Systematic review of farming practices: translating science in policy relevant information for GHG mitigation

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It is a team work

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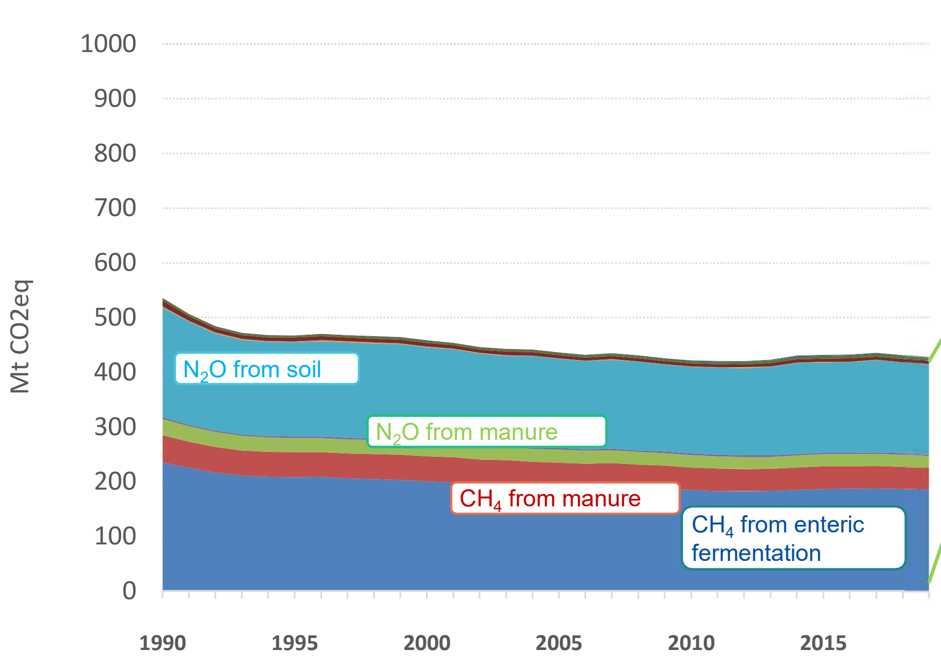
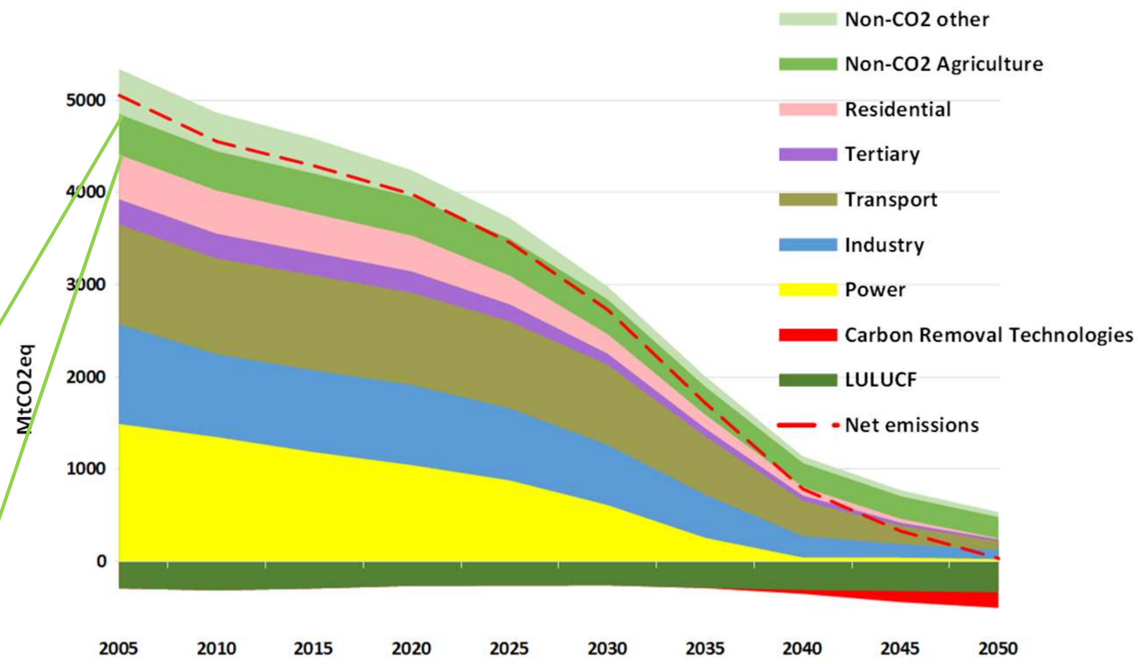
Trends and scenarios for GHG emissions in agriculture



EEA, 2021 – GHG emissions in EU28



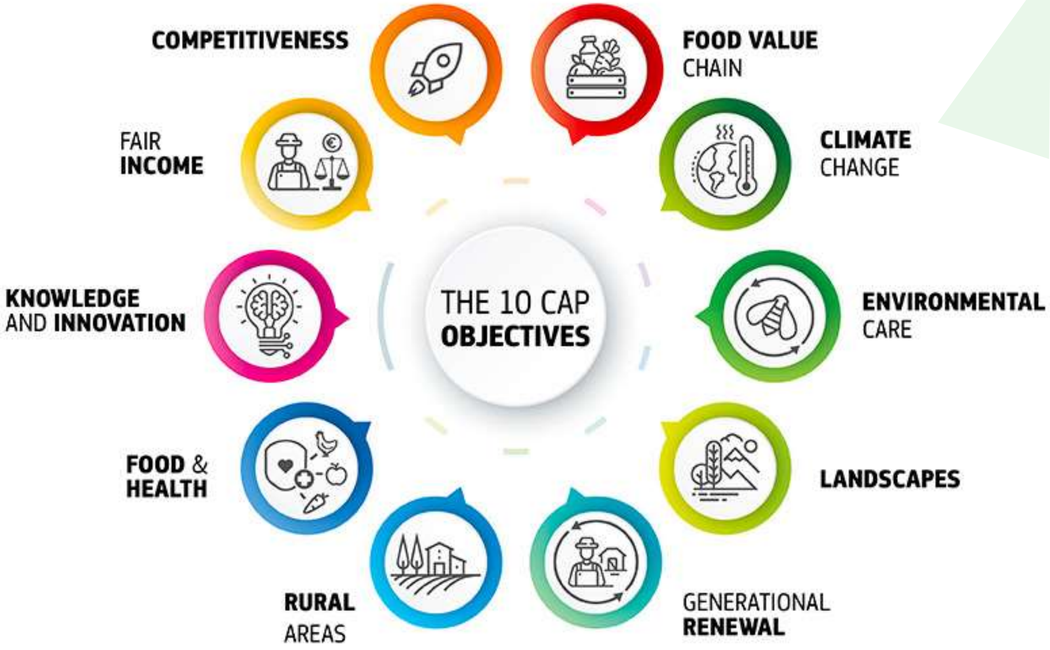
COM(2018) 773

GHG emissions trajectory in a 1.5° C scenario

Important moment for climate mitigation in agriculture

- Climate mitigation is included in all the policies related with agriculture
- New Common Agricultural Policy (CAP) will raise climate mitigation ambition

Evaluating the best option for climate mitigation in agriculture



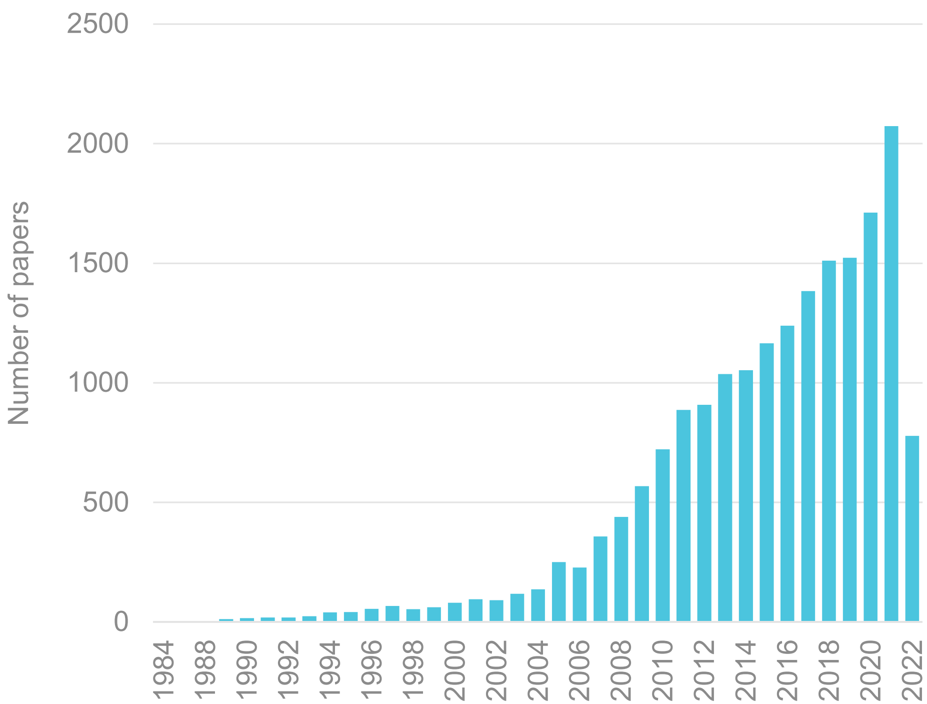
SO 4: Contribute to climate change mitigation and adaptation, as well as sustainable energy

These targets should be reflected in the CAP Strategic Plans of Member States

Which measure should be adopted by Member States?

Are CAP Strategic Plan ambitious enough?

Need of evidence based knowledge for policy



- High number of papers in the last 2 decades:
- **18,792** papers in Scopus on GHG emission AND agriculture
- How to synthesize this knowledge?

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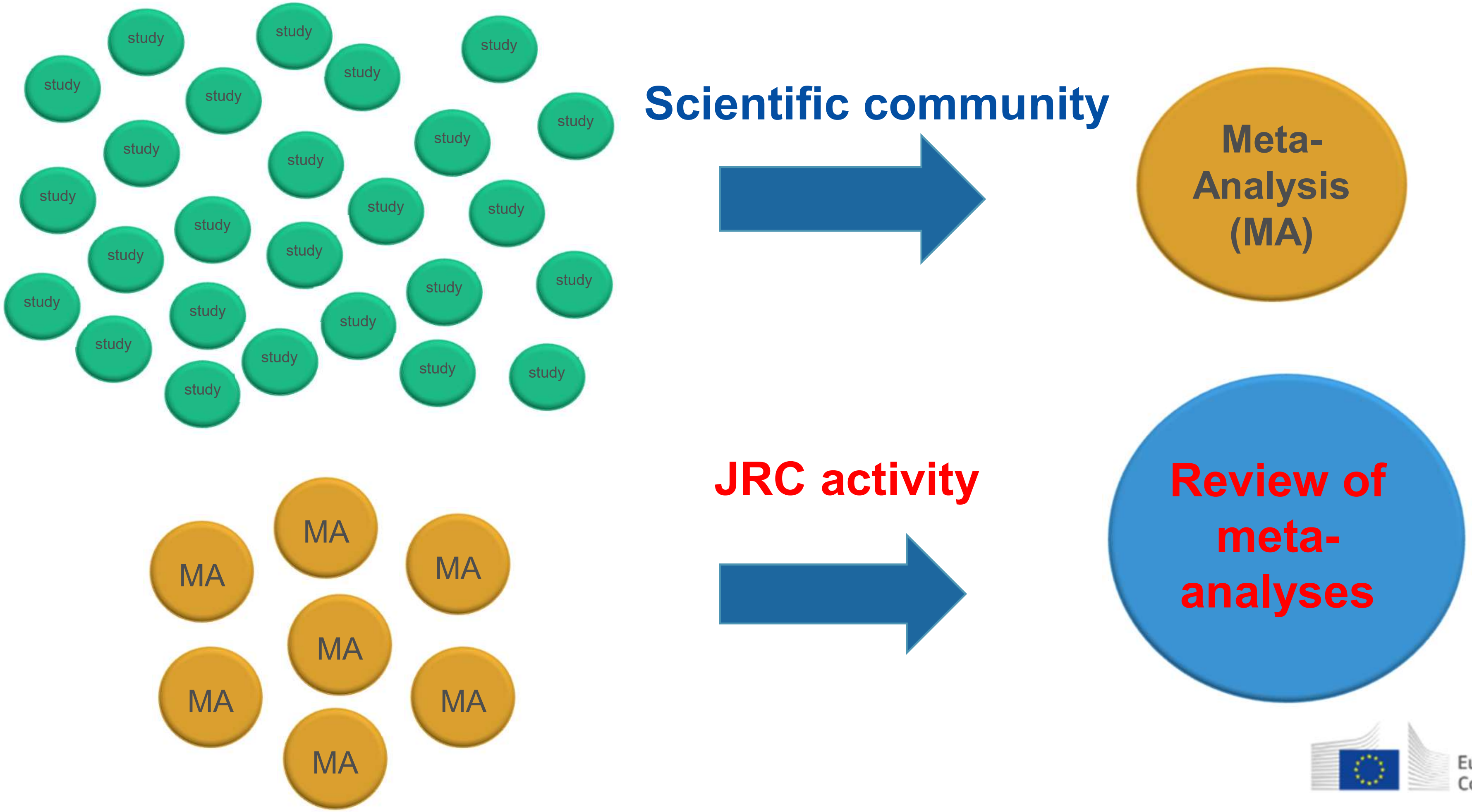
JRC method to synthesise scientific evidence



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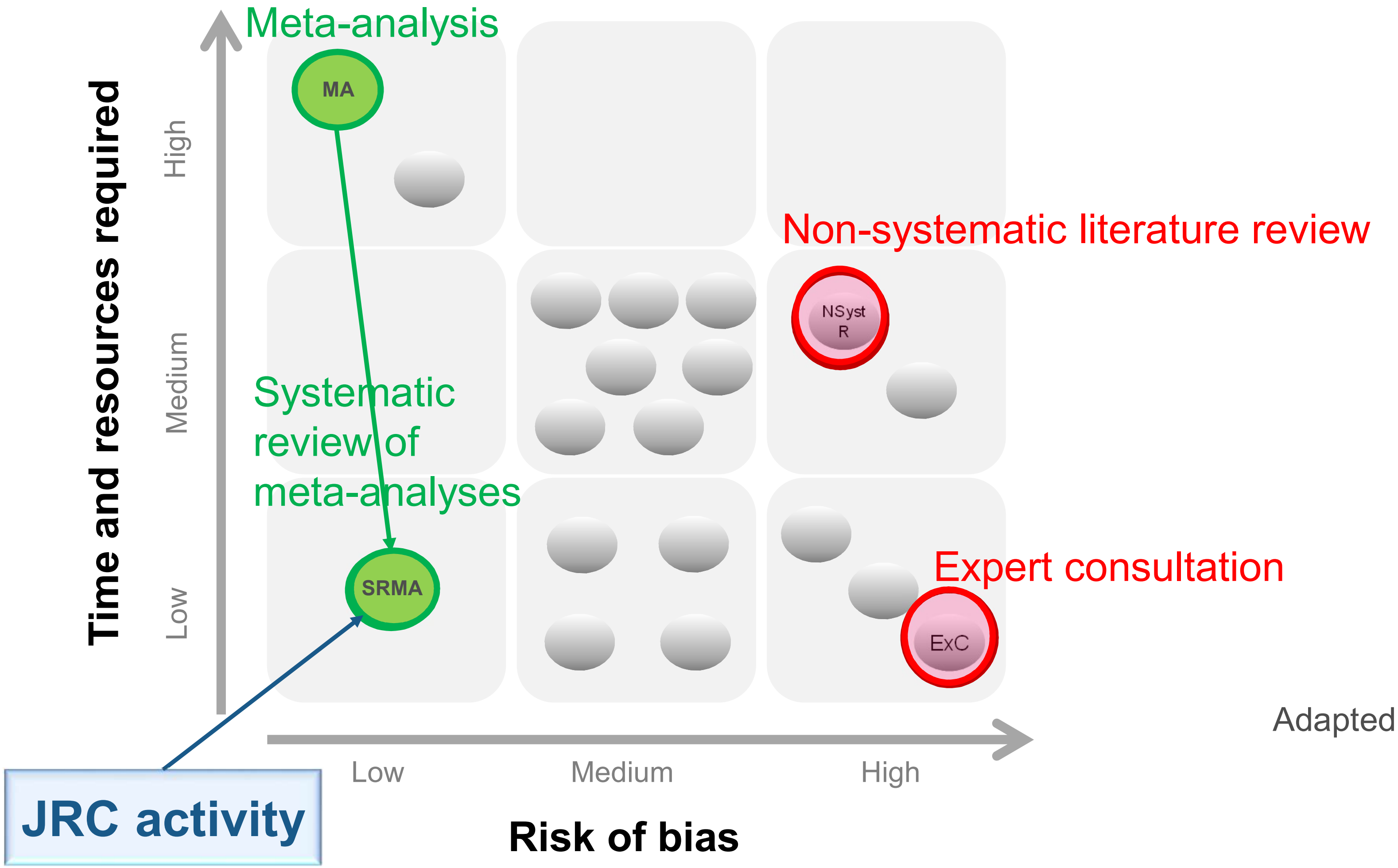
Methods available for knowledge synthesis



Adapted from EKLIPSE (2018)

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Systematic review of meta-analyses: the methodological framework

- Literature search of existing meta-analyses
- Screening and selection of meta-analyses
- Data extraction and quality assessment
- Reporting

- Search done both in WoS and Scopus DB
- The proposed framework is semi-automatic and it allows scientific experts to reduce the time needed in the reporting step.

Makowski et al., 2021. DOI:10.31219/osf.io/byuw9

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Quality criteria of the meta-analyses

Quality of meta-analysis

- 1. List of studies
- 2. Selection criteria
- 3. Objective specified
- 4. Databases mentioned
- 5. Search string
- 6. Number of studies at each step of the selection process
- 7. Quantitative results described

Quality of statistical analysis

- 8. Statistical methods described
- 9. Individual effect sizes presented
- 10. Individual effect sizes weighted
- 11. Dataset available
- 12. Confidence intervals presented
- 13. Method of data extraction described

Risk of bias

- 14. Heterogeneity of results analyzed
- 15. Funding sources mentioned
- 16. Publication bias analyzed

Effect size: is a quantitative measure of the magnitude of the experimental effect.

Review of farming practices (2021-2022)

- Agroforestry
- Organic systems
- Fallowing
- Landscape features
- Fertilisation strategies
    - Organic fertilisation
    - Green manure
    - Enhanced efficiency fertilisers
    - Nitrification inhibitors
    - Low ammonia emission techniques
- Soil amendments
    - Lime or gypsum
    - Biochar
- Pesticide reduction strategies

- Crop rotation
- Intercropping
- Cover crop
- No tillage, reduced tillage, conservation agriculture
- Grassland:
    - Grassland management
    - Grassland conservation and restoration
    - Grazing
- Livestock practices
    - Manure land application
    - Manure storage
    - Manure processing
    - Livestock dietary manipulation
    - Livestock housing techniques

THE DATASET:

- **24** farming practices
- **540** meta-analyses
- Average of **22** meta-analyses per farming practice
- **27** impacts related to the environment and climate
- **4** impacts related to yield

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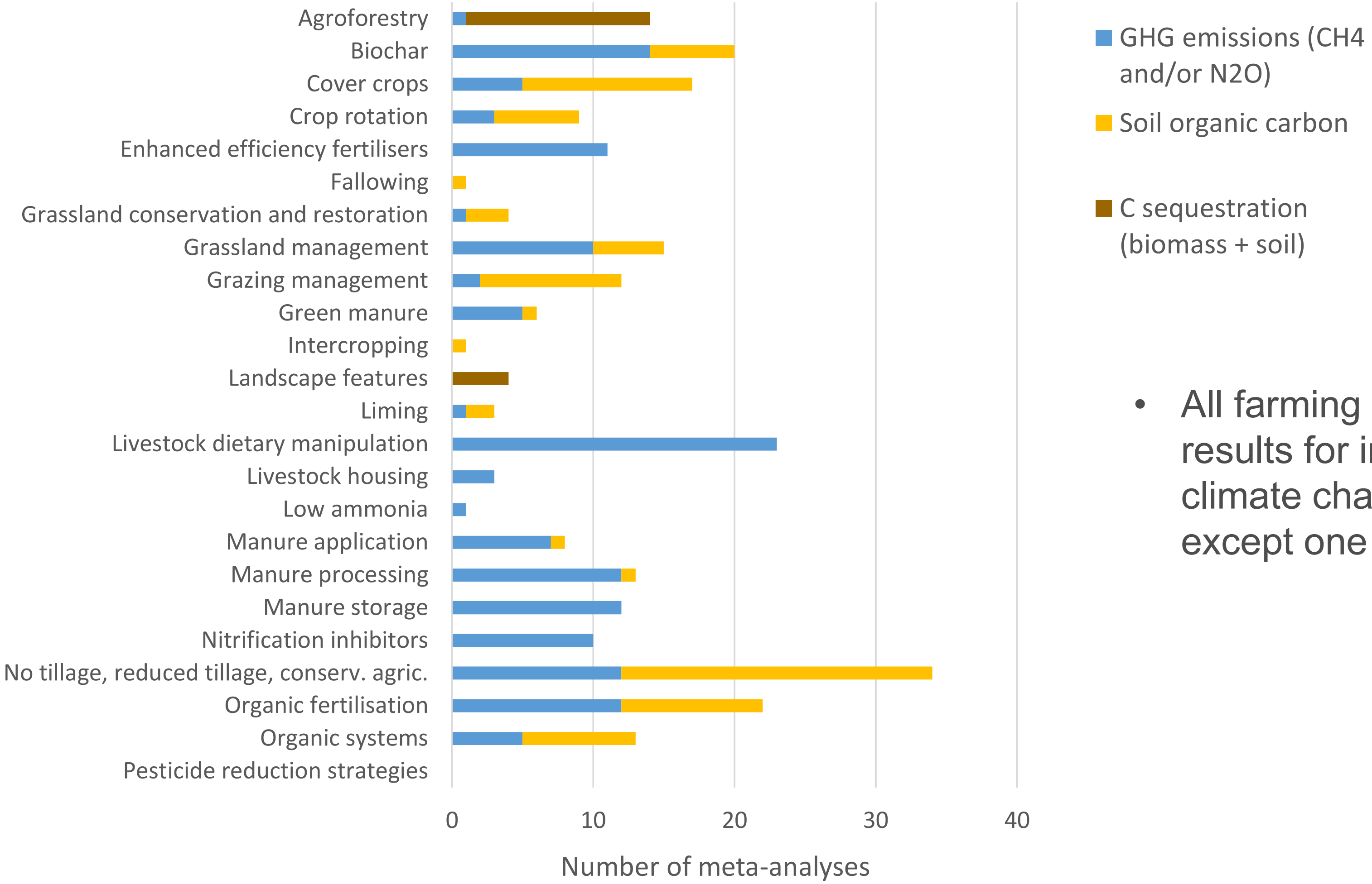
Three impacts related to climate change mitigation



- All farming practices included results for impacts related to climate change mitigation except one

Some results on impact of farming practices on GHG emissions

- Enhanced efficiency fertilisers
- Livestock dietary manipulation
- Organic systems

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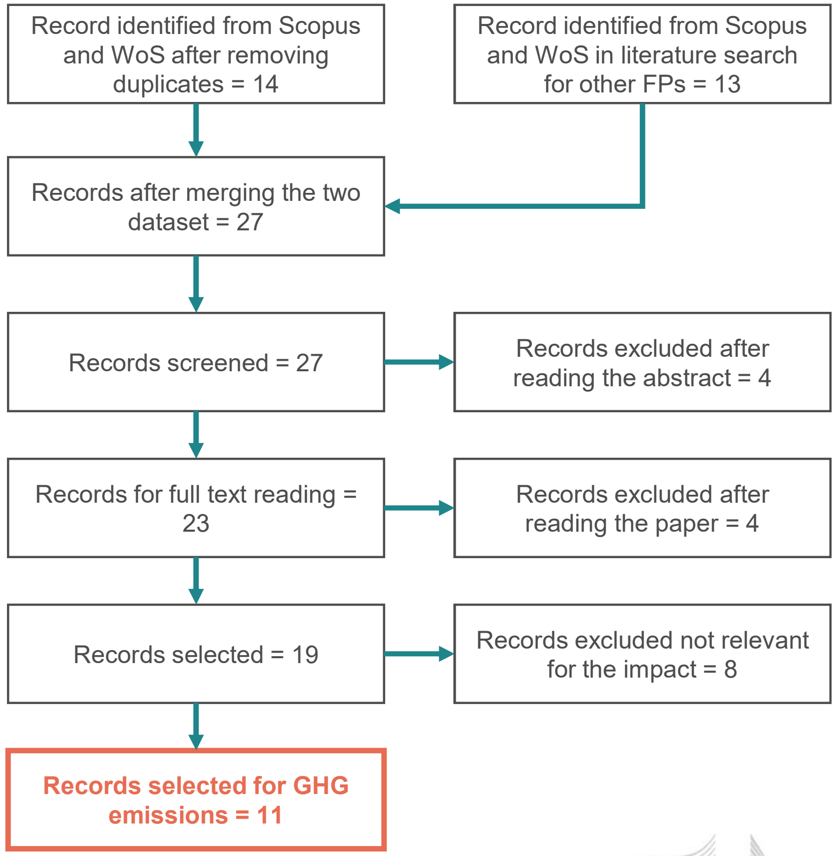
Enhanced efficiency fertilisers: data extraction

- 19 meta-analyses from 1530 single papers
- 11 meta-analyses from 735 reporting results on GHG emissions
- We found 3 fertiliser types:
    - Control-release fertilisers
    - Fertilisers amended with urease inhibitors
    - Fertilisers amended with double inhibitors



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Enhanced efficiency fertilisers: summary of impacts

Effect of an intervention on a specific env. impact

Fertiliser type	Impact	Positive	Negative	No effect	Uncertain
Control-release fertilisers (CRF)	Decrease air pollutant emissions (NH_3)	**6 (6)**	0	0	1 (0)
	Decrease air pollutant emissions (NO)	**1 (1)**	0	0	0
	Decrease GHG emissions (N_2O)	**6 (6)**	0	3 (3)	1 (0)
	Decrease N leaching/run-off	**2 (2)**	0	0	0
	Increase plant N uptake	**2 (2)**	0	0	0
	Increase crop yield	**4 (4)**	0	3 (3)	0
Fertilisers amended with urease inhibitors (UI)	Decrease air pollutant emissions (NH_3)	**5 (5)**	0	0 (0)	2 (0)
	Decrease GHG emissions (N_2O)	2 (2)	0	**3 (3)**	0
	Decrease N leaching/run-off	0 (0)	0	**1 (1)**	0
	Increase plant N uptake	**4 (3)**	0	0	0
	Increase soil N content	**1 (1)**	0	0	0
	Increase crop yield	**4 (3)**	0	0	0
Fertilisers amended with double inhibitors (DI)	Decrease air pollutant emissions (NH_3)	**1 (1)**	0	0	0
	Decrease GHG emissions (N_2O)	**4 (4)**	0	0	0
	Decrease N leaching/run-off	0 (0)	0	**1 (1)**	0
	Increase plant N uptake	**2 (2)**	0	0	0
	Increase soil N content	0	0	**1 (1)**	0
	Increase crop yield	**2 (1)**	0	**2 (1)**	0

(n) = number of studies with a quality > 50%

- Mainly positive results
- No trade-off.
- Knowledge gaps: results only for main crops (wheat and maize)

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Livestock dietary manipulation: summary of impacts for GHG emissions

Impact	Metric	Intervention group	Intervention	Control	Positive	Negative	No effect	Uncertain*
Decrease GHG emissions	CH_4	Diet formulation	Dietary legumes	Grass pasture/silage	0	0	0	1 (1)
			Forage with higher digestibility	Forage with lower digestibility	0	0	0	1 (1)
			High concentrate level in diet	Low concentrate level in diet	0	0	1 (1)	1 (1)
			Low CP diet	No reduction of dietary CP	0	1 (0)	1 (1)	0
			Tannin-rich forages	No tannin-rich forage	0	0	0	1 (1)
		Feed additives	Coccidiostats and histomonostats	No feed additive	3 (3)	0	1 (1)	1 (1)
			Lipids	No lipid	4 (3)	0	3 (2)	1 (1)
			Non specified feed additives	No feed additive	0	1 (0)	0	0
			Nutritional additives	No feed additive	0	0	0	1 (1)
			Sensory additives	Monensin[3]	0	0	1 (1)	0
			Sensory additives	No feed additive	6 (5)	0	5 (5)	3 (3)
			Technological additives	No feed additive	1 (1)	0	3 (3)	0
			Zootechnical additives	No feed additive	8 (6)	0	2 (2)	2 (2)
	GHG	Diet formulation	High concentrate level in diet	Low concentrate level in diet	0	0	1 (1)	0
		Feed additives	Nutritional additives	No feed additive	1 (1)	0	0	0
	N_2O	Diet formulation	Low CP diet	No reduction of dietary CP	1 (0)	0	1 (1)	0
			High concentrate level in diet	Low concentrate level in diet	0	0	0	1 (1)
		Feed additives	Coccidiostats and histomonostats	No feed additive	0	0	0	1 (1)
			Non specified feed additives	No feed additive	0	1 (0)	0	0
			Technological additives	No feed additive	0	0	1 (1)	0
			Zootechnical additives	No feed additive	0	0	0	1 (1)

- **30** meta-analyses (**23** with results on GHG emissions.
- > 80% on CH_4 from ent. Fermentation
- Including several animal categories

Two main intervention groups:

- **Diet formulation**
- **Feed additives**

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Livestock dietary manipulation: main results

- **Diet formulation**: no effect on CH_4 emissions
- **Feed additives**: some categories (coccidiostats, lidips and zootecnical additives) are effective for reducing CH_4 emissions but not N_2O emissions. Feed additive type and rate are the main driving factors.
- Trade-off:
  - Most do not have yield decrease except low crude protein diet and lipids;
- Knowledge gap: There is the need of studies on the whole-farm modelling in different feeding scenarios.

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Organic farming: summary of impacts

	Effects per unit of AREA			
Impact	**Positive**	**Negative**	**No effect**	**Uncertain**
Increase soil organic carbon	**7 (6)**	0	0	2 (1)
Decrease greenhouse gas emissions (CH_4)	**1 (1)**	0	0	**1 (1)**
Decrease greenhouse gas emissions (N_2O)	**2 (2)**			1 (1)
Decrease ammonia emission	0	0	**1 (1)**	0
Decrease nutrient loss (Nitrogen)	**3 (3)**	0	0	0
Decrease nutrient loss (Phosphorus)	0	0	**2 (2)**	0
Increase soil nutrients	0	0		**1 (0)**
Improve soil biological quality	**1(1)**	0	0	**1 (0)**
Increase biodiversity	**9 (9)**	1 (1)	1 (1)	1 (0)
Increase abundance of pests natural enemies	**2 (2)**	0	0	0
Reduction of pests and diseases	0	**2 (2)**	0	0
Increase crop yield	0	**9 (9)**	2 (2)	1 (0)

- **30** meta-analyses
- **5** on GHG emissions
- **8** on soil carbon

- Trade-off for crop yield: effects per unit of product show contrasting results
- Meta-analysis of LCA studies

Organic farming: summary of impacts

	Effects per unit of PRODUCT			
Impact	**Positive**	**Negative**	**No effect**	**Uncertain**
Increase soil organic carbon	0	0	0	0
Decrease greenhouse gas emissions (CO2eq)	1 (1)	0	**3 (2)**	1 (1)
Decrease greenhouse gas emissions (CH_4)	**1 (1)**	0	0	**1 (1)**
Decrease greenhouse gas emissions (N_2O)	0	**1 (1)**	**1 (1)**	**1 (1)**
Acidification	0	**1 (1)**	**1 (1)**	**1 (1)**
Decrease ammonia emission	0	0	**1 (1)**	0
Energy Use	**3 (3)**	2 (1)	2 (1)	1 (1)
Decrease eutrophication	0	1 (1)	**2 (2)**	1 (1)
Decrease nutrient loss (Nitrogen)	0	**1 (1)**	**1 (1)**	0
Increase Land Use	0	**3 (3)**	0	1 (1)

- **30** meta-analyses
- **5** on GHG emissions
- **8** on soil carbon

- Trade-off for crop yield: effects per unit of product show contrasting results
- Meta-analysis of LCA studies

Quantitative results for policy and science

- Quantitative results from meta-analyses:
  - Overall effect size for policy assessment:
    - ➢ Consistent evaluation of mitigation potential and several environmental impacts to evaluate CAP Strategic Plans
  - One effect size does not fit all, we are extracting effect sizes for sub-groups (animal and crop type, climate, geographical area,…).
    - ➢ Provide EF and parameters as input to models (e.g. CAPRI model, …)
    - ➢ Need to analyse driving factors, such as climate and land-related ones, and on management-regionalisation.

Potential use of these results in GHG inventories

- This review of meta-analyses showed the mitigation potential of several farming practices that are not always well represented in the GHG inventories. How to use these data to improve the GHG inventories?
- Information on the uptake of these farming practices should be shared with environmental agencies.
- The inventory systems should be able to use these data (tier 2-3 methods).
    - CH_4 emissions from enteric fermentation: effect of mitigation strategies (diet formulation, feed additives) could be included in advanced tier 2 and in tier 3 (models)
    - N_2O emissions from soil: lower tiers are used. Need of include mitigation practices (correction factors, additional parameters, models)
- Benchmarking of models?

Concluding remarks

- This methodological framework ensures access to the best current scientific evidence with a lower risk of bias
- Study was developed for rapid policy assessment, but there is large potential to improve tiered approaches in GHG inventories, to use it as input and benchmark for models.
- We are using 16 quality criteria for our review. Quality of single studies and meta-analyses is pivotal.

Dissemination of results

- A wiki is already available to the European Commission policymakers and Member States
- A public wiki to share this information is about to be released
- Workshops with relevant stakeholders including scientific community will be organized

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Thank you

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Access the wiki

- Accessibility to the wiki is granted based on EU login registry, which is needed: external users can have access contacting JRC through the Functional Mail Box to be accredited

- https://webgate.ec.europa.eu/fpfis/wikis/display/IMAP/Home

- JRC-wiki-CAP-SP@ec.europa.eu