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# Overview of Enteric Fermentation Methane Emissions and Options for Mitigation

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Methane to Markets
Partnership Expo
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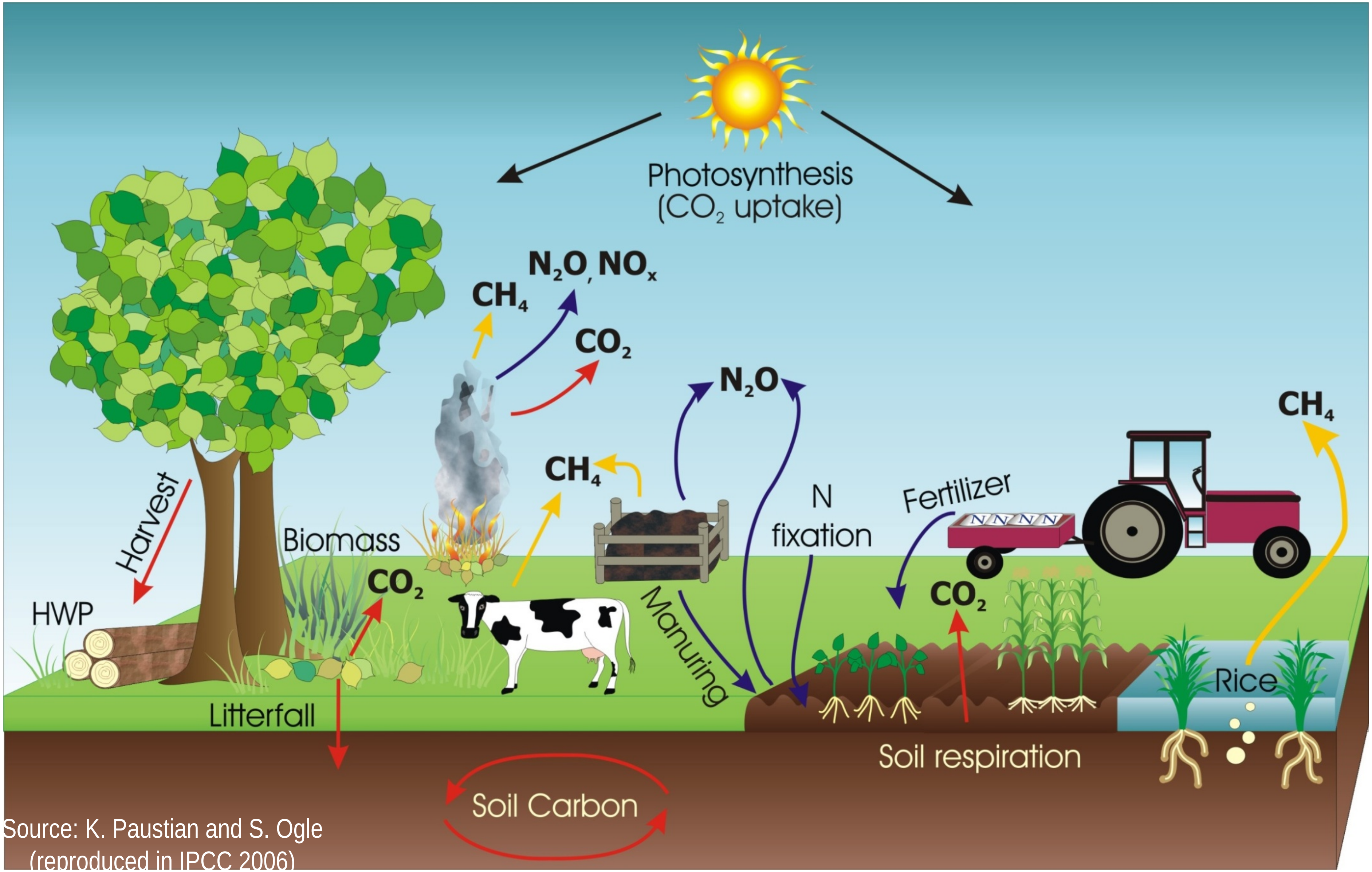
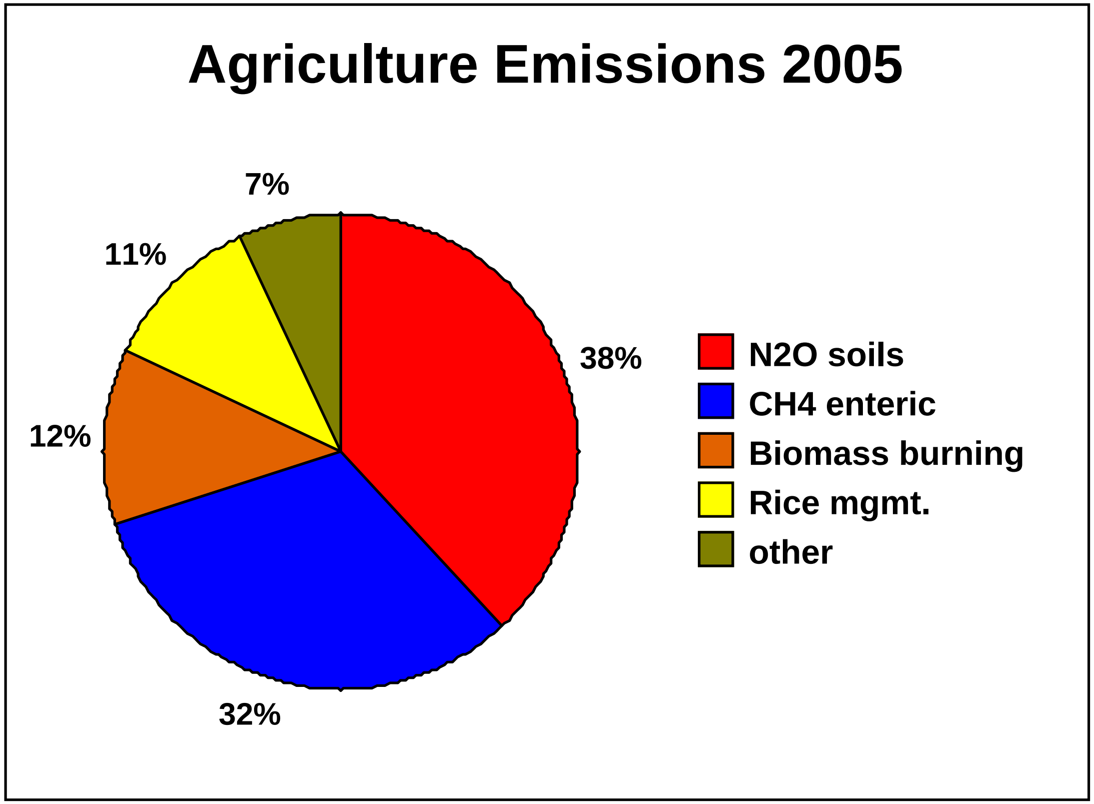
# Enteric Fermentation in the Context of AFOLU



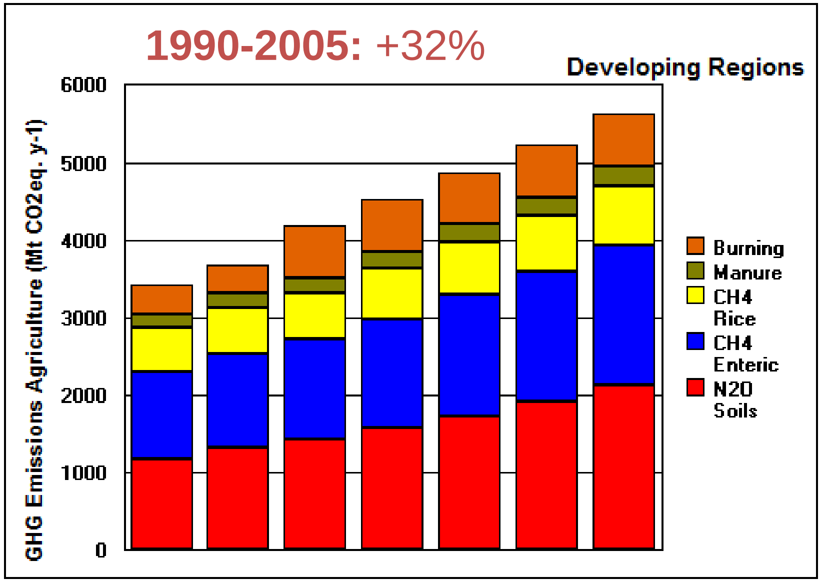
Source: K. Paustian and S. Ogle
(reproduced in IPCC 2006)

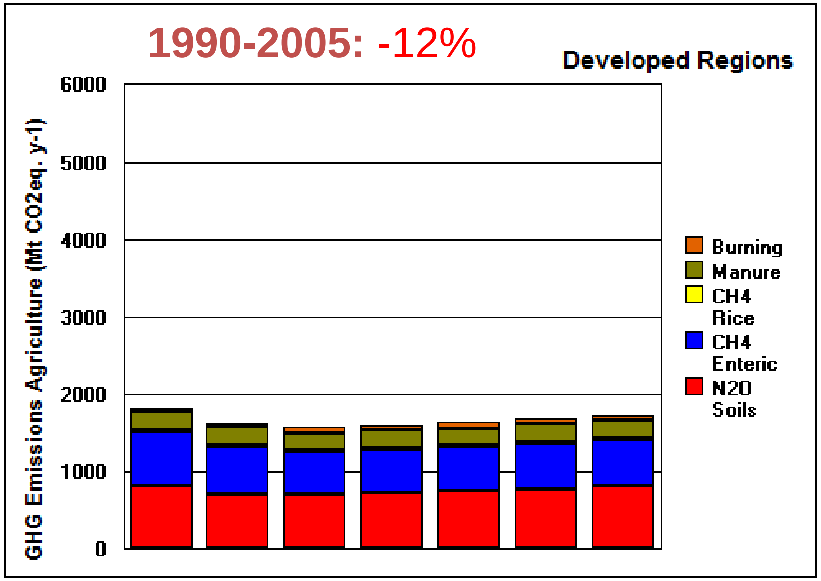
# Global $CH_4$ Emissions from Enteric Fermentation



- **Total GHG emissions in 2005: 45 Gt $CO_2$-e**
- **Total agricultural emissions ($CH_4$, $N_2O$) in 2005: 6.2 Gt $CO_2$-e**
- **$CH_4$ from enteric fermentation: 6.2 Gt $CO_2$-e (4.4 % of global emissions)**

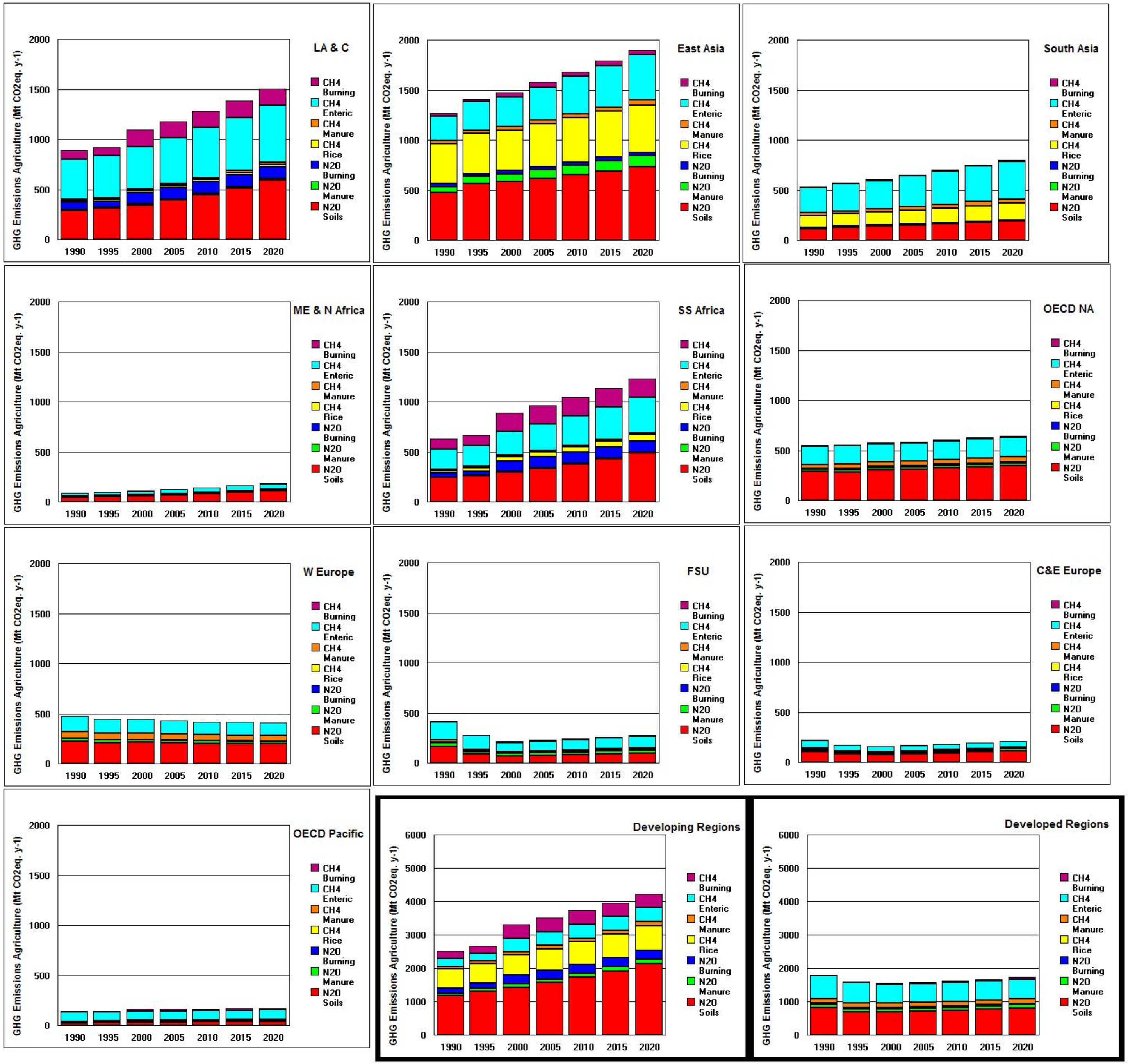
# Agriculture Emissions 1990-2020





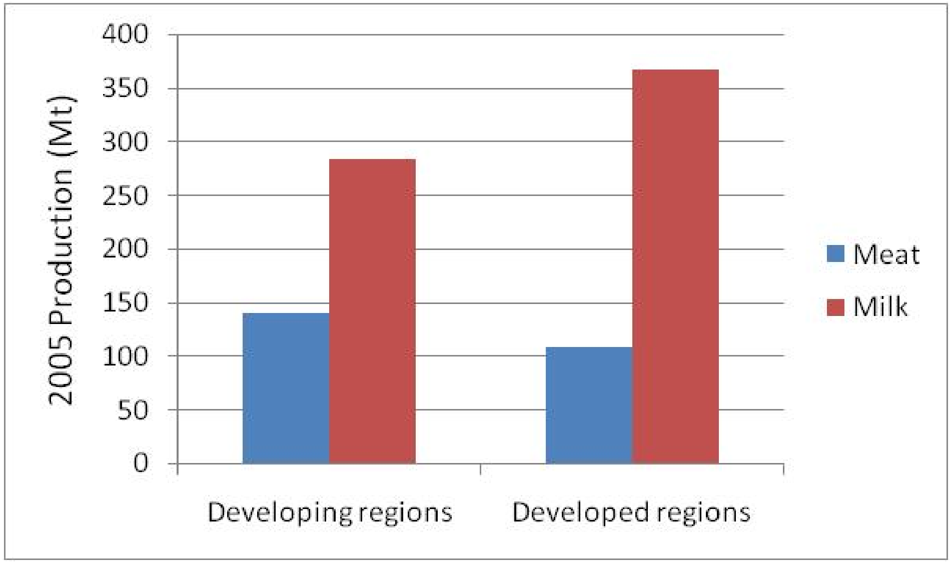
## Main drivers for trends

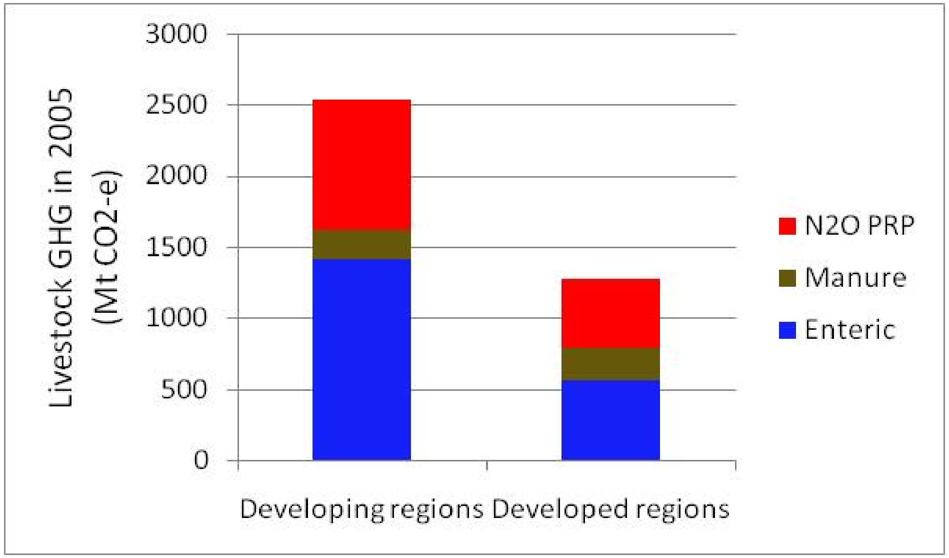
- Increase in GHGs: population pressure, income increase, diet changes, technological changes
- Decrease in GHGs: increased land productivity, conservation tillage, non-climate policies



Source: US-EPA 2007

# Livestock Production and GHG Emissions

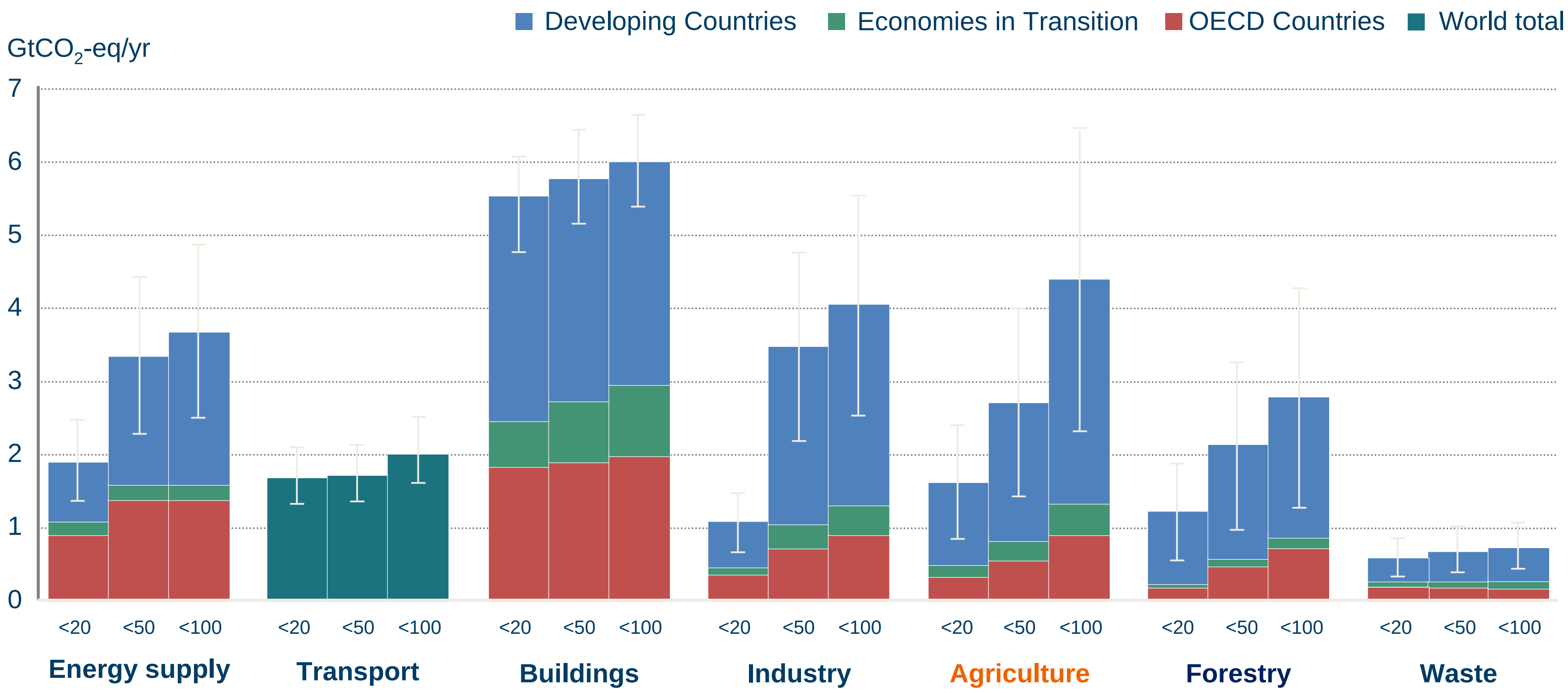




In spite of relatively similar levels of production of meat and milk, GHG emissions from livestock are much higher in developing than in developed regions

- Enteric: 150% higher
- $N_2O$ PRP: 90% higher
- Manure: 10% lower
- LULUCF emissions and biomass burning were not considered. These are most significant in developing regions

# IPCC AR4: Mitigation Potentials by Sector



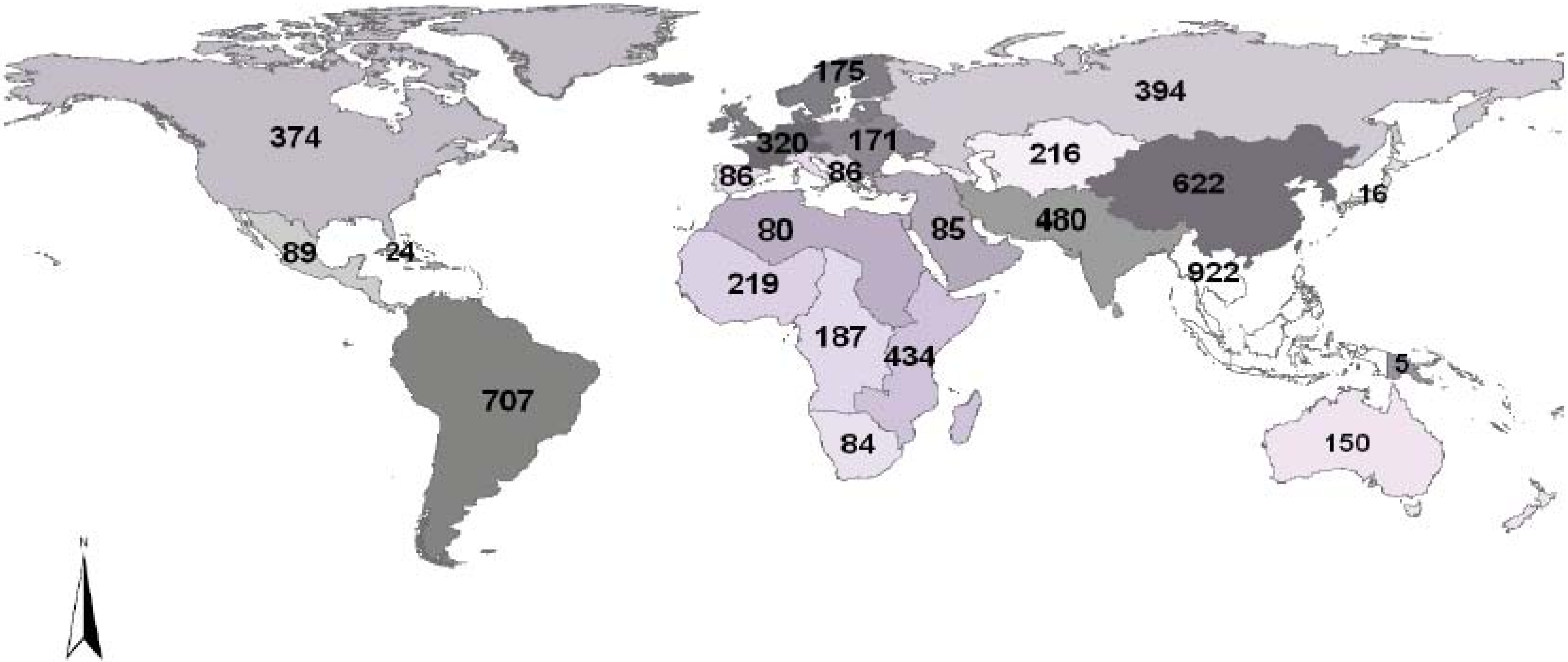
**Relative contribution of Agriculture to total mitigation potential**

**US$ 20/tCO2 – 12%**

**US$ 50/tCO2 – 14%**

**US$ 100/tCO2 – 19%**

# Agriculture: Regional Distribution of Technical Potential



**70% of technical potential is in developing regions**

**2/3 of potential not covered by Kyoto mechanisms**

# IPCC AR4: Economic Mitigation Potential in 2030

| **Carbon price (US$/$tCO_2$-eq)** | **Economic Potential 2030 in Agriculture ($GtCO_2$-eq/yr)** |
|---|---|
| **20** | **1.6** (0.3-2.4) |
| **50** | **2.7** (1.5-3.9) |
| **100** | **4.4** (2.3-6.4) |
| **Baseline Emissions in 2030** | **8.2** |

**Mitigation practices in agriculture**

Cropland management; Restoration of organic soils; Rice management; Grazing land management – 90% of potential is carbon sequestration

The mitigation potential in agriculture is very high, but reduction of ruminant $CH_4$ emissions has a very limited contribution to that potential (**0.2 $GtCO_2$-eq/yr** at US$ 100/$tCO_2$)

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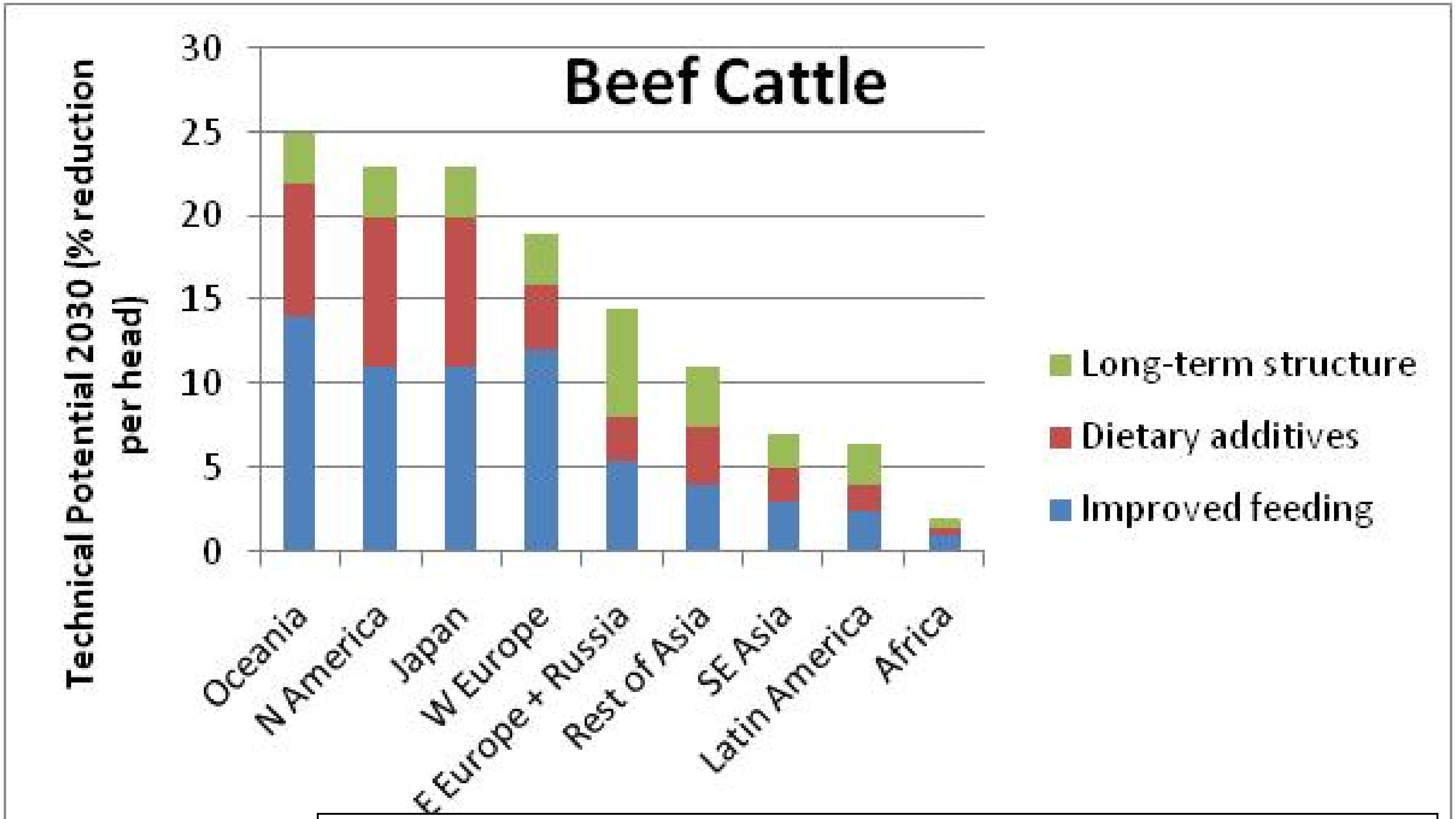
# Mitigation of $CH_4$ from Enteric Fermentation Practices identified in IPCC AR4

- Improved feeding practices
  - Pasture improvement
  - Supplementation with concentrates
  - Adding oils or oilseeds to the diet
  - Optimizing protein intake to reduce N excretion (impact on $N_2O$ emissions)
- Specific agents and dietary additives
  - Ionophores and antibiotics, halogenated compounds, condensed tannins, essential oils, probiotics, propionate precursors, vaccines, bST and hormonal growth implants
- Animal breeding, other changes in structure
- Lifestyle changes, substitution effects not considered in the analysis

# Ruminant $CH_4$ Mitigation - technical potential



Source: IPCC Fourth Assessment Report (2007), Vol 3, Ch.8 (adapted from Table 8.5)

**Per cent reductions are per head**

# Two different, complementary strategies

- **Already efficient systems** (mostly in developed regions)
  - Limited options for mitigation
  - Focus on research (e.g., New Zealand’s PGgRc) aiming at reducing emissions per animal (and per unit product).
  - Need to consider land use emissions associated with production of feed.
- **Less efficient systems** (mostly in developing regions)
  - Intensification of pastoral systems provides the best opportunities (large area of grassland). Adoption of mixed crop/livestock systems in cropland would also be effective.
  - Rapid implementation is possible, synergies with adaptation, food security and SD.
  - Focus on integral approach (AFOLU) including consideration of avoidance of deforestation, C sequestration in soils and $N_2O$ to reduce emissions per unit product

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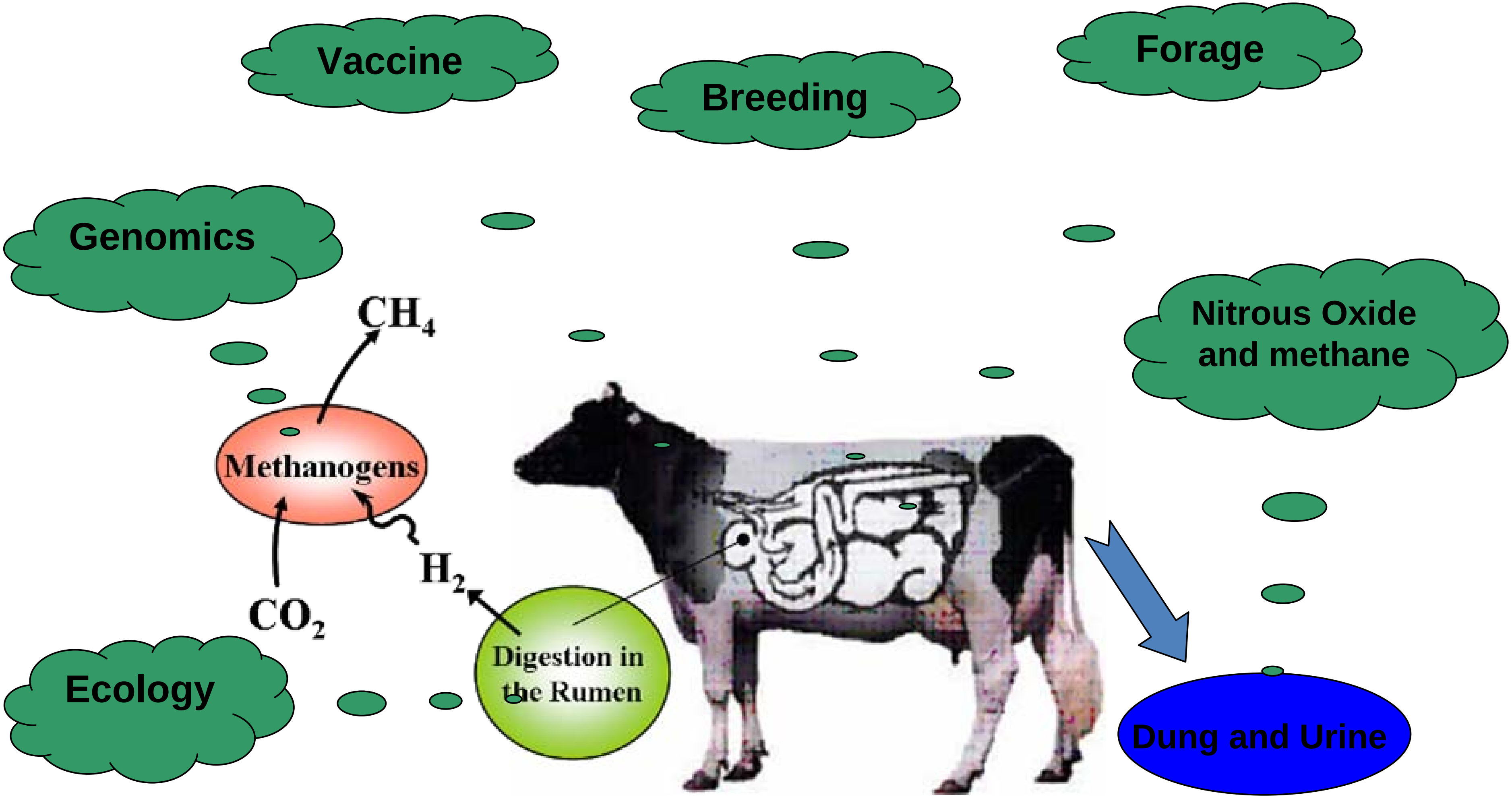
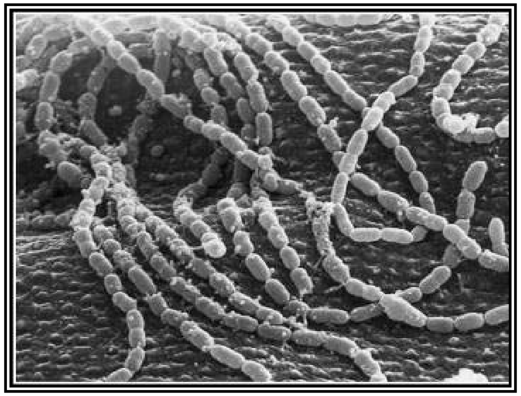
# PGgRc Research Programme



# Rumen Ecology and Microbiology

- Central to research programme
- Underpins all work in methane mitigation
- Strong focus on understanding what occurs when changes are made in rumen microbe populations



# Methanogen Genomics

- Use of genome sequencing to identify the fundamental physiology
- Has given insights and leads in:
  - Identifying populations
  - Basic specific physiology
  - Targets for inhibition or mitigation of the organism

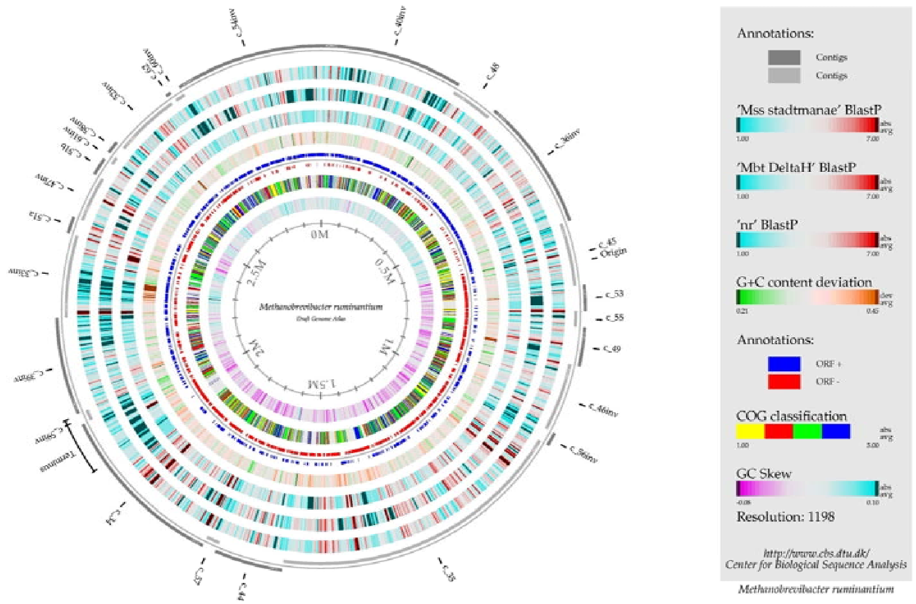
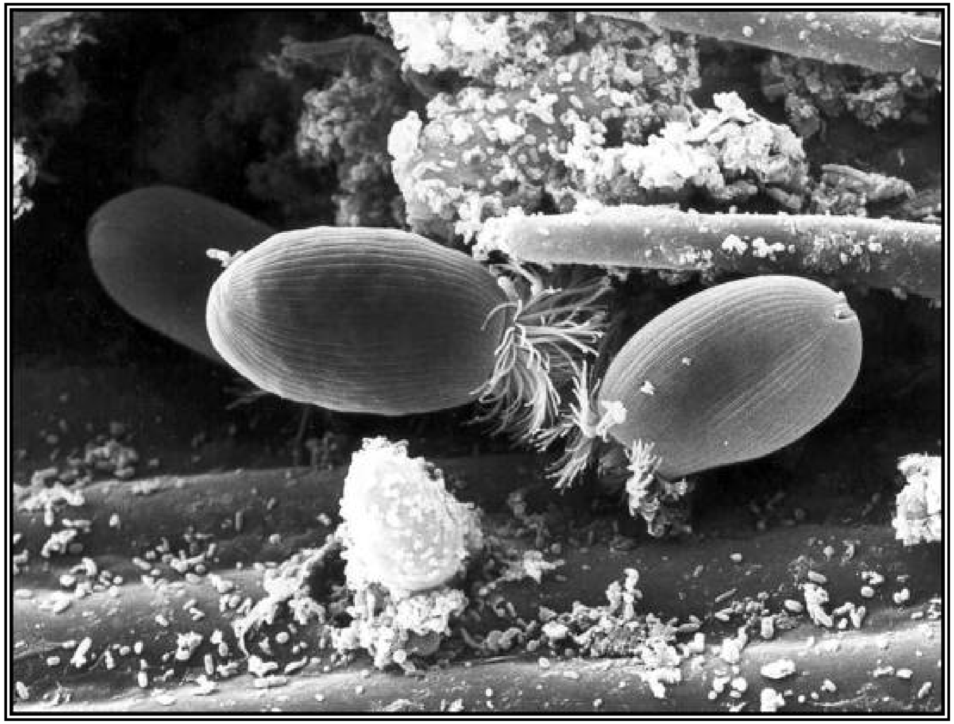


Figure 1. *Methanobrevibacter ruminantium* contigs scaffolded onto the *Methanothermobacter thermoautotrophicus* genome sequence, also showing good alignment of genes with *Methanosphaera stadmanae*.

# Methane Vaccine

- Developing the concept of a vaccine against Methanogens
- Drawing on the other microbiological knowledge and combining that with immunology
- Opportunity to deliver solution though direct  livestock management



# Animal Selection

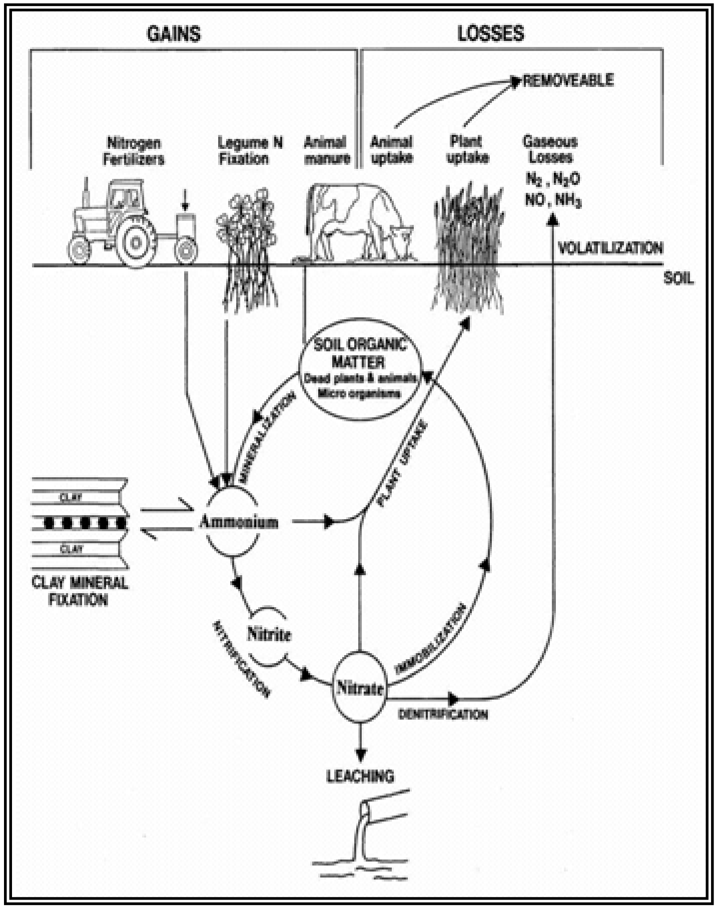
- Methane measurements of individuals
- Refine measurements in controlled conditions
- Gene marker selection and bio markers to identify low emission animals

# Plant / Forage Inhibitors

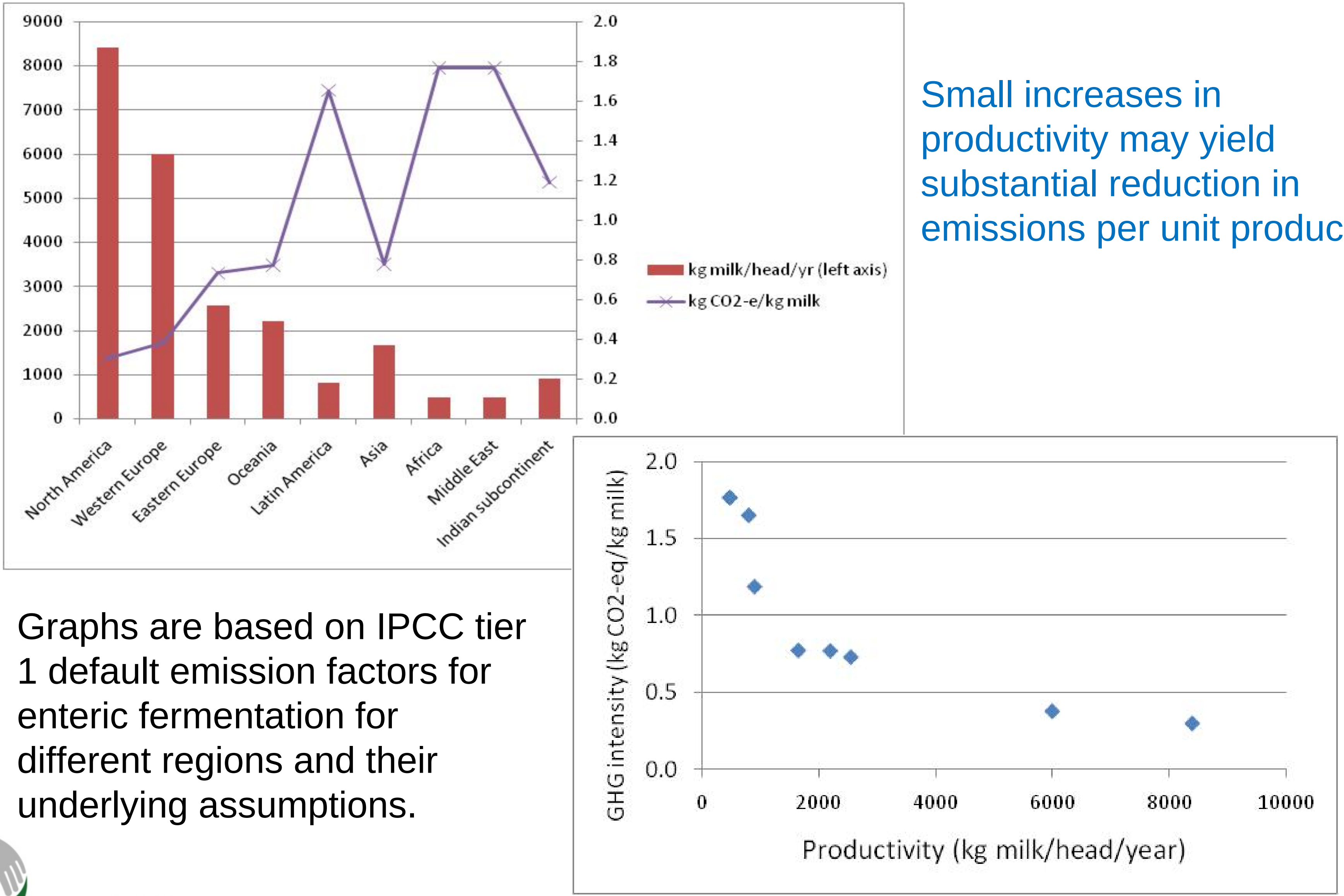
- Trying to identify forage plants that reduce methane and/or nitrous oxide
- Have identified plant constituents that lead to lower methane or reduced nitrogen
- However, the cost of forage is a key issue in our farming systems remaining competitive

# Soil nitrous oxide mitigation

- Nitrification Inhibitors - block the activity of soil microbes that transform nitrogen from its ammonium form to its nitrate form
- Inhibitors are proven experimentally and are commercially available. Conducting field tests to identify mitigation achievable under varying conditions
- Diet changes - changing plant constituents so that there is reduced protein (N) cycling through animal



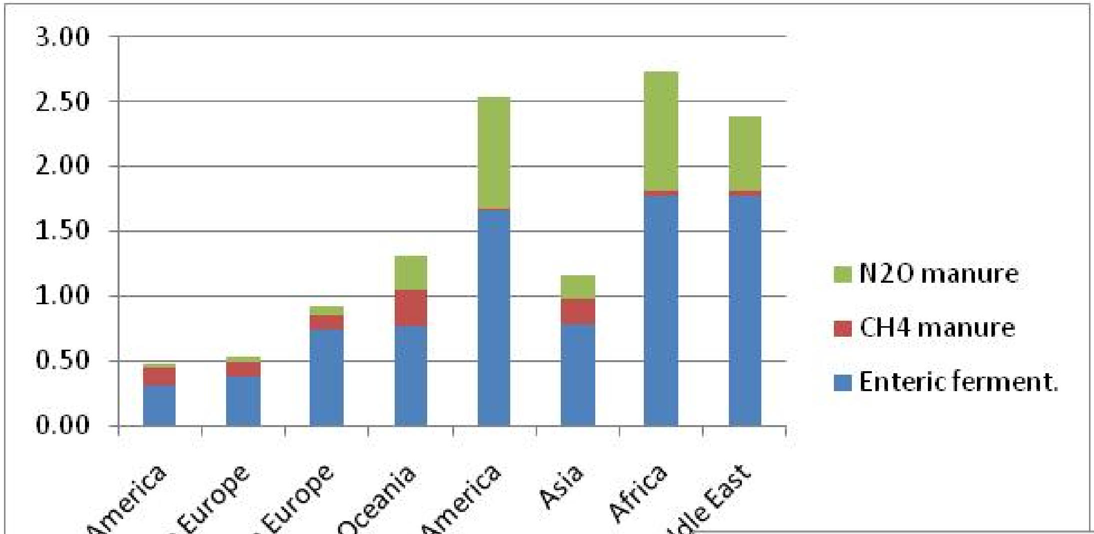
# Productivity and $CH_4$ Emissions from Enteric Fermentation



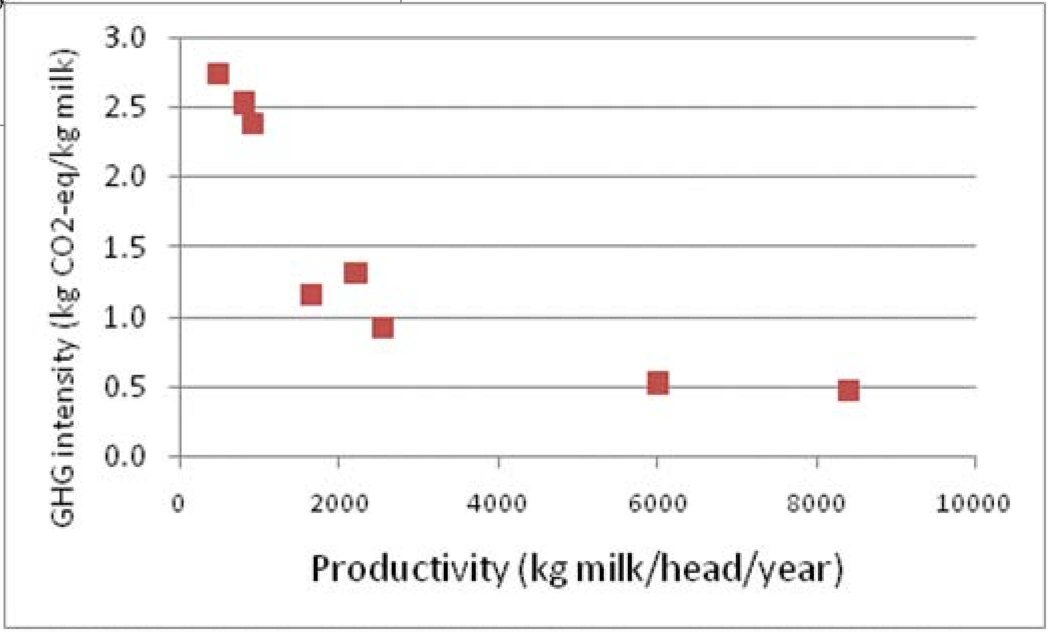
Small increases in productivity may yield substantial reduction in emissions per unit product

Graphs are based on IPCC tier 1 default emission factors for enteric fermentation for different regions and their underlying assumptions.

# Productivity and GHG Emissions per unit product (milk)



N2O emissions from manure magnify the differences between regions



Graphs are based on the following sources:

- IPCC tier 1 default emission factors for enteric fermentation for different regions and their underlying assumptions
- US-EPA 2005
- FAO Fertilizers Statistics

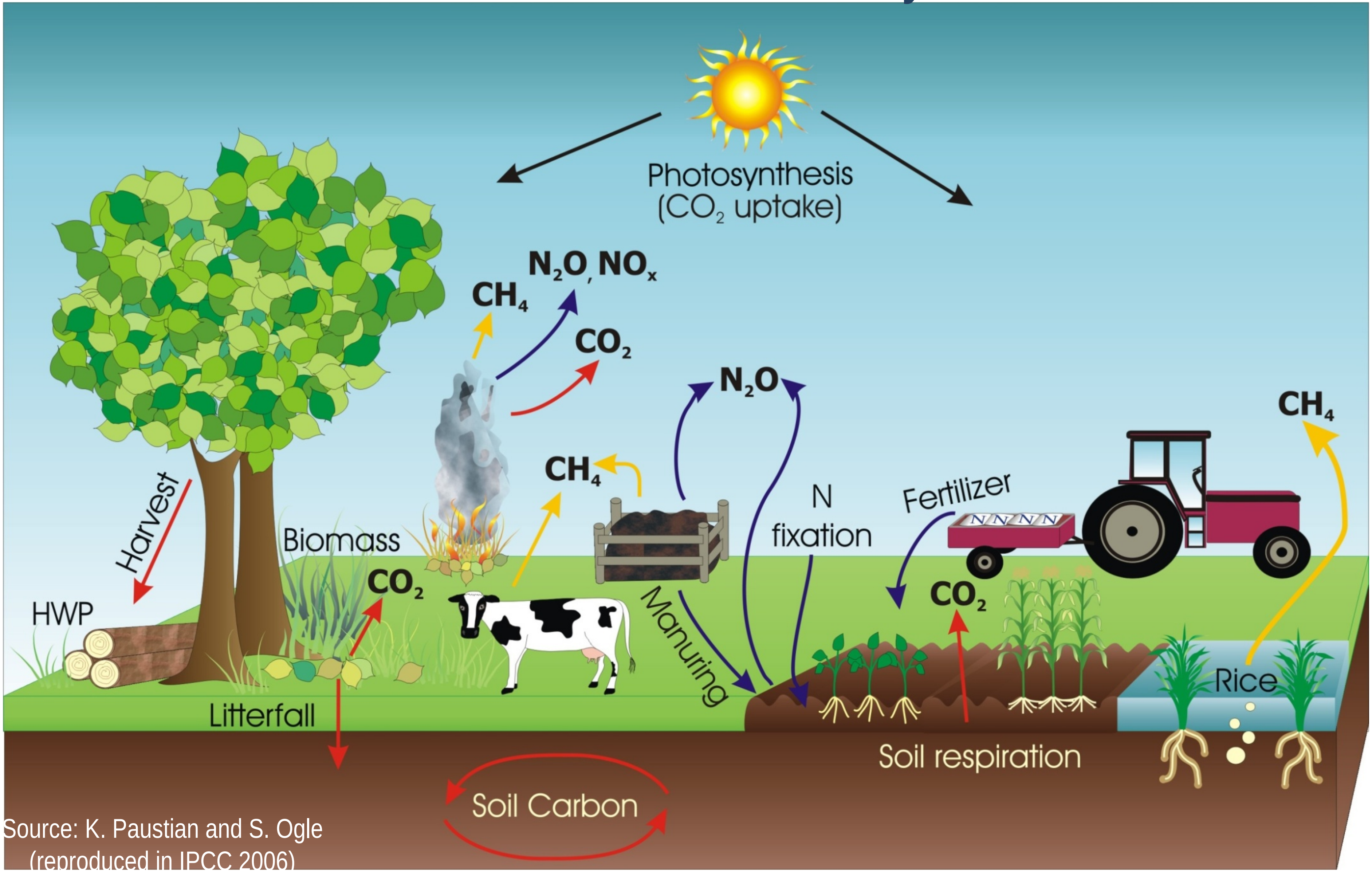
# Beef cattle: Emissions per unit product

| **System** | **GHG emissions (kg $CO_2$-eq/kg CW)** |
|---|---|
| **High-quality pasture (NZ)** | **12-18** |
| **Grain-fed, Medium-quality pasture** | **20-40** |
| **Poor quality pasture (tropical)** | **40-100** |
| **Tropical pasture + recent deforestation** | **>>100** |
| **Global average** | **>40?** |

**Substitution of high carbon intensity systems (extensive grazing of grassland, particularly on recently deforested land) by more productive systems would enable large emission reductions.**

**Adoption of mixed livestock-crop systems (e.g., crop and pasture rotations) may also be very effective in reducing emissions**

# Intensification of Pastoral Systems



Source: K. Paustian and S. Ogle
(reproduced in IPCC 2006)

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# Opportunities for reducing emissions through pasture improvement and/or adoption of mixed systems

- Meat (and, to a lesser extent, dairy) production is based on low-quality pastures in large areas.
- Adoption of pasture improvement on those areas would bring about:
  - Reduced $CH_4$ emissions (somewhat offset by small increases in $N_2O$ if legumes followed by soil tillage or N fertilisers are used).
  - Increased $CO_2$ removals (sequestration in soils)
  - Reduced emissions from deforestation (where it is driven by expansion of grazing areas).
- Associated benefits
  - Improved land productivity and resilience, soil conservation
  - Optimization of land use, risk management through diversification
  - Reduced emissions from deforestation (where it is driven by expansion of grazing areas or by procurement of timber) and reduced pressure on land.

# Pasture Improvement: an example from Uruguay ($CH_4$)

| | Range | Improved Pasture |
|---|---|---|
| Total Digestible Nutrients (%) | 50 | 55 |
| Crude Protein (%) | 9 | 13 |
| Fibre Detergent Acid (%) | 50 | 41 |
| Pasture productivity (kg d.m./ha/yr) | 1,840 | 3,500 |
| Intake (kg d.m./head/day) | 6.3 | 7.1 |
| Weight gain (kg/head/day) | 0.16 | 0.47 |
| Stocking rate (livestock units/ha) | 1 | 1.37 |
| Meat production (kg/ha/yr) | 60 | 237 |
| Emission factor (kg $CH_4$/head/yr) | 45.8 | 51.0 |
| Emissions per unit area (kg $CH_4$/ha/yr) | 45.8 | 69.9 |
| Emissions per unit product (kg $CH_4$/kg meat) | 0.76 | 0.29 |

Source: Mieres and Martino, unpublished

# Pasture Improvement: an example from Uruguay ($N_2O$)

| | Range | Improved Pasture |
|---|---|---|
| Total Digestible Nutrients (%) | 50 | 55 |
| Crude Protein (%) | 9 | 13 |
| Fibre Detergent Acid (%) | 50 | 41 |
| Pasture productivity (kg d.m./ha/yr) | 1,840 | 3,500 |
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| Weight gain (kg/head/day) | 0.16 | 0.47 |
| Stocking rate (livestock units/ha) | 1 | 1.37 |
| Meat production (kg/ha/yr) | 60 | 237 |
| Emission factor (kg $N_2O$/head/yr) | 2.2 | 3.0 |
| Emissions per unit area (kg $N_2O$/ha/yr) | 2.2 | 4.1 |
| Emissions per unit product (kg $N_2O$/kg meat) | 0.036 | 0.019 |

Source: Mieres and Martino, unpublished

# Pasture Improvement: an example from Uruguay ($CH_4 + N_2O$)

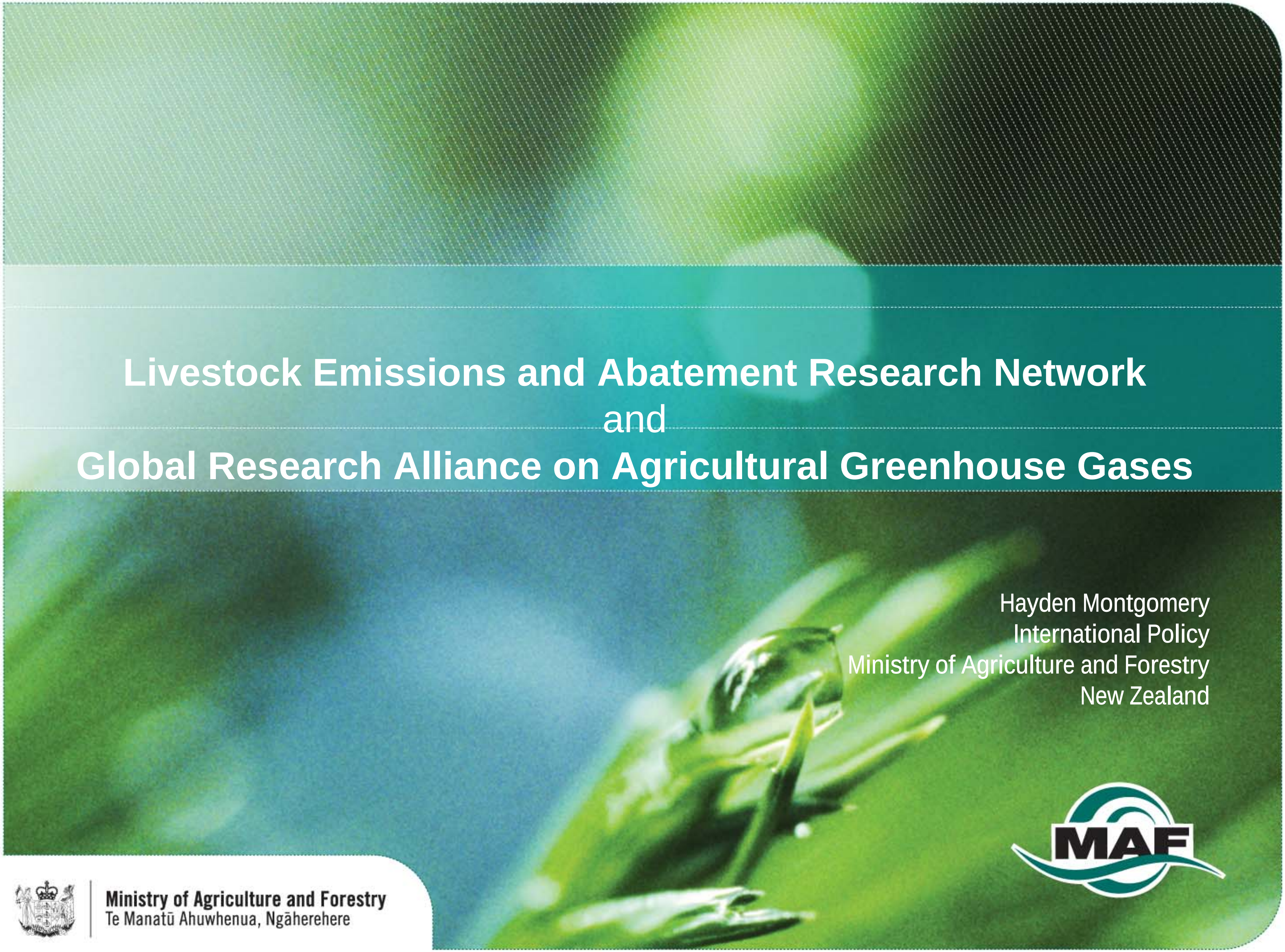
| | Range | Improved Pasture |
|---|---|---|
| $CH_4$ emissions per unit product (kg $CH_4$/kg meat) | 0.76 | 0.29 |
| $N_2O$ emissions per unit product (kg $N_2O$/kg meat) | 0.036 | 0.019 |
| Total emissions per unit product (kg $CO_2$-e/kg meat) | 27.1 | 12.0 |

Source: Mieres and Martino, unpublished

**In addition to reducing emissions per unit product, pasture improvement would cause the removal of ca. 2 t $CO_2$/ha/year from the atmosphere during a period of ca. 20 years.**

# Final Remarks

- For livestock emissions, IPCC AR4 assessed per-head emissions only, leading to higher potentials where production is more intensive. However, significant potential exists to reduce emissions per unit product in more extensive (e.g., grazing) systems
- Project-based activities seem to offer the most cost-effective opportunities for reducing livestock GHG emissions. Significant barriers (e.g., lack of approved methodologies, need for large-scale projects, non-eligibility of soil C sequestration in the CDM) exist for implementation of these projects.



# Livestock Emissions and Abatement Research Network
and
# Global Research Alliance on Agricultural Greenhouse Gases

Hayden Montgomery
International Policy
Ministry of Agriculture and Forestry
New Zealand

Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

# Livestock Emissions and Abatement Research Network (LEARN)

Established November 2007

Agreed the objectives and focus areas at the inaugural meeting - 50 people from 25 countries in attendance.

Objectives:

- To improve understanding, measuring and monitoring of non-$CO_2$ greenhouse gas emissions from animal agriculture at all scales
- To facilitate the development of cost effective and practical greenhouse gas mitigation solutions

www.livestockemissions.net

Four initial focus areas:

- Methane emissions from ruminant livestock
- Nitrous oxide emissions from ruminant livestock
- Integrated whole farming system impacts at all scales( including region and watershed)
- National livestock inventory development

# LEARN Activities

Membership

- Now more than 600 members from 75 countries

Workshops

- plant breeding (Australia)
- Measurement and mitigation in grazing livestock systems (Uruguay)
- Climate change and Andean agriculture (Peru)
- Animal breeding (New Zealand)
- Nitrous Oxide in grazing systems (Chile)

LEARN Fellowship Programme - launched June 2008 (see next slide)

# New Zealand LEARN Fellowship Programme

Fellowships available for researchers from developing countries

Post-Graduate and Post-Doctoral opportunities with up to 12 months tenure

Fellowships have been awarded to researchers from:
- Uruguay, India, Indonesia, Colombia, China, Peru, Iran, Brazil, Chile

Fellowships have focussed on:
- Understanding nitrous oxide emissions in grazing systems
- Measurement of methane emissions in livestock
- Developing research capabilities in home country
- Modelling of emissions at landscape scale
- Farm extension

Details of how to apply: www.newzealandeducated.com

# Global Research Alliance on Agricultural Greenhouse Gases

Establishment in December 2009 of a **Global Research Alliance on agricultural greenhouse gases** to help reduce the emissions intensity of agricultural production and increase its potential for soil carbon sequestration thereby contributing to overall mitigation efforts.

There are now 24 member countries: Australia, Canada, Chile, Colombia, Denmark, France, Germany, Ghana, India, Indonesia, Ireland, Japan, Malaysia, Netherlands, New Zealand, Norway, Peru, Spain, Sweden, Switzerland, United Kingdom, United States, Uruguay, Vietnam.

In the context of food security, and recognising links to adaptation and broader sustainability.

US$150 million new research funding pledged by NZ, US and Canada to support the Alliance.

# Global Research Alliance on Agricultural Greenhouse Gases

Specifically, the Global Research Alliance will seek to increase international cooperation, collaboration and investment in both public and private research activities to:

- Improve knowledge sharing, access to and application by farmers of mitigation and carbon sequestration practices and technologies, which can also enhance productivity and resilience.
- Promote synergies between adaptation and mitigation efforts.
- Develop the science and technology needed to improve the measurement and estimation of greenhouse gas emissions and carbon sequestration in different agricultural systems.
- Develop consistent methodological approaches for the measurement and estimation of greenhouse gas emissions and carbon sequestration to improve research coherence and the monitoring of mitigation efforts.
- Facilitate the exchange of information between scientists around the world.
- Help scientists gain expertise in mitigation knowledge and technologies, through developing new partnerships and exchange opportunities.
- Develop partnerships with farmers and farmer organisations, the private sector, international and regional research institutions, foundations and other relevant non-governmental organisations, to facilitate and enhance the coordination of research activities and dissemination of best practices and technologies.

# New Zealand Centre for Agricultural Greenhouse Gas Research

Launched march 3rd

Recognised world leading research programme on mitigation.

New funding commitment of $5 million per annum over 10 years.

Provides certainty in order to undertake long-term research projects.

The Centre will focus on agriculture GHG mitigation research including:

- methane from ruminant animals and waste systems,
- nitrous oxide from ruminant animals and nitrogen fertiliser, and
- soil carbon from agriculture and horticulture.

International linkages

- The research carried out or coordinated by the Centre will have strong international links.

# Conclusions

Members are free to bring to the Alliance what they want, take from it what they want.

First meeting of Alliance members in April in New Zealand to start to operationalise it.

LEARN will continue in short/medium term as a complementary initiative.

NZ Centre for Agricultural Greenhouse Gas Research will play an important role in the Alliance and in LEARN.

Further information

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