GHG emissions from dairy food chains

Development of a quantification model using the Life Cycle Assessment approach

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- Tentative results
  - allocation: meat versus milk
  - intensivity: regional differences and farming systems
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The dual challenge

- Livestock: a growing sector, especially in developing countries
  - driven by income, demography and changing preferences,
  - among highest growth rate in agriculture commodity
  - over 80% of production growth in non OECD countries

(OECD-FAO, 2009)

- Climate change
  - the worst-case ipcc scenario trajectories are being realized
  - societies are highly vulnerable, with strong differential effects on people within and between countries and regions.
  - risk of crossing tipping points
  - there is no excuse for inaction

(Climate Change: Global Risks, Challenges & Decisions – 2009, Copenhagen)

↳ Dual challenge of food security and climate change mitigation

Objectives

- General objective: inform decision making
  - Policy makers: climate, agriculture and food security policies
  - Private sector: benchmarking and identification of mitigation options
  - *Consumer: food choices*

- Specific objective: Produce estimates of GHG emissions for:
  - major dairy products and related services: milk, cheese, butter, cream, milk powder, manure, and traction;
  - predominant dairy production systems (e.g. grass-based, mixed crop-livestock);
  - main world regions and agro-ecological zone; and
  - major activity steps along the dairy chains.

The choice of LCA

- Widely **accepted**.
- Ability to provide a **holistic assessment** of production processes.
- Provides a framework to **identify the most effective** ways to reduce environmental burdens.
- Capacity to **prevent shifting** environmental problems from one phase of the life cycle to another.

Approach

- Requirements
  - design an "universal" approach, that allows cross-systems and cross-regional comparisons.
  - design an approach that can be implemented using currently available datasets.

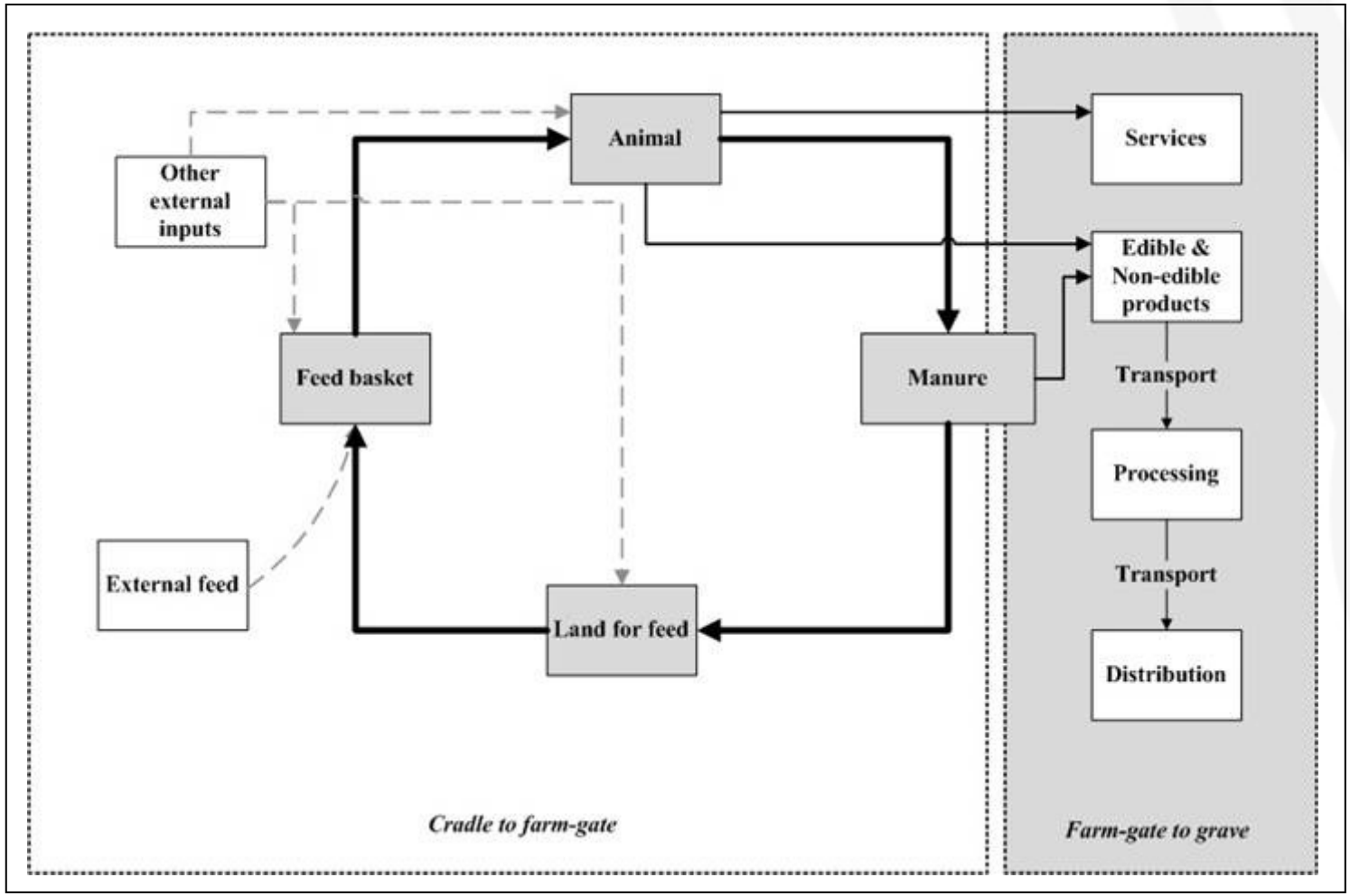
- Main features:
  - draw from national inventories and a growing body of literature.
  - methodological issues and preliminary results discussed with a group of experts (WUR, INRA, SIK, ILRI, Danone, ITE, Agroscope, JRC).
  - coupled with economic modeling – cost effectiveness analysis, poverty and food security implications.
  - Attributional assessment.

Functional units

- Dairy-cattle production systems produce :
  - Edible products: meat and milk
  - Non-edible products and services: draught power, leather, manure and capital.

- Functional Units: kg of FPC milk and bone- free meat at the farm gate.

System boundaries



System boundary

GHG emissions sources included

From cradle to farm gate

- Processes for producing grass, feed crops, crop residues, by-
- f fertilizer
- ement of
- n carbon
- gen losses.
-
-
- g, cooling,

Fr

- uses.
- ilk,

yoghurt, cheese, butter, milk powder and bone free meat.

- Packaging and waste handling.
- Refrigeration.
- Transport of processed products to retailer.

The assessment does not include GHG emissions related to:

- land use under constant management practices;
- capital goods such as farm equipment and infrastructure;
- on-farm milking and cooling;
- production of cleaning agents, antibiotics and pharmaceuticals

GHG emissions calculations

- Follows IPPC Tier 2, GHG emissions expressed in CO_2eq.
- Input data
  - animal numbers
  - feed composition (digestibility, N content)
  - feed production parameters (land use change, fertilization, mechanization)
  - manure management
- Land use change
  - 3 types of soybean considered
  - no emissions under constant management practices, 20 years time frame
- Post farm gate
  - 6 commodities
  - statistics and literature review

GHG emissions calculations

- Emissions related to goods and services other than meat and milk calculated separately and deducted from overall emissions before attribution to meat and milk.

- Allocation rules
  - beef versus dairy: based on relative protein content.
  - manure: emissions corresponding to chemical fertilizer of equivalent content attributed to crops, remainder to livestock; manure burnt exits the system after deposition.
  - draught power: physical allocation based on extra longevity of animals.
  - financial and insurance services: no emissions allocated.

Overview of system classification

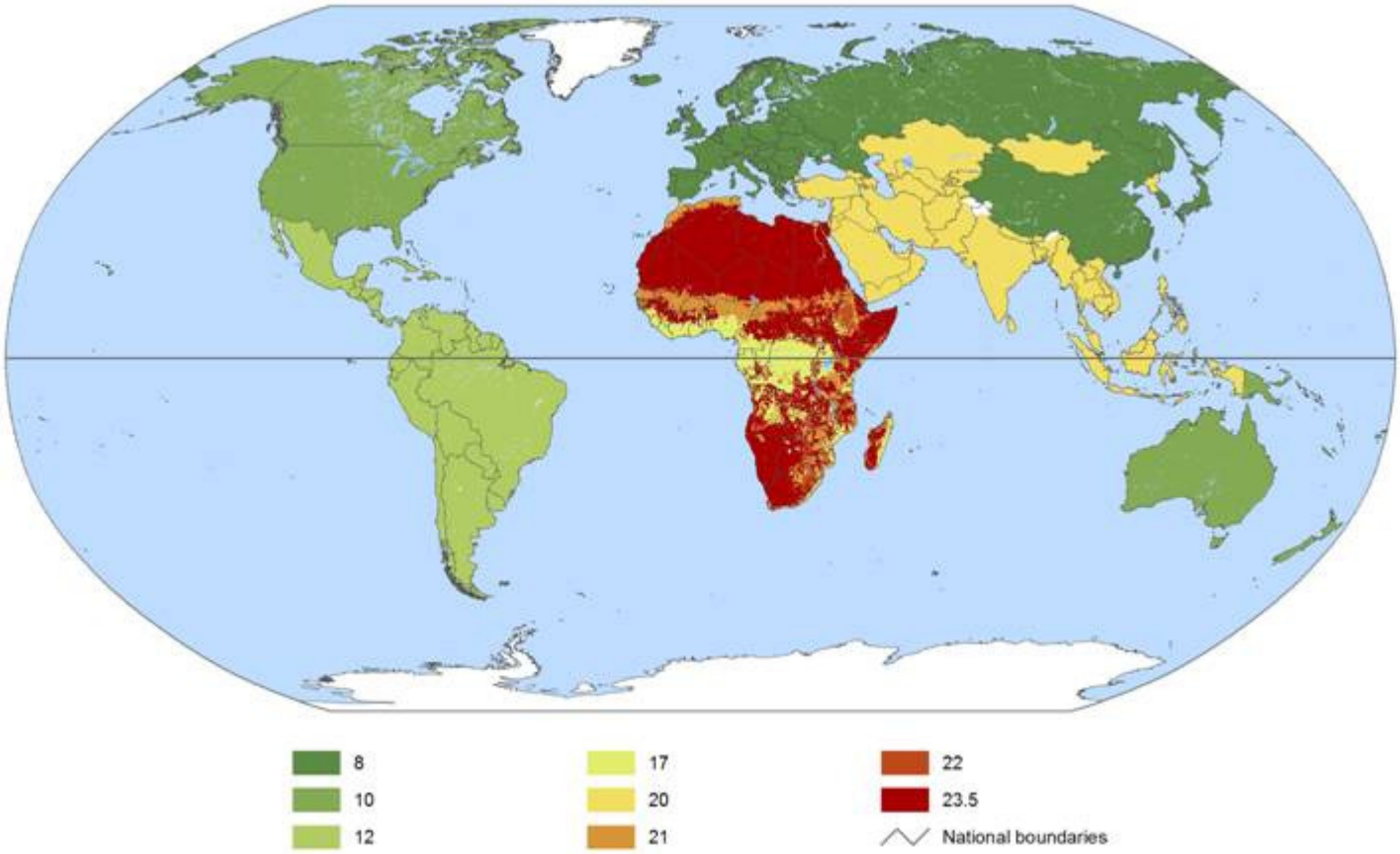
Specie	Techn. 1	Techn. 2	Climate	Country
Cattle	Dairy	Mixed	arid humid temperate	A B …
		Grazing	arid humid temperate	A B …
	Pure beef	Mixed	arid humid temperate	A B …
		Grazing	arid humid temperate	A B …
	Dual purpose	Mixed	arid humid temperate	A B …
		Grazing	arid humid temperate	A B …

Data management and calculation

- Entirely based on GIS
  - finest resolution: 0.0089 arc degrees, or ca. 8.3km x 8.3 km at equator
  - calculation implemented in GIS software
  - results re-aggregated at various levels (e.g. species, farming system, region, climatic zone)

Input data example (i)

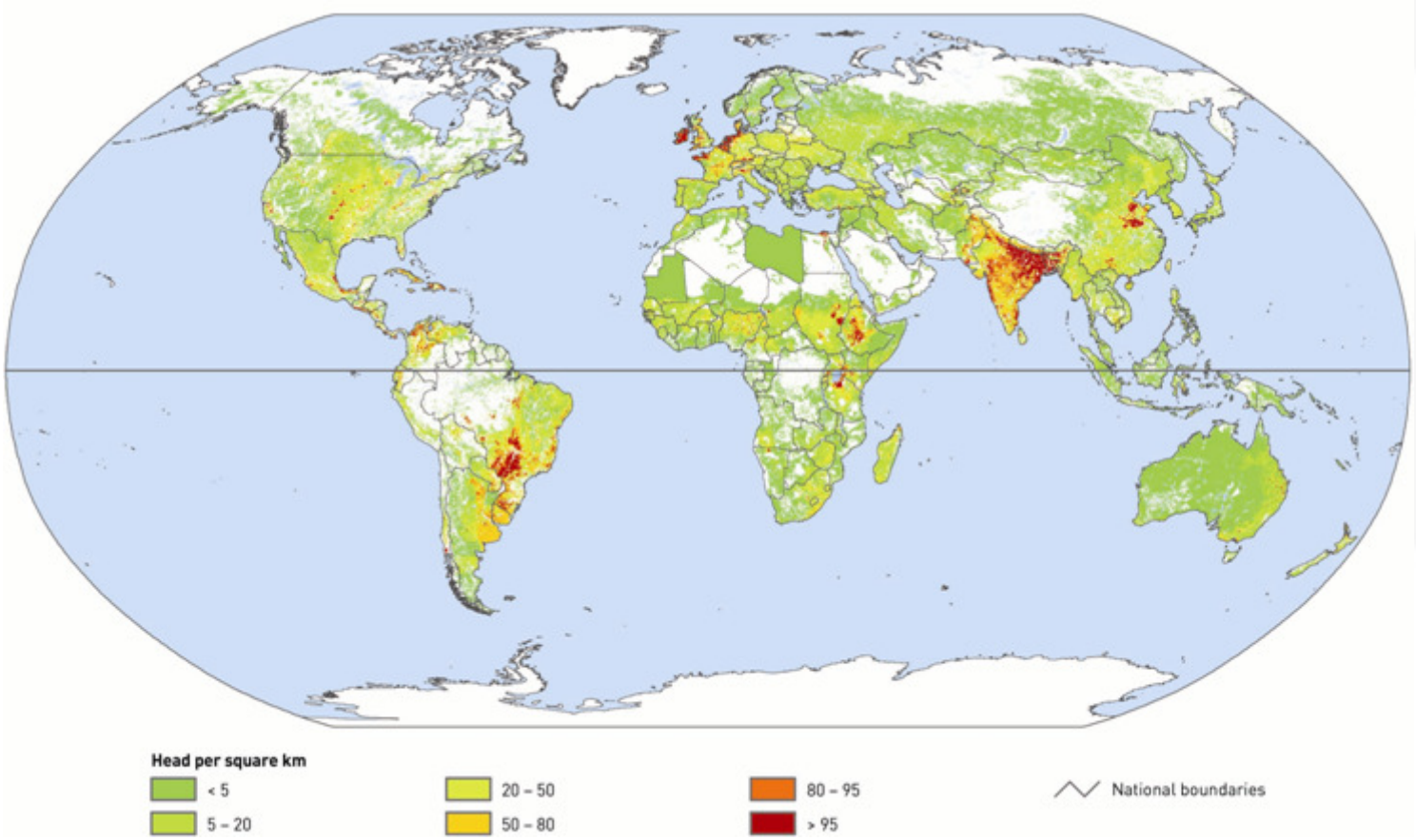
Death rate of calves (%)



Source: various

Input data example (ii)

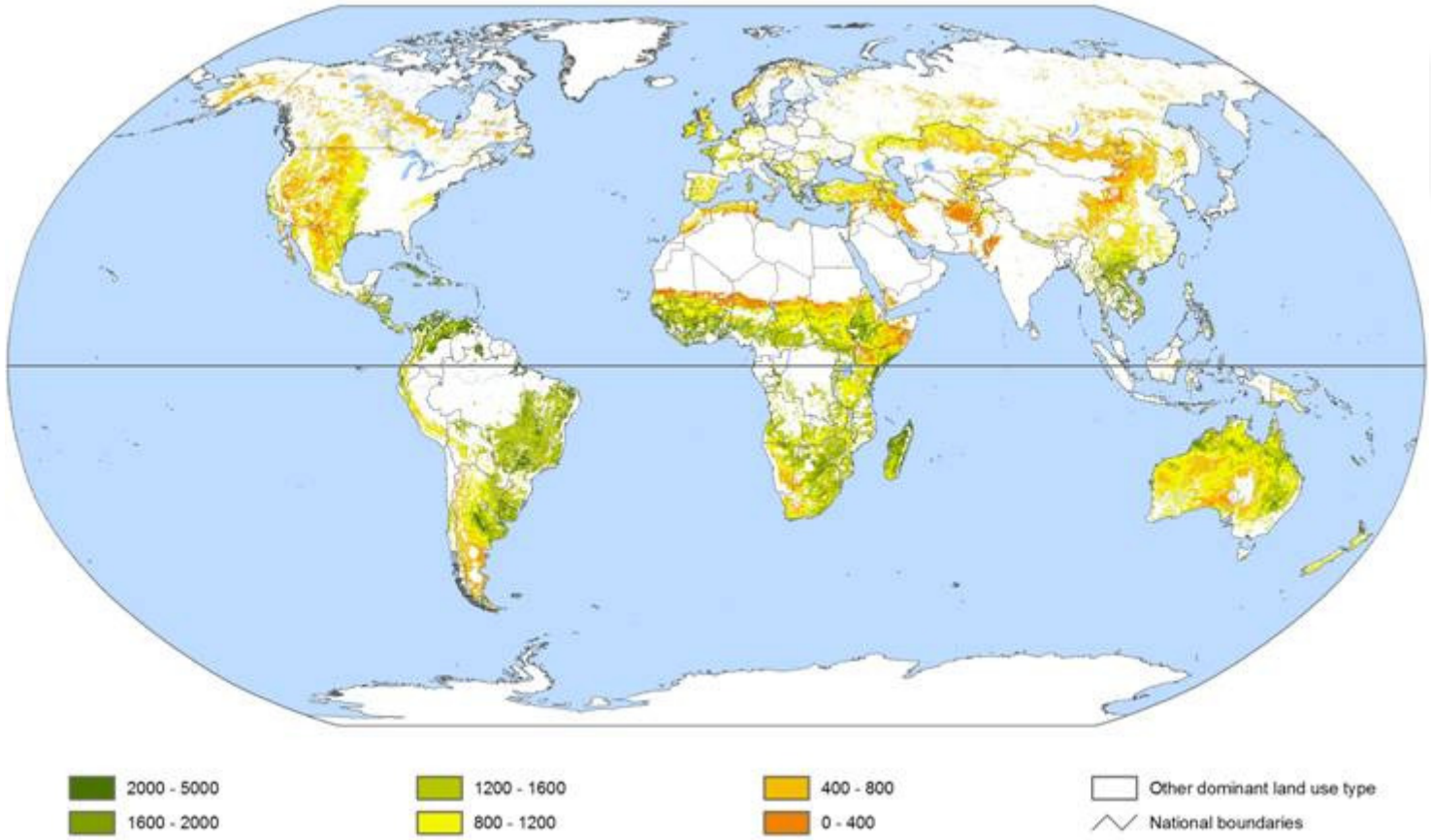
Estimated cattle distribution



Source: FAO

Input data example (iii)

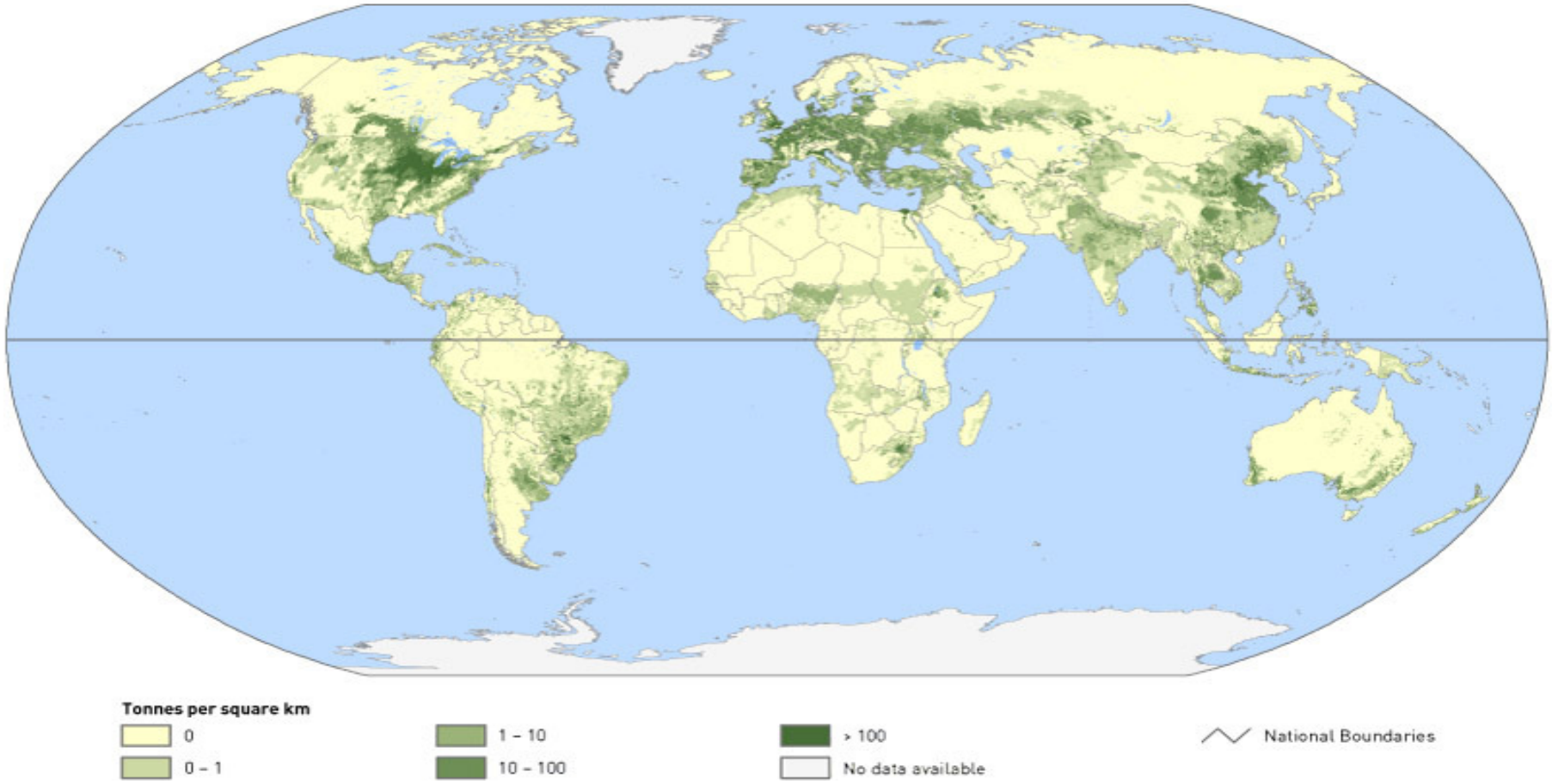
Estimated net primary productivity in areas dominated by pasture (g. of C per m2 per year)



Source: Prince and Goward, 1995

Input data example (iv)

Estimated maize, wheat and barley production for animal feed



Source: FAO-IFPRI

Herd model – results for the Netherlands

Herd constitution matters

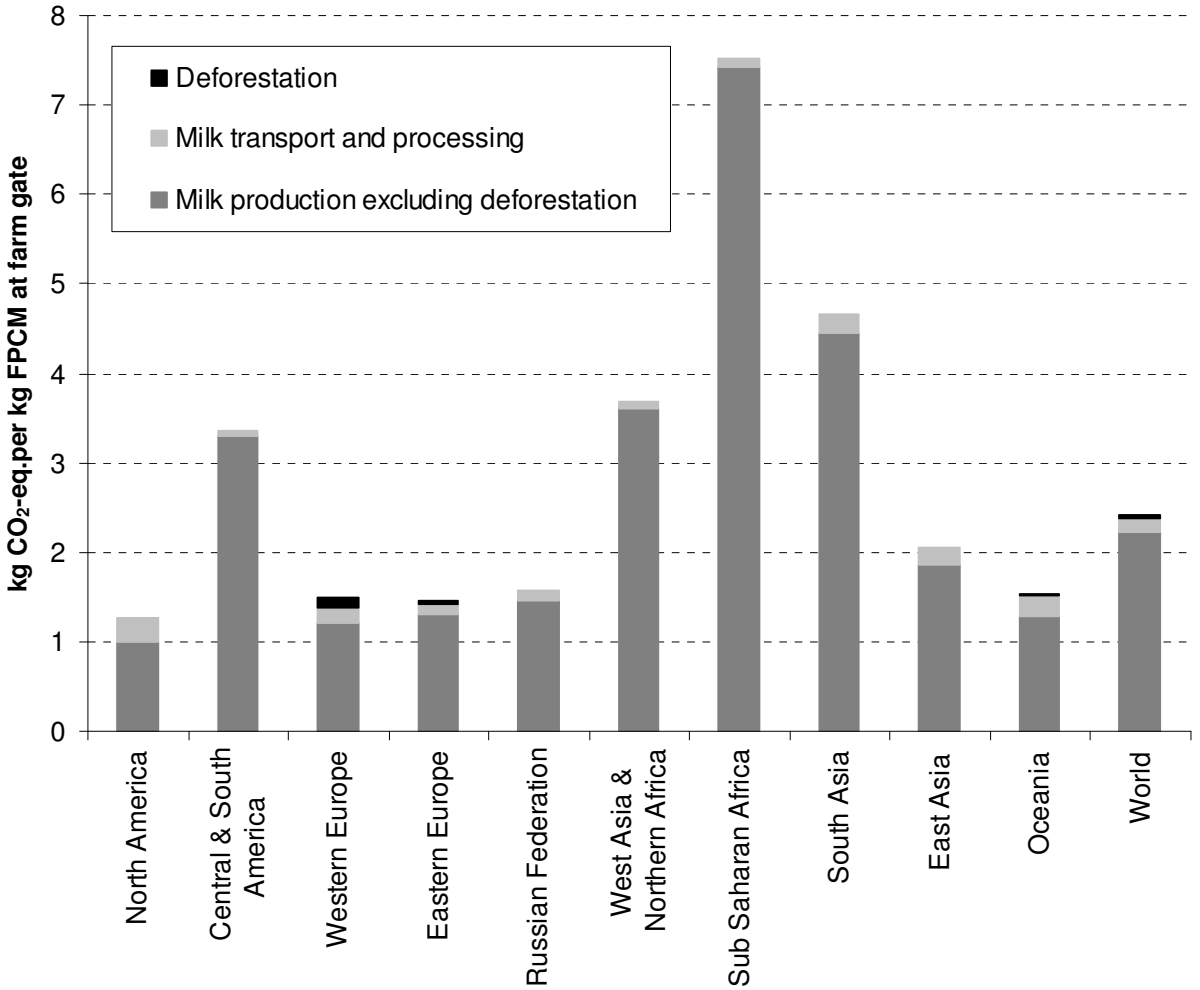
Total cattle	**3 730 000**	
	Dairy herd	**Beef herd**
Milked cows	**1 450 000**	139 500
Replacement female	1 025 032	43 860
Male for reproduction	14 500	5 580
Replacement male	15 117	5 695
Meat female	233 398	54 687
Meat male	682 998	59 613
Dairy related herd	**3 421 045**	**308 955**

Results - overview

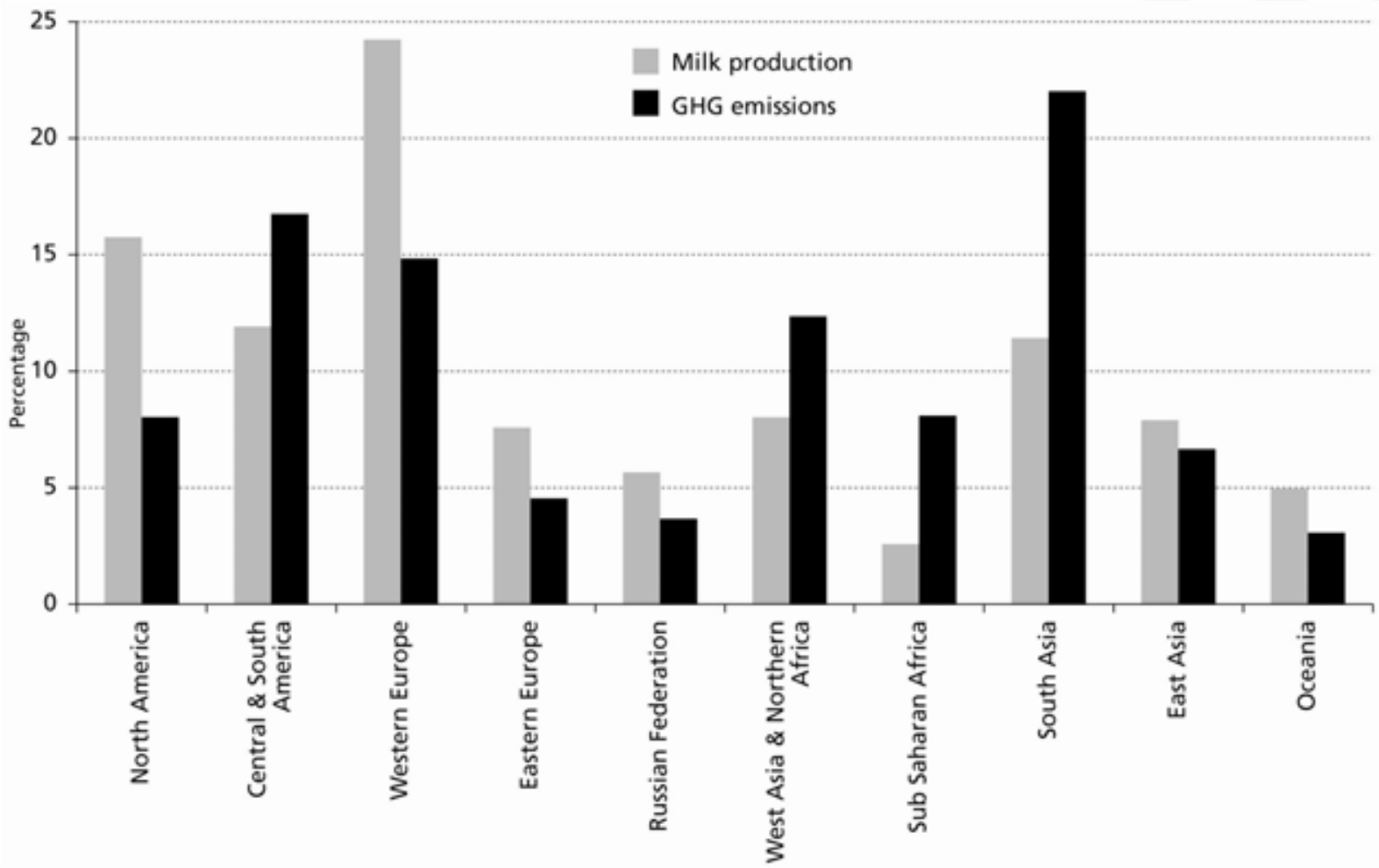
- The global dairy sector contributes 4.0 percent to the total global anthropogenic GHG emissions [±26 percent].
- The overall contribution of the global milk production, processing and transportation to total anthropogenic emissions is estimated at 2.7 percent [±26 percent].
- The average global emissions from milk production, processing and transport is estimated to be 2.4 kg CO2-eq. per kg of FPCM at farm gate [±26 percent].

Results – regional variations

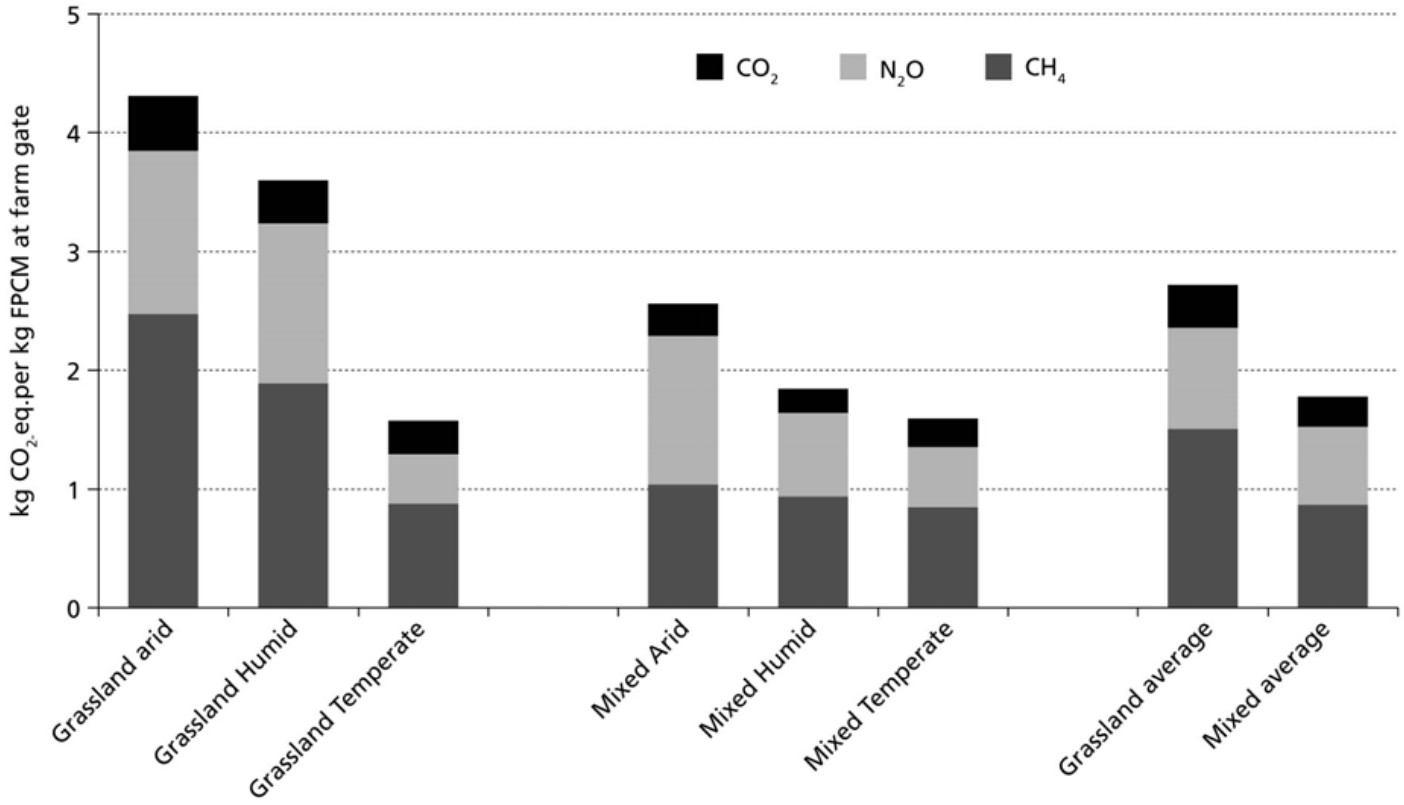
GHG emissions per kg of FPCM, averaged by main regions and for the world.



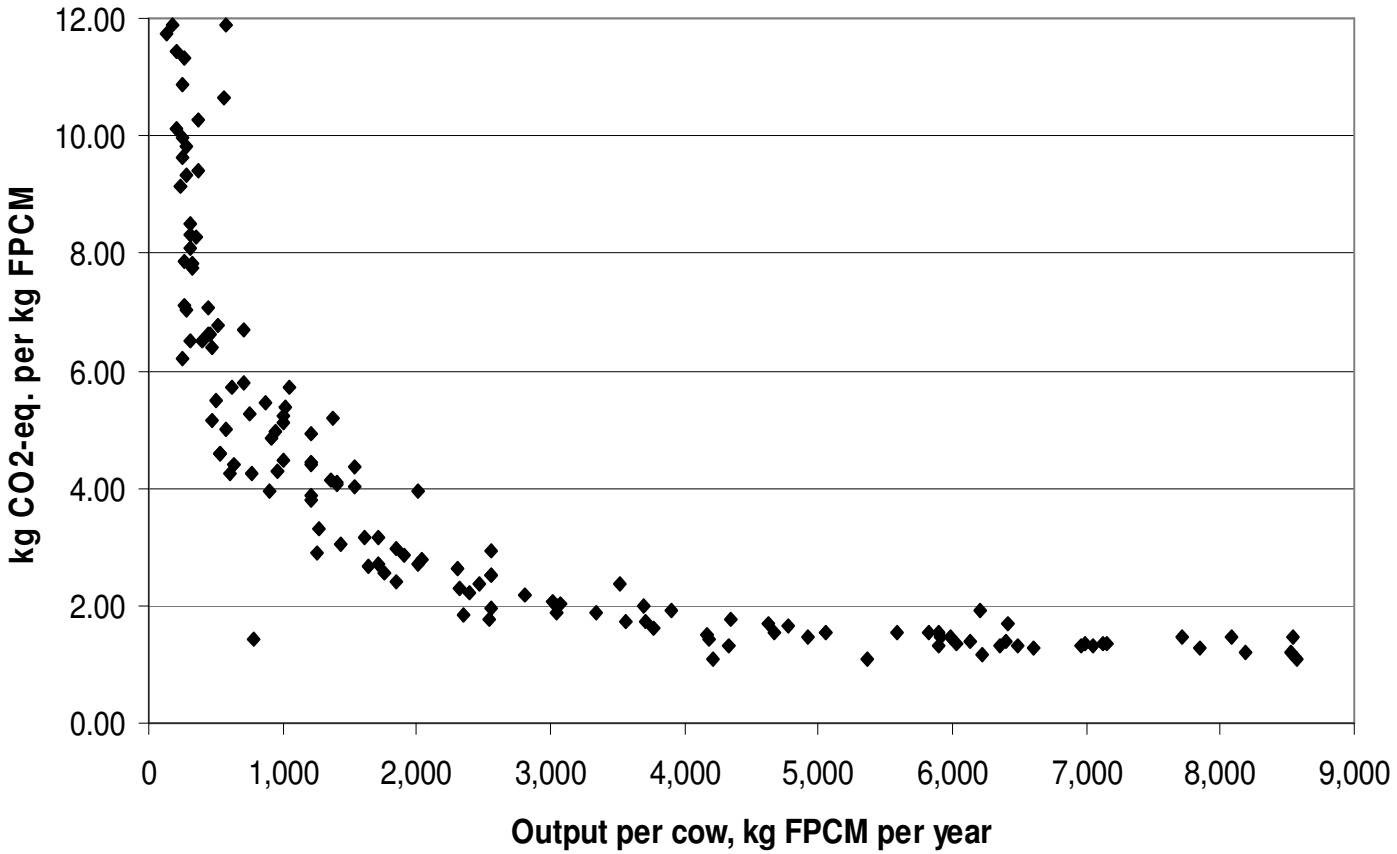
Relative contribution of world regions to milk production and GHG emissions associated to milk production, processing and transportation



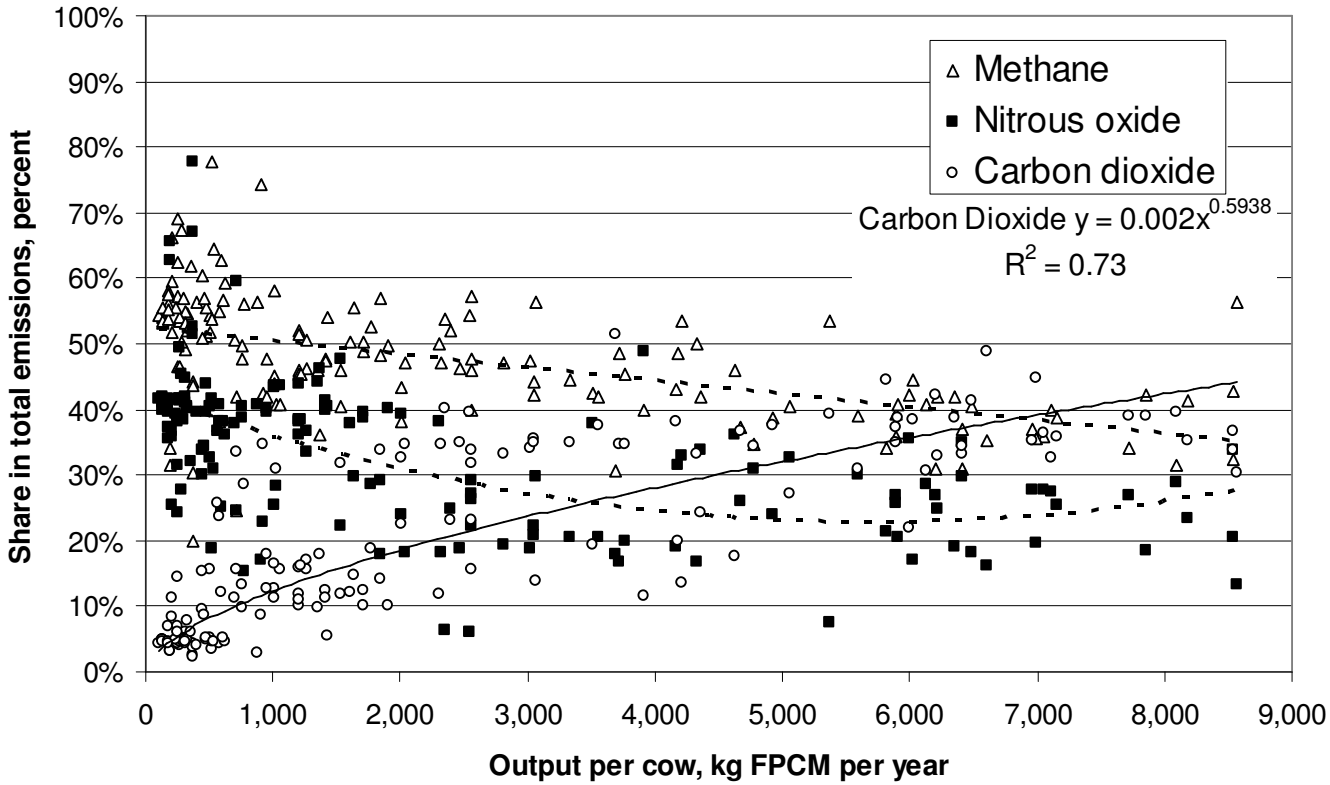
GHG emissions per kg of FPCM, by main farming systems and climatic zones



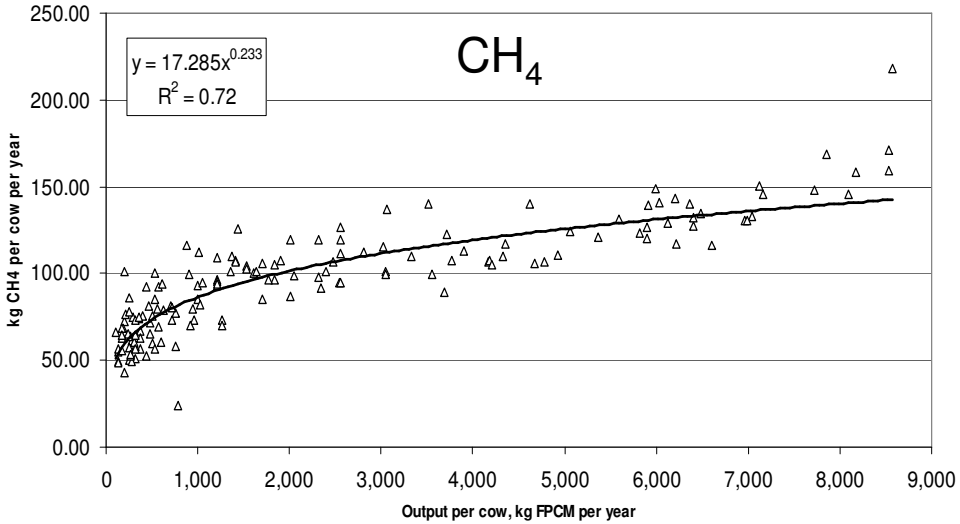
Relationship between total greenhouse gas emissions and output per cow

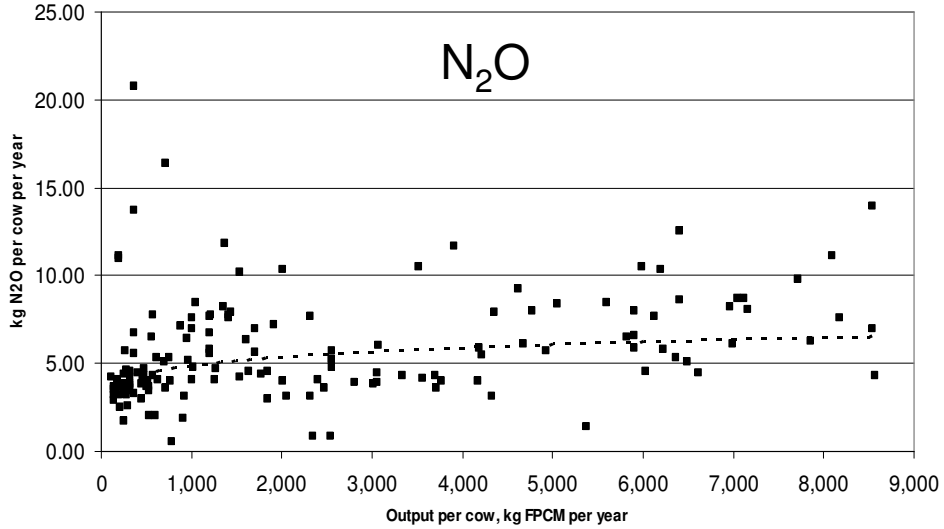


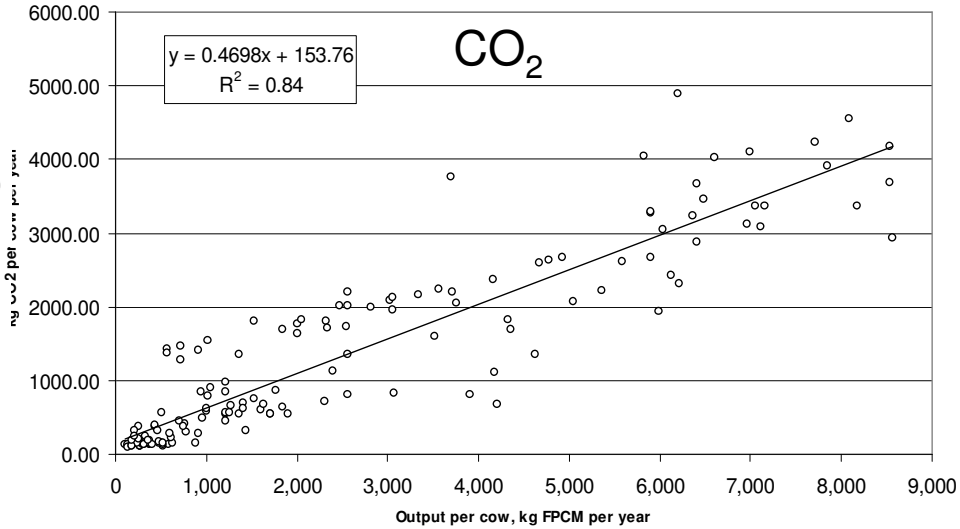
Fraction of methane, nitrous oxide and carbon dioxide in total GHG emissions, in relation to output per cow



Relationship between: GHG emissions per cow and output per cow







Compared performances of dairy and beef herds

Country	Emissions to proteins (kg CO2eq./kg protein)	
	Dairy herd	Beef herd
The Netherlands	46	176
Brazil	128	455
India	160	543

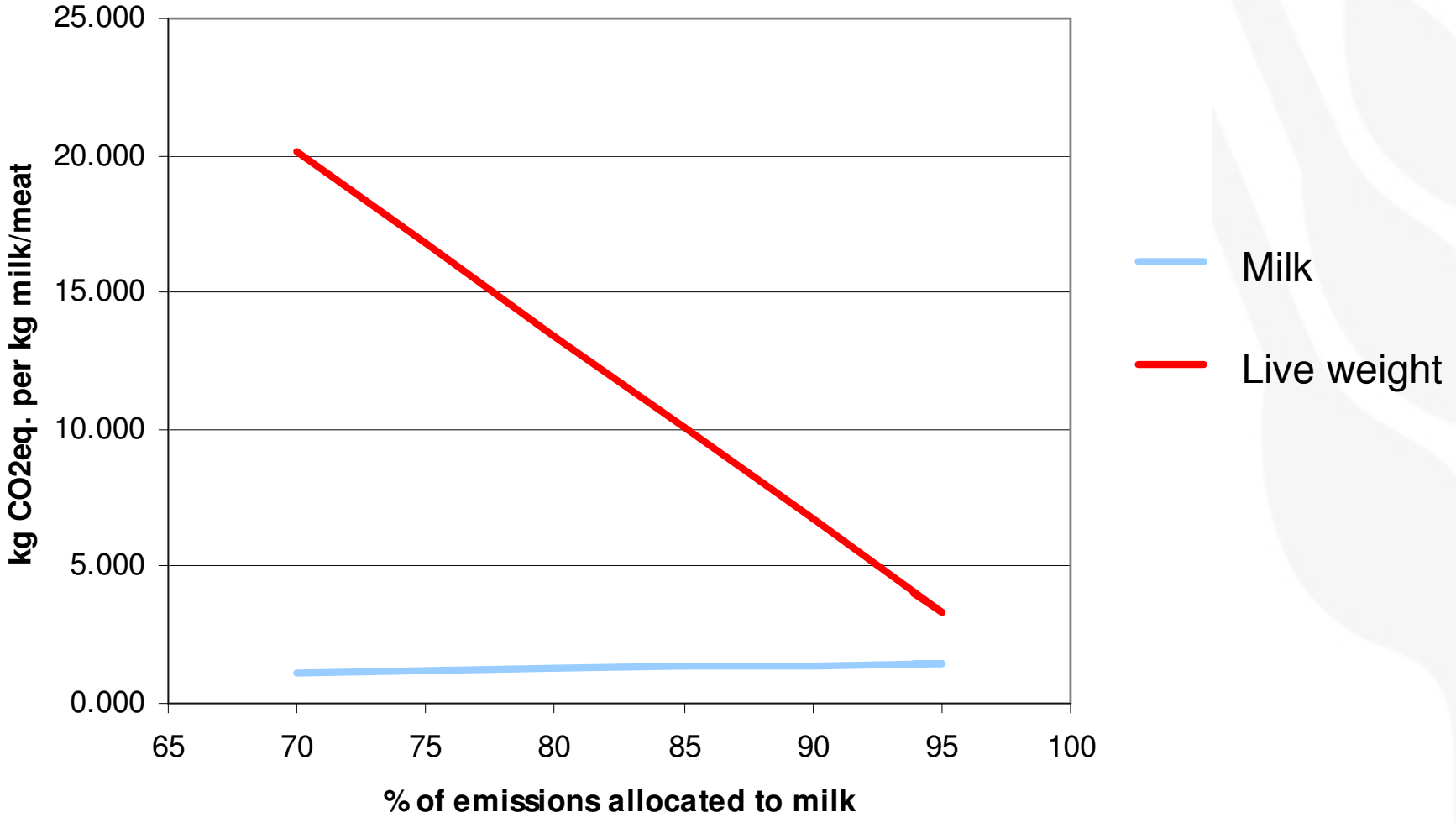
Effect of replacement rate in milked cows in the Netherlands

		rr of 33% (3 lactations)	rr of 12.5% (8 lactations)
Meat, carcass weights	t/year	280,428	206,081
Milk	t/year	10,585,000	10,585,000
Emission per kg animal protein	kg CO2eq / kg protein	45.70	42.25
Emission per kg milk	kg CO2eq / kg milk	1.55	1.44
Emission per kg meat	kg CO2eq / kg meat	8.68	8.02

Effect of replacement rate in milked cows in the Netherlands

		rr of 33% (3 lactations)	rr of 12.5% (8 lactations)	rr of 12.5% (8 lactations) + Beef production
Meat, carcass weights	t/year	280,428	206,081	280,428
Milk	t/year	10,585,000	10,585,000	10,585,000
Emission per kg animal protein	kg CO2eq / kg protein	45.70	42.25	47.52
Emission per kg milk	kg CO2eq / kg milk	1.55	1.44	1.44
Emission per kg meat	kg CO2eq / kg meat	8.68	8.02	15.66

Sensitivity to allocation



Overview of results

- **Emissions per unit of animal protein** is substantially lower in the dairy systems (including meat) than in the pure beef systems.
  - most difference come from cows and replacement females.
- Emissions from milk and beef production need to be addressed in an **integrated approach.**
- Milk emissions expressed per unit of output are marginally sensitive to **allocation rule**, contrary to emissions from meat production. (total volume of output is greater for milk – factor 5 in the Netherlands).
- **Feed digestibility and milk yield** are key factors influencing emission level (C fluxes related to land use and land use change not yet included).

Discussion

- Uncertainties
  - statistics
  - emission factors (IPCC)
- Simplifications and assumptions
  - allocation
  - land use change

➢ sensitivity analysis, margin of error of ±26 percent.

- Validation
  - no comparison with direct measurements
  - herd model results with national statistics where available
  - results compared with literature where available

- Continuing process
  - data management and automatic scripts
  - country reporting?
  - interval and need for continuous effort

Next steps

- Adapt the model for pig and poultry
- Complete data collection
- Improve sensitivity analysis
- Prepare reports and feed results into economic analyses

- Completion estimated by late 2010