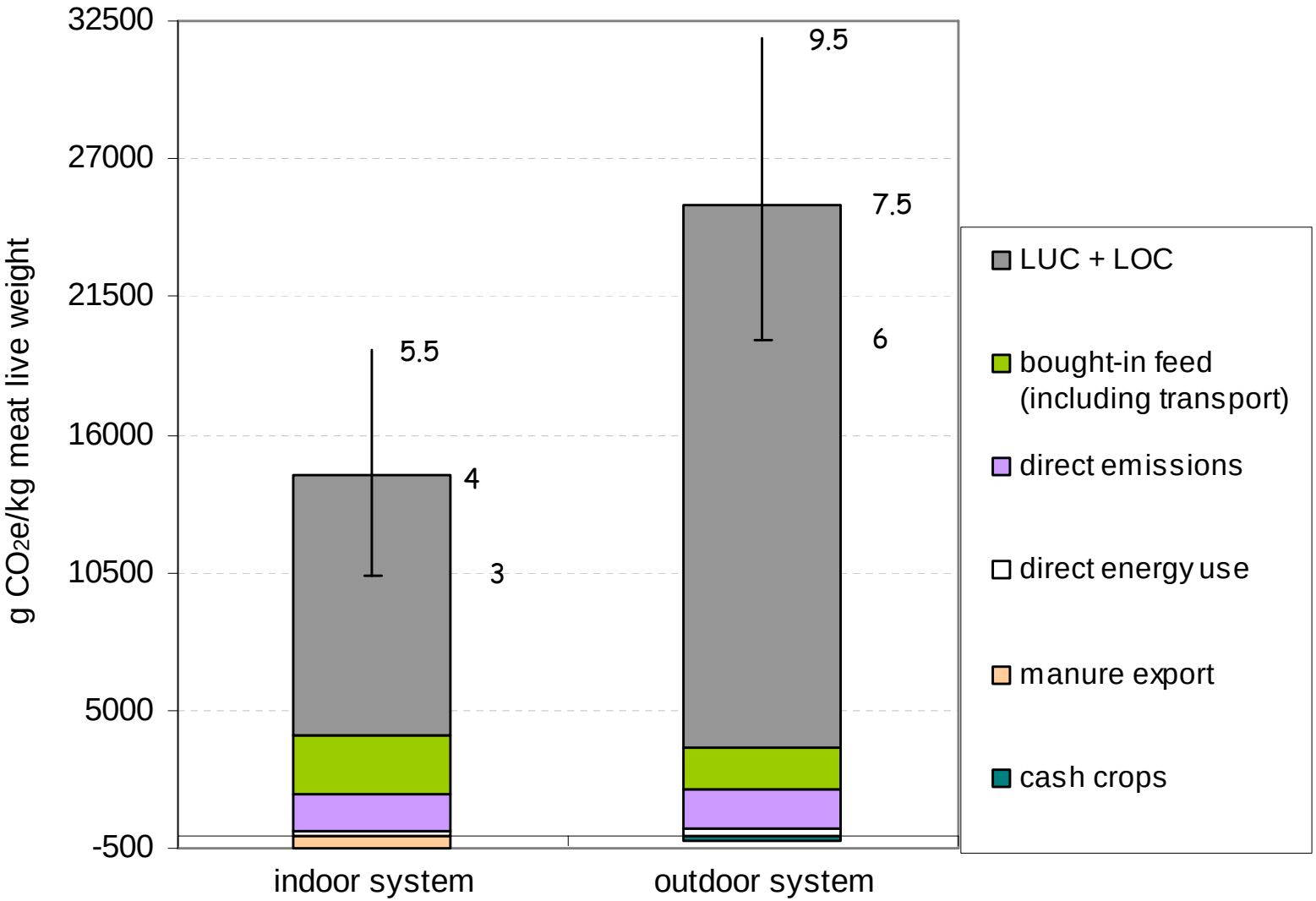
Materials and methodology

World region	Forest ⇄ cropland		Forest ⇄ grassland	
	Total C lost w.a. forest ecosystems t C/ha	kg CO_2/m^2yr (30 year depreciation)	Total C lost w.a. forest ecosystems t C/ha	kg CO_2/m^2yr (30 year depreciation)
Pacific Developed	133	1.6	110	
North Africa/Middle East	118	1.4	96	
Canada	150	1.8	101	
The United States	198	2.4	163	
Latin America	166	2.0	142	
South and SE Asia	234	**2.9**	211	
Africa	97	**1.2**	67	
Europe	183	**2.2**	151	**1.8**
Former Soviet Union	160	2.0	118	
Weighted average	158	**1.9**	125	

Materials and methodology

Livestock feed	kg CO_2e/kg **without LUC, LOC**	m^2a/kg	kg CO_2e/kg **with LUC, LOC**
Conventional			
Barley	0.70	**2.0**	4.5 (3.1-6.5)
Wheat	0.74	**1.5**	3.6 (2.5-5.1)
Soy meal	0.62	**3.6**	7.5 (4.9-11.1)
Organic			
Barley	0.76	**3.2**	6.8 (4.6-10.1)
Wheat	0.53	**2.5**	5.3 (3.5-7.8)
Soy meal	0.86	**4.9**	10.2 (6.8-15.1)

Results and discussions



GHG emissions from the two pig production systems

Results and discussions

- Land use is a key factor in env. assess. of livestock production: accounting for its impact may change the ranking of environmental performance of different systems
- The outdoor system considered here besides having a relatively poor FCR is connected to overall lower crop yields in organic production, which in turn increases the impact on GWP when land use is taken into account
- The question is whether and how land use intensity of organic pigs can be reduced by improving FCR as well as raising yields of organic feed crops without paying any extra environmental costs

Results and discussions

- The results with land use consideration → a range of uncertainty depending on the value of carbon emissions rate used to estimate land-use related GHG emissions.

⇒ The need to develop a standard and acceptable method to assess land use impacts in LCA.

Conclusions

- GHG implications of land use play an important role in evaluating GHG performance of livestock products

- There is a need for discussions and actions in promoting sustainable land use in livestock systems not only for climate change mitigation but also for conservation of other values of land e.g. biodiversity.

Thanks for your kind attention!