GHG abatement potential of the world's ruminant systems

A biophysical and economic assessment

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Objectives

- Assess global abatement potential of ruminant production systems:
  - Identify best available abatement practices
  - Assess technical abatement potential (considering system applicability/feasibility)
  - Assess marginal abatement costs – what can realistically be achieved given likely carbon prices
  - Explore economic trade-offs, taking into market interactions (e.g. trade and substitution effects)

Approach

- Review “Mitigation of GHG emissions in livestock production” …Hristov et al. 2013 (Eds: Gerber et al.)
  - Derived shortlist of abatement dietary options for reducing enteric CH_4, including info on region/system applicability
- Century/Daycent used to assess soil C sequestration of grazing/pasture measures
  - Regional applicability an emergent model outcome
- GLEAM model provided:
  - Animal GHG emission, diet, and production linkages
  - Spatial framework for assessing potentials & costs/benefits of abatement options (dietary and soil C measures)
- GTAP model (global market model)
  - Assess abatement potential and consequences in the presence of market interactions

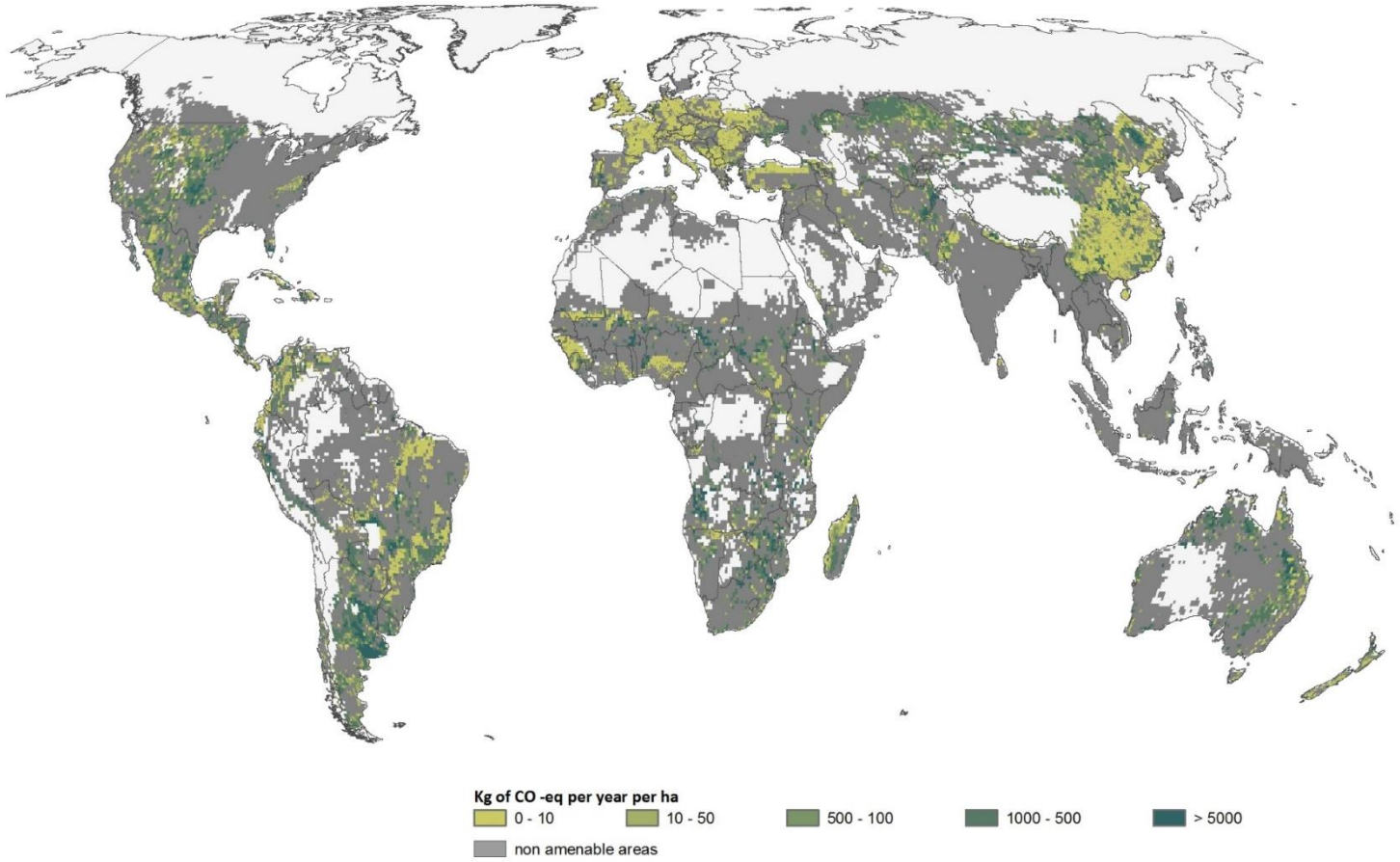
Summary of abatement practices

Abatement practice	**Applicability**	**Productivity increase**	**Abatement source**	**Models used**
Dietary oils	Developed/emerging country fattening & milked animals, with high concentrate diets	No	CH_4	GLEAM
Nitrates	Developed/emerging country fattening & milked animals, with high concentrate diets	No	CH_4	GLEAM
Urea treatment straw	Developing country systems with high straw diets	Yes	All animal GHGs	GLEAM
Grazing management	All rangelands & pasturelands, and all regions	Yes	Soil C	Century, GLEAM
Legume sowing	All pastureland (non-range) systems	Yes	Soil C, All animal GHGs	Daycent, GLEAM

Soil C sequestration: grazing management

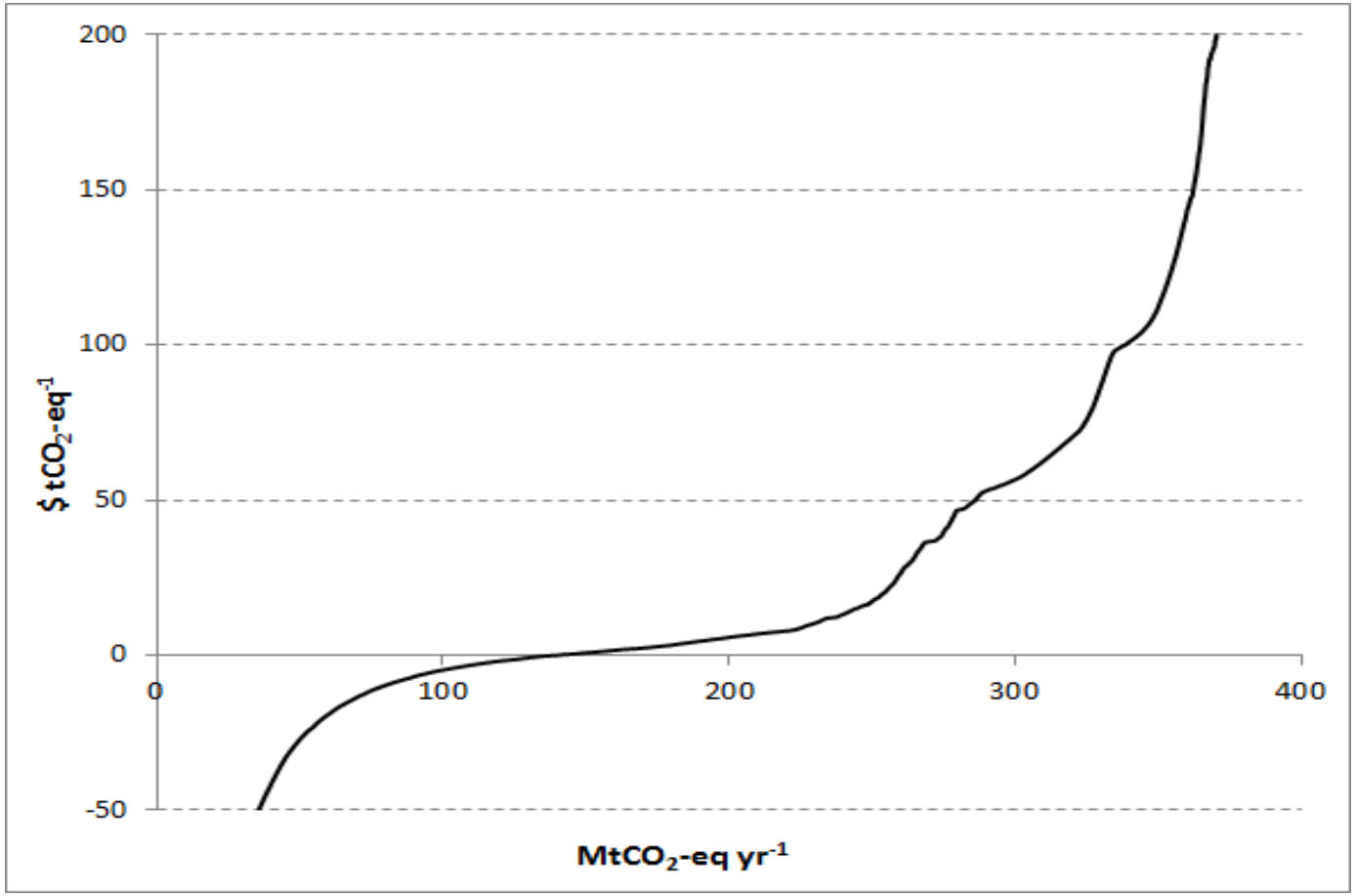
Grazing manag. = **148** $MtCO_2\ yr^{-1}$
- applied over 712 million ha

Legumes = **147** $MtCO_2$-eq yr^{-1}
- applied over 72 million ha



Henderson et al. (2015). Agriculture Ecosystems Environment

Aggregate global MAC curve



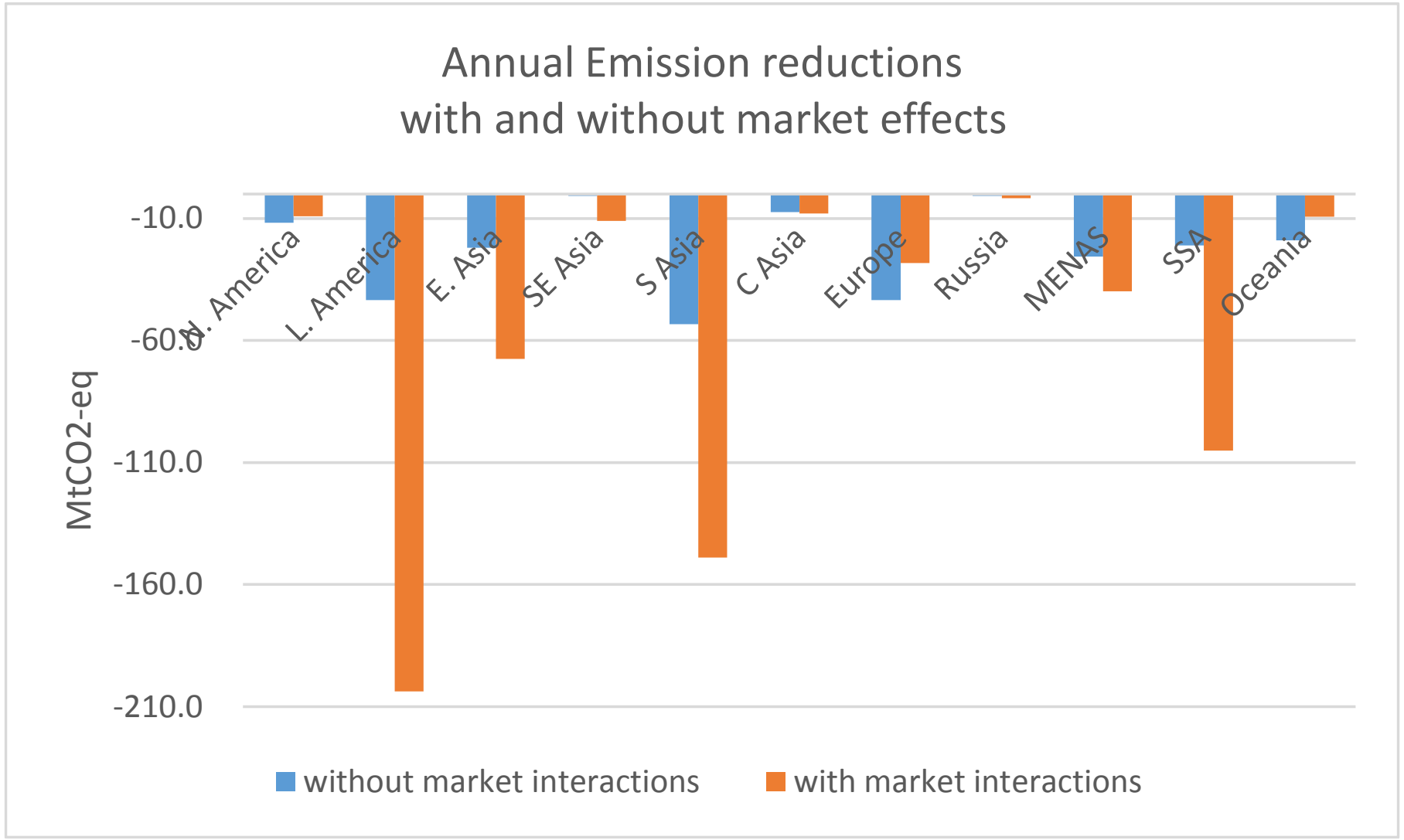
Blending of practices (global)

Marginal cost ($\$tCO_2\text{-}eq^{-1}$)	Total abatement ($MtCO_2\text{-}eq\ yr^{-1}$)	Improved grazing (%)	Legume sowing (%)	Urea treatment (%)	Dietary oils (%)	Nitrates (%)
-50	32	20	45	35	0	0
0	136	33	46	21	0	0
20	249	30	43	27	0	0
50	282	29	40	31	0	0
100	335	26	34	40	0	0
150	360	24	32	43	0.1	0.8
Total	**379**	**24**	**30**	**42**	**0.2**	**3.4**

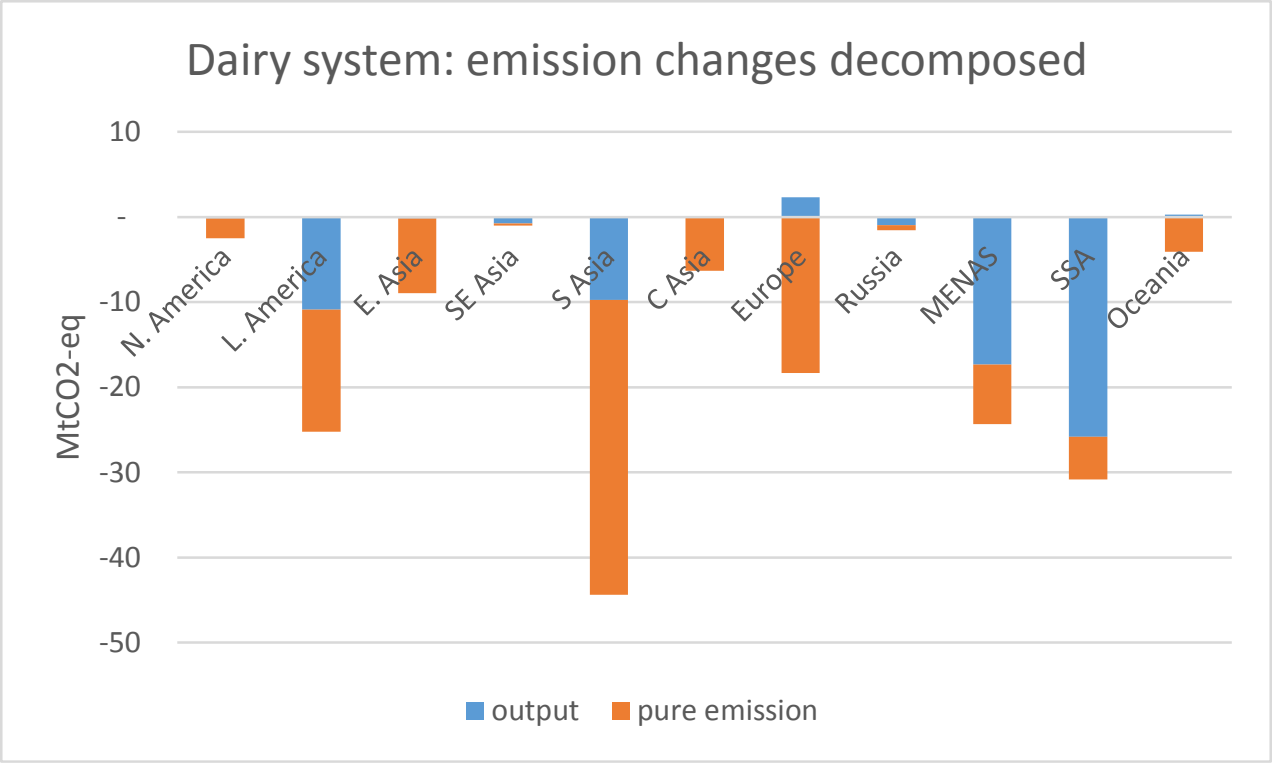
Findings published in *Mitigation and adaptation strategies for global change*:
Henderson et al. (2015)

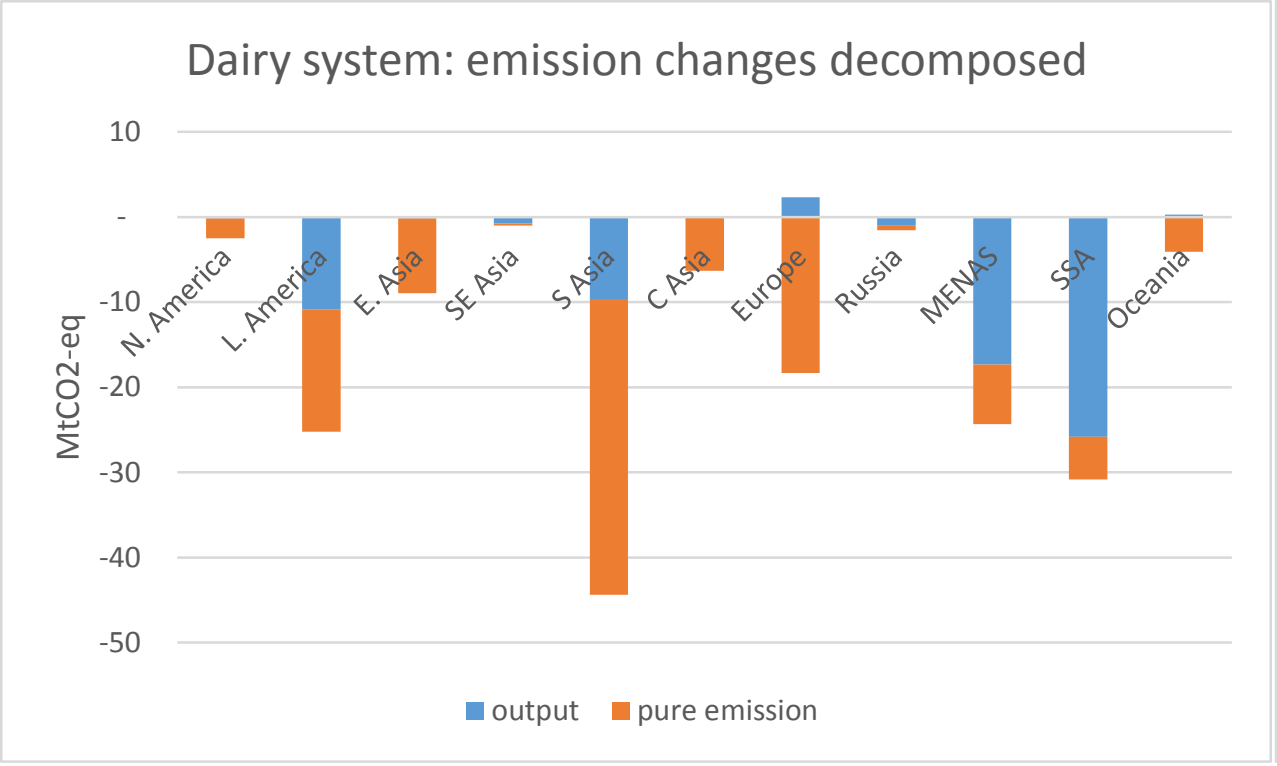
Market effects (substitution and trade)

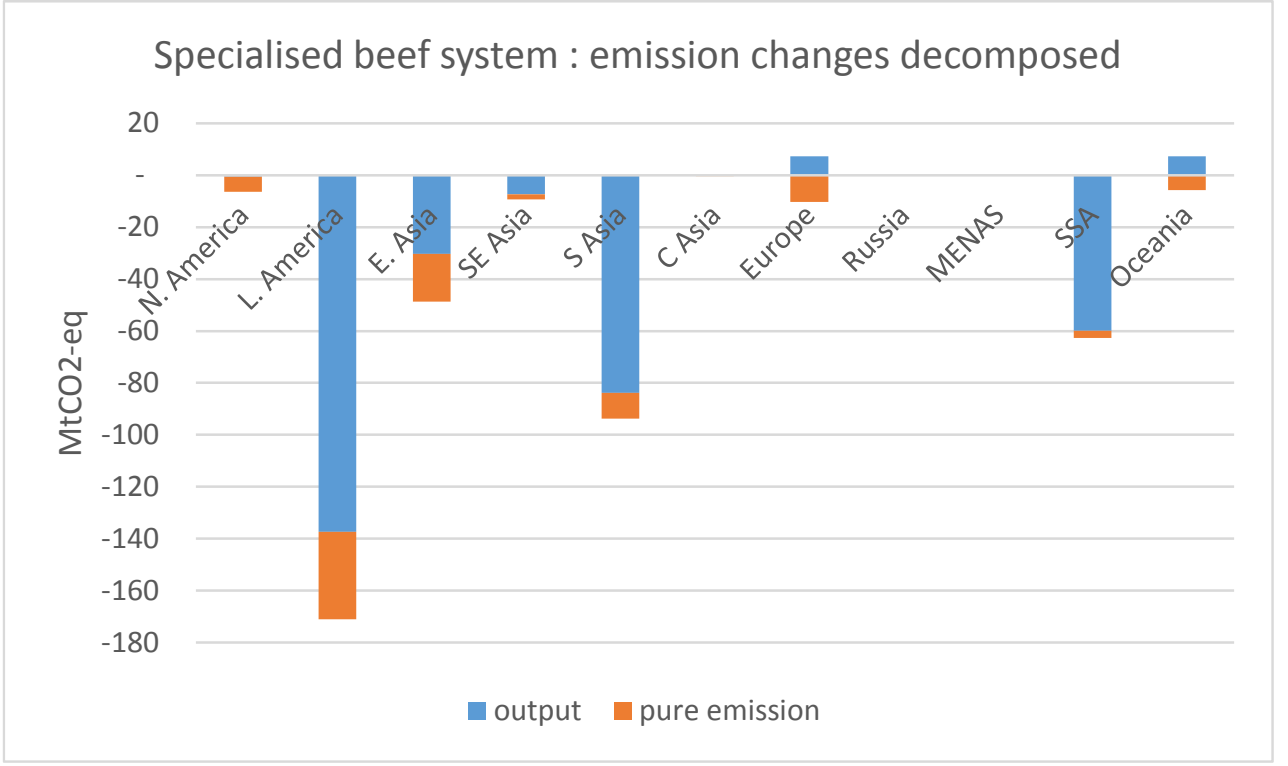
- Incorporated MAC curves into global market model (GTAP-AEZ-GHG)
- 20 $/t$CO_2$-eq carbon experiment
- Objectives:
  - Assess additional abatement potential from market effects
  - Test hypothesis: in presence of carbon policy → change in % of meat supplied by dairy system relative to specialised beef

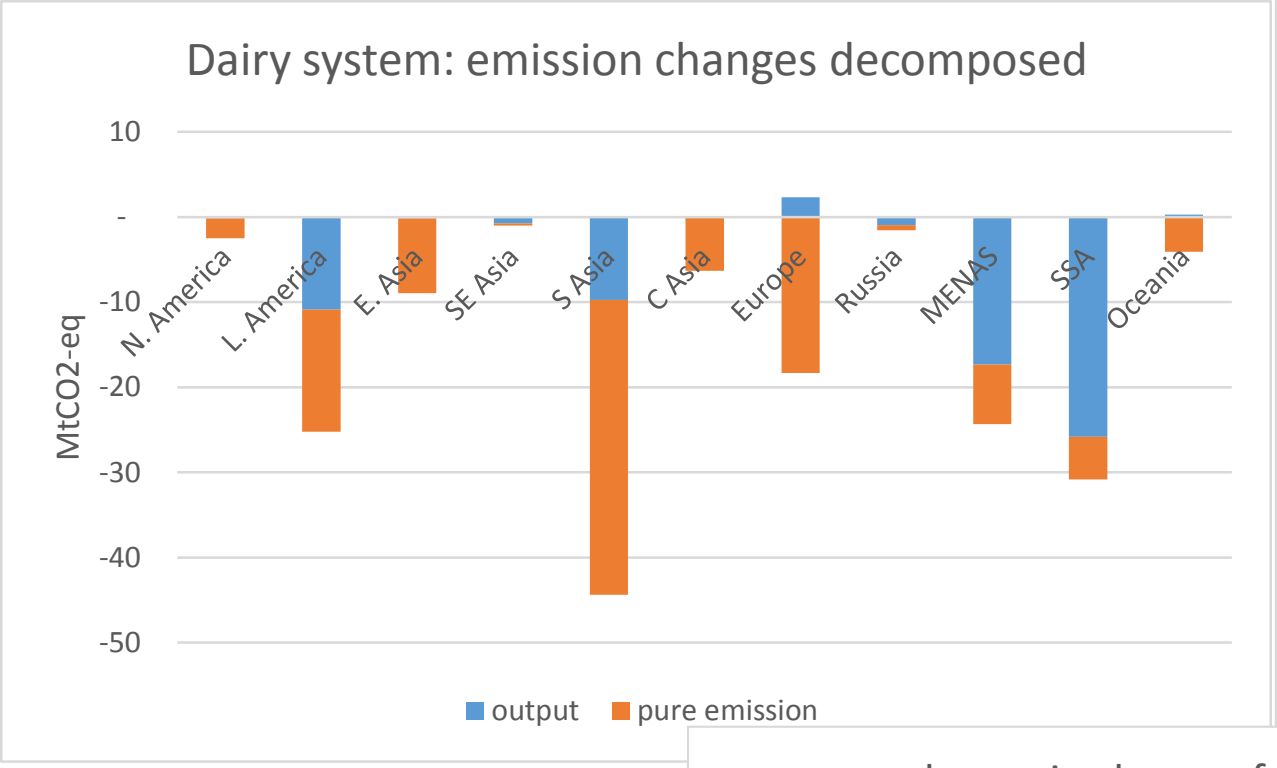


Global abatement increases from 249 to 633 $MtCO_2$-eq


Dairy system: emission changes decomposed
10
-
-10
-20
-30
-40
-50
MtCO2-eq
N. America
L. America
E. Asia
SE Asia
S Asia
C Asia
Europe
Russia
MENAS
SSA
Oceania
output
pure emission


Dairy system: emission changes decomposed
10
-
-10
-20
-30
-40
-50
MtCO2-eq
N. America
L. America
E. Asia
SE Asia
S Asia
C Asia
Europe
Russia
MENAS
SSA
Oceania
output
pure emission


Specialised beef system : emission changes decomposed
20
-
-20
-40
-60
-80
-100
-120
-140
-160
-180
MtCO2-eq
N. America
L. America
E. Asia
SE Asia
S Asia
C Asia
Europe
Russia
MENAS
SSA
Oceania
output
pure emission


Dairy system: emission changes decomposed
MtCO2-eq
10
-
-10
-20
-30
-40
-50
N. America
L. America
E. Asia
SE Asia
S Asia
C Asia
Europe
Russia
MENAS
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Oceania
output
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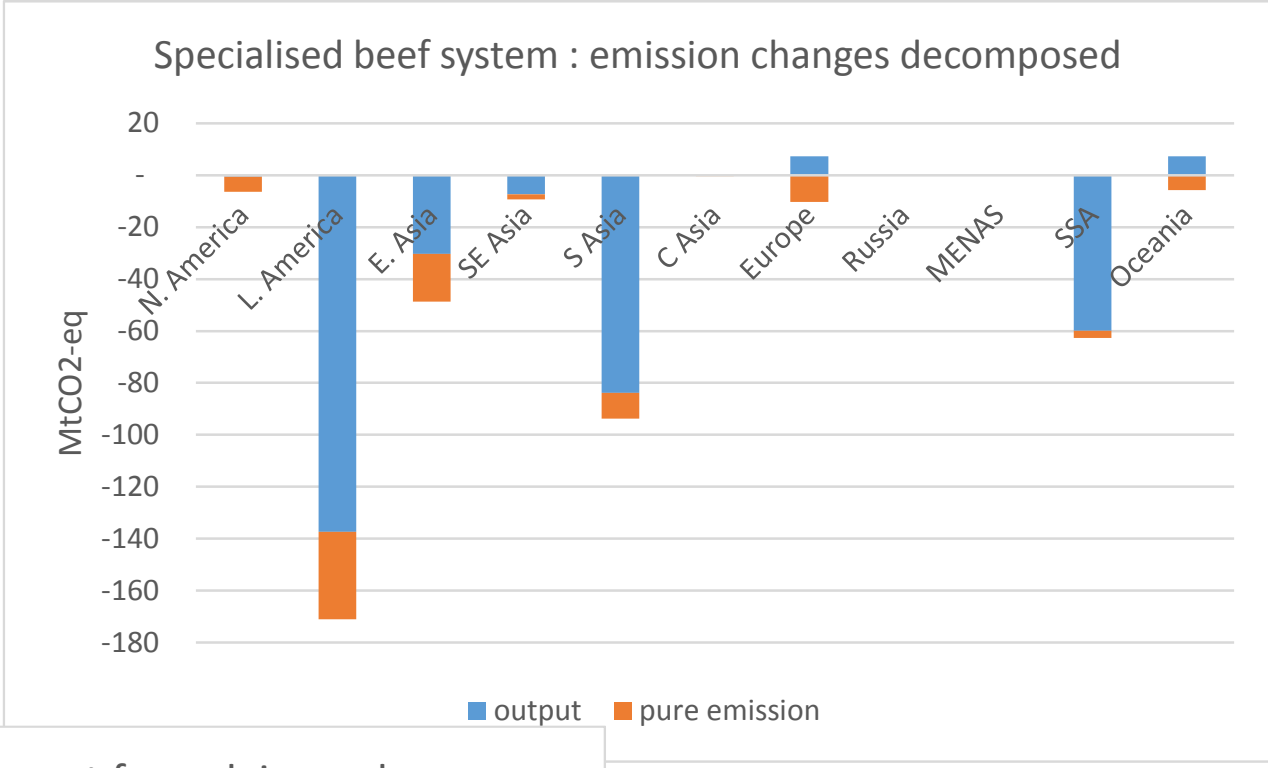
Specialised beef system : emission changes decomposed
MtCO2-eq
20
-
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N. America
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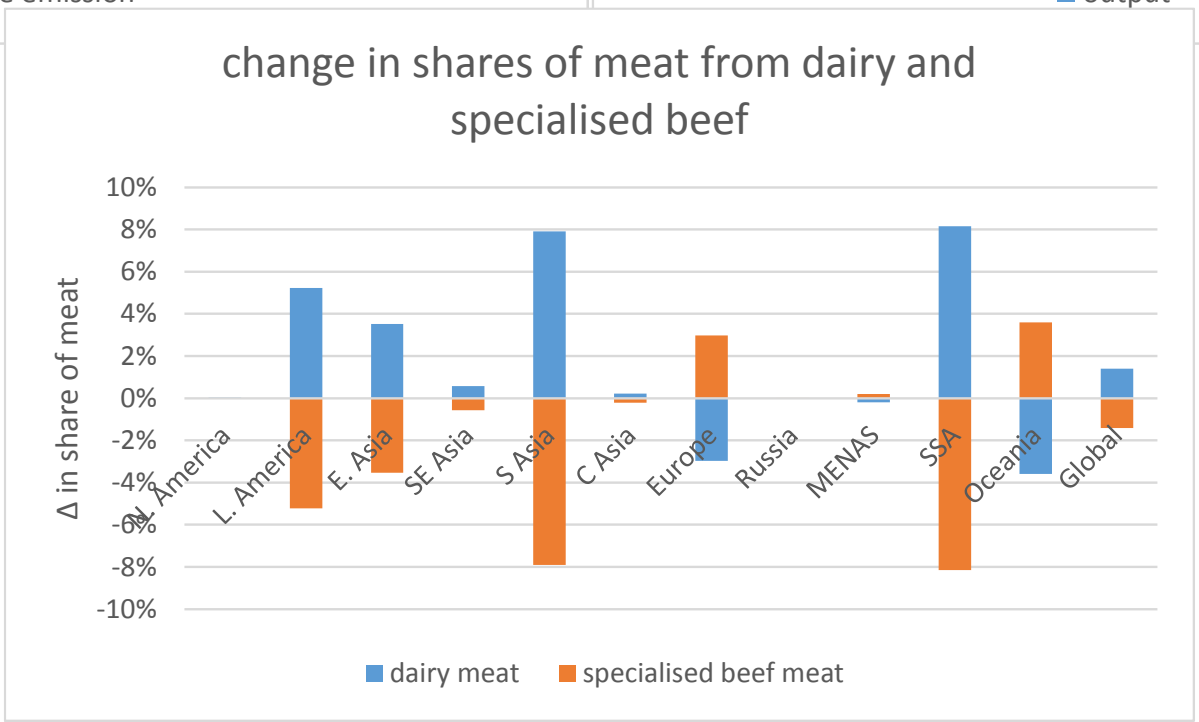
MENAS
SSA
Oceania
output
pure emission


change in shares of meat from dairy and specialised beef
Δ in share of meat
10%
8%
6%
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
N. America
L. America
E. Asia
SE Asia
S Asia
C Asia
Europe
Russia
MENAS
SSA
Oceania
Global
dairy meat
specialised beef meat

Conclusions

- Reasonably large potential from subset of practices assessed, but soil C potential is far below what IPCC have estimated
- Market is a powerful abatement amplifier, but too indiscriminate – lots of mitigation, but some pretty undesirable impacts in developing countries
- More nuanced market instrument design needed
  - Recycling of revenue collected through C tax back to farmers
  - Border carbon adjustment (BCA) tariffs for countries/regions acting unilaterally

MAC curves:
grazing management – regions