Tackling climate change in agriculture- key mechanisms in GHG mitigation

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EU 2030 Energy and Climate Package - Emissions Sharing Regulation

≤-40 % Greenhouse Gas Emissions (domestic) (vs 1990)

ETS

-43 %

vs 2005

Including: Power/Energy Sector and Industry, Aviation

Max 100 MTCO 2eq

Non-ETS ≤-30% vs. 2005

Effort Sharing Regulation (ESR): road transport, buildings, waste, agriculture

-30 %

Full flexibility

Max 280 MtCO2eq

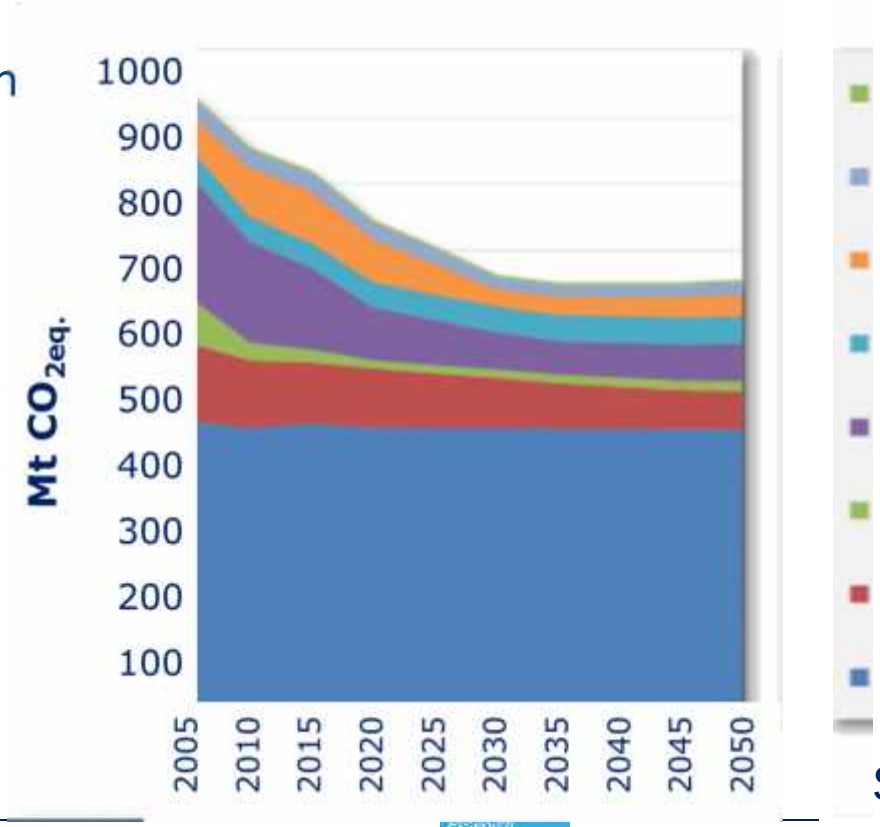
LULUCF

≤ 0 %

"No-Debit"

Projections: emissions go down, agri-emissions remain stable

Projected trends in sectors outside of the EU-Emissions Trading System



Source: GAINS, IIASA

List of mitigation measures

Livestock disease management - Use of sexed semen for breeding dairy replacements - Genetically improved cow replacement rate - Animal breeding for enhanced productivity - Livestock selection based on growth, milk production and fertility - Use of products to increase production (meat or milk) per animal (like somatotropin) - Feed additives to reduce CH4 (lipids, nitrates or sulphates, propionate precursors, plant bioactive compounds) - Breeding low methane emissions in ruminants - Vaccination against methanogenic bacteria in the rumen - Develop cross-breeding with lower emissions - Change fodder composition, favouring non-methanogenic compounds (increase sugar, tannins…) - Use of antibiotics to regulate microorganisms producing methane in the rumen - Use of biotechnology to control microorganisms in the rumen - Feed advisory tool - Optimised feed strategies (multi-phase feeding) - Changes in composition of animals' diet (optimising feed mix in ruminants) - Low nitrogen feed - Genetic improvement of cattle based on feed use efficiency - Increase concentrates in feed rations - Optimised manure storage and application - Covering slurry pits - Incorporation of slurry - Decrease the quantity of manure stock - Optimise the type of manure produced to balance N2O/CH4 emissions - Anaerobic digestion - Produce dihydrogen from manure in anaerobic conditions - Slurry acidification - Rice - Soil and nutrient management plans - Improved nitrogen efficiency - Variable Rate Technology (VRT) - Precision farming - Genetic improvement of crops for better nitrogen uptake and use efficiency - Delay in applying mineral N in crops that have had slurry applied - Reducing soil compaction and avoiding fertilization in the traffic lanes - Biological N fixation in rotations and in grass mixes - Increase legume share in temporary grassland - Substitution of mineral fertilizer by N from legumes - Use of urease inhibitors and next-generation nitrification inhibitors - Nitrification inhibitors - Modify microbial communities in the soil, introducing microorganisms which reduce N2O and N2 - Maintain soil pH at suitable level for crop/grass production - Burn - Agro-forestry, short rotation forestry - Maintaining permanent grasslands - Conversion of arable land to grassland to sequester carbon in the soil - Woodland creation (afforestation, including new shelterbelts, hedgerows, woody buffer strips and in-field trees) - Woodland management: preventing deforestation - Woodland management (including existing shelterbelts, hedgerows, woody buffer strips and in-field trees) - Improving grassland management (e.g. optimizing productivity, livestock density, nutrient management, grass varieties) to increase carbon sequestration - Extend the perennial phase of crop rotations - Leaving Crop Residues on the soil surface - Use cover/catch crops, green manure, and reduce bare fallow - Restauration of degraded soils to increase the production and stock of organic matter - Increase biomass production by optimising the input use, increasing carbon return to the soil - Select crops providing higher carbon return to soils - Measures targeting C-sequestration (reduced tillage, crop rotation, cover crops...) - Reduced Tillage - Zero Tillage - Biochar applied to soil - Wetland and peatland conservation/restoration - Fallowing histosols - Carbon calculator - Improved on-farm energy efficiency - Reduce the use of fossil energy use on-farm in buildings and machinery - Use of solar energy to dry agricultural products - Use of solar, wind, and geothermal energy - Biofuel production and use on site - Produce energy on-farm through biomass burning to decrease CO2 emissions -

Do mitigation measures show up in GHG emission inventories?

Review of mitigation measures

- **Meta-review of Common Agricultural Policy (CAP) mainstreaming**. Effective performance of tools for climate action policy. DG-Clima.
- **ECAMPA project**: 'Economic assessment of GHG mitigation policy options for EU agriculture'. It selected a set of measures to be implemented in CAPRI (Common Agricultural Policy Regional Impact model) to allow the assessment of measures.
- Pellerin, S., Bamière, L., Angers, D., Béline, F., Benoît, M., Butault, J.,… Pardon, L. (2013). Quelle contribution de l'agriculture **française** à la réduction des émissions de gaz à effet de serre? Potentiel d'atténuation et coût de dix actions techniques (Synthèse du rapport d'étude). Paris: INRA.
- Finnish Ministry of Agriculture and Forestry (2014). Climate Programme for **Finnish** Agriculture- Steps towards Climate Friendly Food. ISBN 978-952-453-871-8.
- Osterburg, B., Rüter, S., Freibauer, A., de Witte, T., Elsasser, P., Kätsch, S., Leischner, B., Paulsen, H.M., Rock, J., Röder, N., Sanders, J., Schweinle, J., Steuk, J., Stichnothe, H., Stümer, W., Welling, J., Wolff, A. (2013). Handlungsoptionen für den Klimaschutz in der **deutschen** Agrar- und Forstwirtschaft. Thünen Report 11.

Classification of mitigation measures

Mitigation strategies

Mitigation mechanisms

JRC TECHNICAL REPORTS

Mitigation measures in the Agriculture, Forestry, and Other Land Use (AFOLU) sector

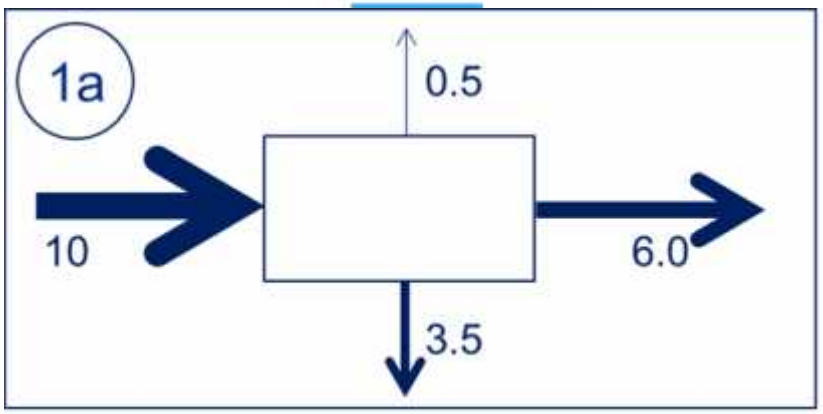
Quantifying mitigation effects at the farm level and in national greenhouse gas inventories

Leip A., Carmona-Garcia G., Rossi S.

2016

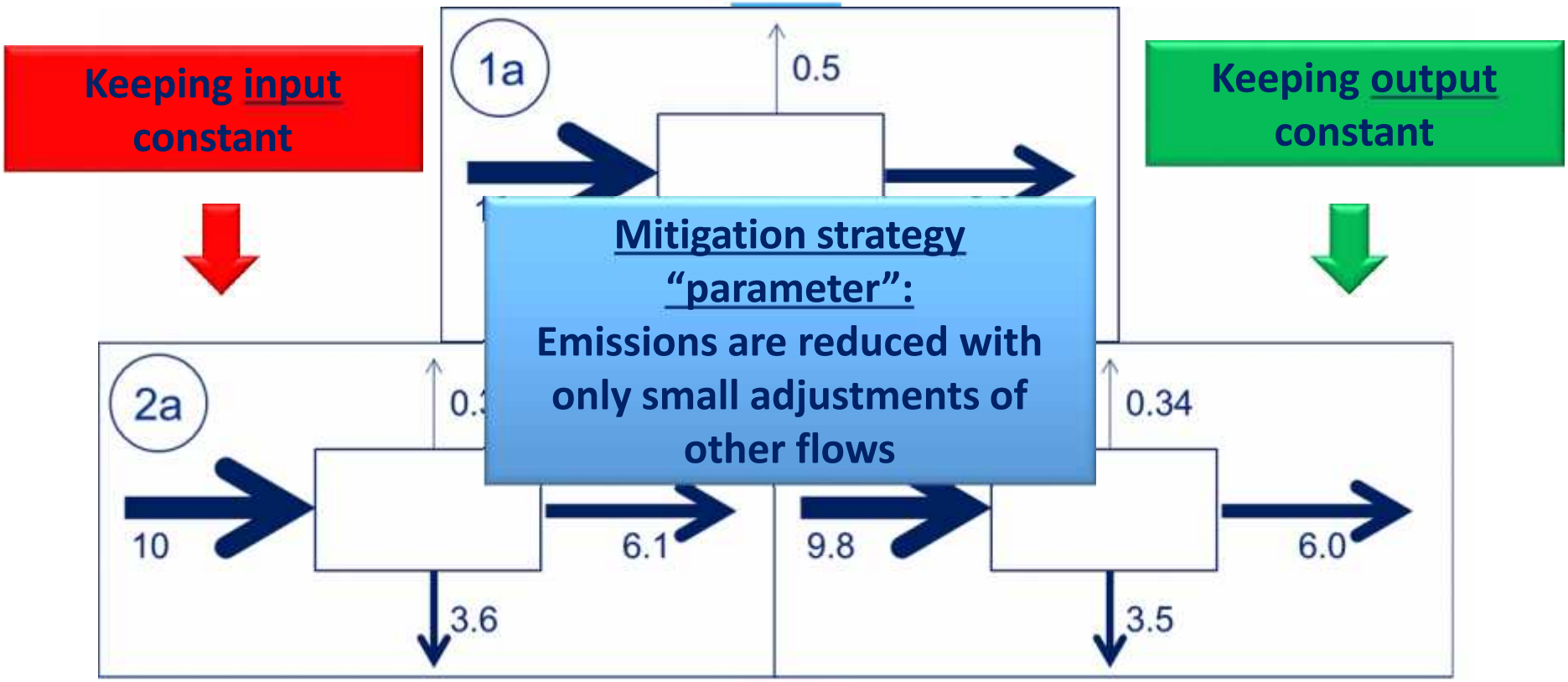
FORTHCOMING

Mitigation strategies



Mitigation strategies

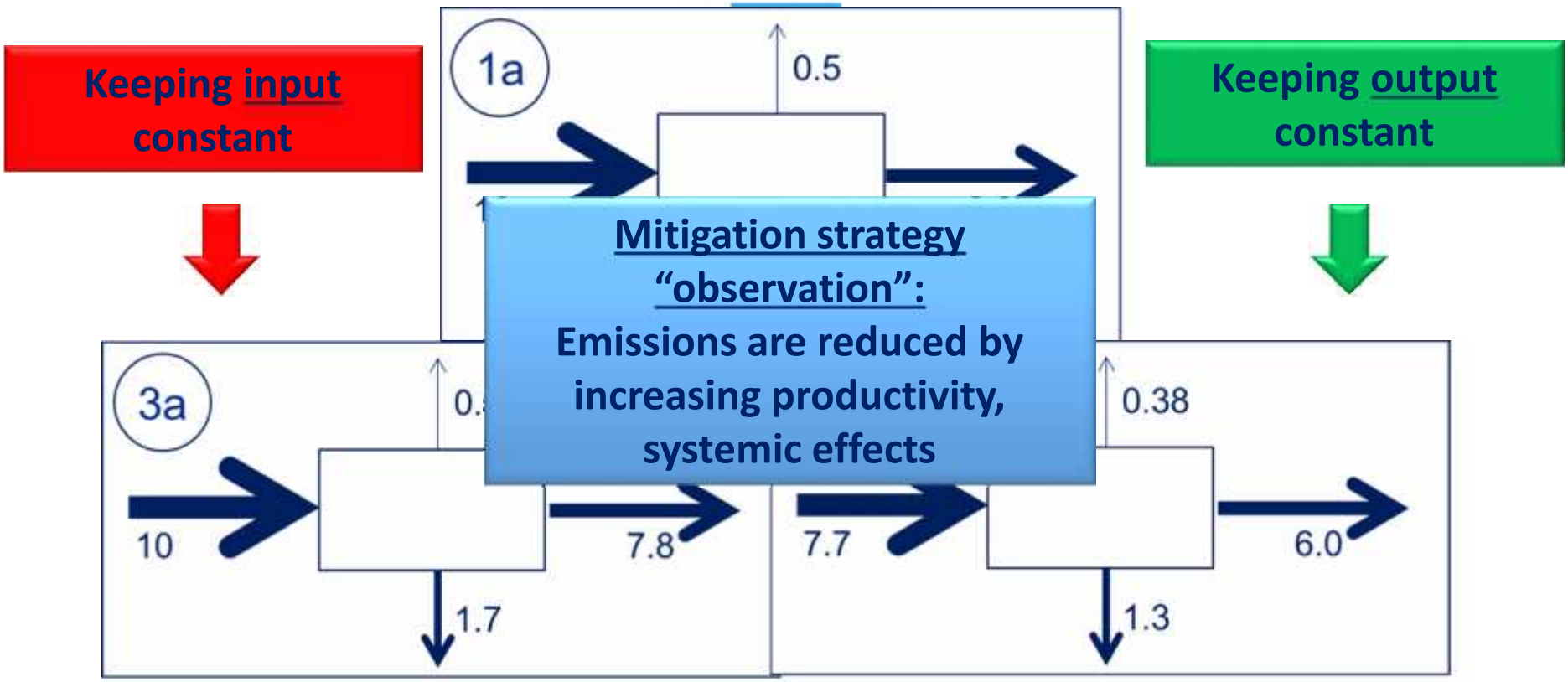
30% decrease of parameter



Schulte, 2016

Mitigation strategies

30% increase in productivity



Schulte, 2016

Mitigation mechanisms

- Bundle of individual mitigation measures
- Common mitigation strategy
- Based on ‘term’ in the standard estimation procedures
- Allow focusing the later discussion on the traceability of mitigation measures.

Mitigation mechanisms: Example Enteric Fermentation

HERD

Reducing #of animal maintaining production (sanitary, increased health, optimised gender balance, etc.)

Eq. 10.19:

$$= \sum_{(I)} \frac{(\quad ( ) \cdot ( ))}{10^6}$$

BREED

Improving productivity (EF needs to be checked as well)

FEED

Optimise feed ration (feed supplements, selective breeding programs)

Eq. 10.21:

$$= \left[\frac{\left(Y \cdot \right) \cdot 365}{} \right]$$

METHGEN

Selectively reducing enteric fermentation (feed supplements, selective breeding programs)

16 Mitigation mechanism groups

Mitigation mechanism groups	Mitigation strategy	Changes provoked	Tackles	Gas(es) targeted	Other gases affected
HERD	Observation	Improves herd productivity, but not individual one	$N_{(T)}$	all	
BREED	Observation	Improves animal productivity	$N_{(T)}$	$CH_{4Ent.}$ CH_{4Man}, N_2O_{Man}	
METHGEN	Parameter	Additives or breeding reducing selectively CH_4 production in rumen	Y_m	CH_{4Ent}	--
FEED	Observation	Adjust rations to (energy, N content) feed needs	GE/DE/Nex	$CH_{4Ent.}$ CH_{4Man}, N_2O_{Man}	3D-N2O
MANSYS	Observation	% manure in each MMS	MS	CH_{4Man}, N_2O_{Man}	
ADIG	Observation	Anaerobic digesters, to reduce emissions form manure and produce energy	MS	CH_{4Man}, N_2O_{Man}	CO_2 energy
MANEF	Parameter	Additives, etc, affecting directly emission factors	MCF/ EF_3	CH_{4Man}/ N_2O_{Man}	--
RICE	Observation	Management practices (e.g. aeration)	$t_{i,j,k}$, $A_{i,j,k}$	CH_{4Rice}	--
NMANAG	Observation	Improved use of available sources (% each type, timing....)	F_{SN}, $F_{PRP,}$ $Frac_{GASF}$, $Frac_{GASM}$, ...	all N_2O	
LEGU	Observation	Increase leguminous share	F_{SN}, $F_{CR}^{(*)}$, F_{PRP}	$N_2O_{Direct,}$ CH_{4Ent}	N_2O_{ATD}, N_2O_{LEACH}, N_2O_{Man}, CH_{4Man}
NEF	Parameter	Substances/ techniques to reduce EFs	EF_1, EF_3	N_2O_{Direct}	--
BURN	Observation	Reduce burnt biomass	A	L_{fire}	
LUSE	Observation	Increasing carbon sequestration/Reducing carbon losses	A	CO_2	CH_4, N_2O
LMAN	Parameter (Observation)	Reducing carbon losses	Stock Change Factors	CO_2	N_2O
ORGSOILS	Observation	Increasing carbon sequestration/preventing carbon losses	Area	$CO_{2,}$ N_2O	CH_4
ENER	Observation	Measures to reduce farm energy use	Energy data in agric.	CO_2	

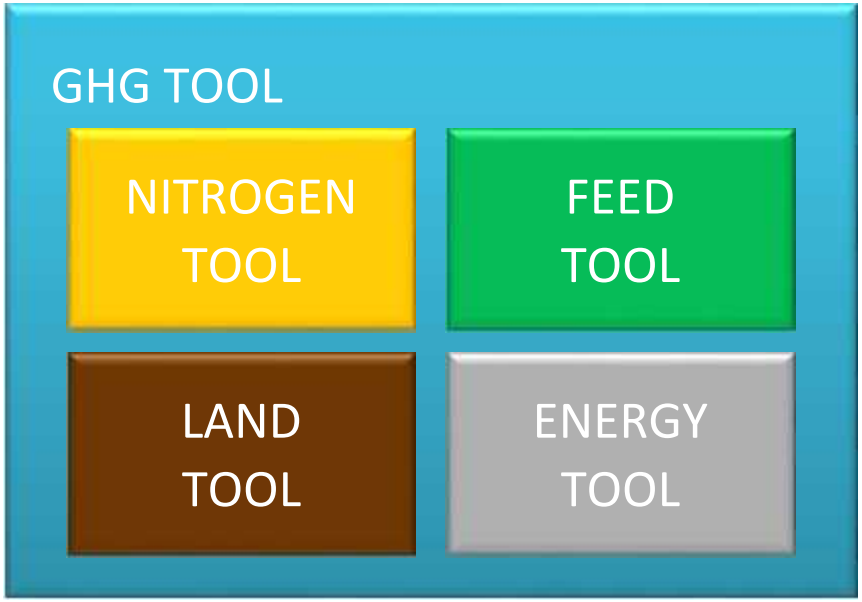
Traceability in UNFCCC national inventory reports - with current scientific understanding

	Tier1	Tier 2	Emissions affected	Comment
HERD	X		Cat. 3A, 3B1, 3B2, 3D	
BREED		X	Cat. 3A, 3B1, 3B2, 3D	Tier 2 Method usually already in use
METHGEN		X	Cat. 3A	EFs not available
FEED		X	Cat. 3A, 3B1, 3B2, 3D	Surveys required
MANSYS	X		Cat. 3B1, 3B2, 3D	Surveys required
ADIG	X (for N_2O)	X (for CH_4)	Cat. 3B1, 3B2, energy sector	Method being developed by IPCC
MANEF		X	Cat. 3B1, 3B2	EFs not available
RICE	X		Cat. 3C	
NMANAG	X		Cat. 3B2, 3D	
LEGU	X		Cat. 3D	Surveys required
NEF		X	Cat. 3D	EFs not available
BURN	X		Cat. 3F	
LUSE	X		Cat 4	
LMAN	X		Cat 4	
ORGSOILS	X		Cat 3D, 4	

What about the farm level?

- Feed and food are key!!
- Reduce (monitor) external N inputs (mineral fertlizer, feed)
- Land use data exist (in Europe) but are (usually) not available
- Additional data for GHG tool: manure management, embodied emissions in inputs

- Many mitigation measures have 'systemic' effect
- They can be monitored and implemented via relatively simple N and Feed farm-level tools



Conclusions

- Differentiation in AD and EF acc. to IPCC terminology not optimal for assessing traceability of mitigation options
- Observations and parameters link directly to 'accessibility' of required information
- Mitigation can be achieved by reducing specific *emissions* (mitigation strategy parameter) or by increasing *productivity* (mitigation strategy observation)
- *Mitigation mechanisms* groups mitigation options that target similar 'terms' in the emission accounting equations
- Assessment of effects on non-target emission sources is important!
- All mitigation measures impact farmer's income (positively or negatively)

Conclusions

Thank you!

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- Many mitigation mechanisms ‘show up’ easily in UNFCCC national GHG emission inventories, but
  - Some require Tier 2 methodology (feed, breed, …) ->
    mostly key categories for which Tier 2 is required
  - Some require additional collection of statistical data
    (manure management systems, feed intake, …)
  - Some require the development of emission factors
    (direct N2O emission factors, methanogetic inhibitors, …)