CLIMATE-SMART
Agriculture
2015

Global Science Conference

March 16-18, 2015
Le Corum, Montpellier France

Livestock and climate change
Mitigation and adaptation options for a sustainable future

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and the EC FP7 'AnimalChange' consortium
www.animalchange.eu

Inra, Paris, France.

Montpellier
March 18, 2015

The AnimalChange Project

- **Funding scheme:** FP7 European Collaborative Project
- **Budget:** 9 Million euros
- **Start date:** 01/03/2011
- **Duration:** 48 months
- **Consortium:** 25 partners
- **Represented countries:** 13 European Countries, 4 African Countries, Brazil, New Zealand
- **Web site:** www.animalchange.eu

AnimalChange is supported by EU FP7 under grant agreement 266018

Dissemination component

- Stakeholder platform including key end-users
- Side events at conferences
- Development of eLearning courses
  - Mitigation and Scale, Adaptation, Equipment and Techniques for Measurement, Inventories and General Awareness for policy makers.
- Regional face-to-face training events:
  - Hungary: 27 to 31 October 2014,
  - Kenya: 1 to 5 December 2014,
  - Senegal: 12 to 16 January 2015,
  - Brazil: 9 to 13 February 2015.

The format is 3 days of training (25 Students) and 2 days of workshop

YOU ARE WELCOME TOMORROW (THURSDAY) AT THE ANIMALCHANGE SIDE-EVENT

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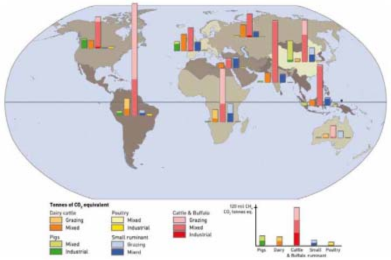
CP3
Farm scale
M&A options

CP4
Regional scale
barriers &
policies

CP2
Field, animal
scale M&A
options

Stakeholders

CP1
BaU livestock
under climate
change



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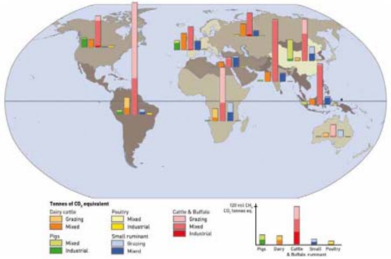

CP2
Field, animal
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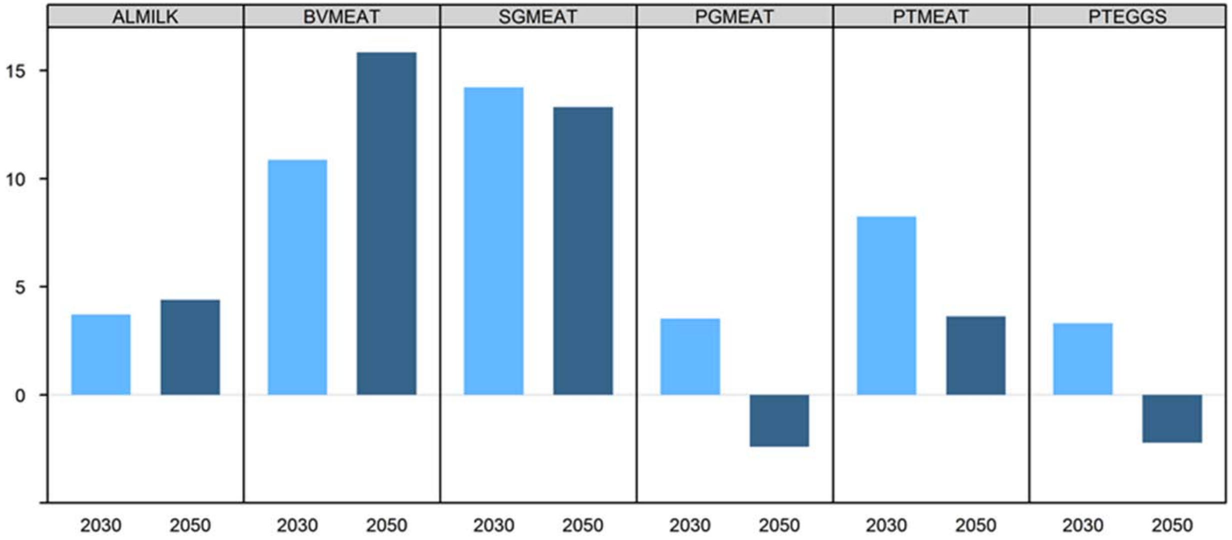
options

SEVENTH FRAMEWORK PROGRAMME

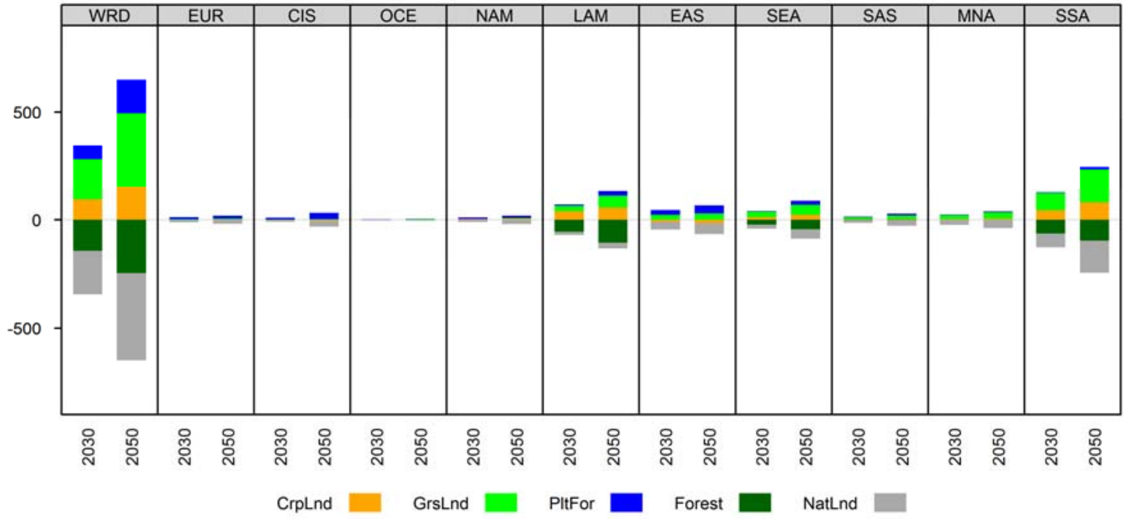
BaU scenarios for livestock
(90% increase in demand by 2050)



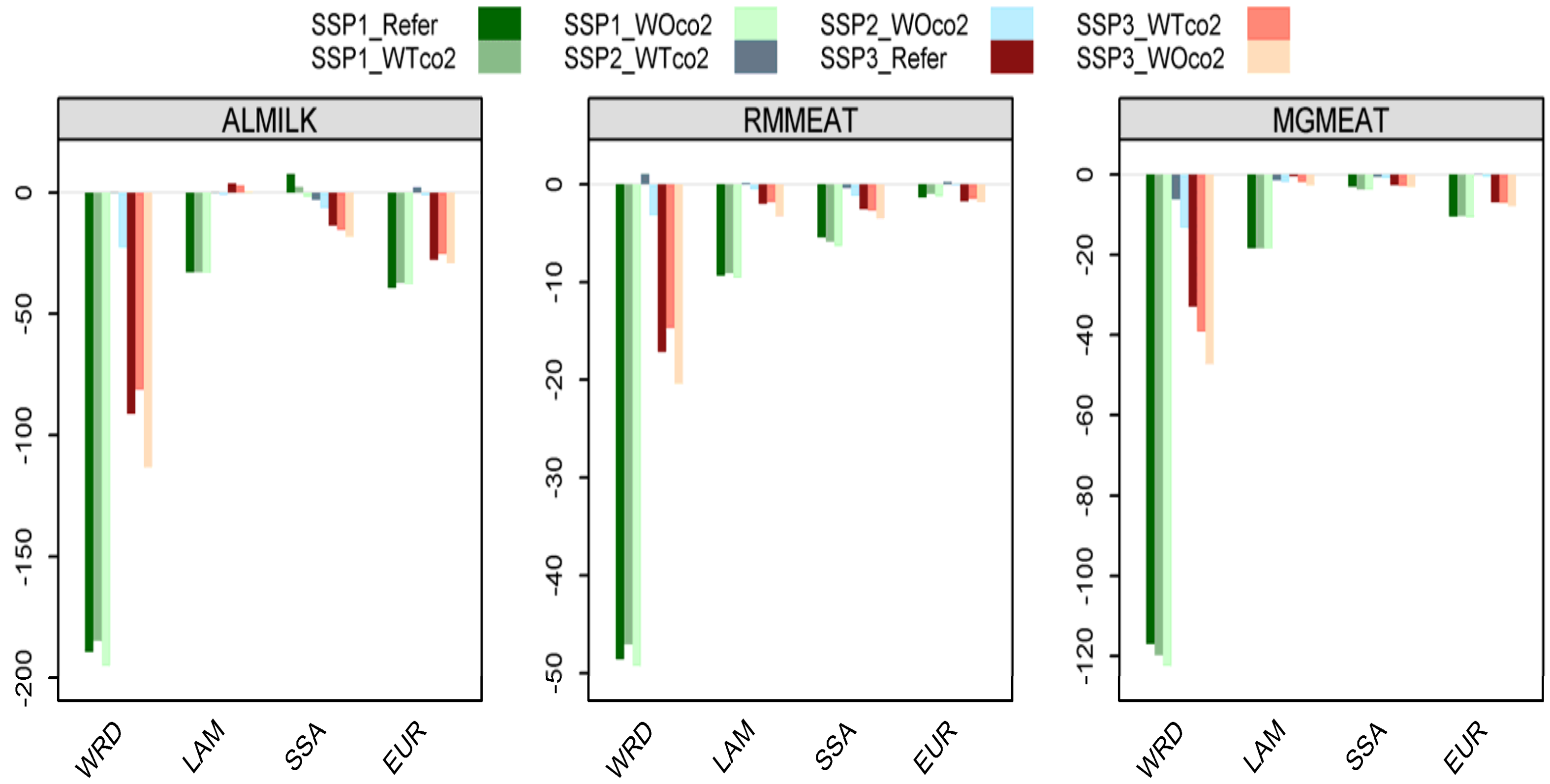
Livestock product price change compared to 2000 [%]

NO climate change, Middle of the road socio-economic scenario (Havlik et al.)

Increased deforestation and increased grassland cover, leading to increased GHG emissions

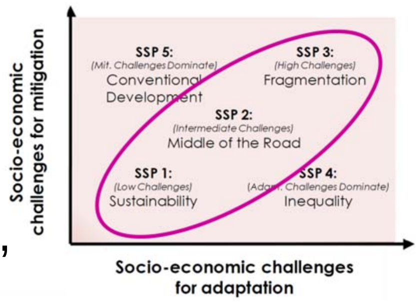


Reduced demand in alternative socio-economic scenarios



SSP1: more environmental
SSP3: more fragmented

Small effects of climate change on ruminants number,


Socio-economic challenges for mitigation
SSP 5:
(Mit. Challenges Dominate)
Conventional Development
SSP 3:
(High Challenges)
Fragmentation
SSP 2:
(Intermediate Challenges)
Middle of the Road
SSP 1:
(Low Challenges)
Sustainability
SSP 4:
(Adapt. Challenges Dominate)
Inequality
Socio-economic challenges for adaptation

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Climate change impacts on land use

- Technological change and less livestock product intensive diets would lead under SSP1 to savings of 300 million hectares of forests and other natural land compared to SSP2 and to reduced emissions
- Under SSP3, because of slow productivity growth, the same amount of land would be cultivated as under SSP3, also the total livestock production is projected some 10% lower.
- Due to climate change, when CO_2 fertilization effects accounted for, the cropland is under SSP2 projected to expand by 33 million ha more than without climate change, and grassland even by 79 million ha more than without climate change.
- Given land use change, global animal numbers are not affected by climate change

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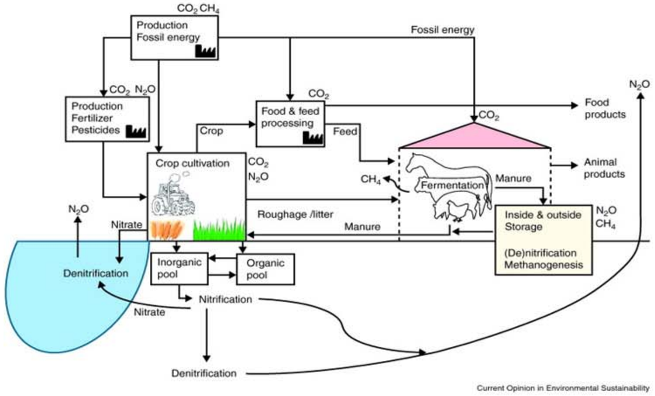
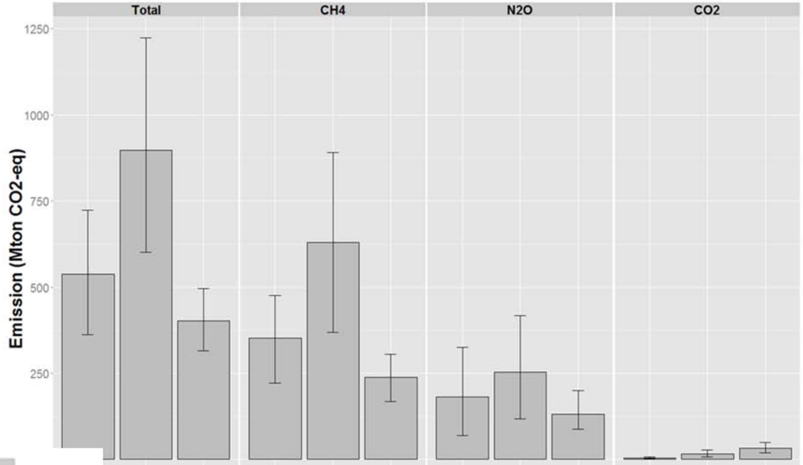
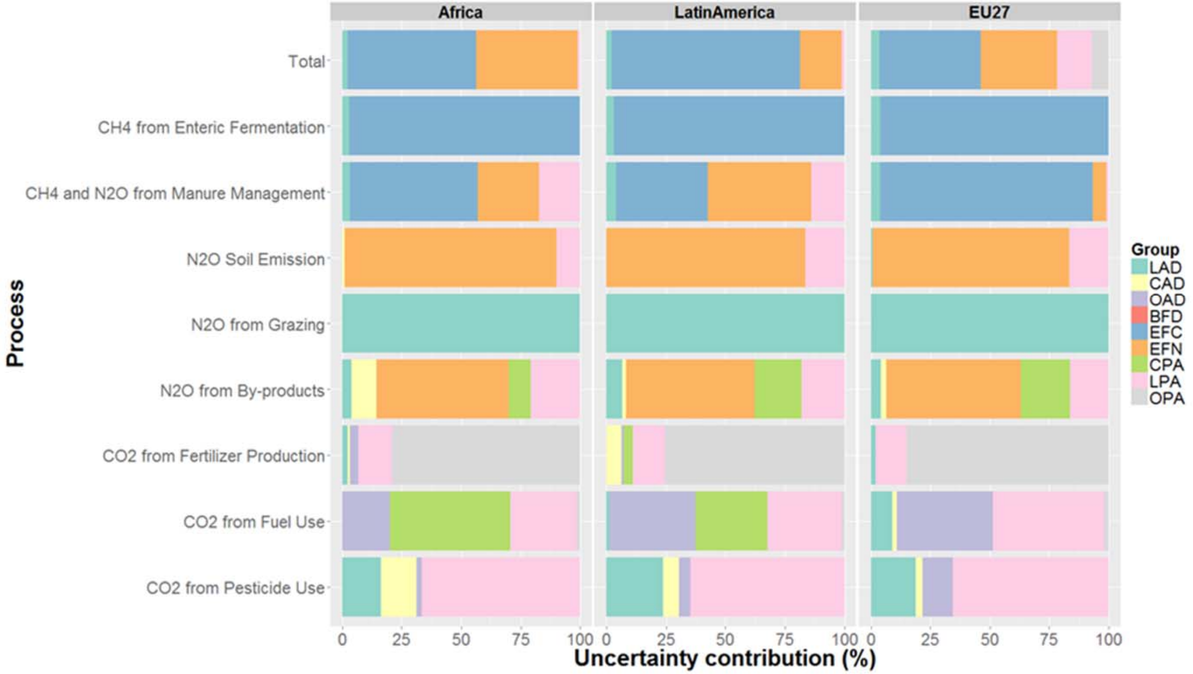
Understanding and reducing uncertainties: GHG emissions (Miterra framework)

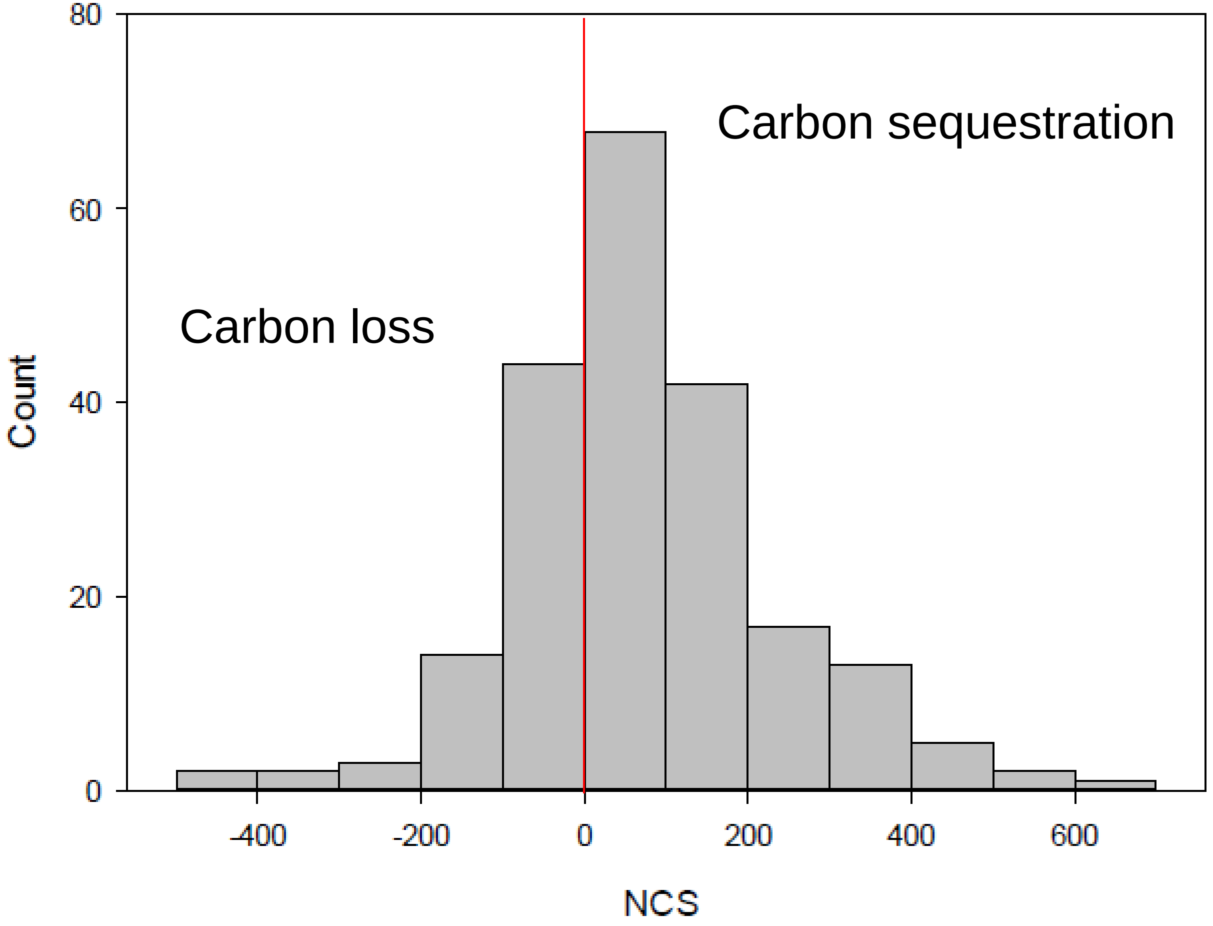

CO_2 CH_4
Production
Fossil energy
Fossil energy
CO_2 N_2O
Production
Fertilizer
Pesticides
CO_2
Food & feed processing
Food products
Crop
Feed
CO_2
N_2O
Crop cultivation
CO_2
N_2O
CH_4
Fermentation
Manure
Animal products
N_2O
Nitrate
Roughage /litter
Manure
Inside & outside Storage
(De)nitrification
Methanogenesis
N_2O
CH_4
Denitrification
Inorganic pool
Organic pool
Nitrification
Nitrate
Denitrification

Current Opinion in Environmental Sustainability





Reducing uncertainties for soil carbon: Carbon sequestration *(NCS)* in European grasslands (g C m^{-2} yr^{-1})



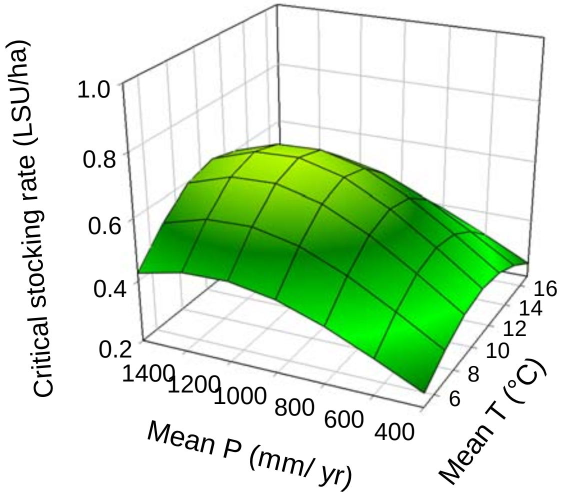
NCS = 76 ± 11 gC m^{-2} yr^{-1} (P <0.001)

$$NCS = (f_2 + k_N . N_s).GPP + k_C . L_C$$ (P<0.001, r^2=0.65)

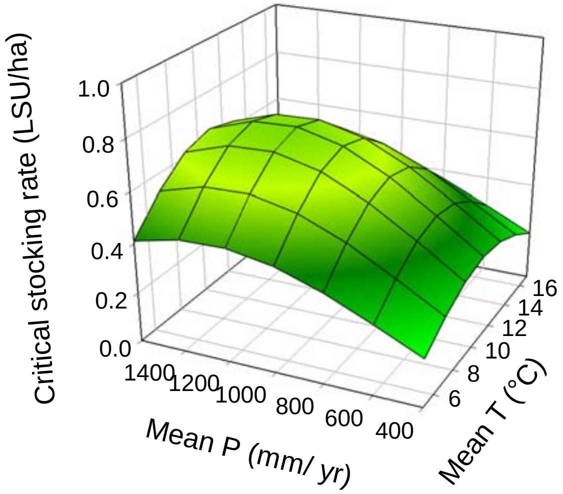
Critical animal stocking density for 'zero carbon' pastures

- **Does C sequestration compensate for non CO_2 emissions (CH_4, N_2O) on-site?**

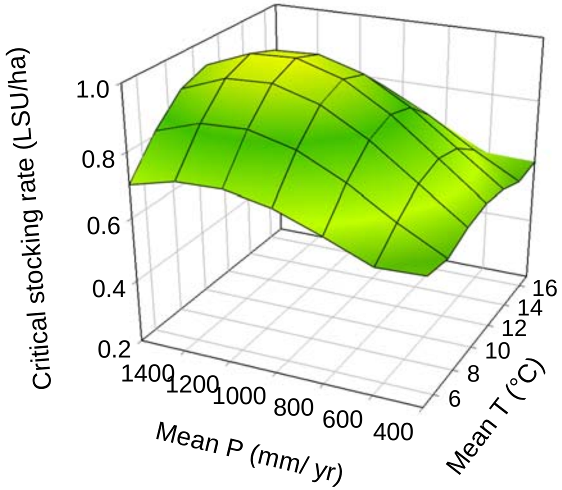
a. Unfertilized pasture (200 d grazing)



b. Mineral N fertilized pasture (200 d grazing)



c. Manure fertilized pasture (200 d grazing)



Critical herbage use efficiency = 0.20*

'Zero carbon' pastures are very extensive

Reducing uncertainties: grassland ecosystem manipulation

Ireland
Switzerland

↓ Summer precipitation (P)

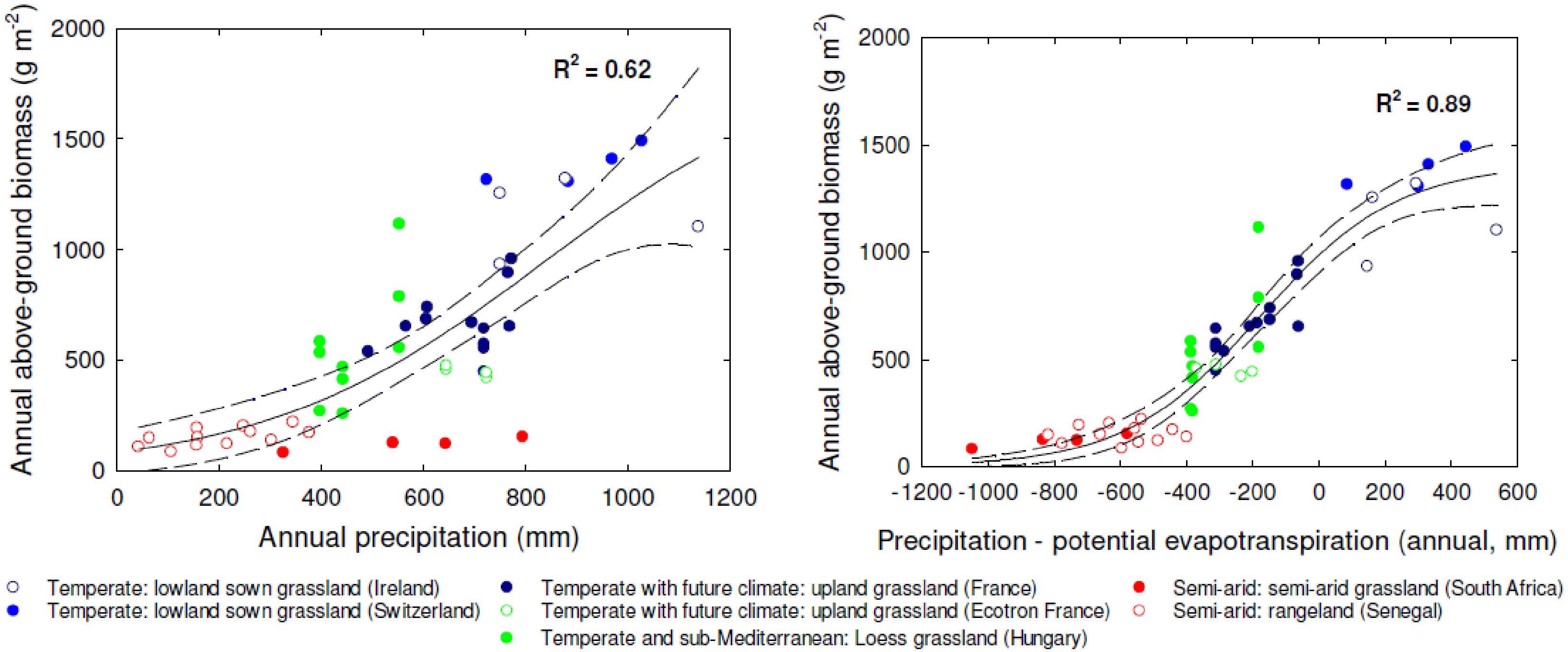
↓ Summer P x warming

Hungary
France

↓ Summer P x warming x elevated CO_2

Brazil
Senegal
South Africa

↓ P during the growing season



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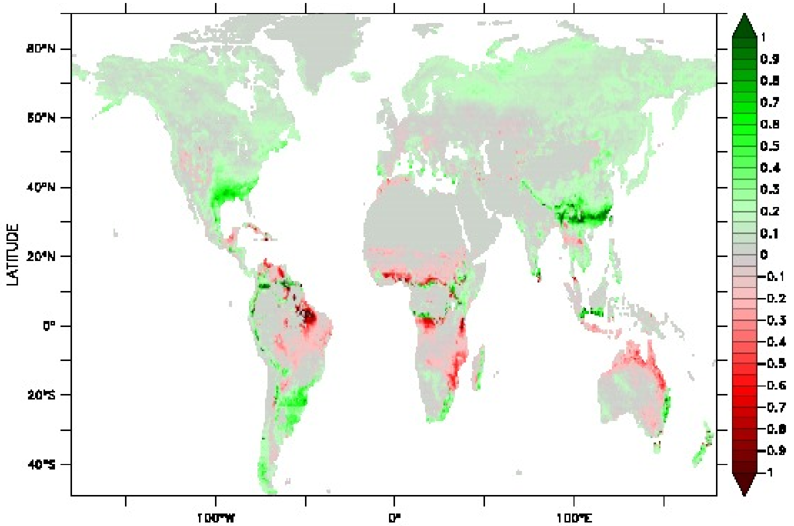
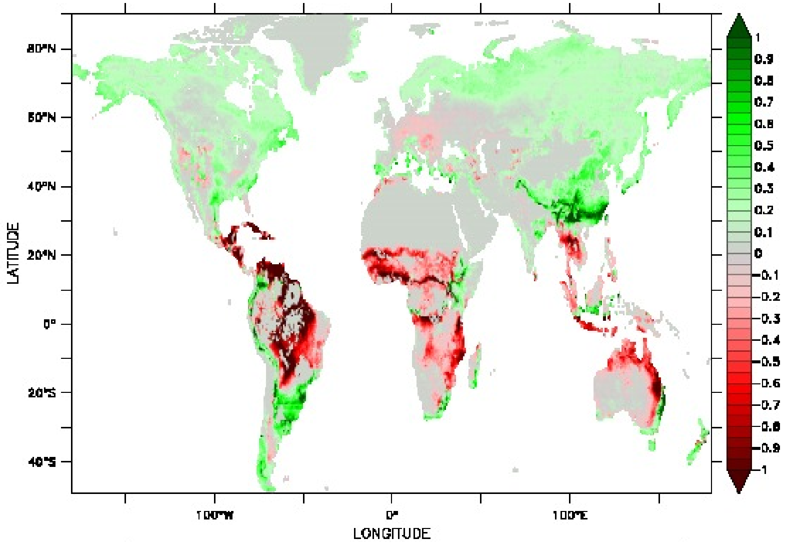
Reducing uncertainties: climate change impacts on global grasslands

From 2005-2015 to 2090-2099, Orchidee (LSU/ha)



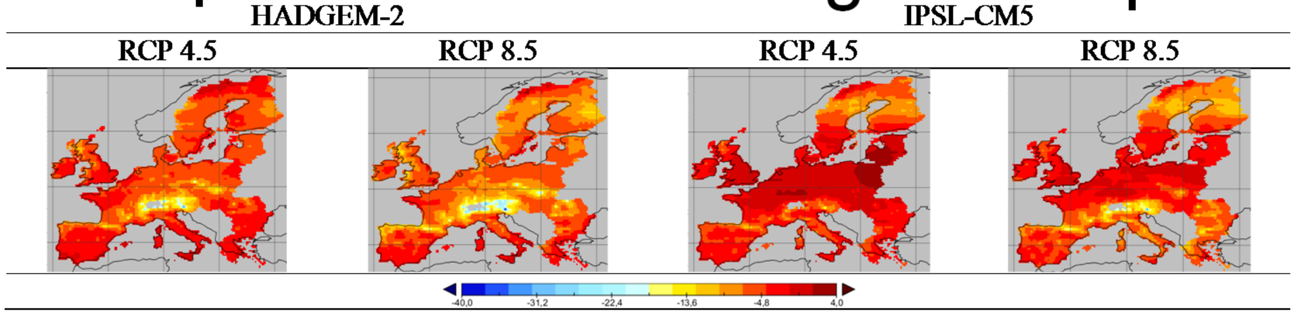
80°N
60°N
40°N
20°N
0°
20°S
40°S
LATITUDE
100°W
0°
100°E
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1

Hadgem2 Rcp 4.5



80°N
60°N
40°N
20°N
0°
20°S
40°S
LATITUDE
100°W
0°
100°E
LONGITUDE
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1

Hadgem2 Rcp 8.5



HADGEM-2
IPSL-CM5
RCP 4.5
RCP 8.5
RCP 4.5
RCP 8.5
-40,0
-31,2
-22,4
-13,6
-4,8
4,0

Difference between the mean values of the aridity index (b) calculated for the years 2005-2099 and 1951-2004 with b<25th percentile, as represented by two climate models and two RCPs. Red to bleu colours indicate growing aridity under future climate (and vice versa for red to brown colours).

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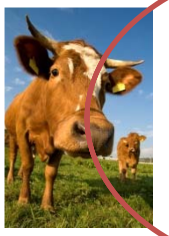

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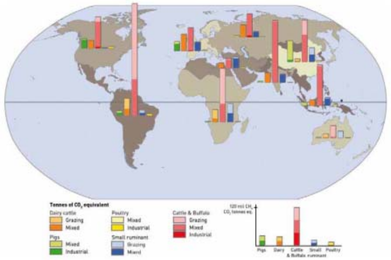
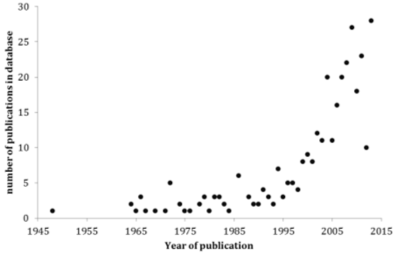
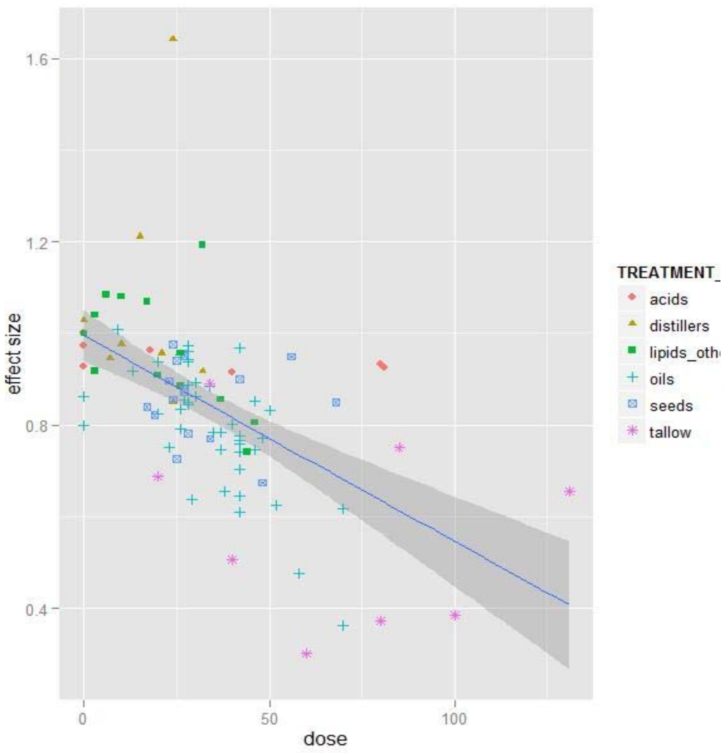
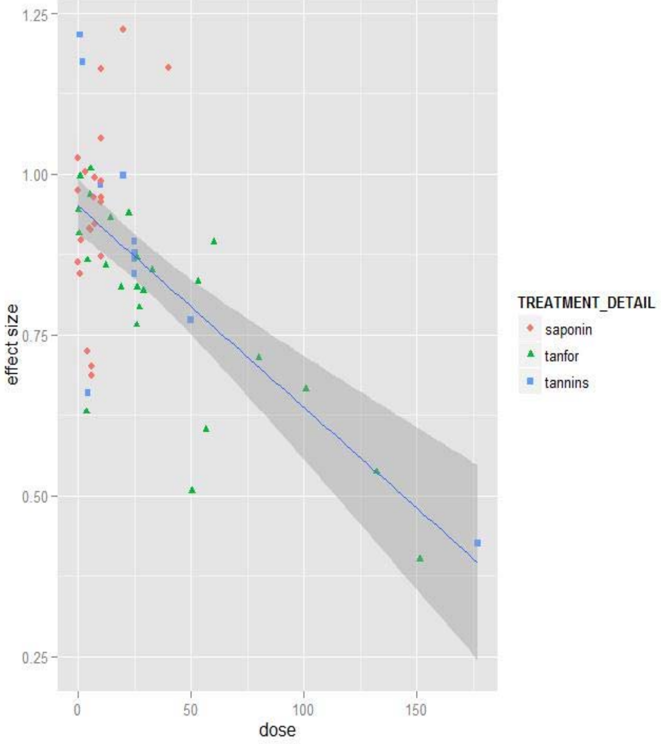


MITIGATION OPTIONS: Meta-analysis of enteric CH_4 mitigation from diet changes and additives



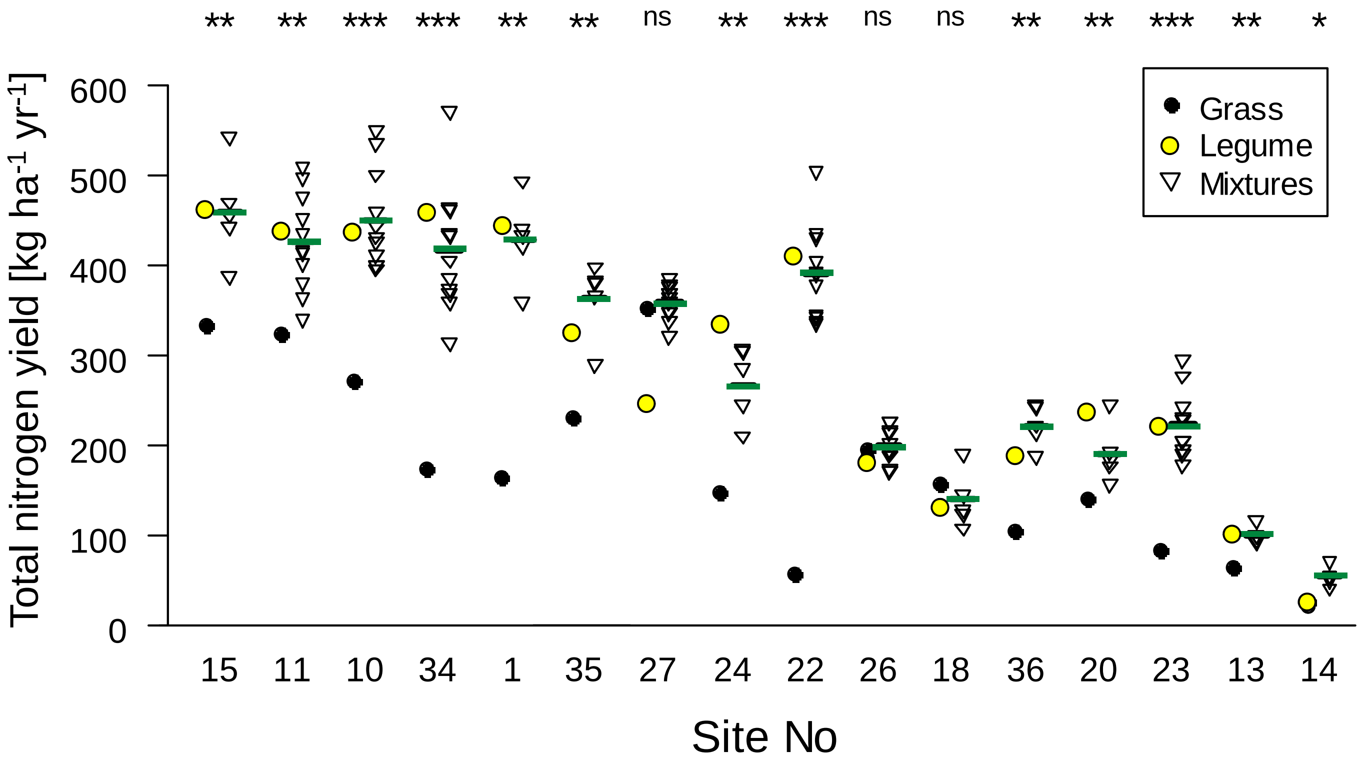
Meta-Gate data base





M&A option: grass-legume mixtures have increased total N yield

And increased drought tolerance in European drought experiments



- Mixtures, on average, outperform grass monocultures at majority of site
- Average N yield of mixtures is at level of legume monocultures

Tropical grazing and browsing: mitigation from secondary plant compounds

- Tropical (e.g. legumes) tannin-rich forage plants reduce methane production *in-vitro,*
- Some of the saponin-rich browsed species could also lead to reduced enteric methane emissions,
- This questions the validity of CH_4 emission factors for some of the tropical grazing/browsing systems

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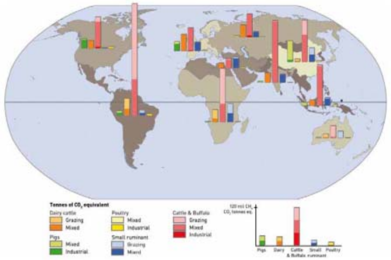
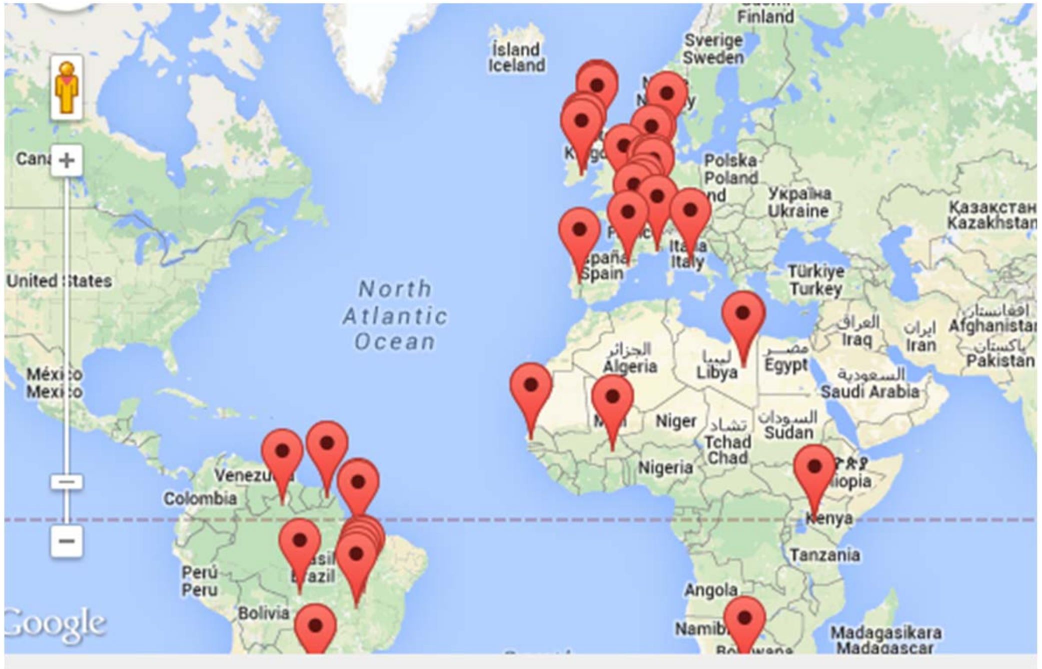


Model & showcase farms


Finland
Sverige
Sweden
Ísland
Iceland
Polska
Poland
Україна
Ukraine
Казахстан
Kazakhstan
United States
North
Atlantic
Ocean
España
Spain
Italia
Italy
Türkiye
Turkey
Afghanistan
Iraq
Iran
Pakistan
México
Mexico
Algeria
Libya
Egypt
Saudi Arabia
Niger
Tchad
Chad
Sudan
Nigeria
Colombia
Kenya
Tanzania
Perú
Peru
Bolivia
Angola
Madagasikara
Madagascar
Google

The model farms are virtual farms representing a livestock system in a region. These virtual farms are created combining estimated data and information based on regional production systems and national statistics.

Showcase farms, however, are real farms. Real-life data are collected on these farms. Data from showcase farms are used in calculations of model farms.

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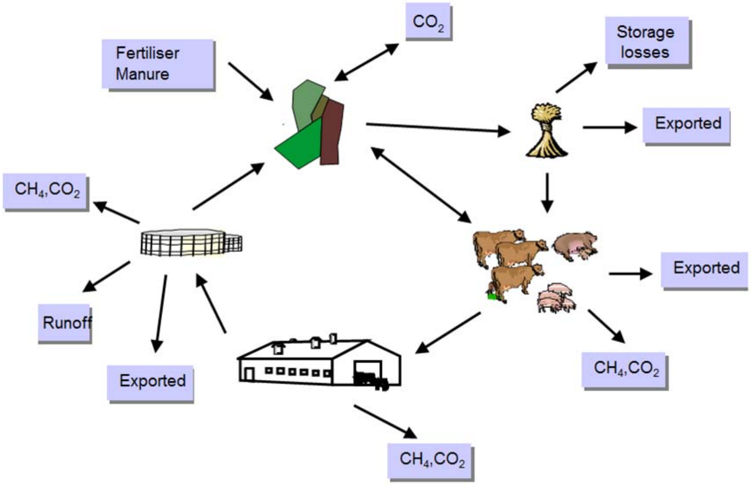
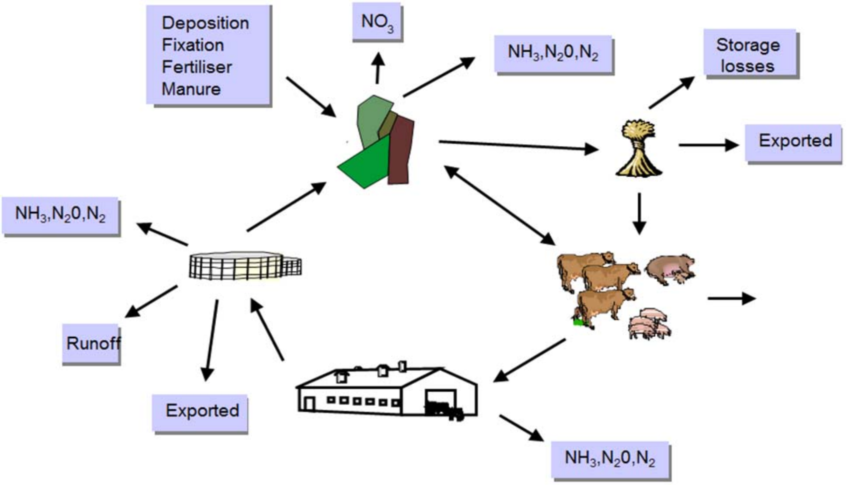
Farm AC model: modeling M&A options



Fertiliser
Manure
CO_2
Storage losses
Exported
CH_4,CO_2
Exported
Runoff
Exported
CH_4,CO_2
CH_4,CO_2

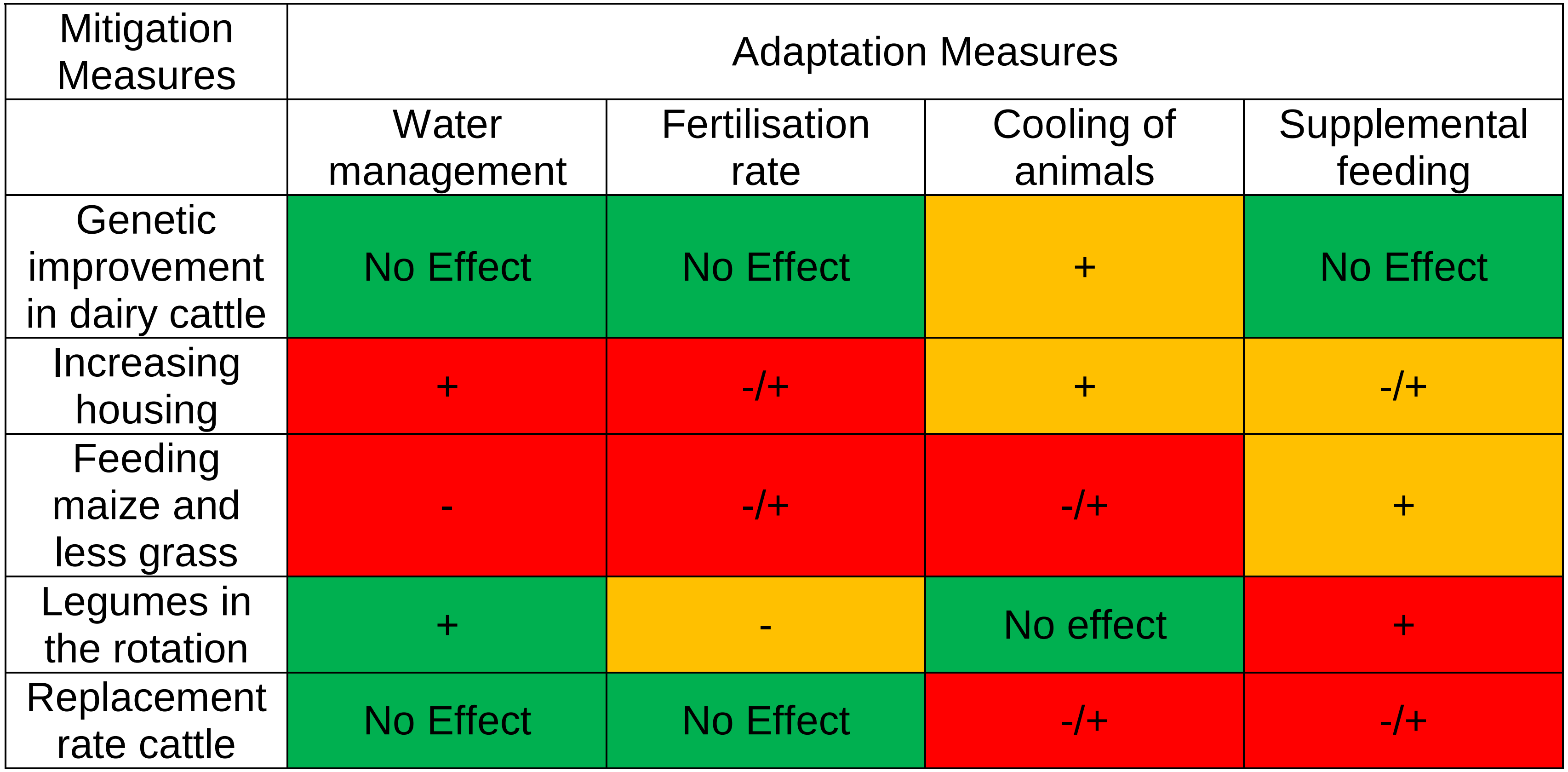
Carbon fluxes



Deposition
Fixation
Fertiliser
Manure
NO_3
NH_3,N_20,N_2
Storage losses
Exported
NH_3,N_20,N_2
Runoff
Exported
NH_3,N_20,N_2

Nitrogen fluxes

M&A options: trade-offs and synergies (Dutch dairy farm example)

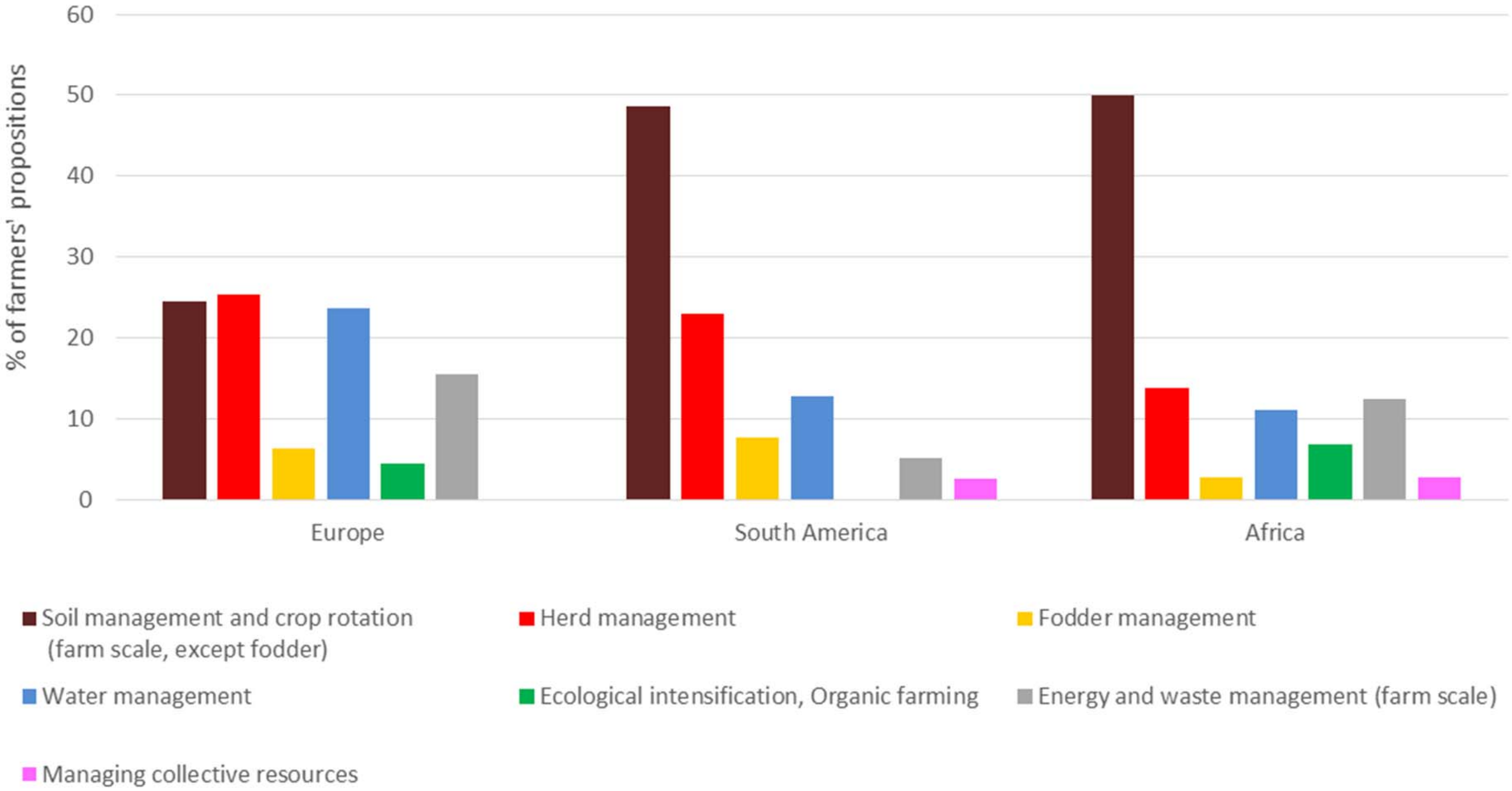


Mitigation Measures	Adaptation Measures			
	Water management	Fertilisation rate	Cooling of animals	Supplemental feeding
Genetic improvement in dairy cattle	🟩 No Effect	🟩 No Effect	🟨 +	🟩 No Effect
Increasing housing	🟥 +	🟥 -/+	🟨 +	🟨 -/+
Feeding maize and less grass	🟥 -	🟥 -/+	🟥 -/+	🟨 +
Legumes in the rotation	🟩 +	🟨 -	🟩 No effect	🟥 +
Replacement rate cattle	🟩 No Effect	🟩 No Effect	🟥 -/+	🟥 -/+

Note ++ is highly positive, + is positive, - is negative and – is highly negative, boxes coloured green are associated with low uncertainty, yellow is medium uncertainty and red is high uncertainty

Distribution of the adaptation and mitigation options proposed by farmers

Survey of 196 livestock farms spread over 10 countries: France, Scotland, Netherlands, Ireland, Senegal, Burkina-Faso, Kenya, South Africa, Madagascar, Brazil.



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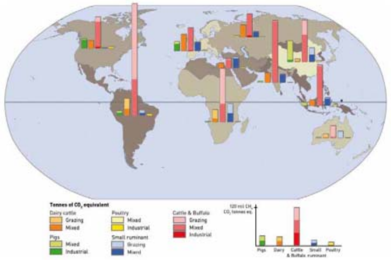

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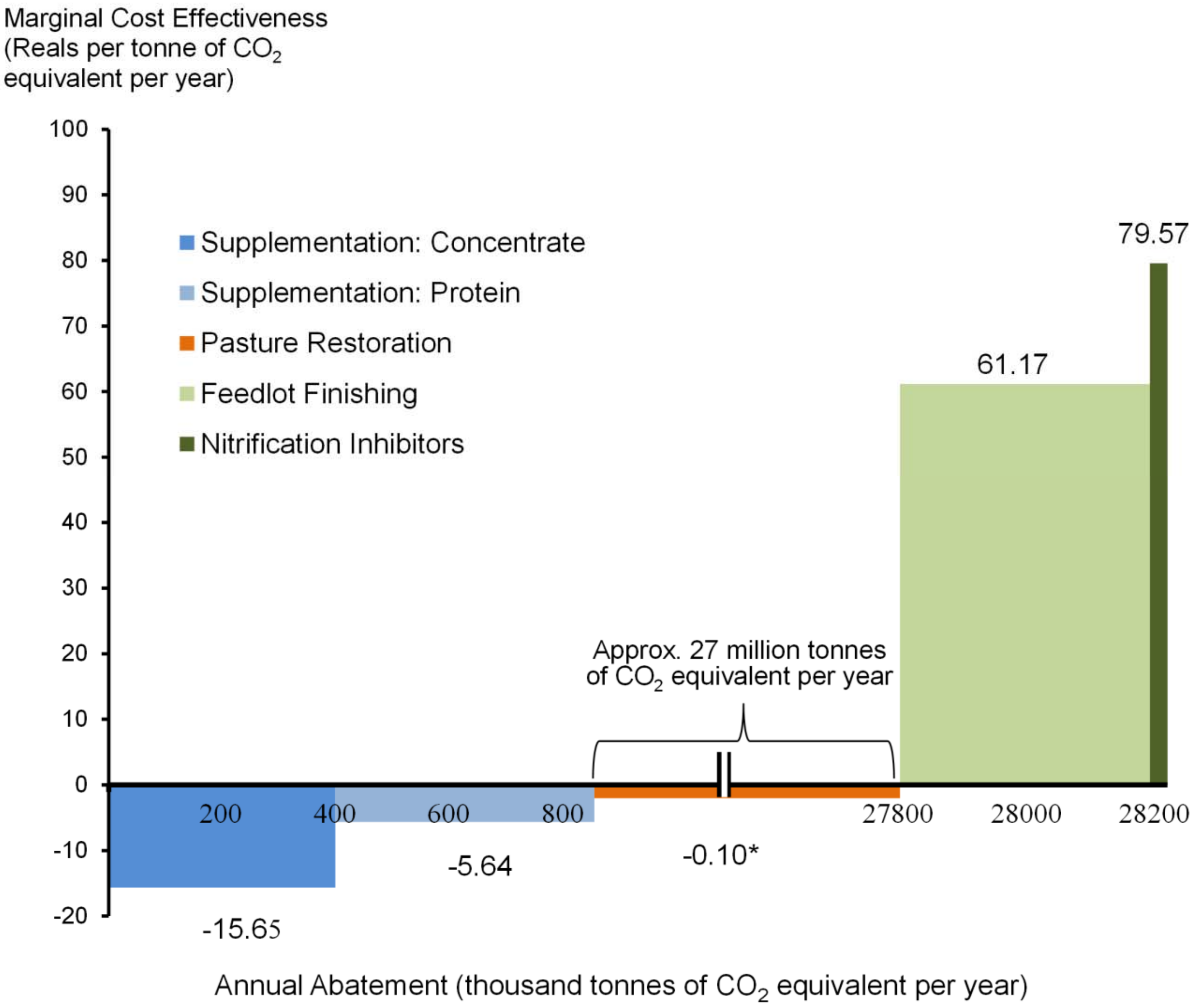
Mitigation abatement cost curve for the Brazilian cerrado (2006-2030)



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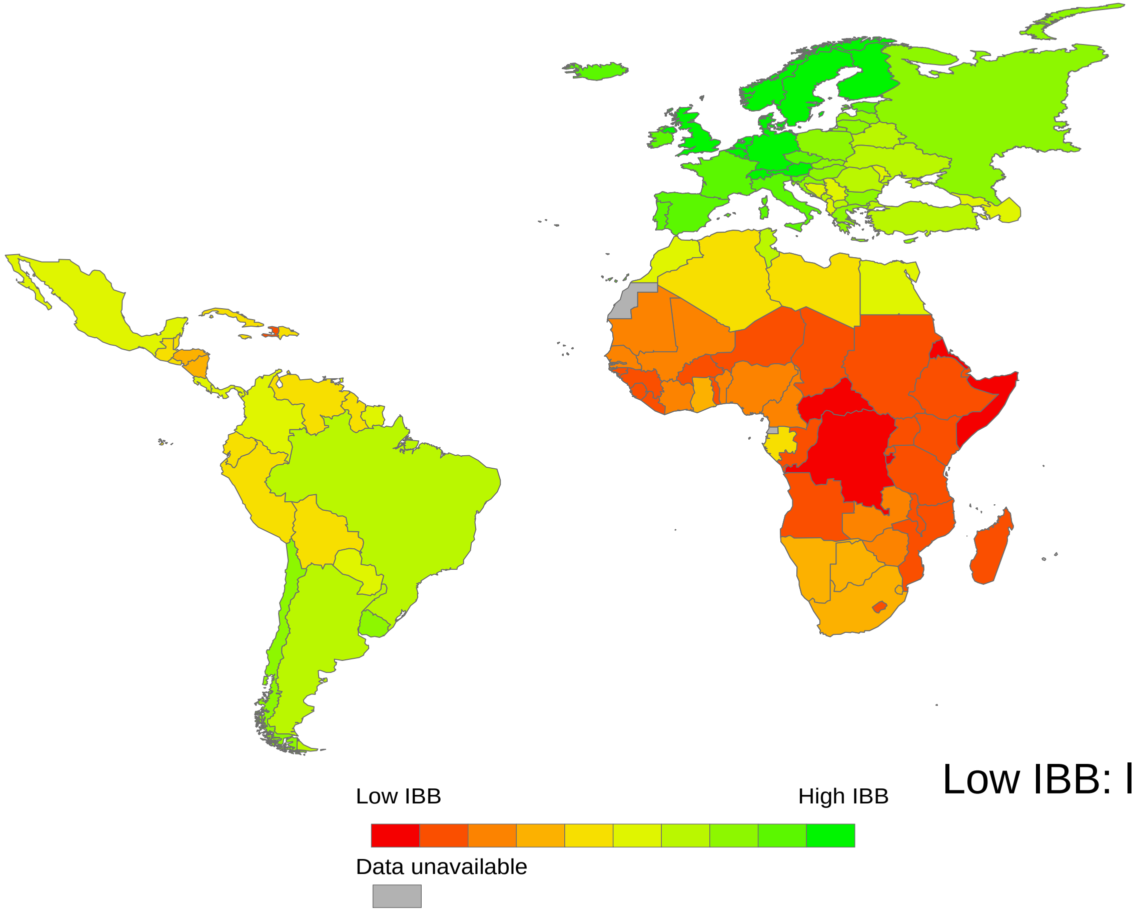
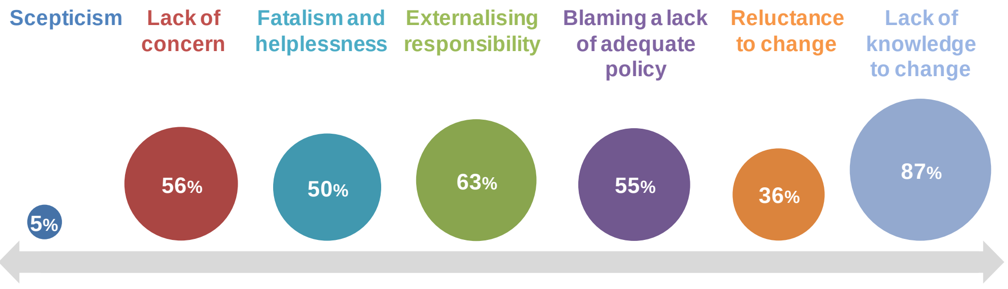
Index of Behavioural Barriers (IBB)


Low IBB
High IBB
🟥🟥🟧🟧🟨🟨🟩🟩🟩🟩
Data unavailable
⬜

Low IBB: low uptake of M & A strategies

Behavioural barriers in Eastern Kenya



Barriers reflecting personal beliefs,
more complicated to overcome

Barriers reflecting limitations in knowledge,
less complicated to overcome

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Mitigation package for Europe

Total emissions from ruminants	
Ruminants	496 Mt CO2-eq.
Mixed dairy	166 Mt CO2-eq.
Mitigation potential	
Fat supplementation (mixed dairy cows)	2.3 to 6.8 Mt CO2-eq.
Manure management (mixed dairy)	5.3 Mt CO2-eq.
Biogas production (mixed dairy)	4.4 Mt CO2-eq.
Energy use efficiency (all ruminants)	23.2 Mt CO2-eq.
Increase legumes in grassland (all ruminants)	14.6 Mt all systems
Grazing management (all ruminants)	0.17 Mt all systems
Total	**50 to 54.5 Mt CO_2-eq** **Or c.a. 11%**

Thank you for your attention!

AnimalChange is supported by EU FP7 under grant agreement 266018