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Maximum ambition GHG abatement scenarios in agriculture: opportunities and limitations of integrated modelling approaches

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Zero Greenhouse Gas Emission in High Productive Agriculture

Copenhagen, May 3-5, 2022

Overview

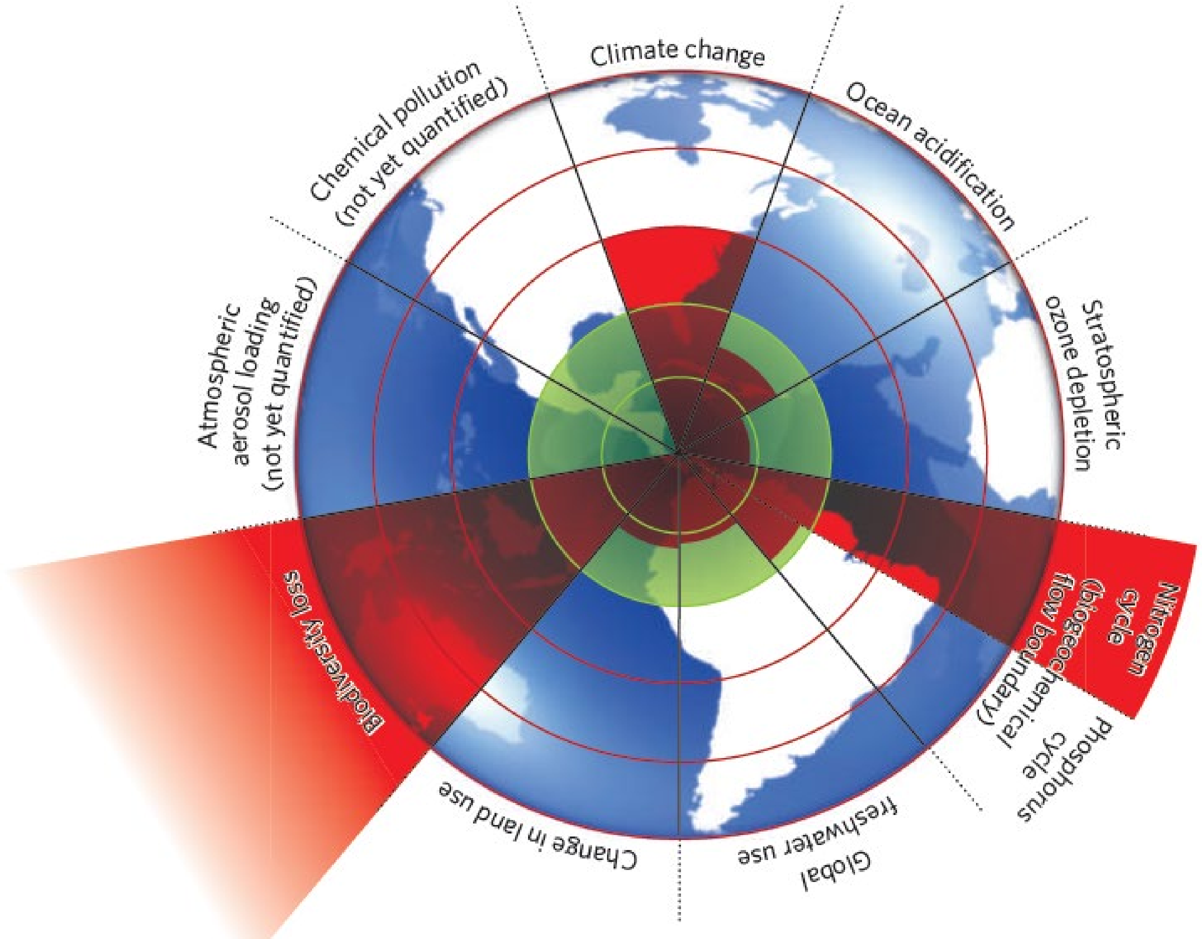
Integrated modelling – purpose and limitations

Key results achieved with the GAINS model

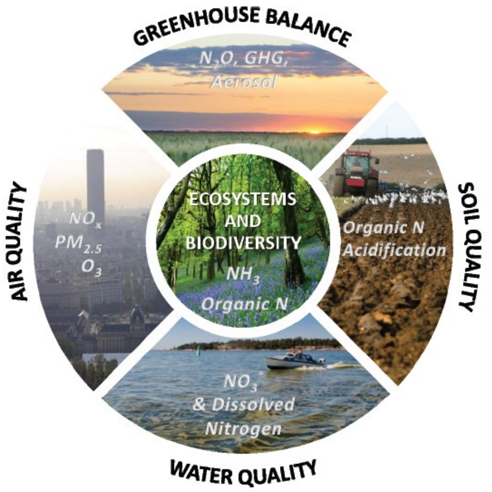
A continuous need to further improvements

Outlook

Planetary boundaries



Source: Rockström et al., Nature, 2009
(Steffen et al., Science, 2015)



ENA, Sutton et al., 2011

Policy needs to tackle a complex world

What do decision makers need?

- Scientific decision support, under uncertain conditions and in varying situations
- Impact assessment in multiple dimensions
- Transparent and consistent messages
- Current situation and expected future scenarios

- Providing a common framework as basis for negotiations among stakeholders. Uncertainty.

… based on scientific guidance

Tools to respond to these needs

- Integrated modelling
- Consistent model assumptions
- Consistency with policy targets
  - Energy projections
  - Agricultural projections
  - Legislation (also when only effective in future)
  - Inventory methodology

Benefit of harmonized approaches: Integrated assessment

Integrated: interdisciplinary process - added value compared to single disciplinary assessment

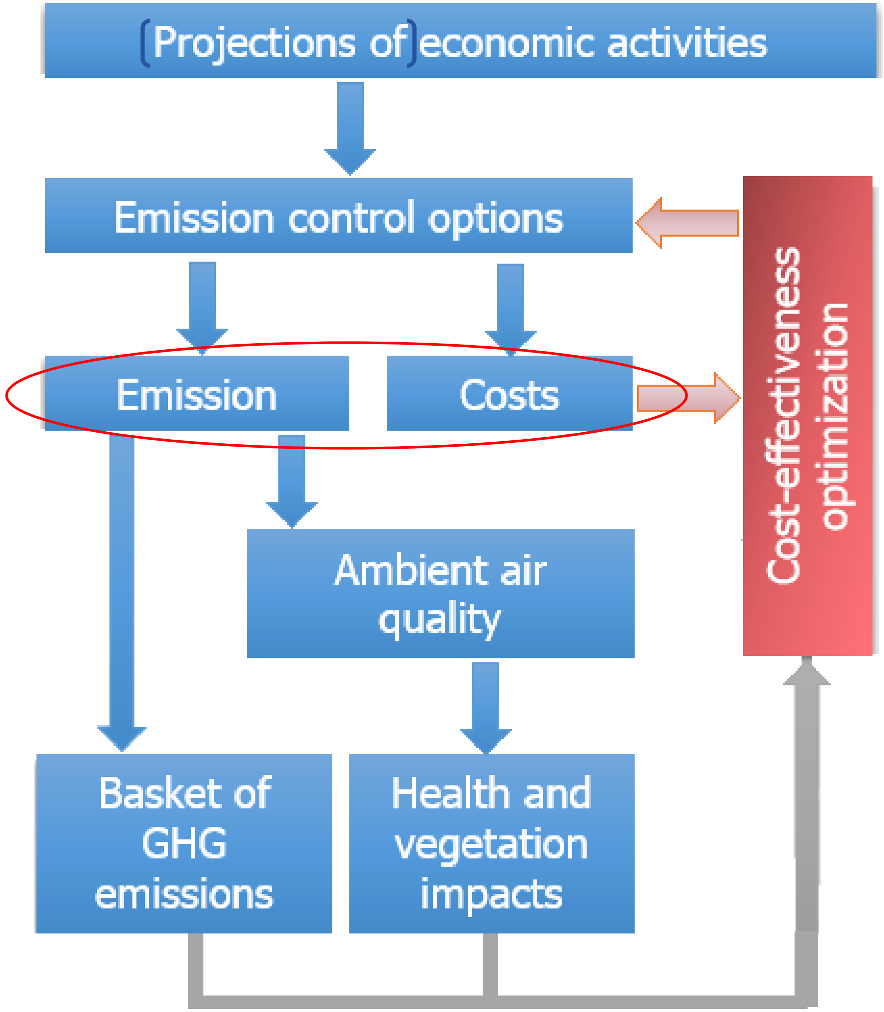
Assessment: Scientific support being useful to decision makers

Thus (IA) is an iterative participatory process that links knowledge (science) and action (policy)

(See: Jeroen P van der Sluijs, Encyclopedia of Global Environmental Change, 2002)

IAM's typically combine biophysical realities with economic optimization

IIASA's GAINS model



The GAINS model

Agricultural modules, based on identical activity numbers and agricultural systems

Ammonia

- Specific measures along manure management chain, and towards urea use

Methane

- Measures focussing on herd management, manure AD, rice cultivation

Nitrous oxide

- Measures to reduce mineral fertilizer, and use of chemical inhibitors

The bigger picture: changes in agricultural structure

livestock systems: meat consumption

integration of feed production and livestock

well managed systems – ecosystem services

Implementation within given economic framework – employing external models

- Human diet (based on EAT-Lancet commission "global planetary health diet")
- Avoiding waste and maximize re-use of bio-substrates
- Impacts beyond agro-food system

(not part of GAINS but necessary inputs for GAINS, e.g. based on SSP's)

NH_3 measures

Improved manure storage (e.g. sealed manure tanks) with a focus on large farms

Manure application close to the soil, such as by trailing hose, trailing shoe or manure injection

Improved application of urea or use of other fertilizer

CH_4 measures

Health orientation in animal breeding for high milk production with few replacement animals

Anaerobic digestion uses methane formed for energy production

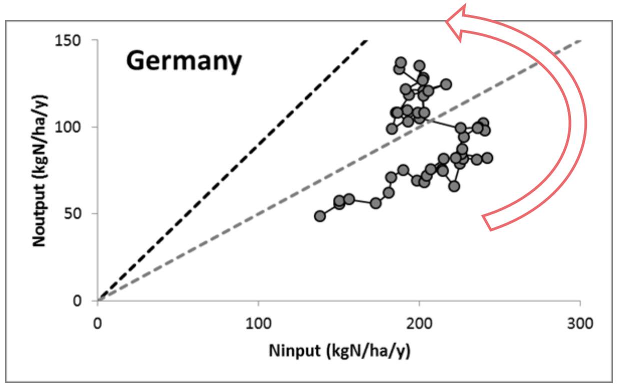
Improved water regime in rice cultivation

N_2O measures

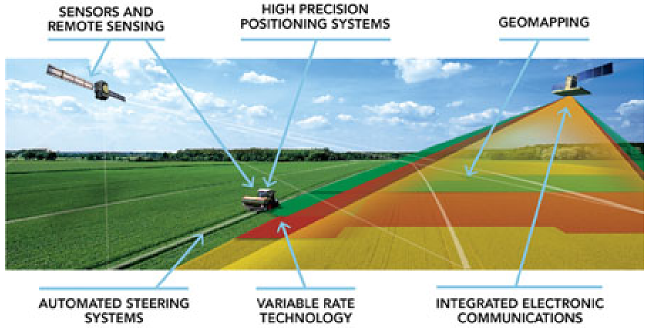
Improved use of fertilizer input (nitrogen use efficiency)

Technology to physically reduce fertilizer amounts

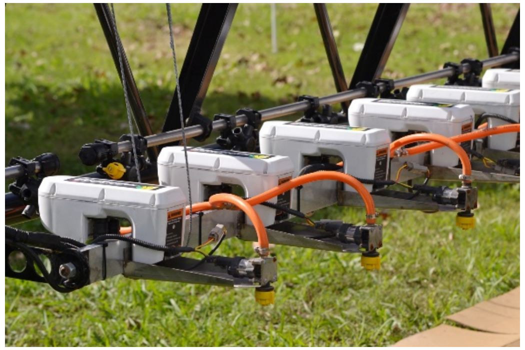
Enhanced efficiency fertilizers



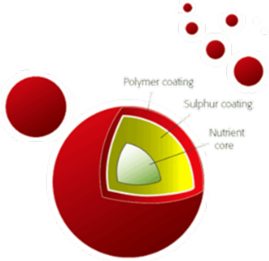
Lassaletta et al.



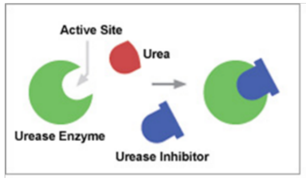
Source: CEMA - European Agricultural Machinery



http://maquinac.com

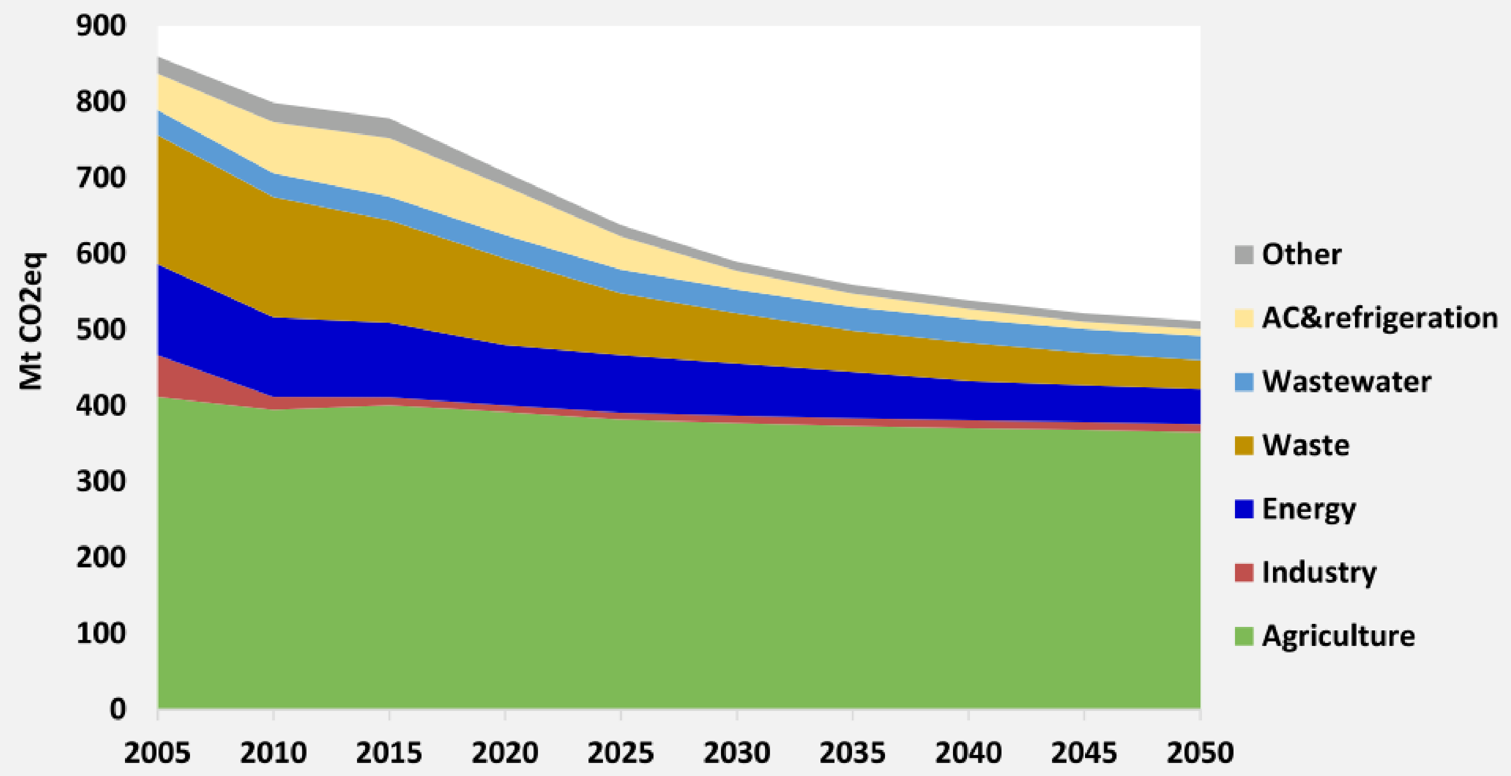


Fertilizer-machine.com



BASF

Some results from GAINS modelling exercises

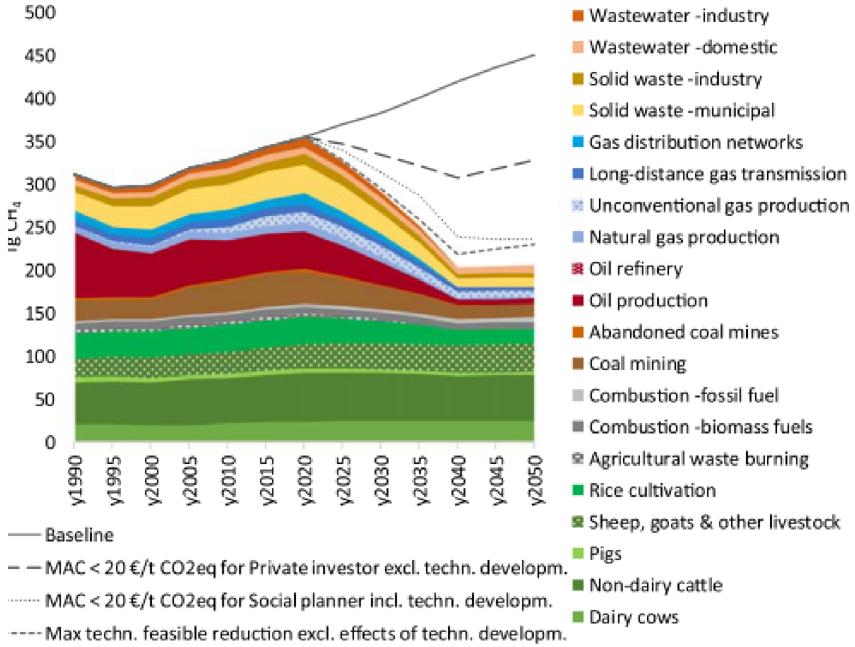


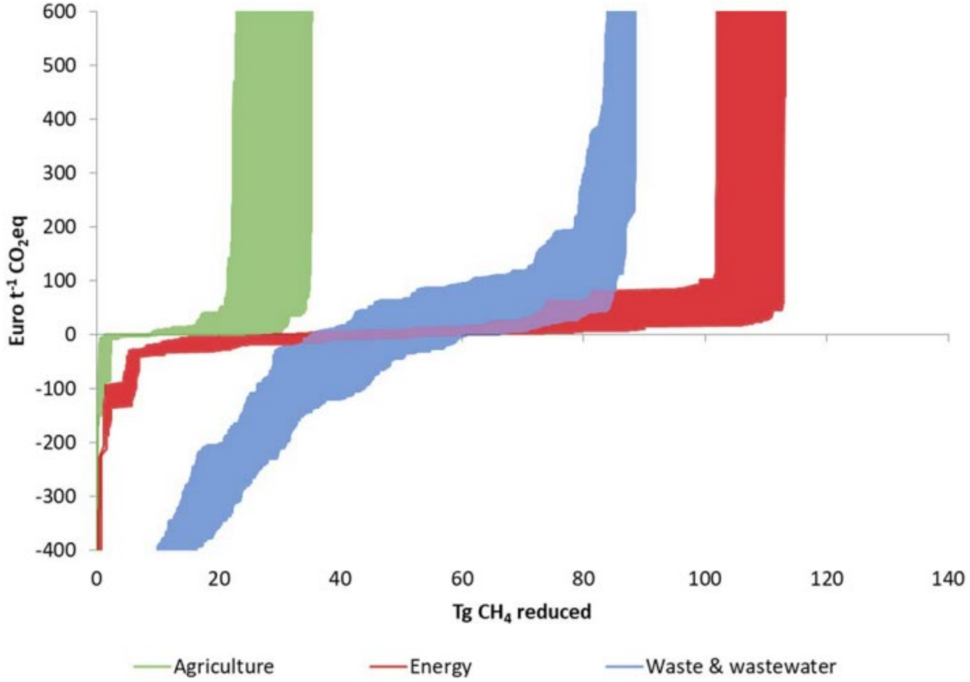
Reduction below 2005:	-18%	-31%	-41%
Non-agricultural sectors:	-30%	-53%	-67%
Agriculture:	-5%	-8%	-11%

Source: IIASA-GAINS

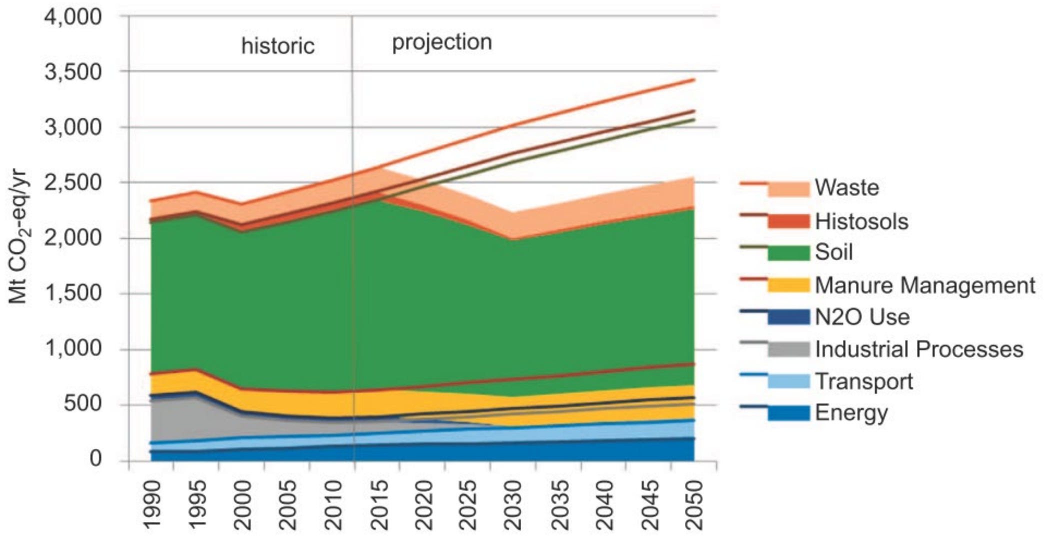
Non-CO_2 baseline emissions: Capros et al., 2020

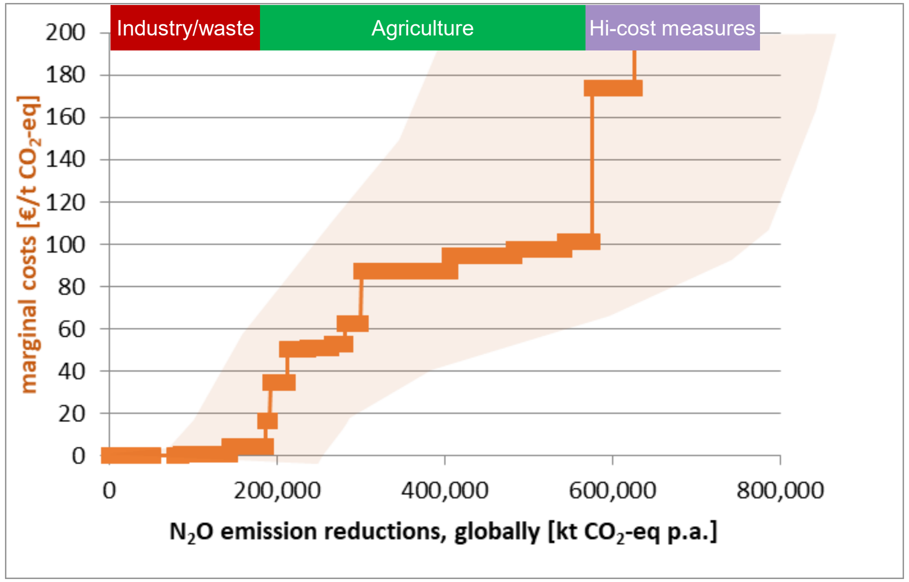
Methane scenario and cost curves





Nitrous oxide scenario and cost curves





Modelling challenges

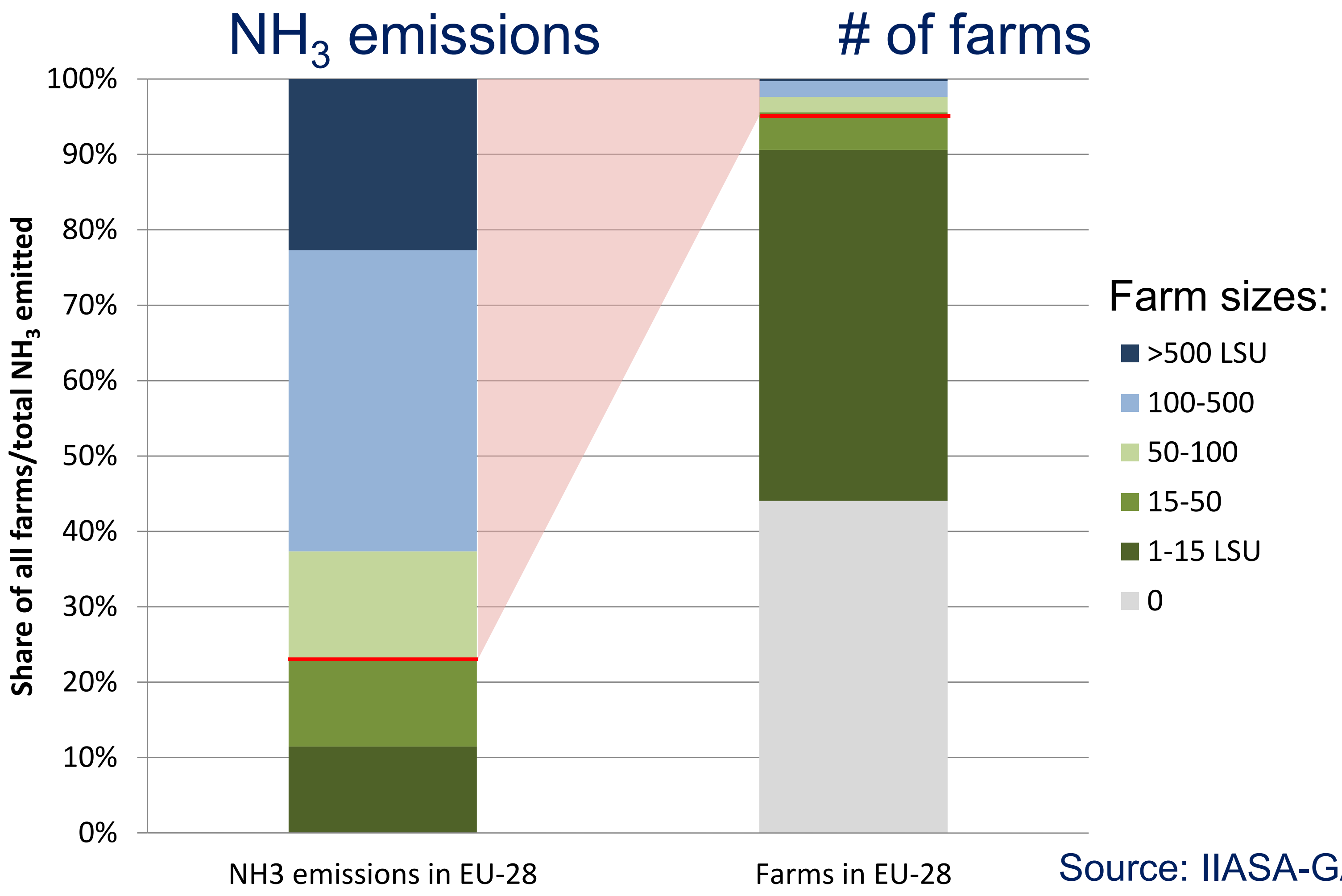
No full integration of sub-modules – parallel processing
(acknowledging extreme advantages of sectoral specialized approaches)

Effect of measures always referenced to a standard situation – which reference to use for Europe? Globally?

How would abatement measures affect different agricultural practices? How will such practices change in the future?

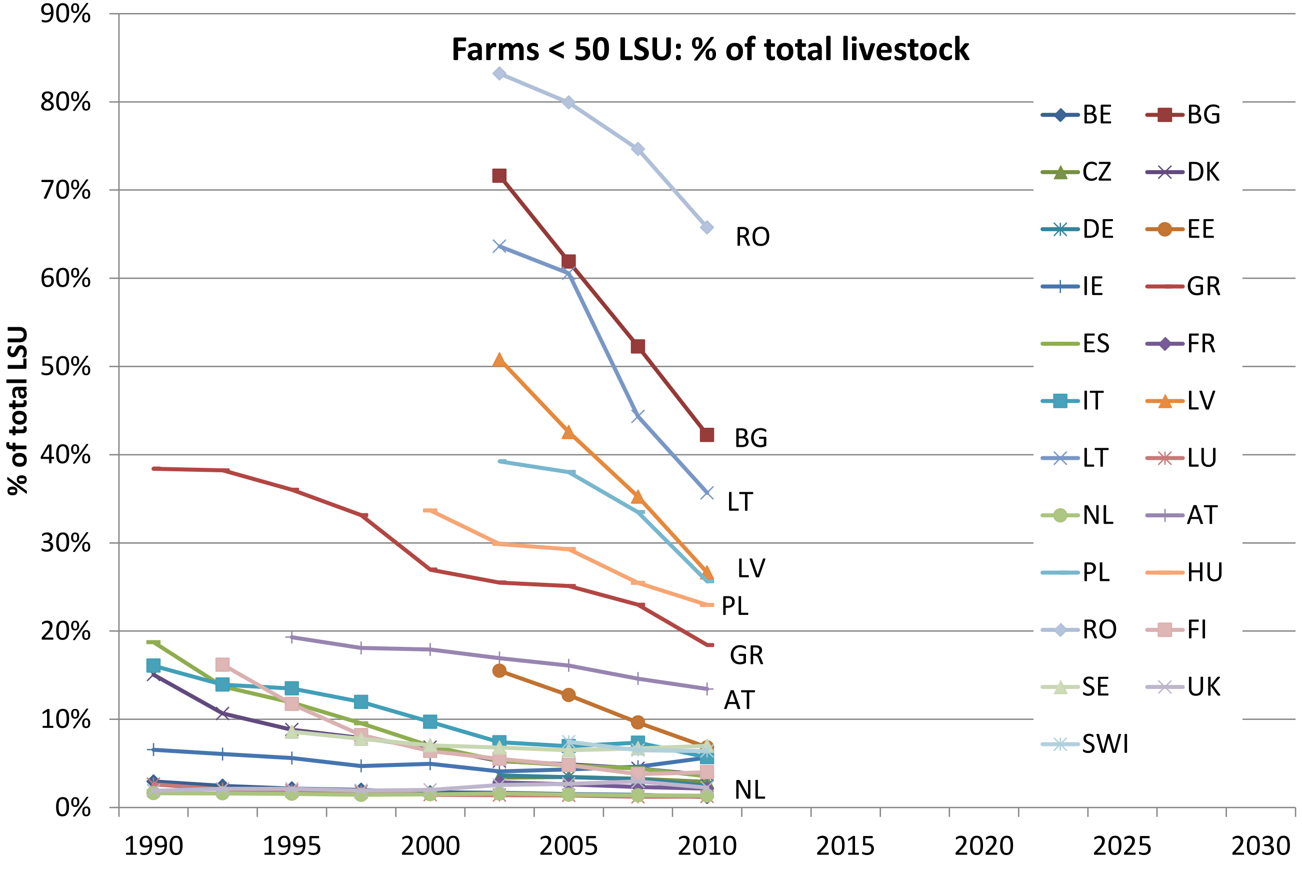
How do abatement measures impact on other compounds? When should we expect rebound effects?

80% of NH_3 emissions emerge from 5% of the farms in the EU



Source: IIASA-GAINS

Farm sizes increase continuously and consistently



Data from Eurostat – can be extrapolated

Efforts to address cha

Match integrated modelling appro UNECE, IPCC guidance; EAGER group)

Identify and address trade-offs of

Feeding

Best NH_3 reduction options | Reduced CP

Best CH_4 reduction options | Conventional feeds

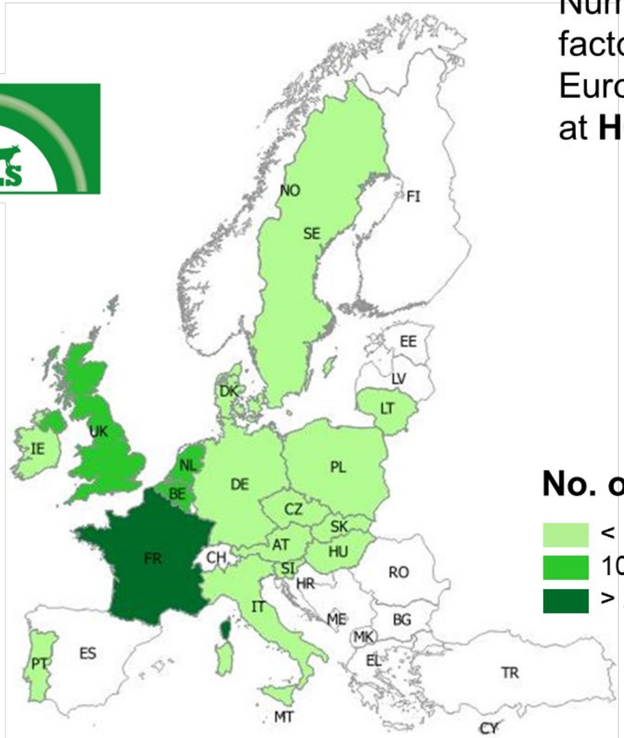
Best N_2O reduction options | Reduced CP

Table 3 Interactions between abatement options and emissions of N_2O, CH_4 and NH_3[4]

Stage	Reference Scenario	Mitigation Options	N_2O	CH_4	NH_3
Feeding	Conventional feed	Reduced crude protein (CP)	↓	↑	↓
		Feed additives	↑	↑	↓
Housing	Liquid manure housing systems	Air scrubbers	↑	↓	↓
		Frequent removal	↓	↓	↓
Treatment	No treatment	Anaerobic digesters	↓	↓	↓
		Acidification	↓	↓	↓
Storage	No cover	Covers	↑	↓	↓
Application technique	Surface spreading	Injection	↑	-	↓

Efforts to address challenges

Assess the situation of farming in non-standard countries, and experience in emission reductions (MELS project – feeds into DATAMAN)



Number of **AMMONIA** emission factors (EFs) collected from European experimental studies at **HOUSING** level

No. of EFs:

- < 100
- 100 – 200
- > 200

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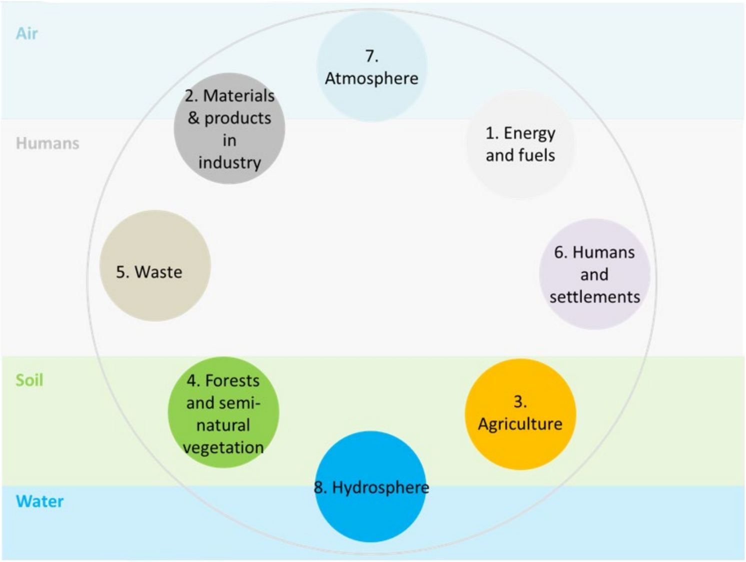
Efforts to address challenges

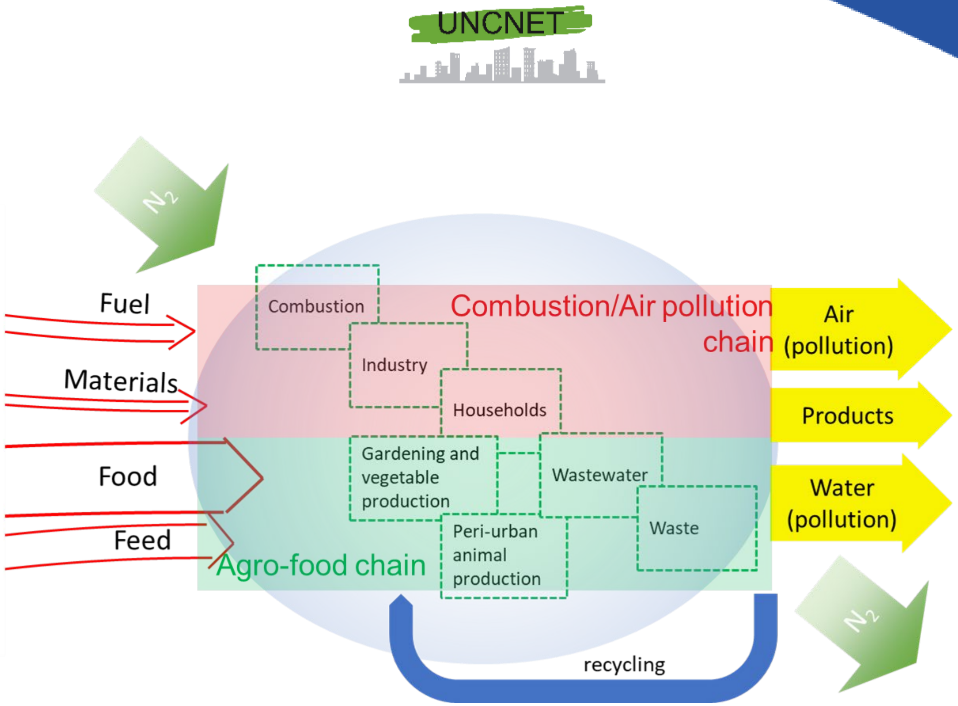
Describe the dairy farming situations in subsistence and part-time farms (MilKey project)

- small subsistence farms characterize farming in Polish southeast
- interviews in Małopolskie, Podkarpackie (50 farmers - operating dairy farms of less than 5 dairy cows)

Efforts to address challenges

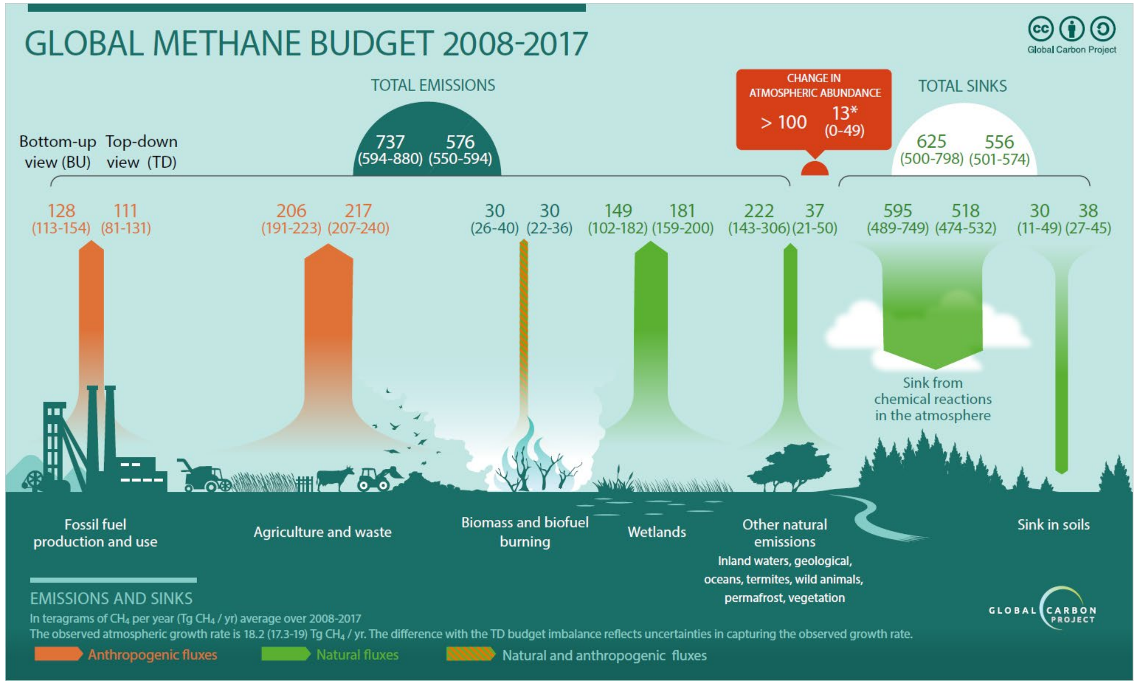


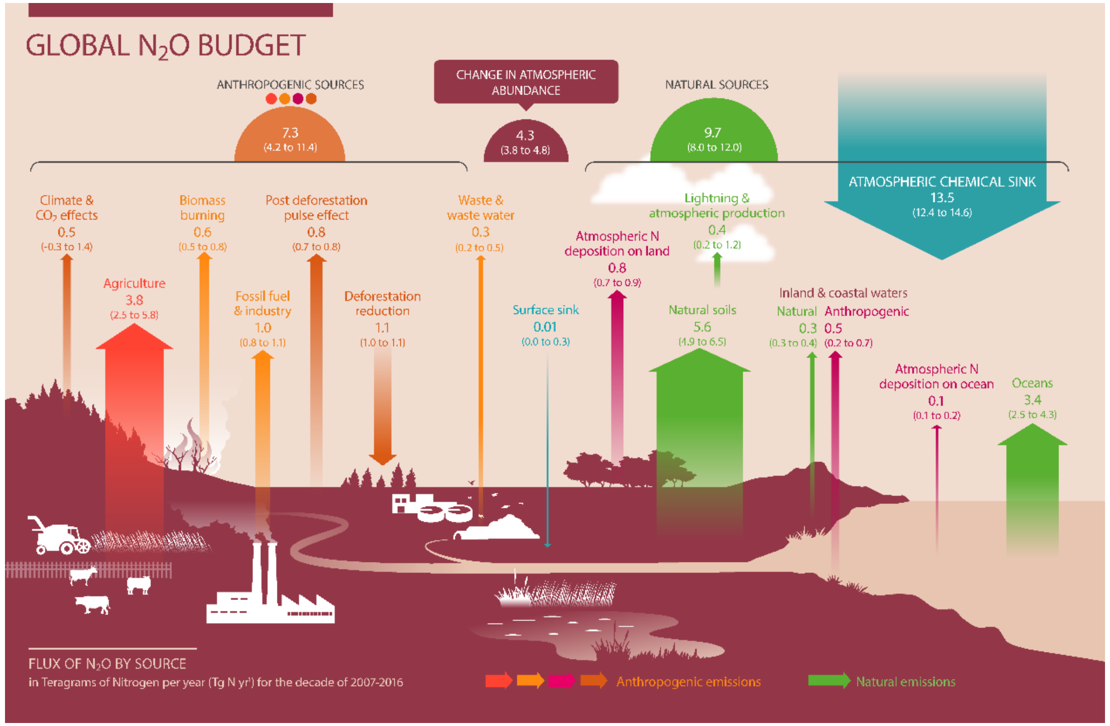
http://www.clrtap-tfrn.org/epnb



Validate the fate of N compounds in the environment using N budget approaches (different scales, farmgate, urban, national scale)

Efforts to address challenges





Global budgets for methane and nitrous oxide (Global Carbon Project)

Outlook

Integrated modelling strives to account for multiple real-world interactions

Sparse real world data of sufficient quality and comprehensiveness

Fast developments require continuous updates of parameters, activity data and abatement measures

Validation of assumptions is key, ideally using independent approaches and central physical theorems.

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