Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Greenhouse Gases and Animal Agriculture – *Finding a Balance Between Food and Emissions*

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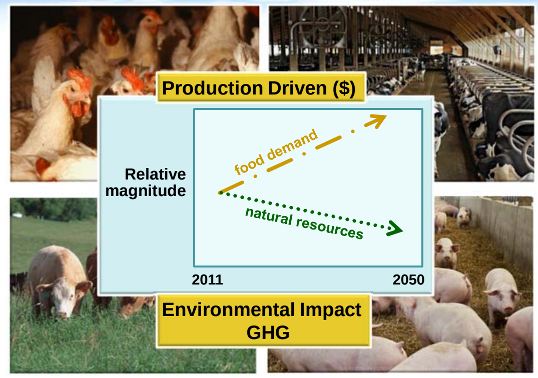
Canada



Livestock Production Contributes Significant Greenhouse Gas Emissions

Globally, livestock production accounts for:

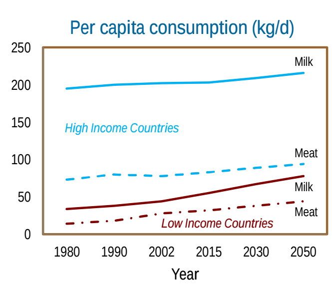
- 8% of GHG (EPA, 2006; IPCC, 2007)
- 18% if land use and land use change is accounted for (FAO Livestock's Long Shadow Report, 2006)
- Meat and dairy products account for about 50% of food-generated GHG emissions (Garnett, 2009)

Livestock - A Key Global Commodity

- Supplies 17% of calories, 33% of protein globally
- Ruminants use pastures, byproducts (human inedible)
- Income support: esp. 1 billion people in low income countries
  - Small holdings, Little need for land ownership or education
  - Low investment

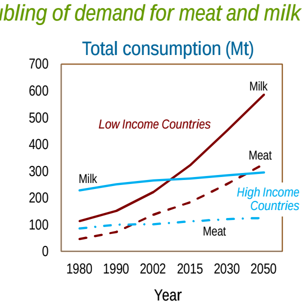
FAO, 2010
Herrero et al. 2009 COES 1:111

Expected Demand for Livestock Products



Expected Demand for Livestock Products

- *Doubling of demand for meat and milk (2000 to 2050)*



Expansion of Global Livestock Production

Demand Drivers

- Global population growth
- Urbanization
- Wealth

Socio-Economic Limitations

- Costs (feed, fertilizer, fuel, labour)
- Carbon constrained economy (GHG)
- Limited land resources
- Competition for water resources
- Animal welfare, others

"business as usual" approach not acceptable…future expansion limited by environmental, social and economic constraints

Food and Agriculture Organization Projections: 2030 versus 1997

- Increasing demand for food will increase global agricultural emissions
  - CH_4 emissions: + 60%
  - N_2O emissions: + 50%

  } Livestock

Given the importance of livestock, and its expected continued growth, how CAN we attenuate the future increase in GHG emissions?

Global Livestock Industry Diversity

Food security issues dominate

Cannot use a "one-size-fits all" approach to lowering GHG emissions

If it costs more, who will pay?

Small holder dairy fa

Small family farm in Wisconsin

Land-less feedlot system in California

Balancing Livestock Production and GHG Emissions

⬇ Meat/milk demand

- Waste (1/3 of food in high income countries)
- Consumption in high income countries
  - 60% decrease in consumption = 15-20% reduction globally (Garnett, 2009)
  - Environmental cost of substitutes (e.g., pasture to crop land? Importation?)

⬆ Efficiency (⬇GHG/food)

⬇ Resource use / food

⬇ Emissions / food

Efficiency: GHG Intensity (Carbon Footprint)

Nitrous oxide (GWP=298)
+ Methane (GWP=25)
+ Carbon dioxide (GWP=1)

→ GHG emissions (kg CO_2 eq)

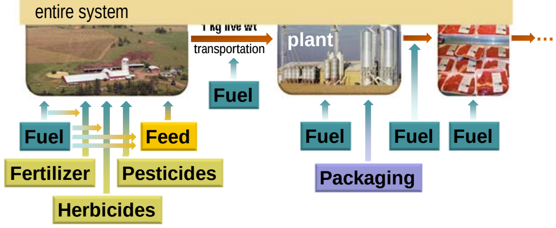
―――――――――

Kg product

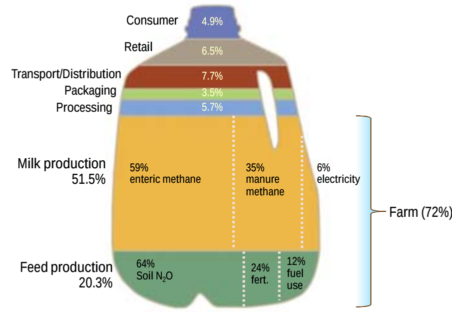
← Functional unit
- kg fat-protein corrected milk
- kg carcass
- kg protein, MJ energy

Life Cycle Assessment

Life Cycle Assessment
- "Cradle to grave" analysis
- Determines how a change in management/diet transfers through entire system



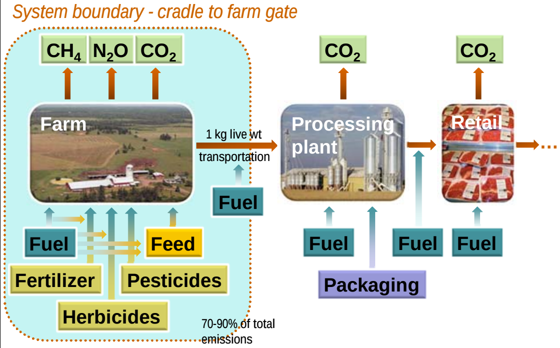
U.S. Fluid Milk Carbon Footprint: Supply Chain Emissions



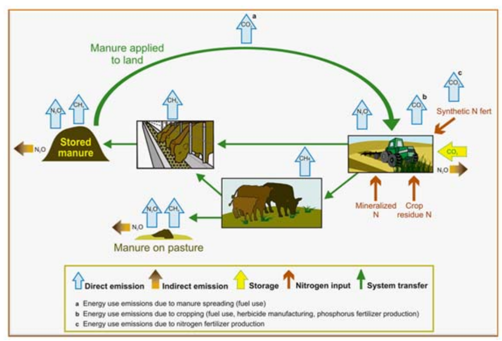
http://www.usdairy.com/Sustainability/Science/Pages/FluidMilk.aspx

Life Cycle Assessment

System boundary - cradle to farm gate

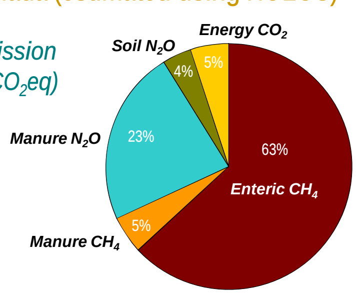


Sources of GHG Emissions from Livestock Production



Sources of GHG from Beef Production in Western Canada (estimated using HOLOS)

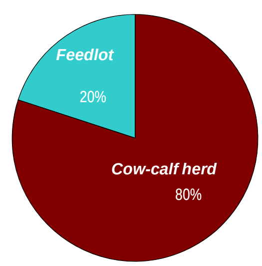
Life cycle emission breakdown (CO_2eq)



Beauchemin et al. (2010). Agr. Syst. 103:371–379

Source of Emission by Sector of Beef Production System (estimated using HOLOS)

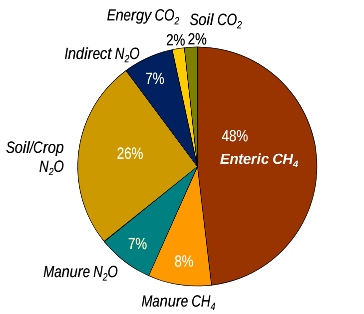
Life cycle emission breakdown (CO_2eq)



Beauchemin et al. (2010). Agr. Syst. 103:371–379

Sources of GHG From Dairy Production in Eastern Canada (est. using HOLOS)

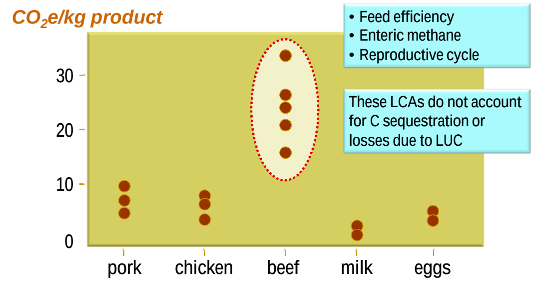
Life cycle emission breakdown (CO_2eq)



McGeough et al. (2012). J Dairy Sci. (in press)

GHG Intensity of Livestock Products

(CO_2eq / kg carcass or milk, farm gate)



From deVries et al. 2010. Livest. Prod. Sci. 128:1-11

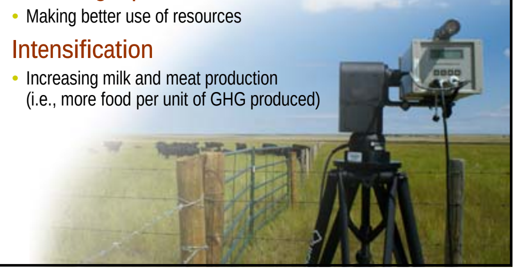
The Ruminant - GHG Conundrum

- Use of non-arable land and inedible cellulosic material
- Maintains grazing lands - important for wildlife habitat, watershed management, recreation, etc.
- Pastures help maintain soil carbon

Focusing ONLY on GHG emissions doesn't give the full picture !!!

Strategies to Improve GHG Efficiency

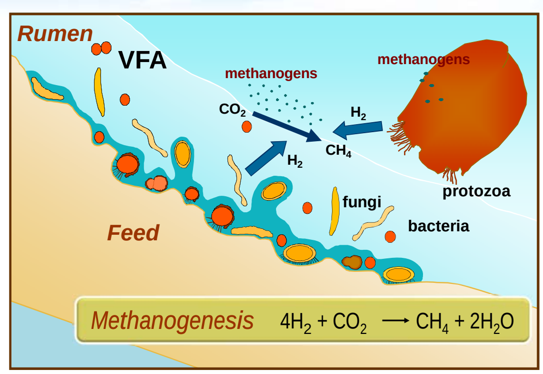
1) Technology to reduce emissions
   - Lowering enteric methane
2) Reducing inputs and inefficiencies
   - Making better use of resources
3) Intensification
   - Increasing milk and meat production (i.e., more food per unit of GHG produced)



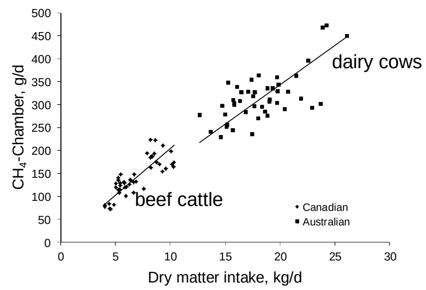
Strategies to Improve GHG Efficiency

1) Technology to reduce emissions
   - Lowering enteric methane

Methane Production in the Rumen



Methane Emission and Dry Matter Intake



Grainger et al. 2007. J. Dairy Sci. 90:2755.

Strategies to Improve GHG Efficiency

1) Technology to reduce emissions

- Lowering enteric methane

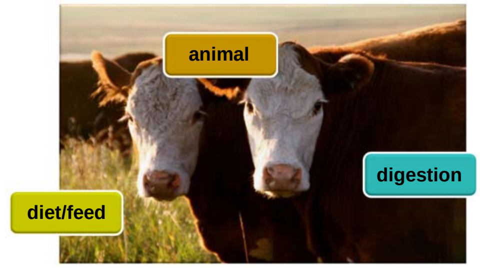


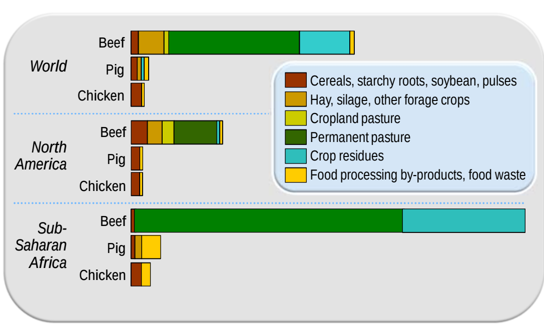
photo by Julia Palmer

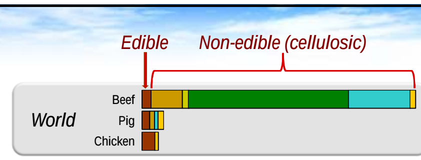
Animal Breeding

- High vs. low methane emitters
  - Realistic given other breeding objectives?
- Genetic selection of efficient animals (eat less, produce the same)
  - Efficient cattle produced 24% less methane/kg gain (Hegarty et al. 2007. JAS 85:1479)

Low Methane Diets

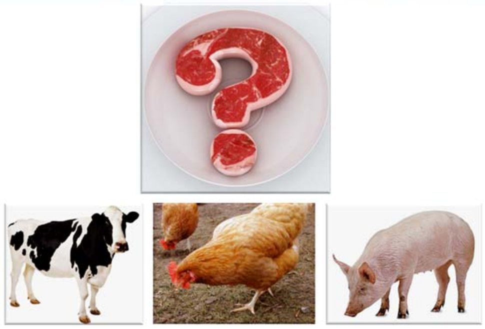
Relative Feed Intake per Carcass Produced (energy basis) Wirsenius 2003. Agric. Sys. 77:219–255



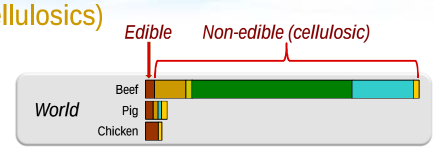


Ruminants

- Enteric methane lower for grain vs cellulosic diets
- Feeding grain decreases methane and (in most cases) total GHG emissions/product
  - need to use a LCA
- Not consistent with niche role of ruminants of converting high fiber feeds to meat/milk



Reducing Enteric Methane from Non-Edible (cellulosics)



- Maturity effects (fiber)
- Legumes vs. grass
- Tannin-containing legumes
- High starch forages (maize, cereal silages)
- High sugar content grasses (Ireland)
- High lipid content ryegrass and clover (NZ)

Oilseeds, High-fat Byproducts

- Boost the lipid content of the diet (up to 4-6%)
- 4-5% reduction in methane (g/kg DMI) /1% added lipid
- Diverse mode of action
- Sources:
  - Oilseeds (e.g., canola [rapeseed], linseed, sunflower)
  - Byproducts (e.g., corn distillers grains)

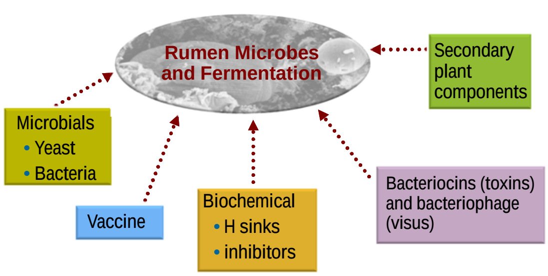
Adding Ground Oilseeds (3% added fat) to Diets fed to Lactating Dairy Cows

Methane	Control	Linseed	Canola (rapeseed)
Dry matter intake, kg/d	18.7[c]	19.0[bc]	20.1[a]
Milk, 3.5% fat	24.2	23.5	23.7
Methane, g/d	293[a]	241[b]	265[b]
Methane, g/kg DMI	16.3[a]	13.4[b]	13.7[b]

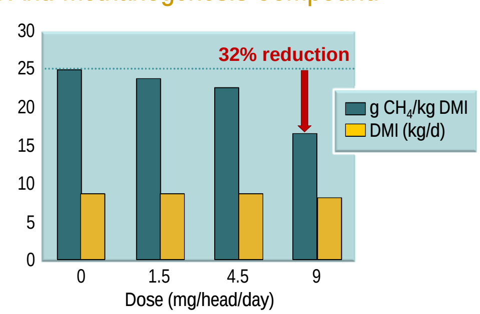
16-18% reduction

(Beauchemin et al., 2009. J. Dairy Sci. 92: 2118)

Modification of Rumen Mircoflora and Fermentation

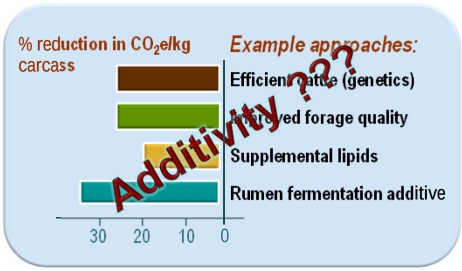


Supplementation of Beef Cattle diets with an Anti-methanogenesis Compound



(Beauchemin et al., unpublished)

Reductions in methane emissions: What is feasible?



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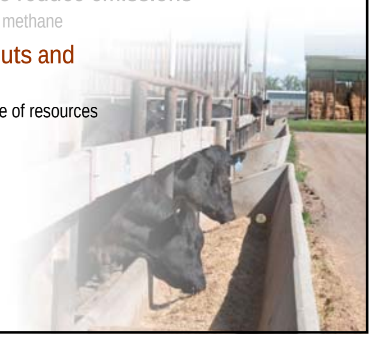
2) Reducing inputs and inefficiencies
   - Making better use of resources



Improving Efficiencies: Animal Management

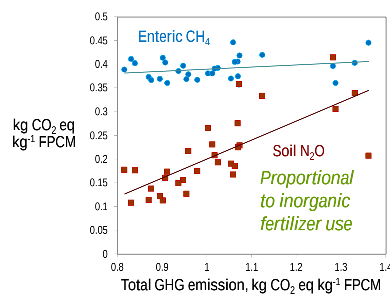
Example:

- Longevity of dairy cows in the herd
- Culling due to reproduction, heath, etc. affects replacement rate (need for replacement heifers)

Replacement Rate	GHG (kg CO_2/kg FPCM)	
22%	0.66	
37% (mean)	0.96	±30%
51%	1.39	

Estimated for a Canadian dairy farm (2011); no allocation

Reducing Inputs: "Cradle-to-Farm Gate" LCA of Milk Production in Norway (Bonesmo et al., unpubl.)



Strategies to Improve GHG Efficiency

1) Technology to reduce emissions
   - Lowering enteric methane
2) Reducing inputs and inefficiencies
   - Making better use of resources
3) Sustainable intensification
   - Increasing milk and meat output
   (i.e., more food per unit of GHG produced)

Sustainable Intensification

- *"The key is to develop sustainable intensification methods that improve efficiency gains to produce more food without using more land, water, or other inputs"*
  - (Herrero et al. 2010 Science 327:822)

Comparing Environmental Impact of U.S. Beef Industry in 1977 to 2007

(J. Capper, Washington State University)

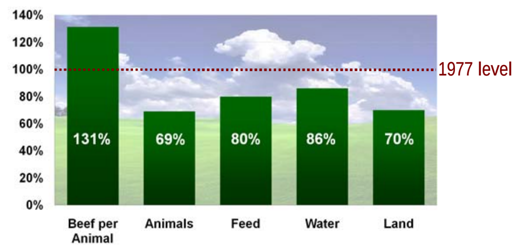


Figure from J Capper, Wash State Univ.

Comparing Environmental Impact of U.S. Beef Industry in 1977 to 2007

(J. Capper, Washington State University)

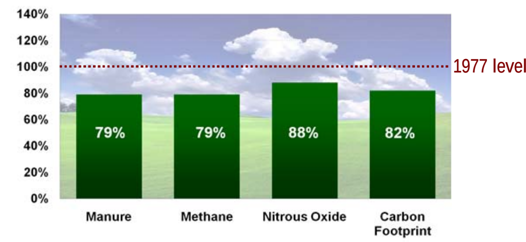


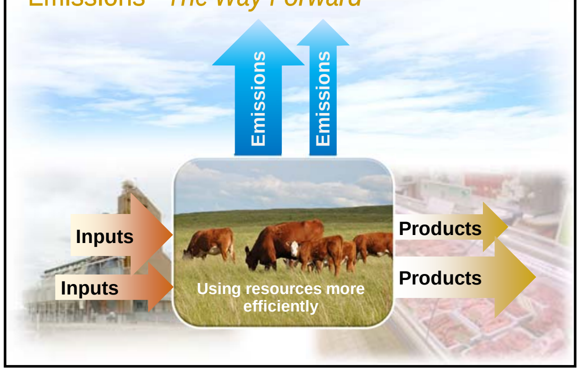
Figure from J Capper, Wash State Univ.

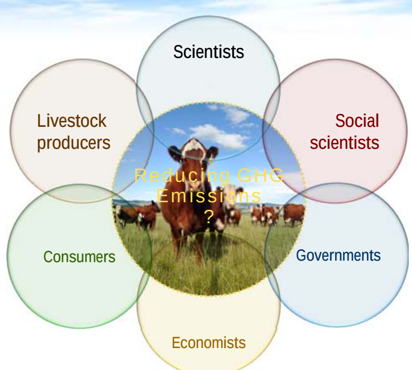
Intensification in Low Income Countries?

- Simply adopting a “western” approach is not an option
- Mainly small holder mixed farms (land ⇄ livestock)
  - Bigger not necessarily better
  - Animal genetics of adapted breeds
  - Feed supply critical
    - Crop residues and by-products
      - 50-70% of feed inputs
      - Need technology to improve feed yield, increase digestibility

Wright et al. 2011. J Sci Fd Ag 92:1010

Finding a Balance Between Food and GHG Emissions - *The Way Forward*





Young scientists to take on the challenge …

Aimable Uwizeye
MS student, Rwanda

Divakar Vyas
Post Doctoral Fellow, India

Atmir Romero Perez
PhD student, Mexico

Emma Mc Geough
Post Doctoral Fellow, Ireland

Martin Huenerberg
PhD student, Germany

Atitthan Nanon
PhD student, Thailand

Paul Escobar Bahamondes
PhD student, Chile

Noppharat Phakachoed
PhD student, Thailand

Riaz Mohmmed
Post Doctoral Fellow, India

Joseph Lynch
Post Doctoral Fellow, Ireland

2011 Bertebos Prize

Established Animal Science –
Environmental Sustainability Scholarship

At Kwame Nkrumah University of Science and Technology (KNUST), GHANA

2012-2013 recipient -