IMPROVING AGRICULTURAL EMISSION ESTIMATES: METHODS, PROJECTS, THE WAY FORWARD

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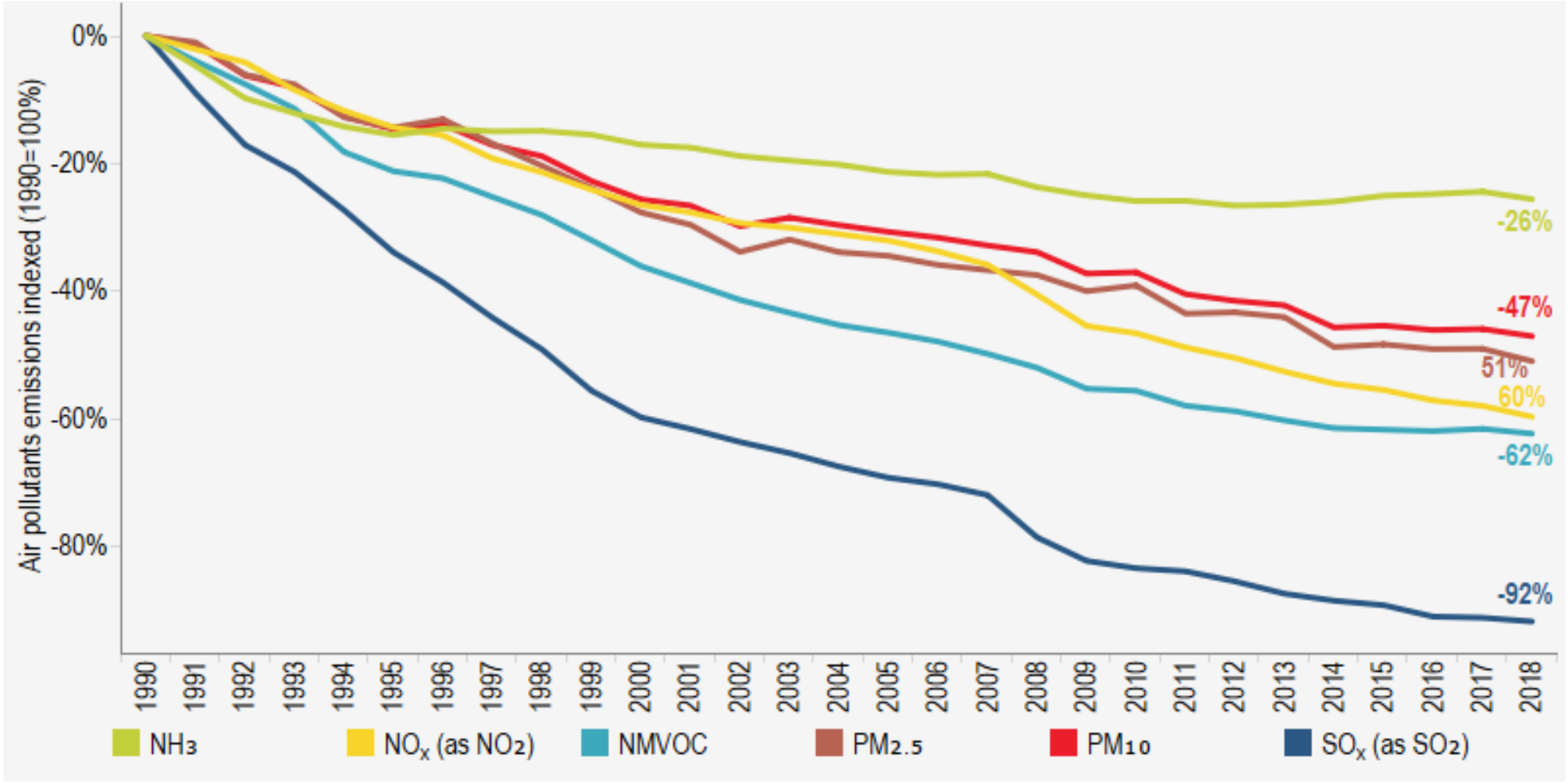
Trends of air pollutant emissions from agriculture



Air pollutant emissions from the EU28 agricultural activities have decreased over the years, but less than other sectors.

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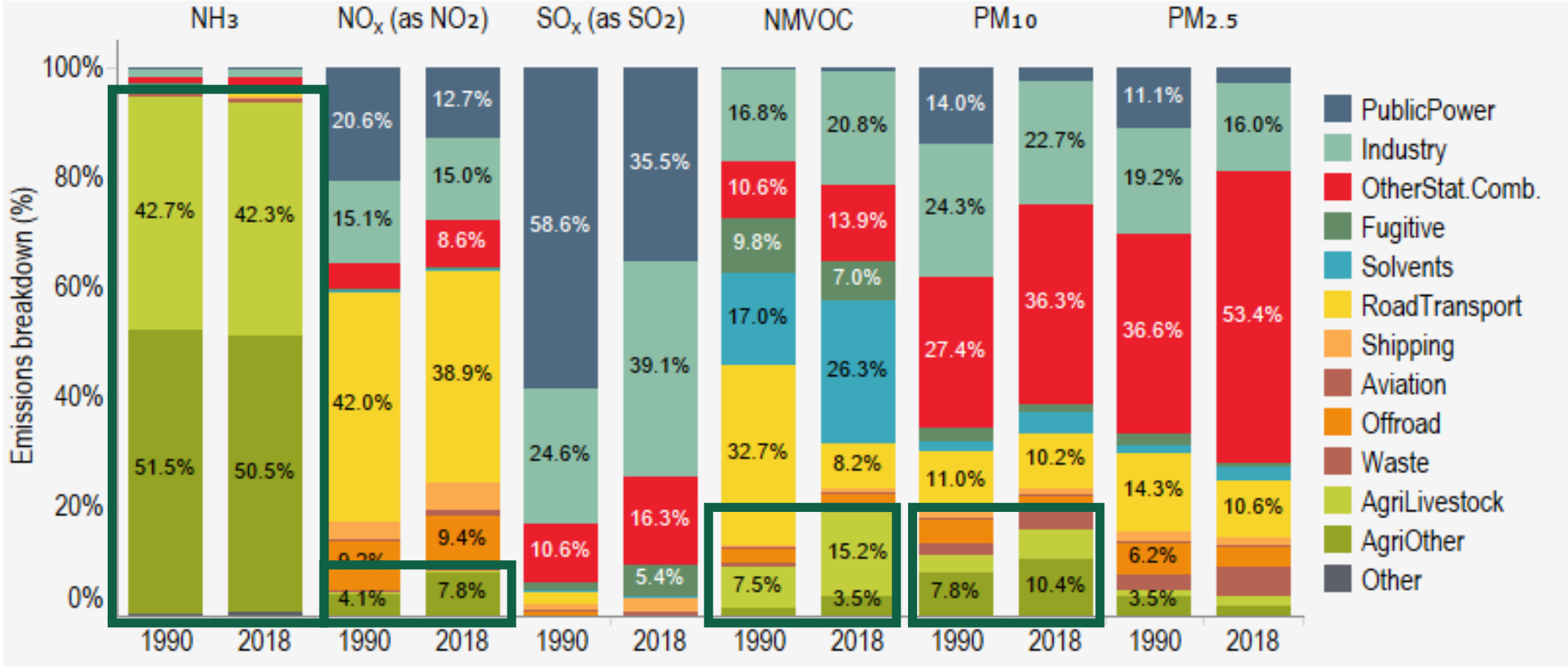
The importance of agriculture in the NECD emissions



NH3 emissions from agriculture represented ca **93% of total NH3 emissions in EU28** in 2018, while NMVOC and PM10 from this sector contributed for 19% and 16%, respectively. **NOx emissions** from agricultural soils activities increased from **4%** in 1990 to nearly **8%** in 2018. **NMVOC emissions** from manure management increased from **7.5%** in 1990 to **15%** in 2018.

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How to improve agricultural emission estimates

This work is part of the project launched by DG ENV in collaboration with the Joint Research Centre (Ispra) for the time period 2020-2021 to "***Support the improvement of national emission inventories for the agricultural sector in Europe***"

Providing more robust emissions under the National Emissions reduction Commitments Directive (NECD), for compliance checking, as well as for the development of emissions projections and policies and measures under the National Air Pollution Control Programmes.

Development of a tool for agricultural emissions through the involvement and data sharing from MS to incorporate very local information on agricultural techniques and practices. The tool could already serve the next cycle of the related NECD reporting obligations.

Online technical platform for emission factors (EFs) and activity data related to the different agricultural sub-sectors.

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Project methodology

- EFs from all agricultural subsectors and for all relevant NECD regulated pollutants (NOx, NMVOC, NH3, PM10 and PM2.5),
- Provide information on CH4 co-emitted by the same sources,
- Gather information on activity data to further refine MS inventories.

EDGAR EMISSION DATABASE FOR GLOBAL ATMOSPHERIC RESEARCH

Detailed information on agricultural practices etc. in various regions/MS

Common Agricultural Policy Regionalised Impact model (CAPRI)

Creation of a consistent database with:

- Activity data (FAO vs. reported data by MS),
- Agricultural practices and technologies for individual countries (based on EDGAR, MS, CAPRI) (e.g. livestock housing & storage type, manure application, etc.),
- Country specific parameters to compute EFs (e.g. climate regional characteristics, feed intake data, etc.).

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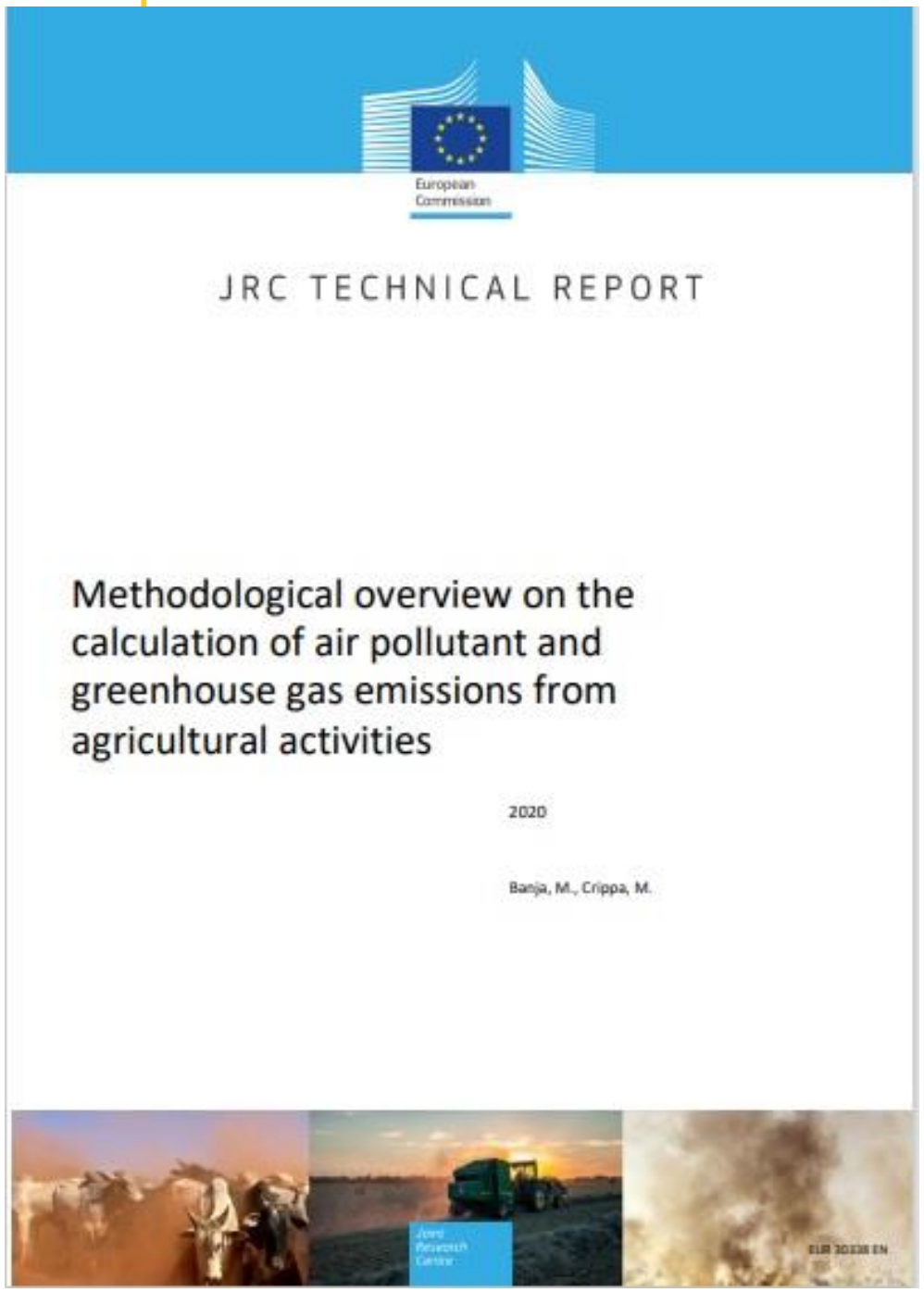

Region of interest: EU28

Period covered: 1990-2018

Air pollutants: NH_3, NOx (as NO_2), NMVOC, PM10, PM2.5

Greenhouse gases: CH_4, N_2O

Enteric Fermentation

Manure Management

Agricultural Soils

Field burning of agricultural residues

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Inventories and Reporting - Approaches and Steps

- Definition of agricultural activities
- Identification of key categories
- Choice of methods – Tier structure and selection criteria

Tier 1 with default values and simple approaches	Tier 2 to be applied for key categories using country-specific (CS) activity data (AD) and emission factors (EFs)	Tier 3 recommended when enough data are available to develop for e.g. sophisticated models

- Choice of activity data – Collection and reporting
- Choice of emission factors – Tools and EFs databases
- Best practices principle
- Inventory quality improvement

Inventories and Reporting - Templates

NECD Reporting (Air pollutants)

- Manure management - 13 categories of livestock
- Agriculture soils – 11 categories
- Field burning of agriculture residues

Activity data: Livestock population, amount of inorganic fertilisers, area of agriculture residues burned

UNFCCC Reporting (GHG) – CRF tables

- Enteric/Manure (CH4 & N2O) - 13 categories of livestock
- Agriculture soils (N2O) – 9 categories (direct emissions) and 2 categories (indirect emissions)

Activity data – 30 datasets (including livestock population, milk yield, nitrogen excretion, emission factors)

Quantifying tools

- ***IPCC Inventory Software*** implements a Tier 1 method for all anthropogenic emitting sectors and a Tier 2 method for most of the categories including those of agriculture.

- ***N-flow approach*** as part of EMEP/EEA Guidebook 2019 provides a Tier 2 approach to calculate N compound emissions from

- Manure Management (3B)
- Manure Applied to Soils (3Da2a)
- Urine and Dung Deposited by Grazing Animals (3Da3)

The tool incorporates 22 default parameters (activity data and EFs)

Methodological overview on emissions calculation

- ***Enteric fermentation:*** Tier 2 approach (CH4)

- ***Manure management:*** Tier 2 or Tier 3 approach (for N-containing compounds: N-flow tool + information on the different techniques of manure storage and manure/sewage application on soils).
  For NMVOC: implementation of Tier 2 approach through expanding of N-flow tool (feed intake data, fraction of housed animals, VS excreted etc.) – inputs to Agriculture Soils in some EU MS

- ***Agricultural soils:*** **Crops cultivation**: Tier 2 approach; **Use of inorganic fertilisers** (NH3): Tier 2 approach considering climate regional characteristics, soil pH, etc.; **Use of animal waste on soils**: Tier 2 approach; **Animals on pasture**: Tier 2 or Tier 3 approach

- ***Agricultural waste burning:*** Tier 2 approach

Methodologies used in manure management

Manure (Air pollutants)	Methods applied	Manure (CH_4 & N_2O)	Suggested method
Dairy cattle	T2/T3/T1 (NH3), T2/T1/T3 (NOx), T2/T1 (NMVOC), T1/T2 (PM10, PM2.5)	Mature dairy cattle	T2/T3
Non-dairy cattle		Other mature cattle	
Swine	T2/T3/T1 (NH3), T2/T1/T3 (NOx), T2/T1 (NMVOC, PM10, PM2.5)	Growing cattle	
Sheep	T2/T1/T3 (NH3), T2/T1 (NOx), T1/T2 (NMVOC, PM10, PM2.5)	Sheep	T1/T2
Buffalo		Swine	T1
Goats		Buffalo	T1/T2
Horses		Camels	T1
Mules and asses		Deer	
Laying hens	T2/T1/T3 (NH3, NOx), T1/T2 (NMVOC, PM10, PM2.5)	Goats	
Broilers		Horses	
Turkeys		Mules and asses	
Other poultry		Poultry	Not developed
Other animals	T2/T1/T3 (NH3), T2/T1 (NOx), T1/T2 (NMVOC, PM10, PM2.5	Other animals	T1

- T1/T2/T3: Tier 1/2/3

Methodologies used in manure management by country

Country	NH_3	EF NH_3	NO_X	EF NOx	NMVOC	EF NMVOC	PM	EF PM
BE	T2	CS/D	T1/T2	D	T1/T2	D	T1	D
BG	T1	D	T1	D	T1	D	T1	D
CZ	T2	CS	T1	D	T1	D	T1	D
DK	T2	CS	T1	D	T2	D	T1	D
DE	T3/T2	CS	T2	CS	T1/T2	D	T1/T2	D
EE	T1/T2/T3	CS	T1/T2	CS	T1/T2	D	T1	D
IE	T2	CS	T2	CS	T2	D	T1	D
EL	T1/T2	CS	T1	D	T1	D	T1	D
ES	T1/T2	D	T1/T2	D	T1/T2	D	T1/T2	D
FR	T2	CS/D	T2	D	T2	D	T2	D
IT	T2	CS	T2	CS	T2	D	T1	D
CY	T2	D	T2	D	T2	D	T2	D
LV	T1/T2	D	T1/T2	D	T1/T2	D	T1/T2	D
LT	T1/T2	D	T1/T2	D	T1	D	T1	D
LU	T2	D	T2	D	T2	D	T1	D
HR	T2/T3	CS/D	T2/T3	CS/D	T2	D	T1	D
HU	T2	CS	T1	D	T1/T2	CS/D	T1	D
MT	T2	D	T2	D	T2	D	T1	D
NL	T3	CS	T3	CS	T2	D	T2	CS
AT	T2/T3	CS/D	T2	D	T2	D	T1	CS
PL	T2	CS	T2	CS	T1	D	T1	D
PT	T2	D	T2	D	T2	D	T1	D
RO	T1/T2	D	T1	D	T1/T2	D	T1	D
SI	T2	D	T2	D	T2	D	T1	D
SK	T2	CS/D	T2	CS/D	T1/T2	D	T1	D
FI	T3/T2	CS	T2	CS	T2	D	T1	D
SE	T2	CS	T2	CS	T2	D	T1	D
UK	T3	CS	T3	D	T2	D	T1	D

T1/T2/T3: Tier 1/2/3

CS: country specific

D: default

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Methodologies used in agricultural soils

Agricultural Soils	Method	EF calculation
Inorganic N-fertilisers (urea application included)	T2/T1/T3 (NH_3), T2/T1 (NOx)	D/CS (NH_3, NOx)
Animal manure applied to soils	T2/T1/T3 (NH_3), T1/T2 (NOx, NMVOC)	D/CS (NH_3, NOx), D (NMVOC)
Sewage sludge applied to soils	T1/T2 (NH_3), T1 (NOx)	D/CS (NH_3, NOx)
Other organic fertilisers applied to soils	T1/T2 (NH_3, NOx)	D/CS (NH_3, NOx)
Urine and dung deposited by grazing animals	T2/T1/T3 (NH_3, NOx), T2/T1 (NMVOC)	D/CS (NH_3, NOx), D (NMVOC)
Farm-level agricultural operations including storage, handling and transport of agricultural products	T1/T2 (TSP, PM_{10}, $PM_{2.5}$,)	D/CS (TSP, PM_{10}, $PM_{2.5}$,)
Off-farm storage, handling and transport of bulk agricultural products	T1 (TSP, PM_{10}, $PM_{2.5}$,)	D (TSP, PM_{10}, $PM_{2.5}$,)
Cultivated crops	T2/T1/CS (NH_3), T2/T1 (NMVOC)	D/CS (NH_3, NMVOC)

- T1/T2/T3: Tier 1/2/3

Methodological choices in agricultural soils by country

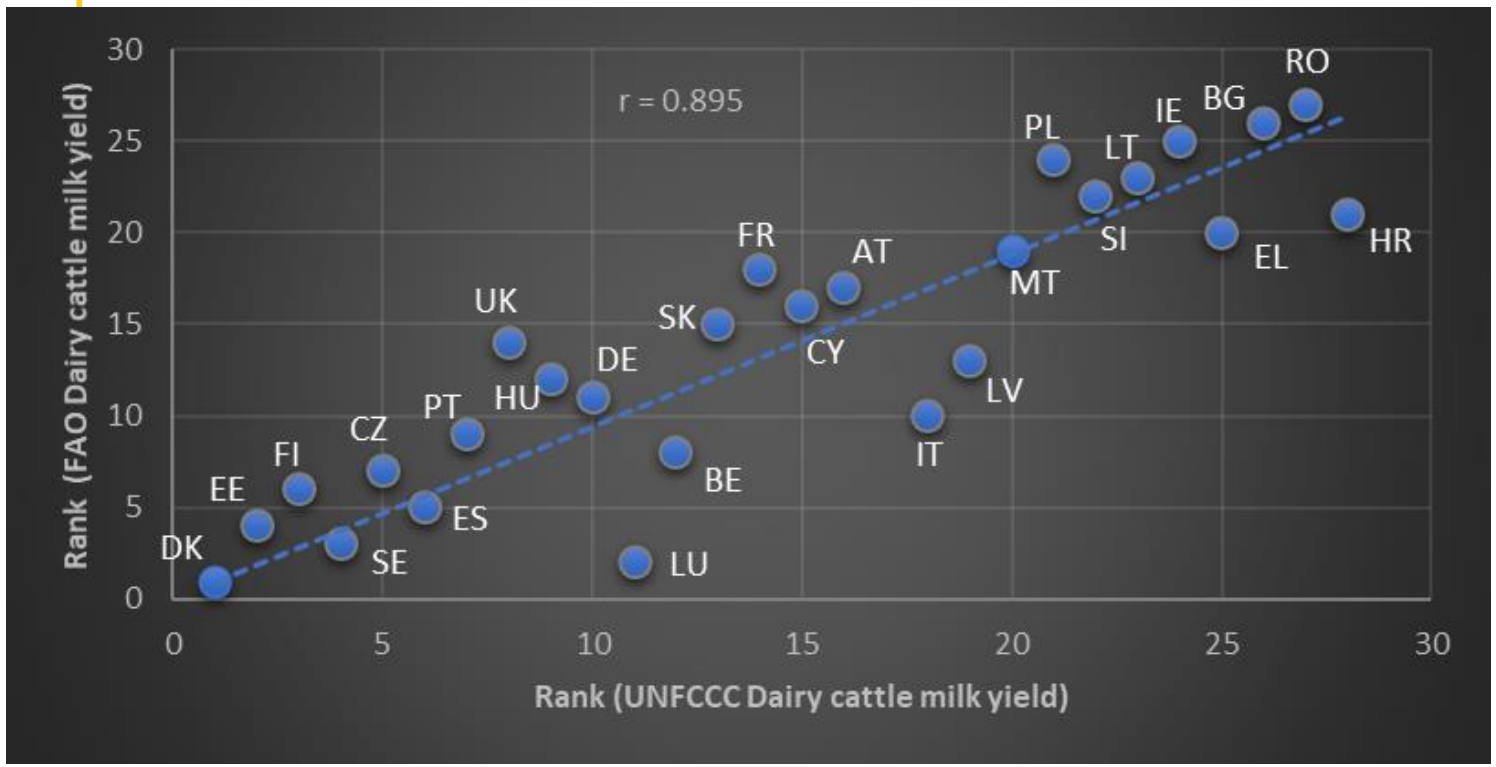
Country	NH_3	EF NH_3	NO_X	EF NOx	NMVOC	EF NMVOC	PM	EF PM
BE	T2/T1/T3	CS/D	T1	D	T1	D	T1	D
BG	T2/T1	D	T1	D	T1	D	T1	D
CZ	T2	D	T1	D	T1	D	T2	D
DK	T1/T2	D	T1/T2	D	T2	D	T2	D
DE	T1/T2	CS/D	T1/T2	CS/D	T2	D	T1	D
EE	T1/T2	D	T1	D	T1/T2	D	T1	D
IE	T2	D	T1	D	T1/T2	D	T1	D
EL	T1/T2	D	T1	D	T1	D	T1	D
ES	T1/T2	D	T1	D	T2	D	T1	D
FR	T1/T2	D	T1/T2	D	T2	D	T1	D
IT	T1/T2/CS	CS/D	T1/T2	CS/D	T1/T2	D	T1	D
CY	T1	D	T1	D	T1	D	T1	D
LV	T1/T2	D	T1	D	T1	D	T1	D
LT	T2	D	T1	D	T1	D	T1	D
LU	T1	D	T1	D	T1	D	T1	D
HR	T1/T2	D	T1	D	T1/T2	D	T1	D
HU	T1/T2	CS	T1	D	T1	D	T1	D
MT	T1/T2	D	T1/T2	D	T2	D	T1	D
NL	T3	CS	T3	D	T2	D	T2	CS/D
AT	T3/T1	CS	T1	D	T2	D	T1	D
PL	T2	CS	T2	CS	T1	D	T1	CS/D
PT	T1/T2	D	T1	D	T1	D	T1	D
RO	T1/T2	CS/D	T1	D	T1/T2	D	T1	D
SI	T1/T2	D	T1	D	T1/T2	D	T1/T2	D
SK	T1/T2	D	T1/T2	D	T2	D	T1	D
FI	T1/T2	D	T1	D	T1	D	T1	D
SE	T2	D	T1	D	T2	D	T1	D
UK	T3	CS	T2	CS/D	T1	D	T1	D

T1/T2/T3: Tier 1/2/3

CS: country specific

D: default

Country specific vs default activity data – Milk yield



Spearman correlation coefficient of 0.895 was found for the FAO and UNFCCC milk yield data sets.

The largest negative differences between FAO and UNFCCC milk yield data are found for Croatia, Greece and Luxembourg respectively 53%, 41% and 20% lower. Positive differences are found for Poland (+7%), Portugal (+4%), UK (+3.2%), Czech Republic (+2.7%) and France (+1.9%).

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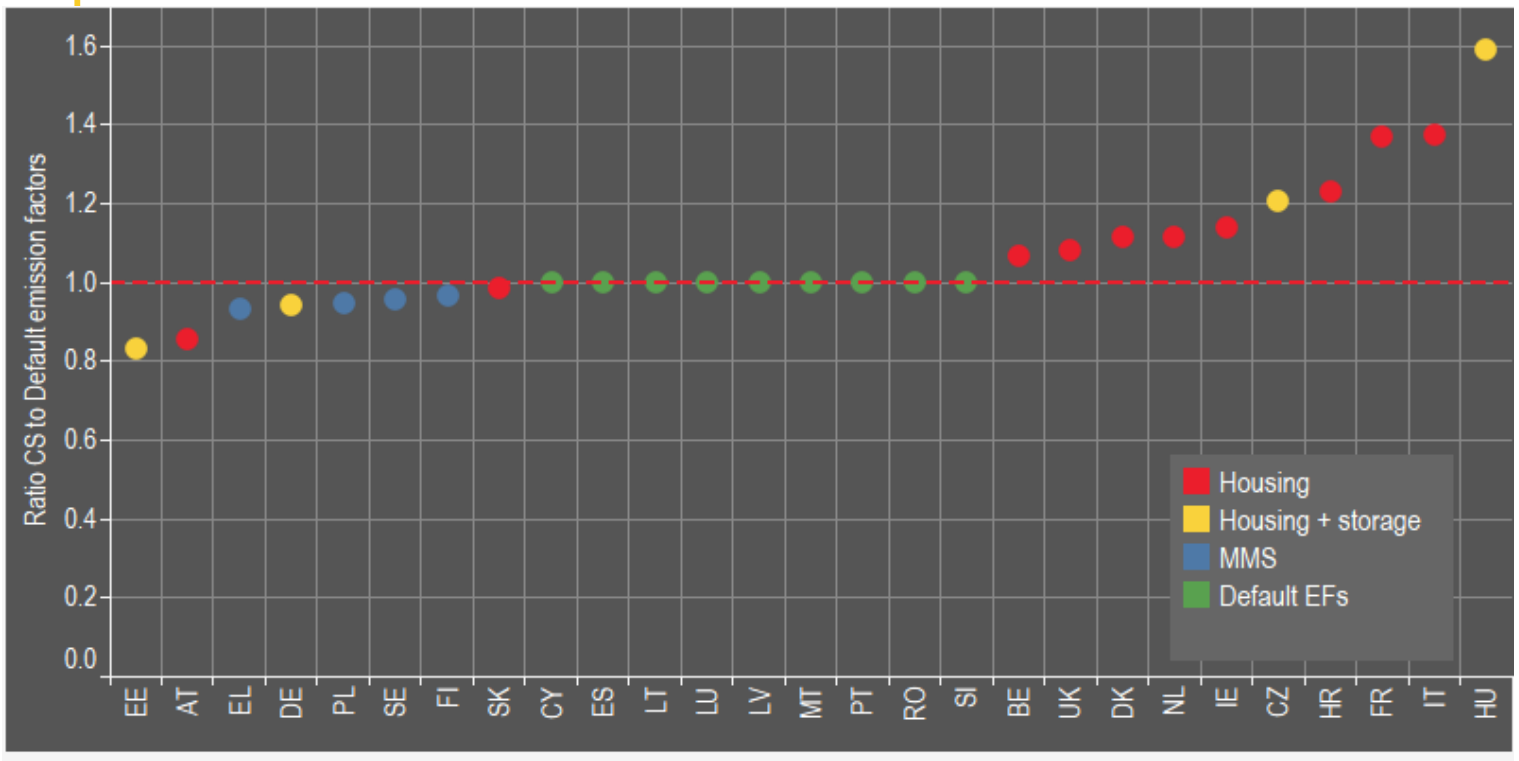
Country specific vs default NH3 EFs-MMS dairy cattle



18 countries apply country specific EFs to estimate NH_3 emissions from dairy cattle in the selected manure managment system (MMS).

10 countries report a country specific EF higher than the default

The country specific EFs were found higher the default ones within a wide range from 5% to 55%. In the cases where the country specific EFs were lower than the default values this range moved from 1% to 17%.

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Improving agricultural emissions estimation

All activity data and emission factors needed to perform the Tier 2 calculations of air pollutants emissions from manure management and agricultural soils subsectors should be collected at MS level

Subsector	Activity data		Emission Factor (EF)
MM	Percentage of excreta on yards		EF NH_3 house, slurry
MM	Animal weight		EF NH_3 house, solid
MM	House period		EF NH_3 yard
MM	Proportion of N excreta as TAN		EF NH_3 storage, slurry
MM	Annual straw use in litter		EF NH_3 storage, solid
MM	Nitrogen content in straw		EF NH_3 application, slurry
MM	Nitrogen added in straw		EF NH_3 application, solid
MM	Nitrogen immobilised to TAN		EF NH_3 grazing
MM	TAN immobilised in organic matter		EF NO storage, slurry
MM	N from bedding		EF NO storage, solid
MM	Mass of bedding		EF N_2 storage, slurry
MM	Grazing time		EF N_2 storage, solid
MM	Manure handling system		EF N_2O storage, slurry
MM	Share of pastured animals		EF N_2O storage solid
MM	Night housing in pasturing period		EF storage leaching, solid
MM	Hours inside in nights		EF NMVOC house – feed intake
MM	Abatement measures		EF NMVOC silage feeding – feed intake
MM	Farm-yard manure system		EF NMVOC grazing – feed intake
MM	Manure spreading		EF NMVOC house – VS excreted
MM	Ratio slurry/solid stored on farms and used for biogas production		EF NMVOC silage feeding – VS excreted
MM	Proportion of slurry manure deposited in houses		EF NMVOC grazing – VS excreted
MM	Share of manure stored in manure storage system		EF TSP (housing)
MM	Share of manure applied with different application techniques		EF PM_{10} (housing)
MM	Feed intake		EF $PM_{2.5}$ (housing)
MM	Volatile solids (VS) excreted		
MM	Fraction silage/Fraction silage storage		

Compilation of the emission factors database

Emission Factors Type: Default + Country Specific

Reference year: 2018

Sources: EMEP/EEA Guidebooks (2013, 2016, 2019), IIRs 2020

Air pollutants: NH3, NOx, NMVOC, PM10, PM2.5

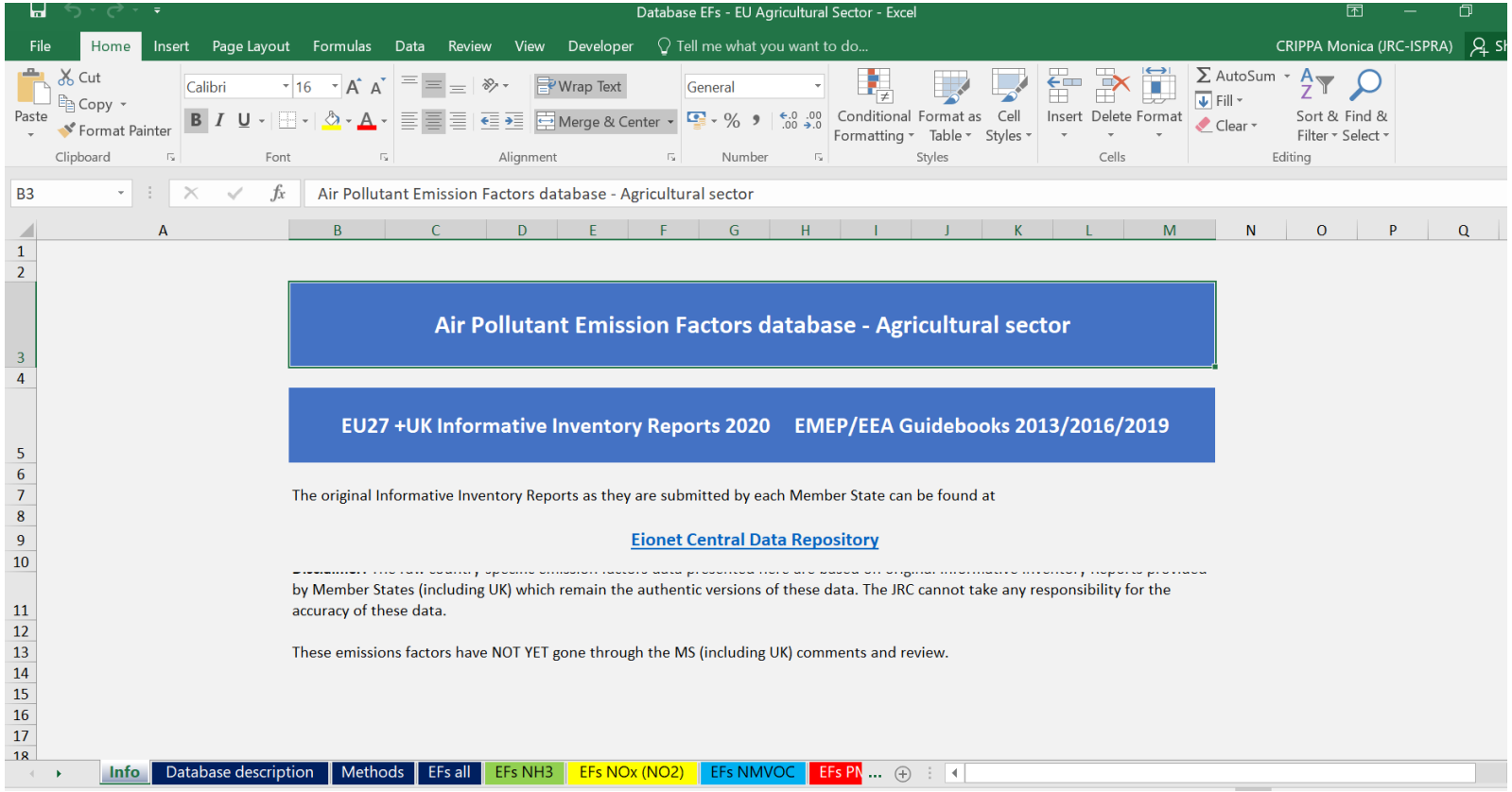
Agricultural subsectors: Manure management, Agricultural soils

Categories:

Dairy cattle, Non-dairy cattle, Sheep. Swine, Buffalo, Goats, Horses, Mules and Asses, Broilers, Laying hens, Turkeys, Other animals

Inorganic N-fertilisers, Animal manure applied to soils, Urine and dung deposited by grazing, Crop residues applied to soils, Cultivated crops

Revision of the emission factors database



- The EF database will be shared with MS for their review.
- **We need to gather all input parameters used to compute country specific EFs from MS.**
- **We are also compiling the activity data database including technologies and abatement measures (input from MS is appreciated).**

Questionnaires to collect information at farm level

Examples from Austria and Switzerland

Livestock	Number		Housing system (tied stalls)			Housing system (multi pen-loose)						Climate		
Cattle 2 years and older			Slurry only	Slurry & solid		Slurry	Solid	Compost	Freezer	Solid floor		Warm	Cool	Cold
Dairy cows		head			%						%			
Suckler cows		head			%						%			
Calfs		head			%						%			
Bulls		head			%						%			
Oxen		head			%						%			
Young cattle 1 to under 2 years														
Bulls		head			%						%			
Oxen		head			%						%			
Calves (breeding)		head			%						%			
Calves (Mast)		head			%						%			
Young cattle under 1 year														
Slaughter calves up to 300 kg		head			%						%			
Calves and young cattle (breeding)		head			%						%			
Calves and young cattle (mast)		head			%						%			

Pasture	Hours/day					Days/year						
Cattle 2 years and older	0	1 - 5	5 - 12	12 - 20	>20	<20	20 - 60	61 - 90	91 - 120	121-150	151-230	>230
Dairy cows												
Suckler cows												
Calfs												
Bulls												
Oxen												
Young cattle 1 to under 2 years												
Bulls												
Oxen												
Calves (breeding)												
Calves (Mast)												
Young cattle under 1 year												
Slaughter calves up to 300 kg												
Calves and young cattle (breeding)												
Calves and young cattle (mast)												

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Conclusions (1)

Tier 2 is the highly advisable method that can reflect changes in livestock production and productivity, measure the effects of the changes in the agricultural sector or measure the specific mitigation actions on air pollutant emissions. An ***optimum number of activity data for each subsector*** should be established for this method to avoid the return to the Tier 1 method even for the key categories.

By the end of 2018, ***almost all EU countries applied a Tier 2 method to calculate NH3 emissions from the manure management*** subsector.

Methodologies to estimate air pollutant and GHG emissions from the manure management subsector ***are more advanced for cattle, swine, and sheep categories***.

Tier 2 methods are not so often applied in the estimation of air pollutant emissions from ***agricultural soil activities*** – mainly for NH3 and NOx emissions.

Conclusions (2)

There is no obligation in the UNECE template ***to report the country-specific emission factors for air pollutants*** in the recommended unit (fraction of TAN) and ***there is no obligation to report these emission factors for each system of manure management or category of agricultural soils.***

Not all countries provide a detailed description of their methodologies (in case of a country-specific methodology) and ***few countries provide additional documentation on methodologies and online tools.***

Discrepancies exist for some activity data and emission factors retrieved from sources as FAO, UNFCCC or UNECE.

The use of models gives the possibility of introducing methods for the calculation of activity data which are not available and for which the default values are not provided.

The way forward

Encouraging the application of country-specific activity data and EFs,
Increasing the transparency related to country specific activity data and emission factors (we will share the collected AD and EFs for MS checking),
Improving the reporting of country-specific emission factors related to each system of manure management and each category of agricultural soils activities,
Improving the reporting template to provide the possibility of collecting country-specific emission factors in an unified measurement unit which will facilitate not only the comparison with default values but also the comparison among countries,
A deeper investigation of the relationship between activity data and emission factors,
Expanding the existing N mass-flow tool also including calculations for other air pollutants such as NMVOC or PM,
Support the application of surveys and questionnaires on farms statistics.

Thank you

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