Agronomic and environmental trends and developments in urea use

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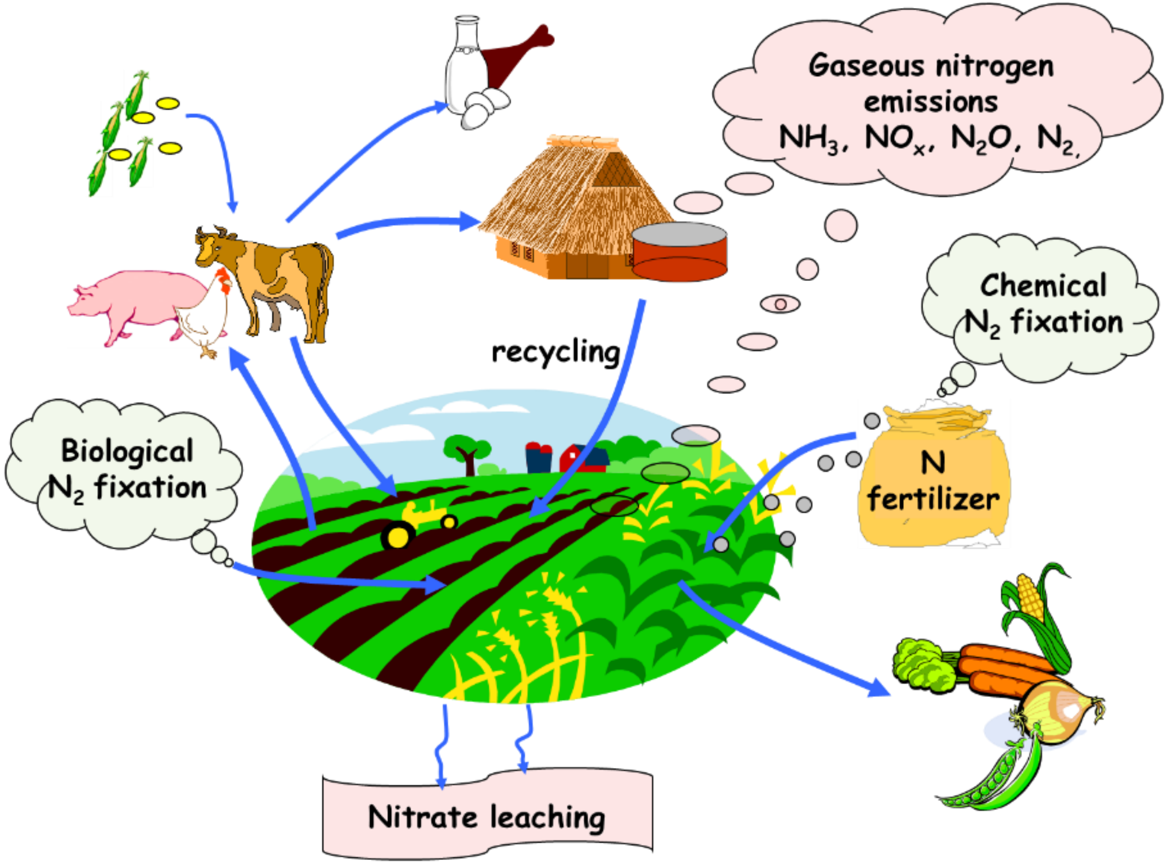
Contents

- Trends and projections of nitrogen fertilizer use
- Nitrogen losses from fertilizers applied to soils
- Measures to decrease nitrogen losses and increase nitrogen use efficiency

Trends and projections of nitrogen fertilizer use

Nitrogen cycle in agriculture



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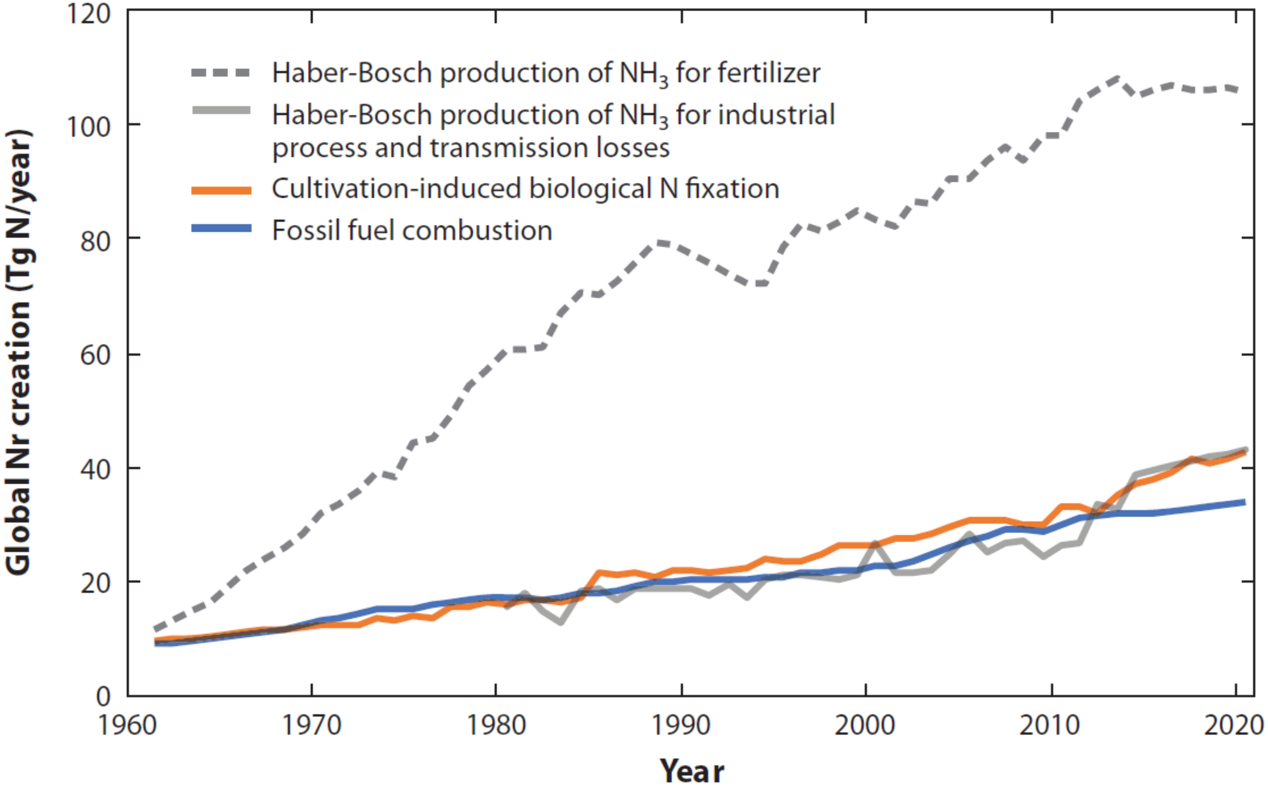
Production of new reactive nitrogen (Nr)

* Fertilizer production

* Industrial processes

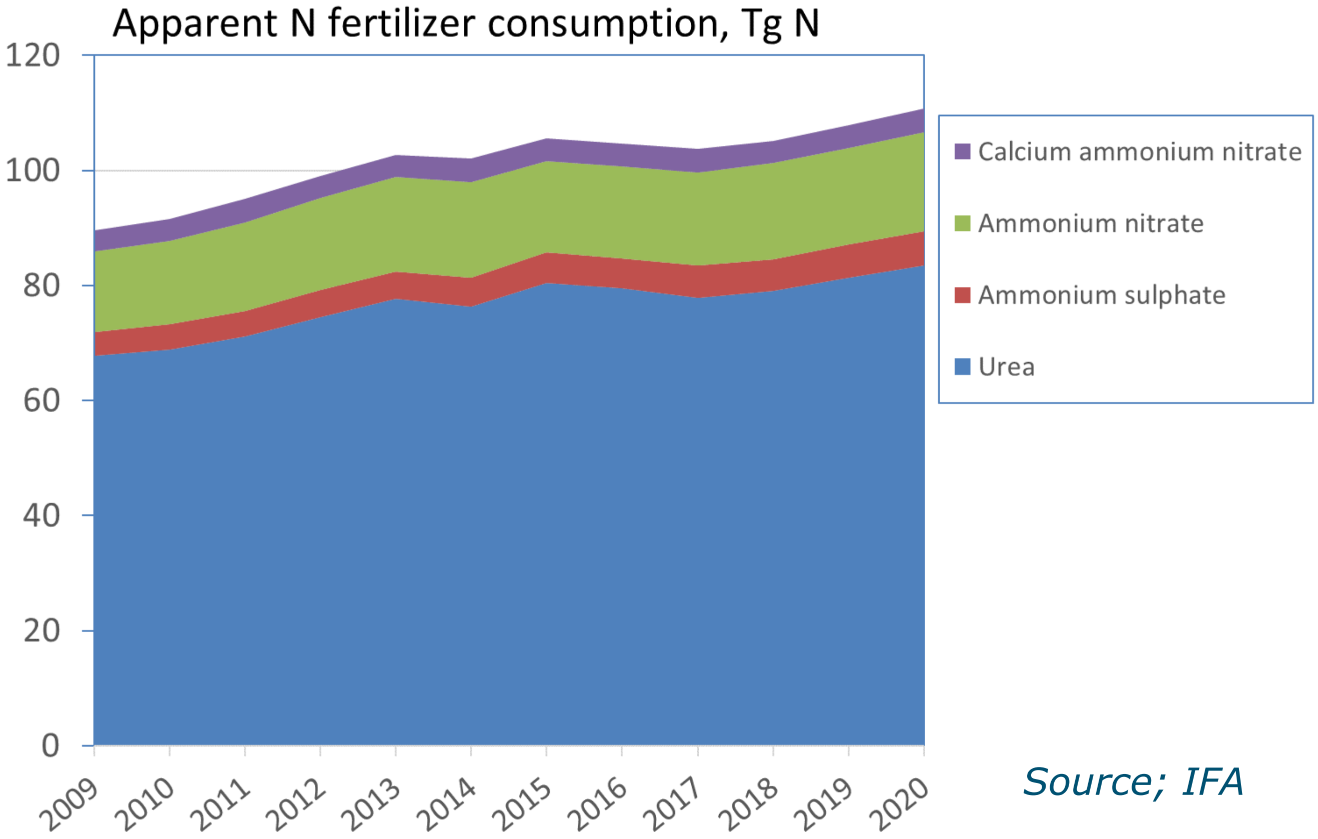
* Biological N fixation

* Fossil fuel combustion



Galloway et al. (2021)

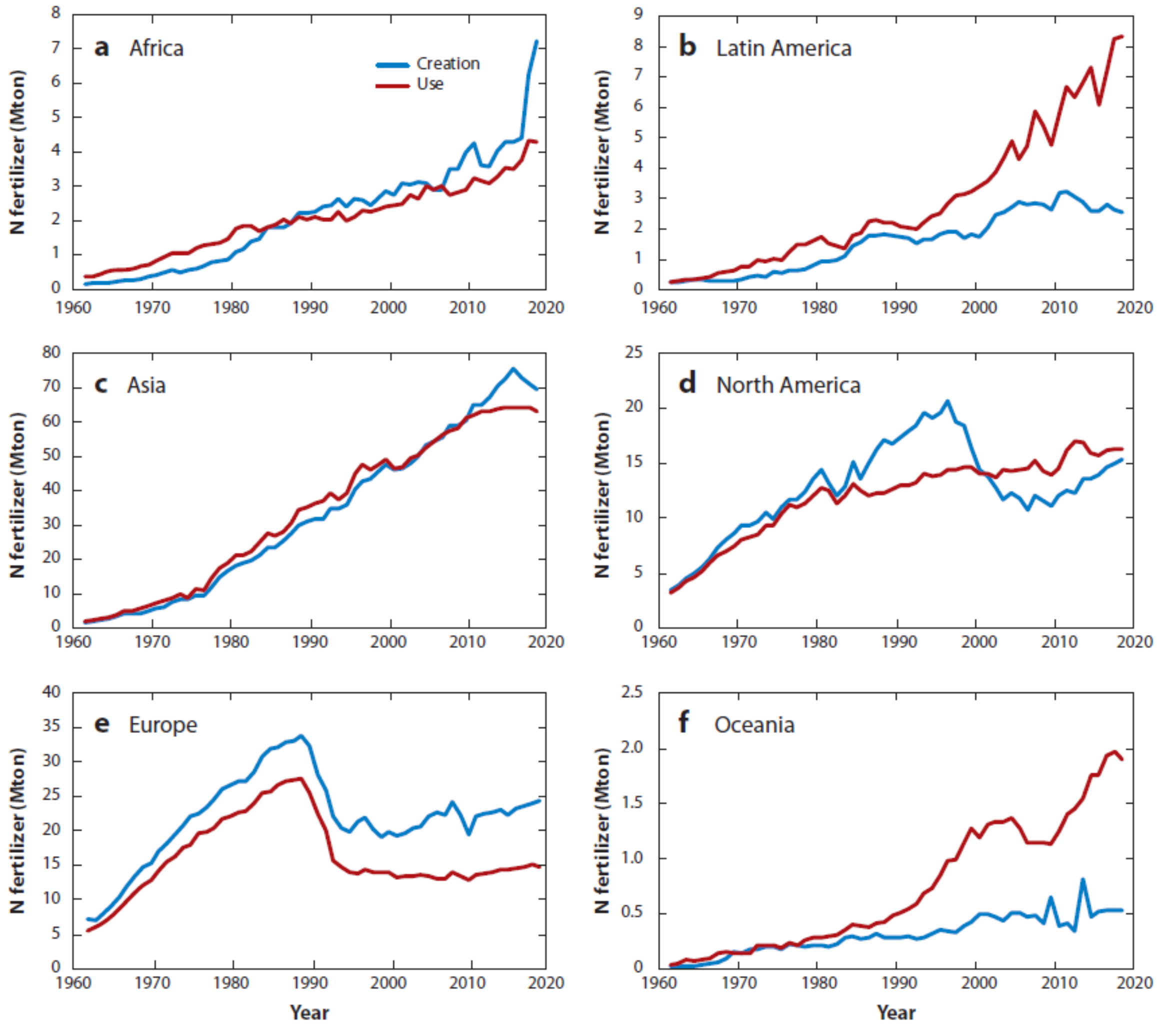
Global nitrogen fertilizer use



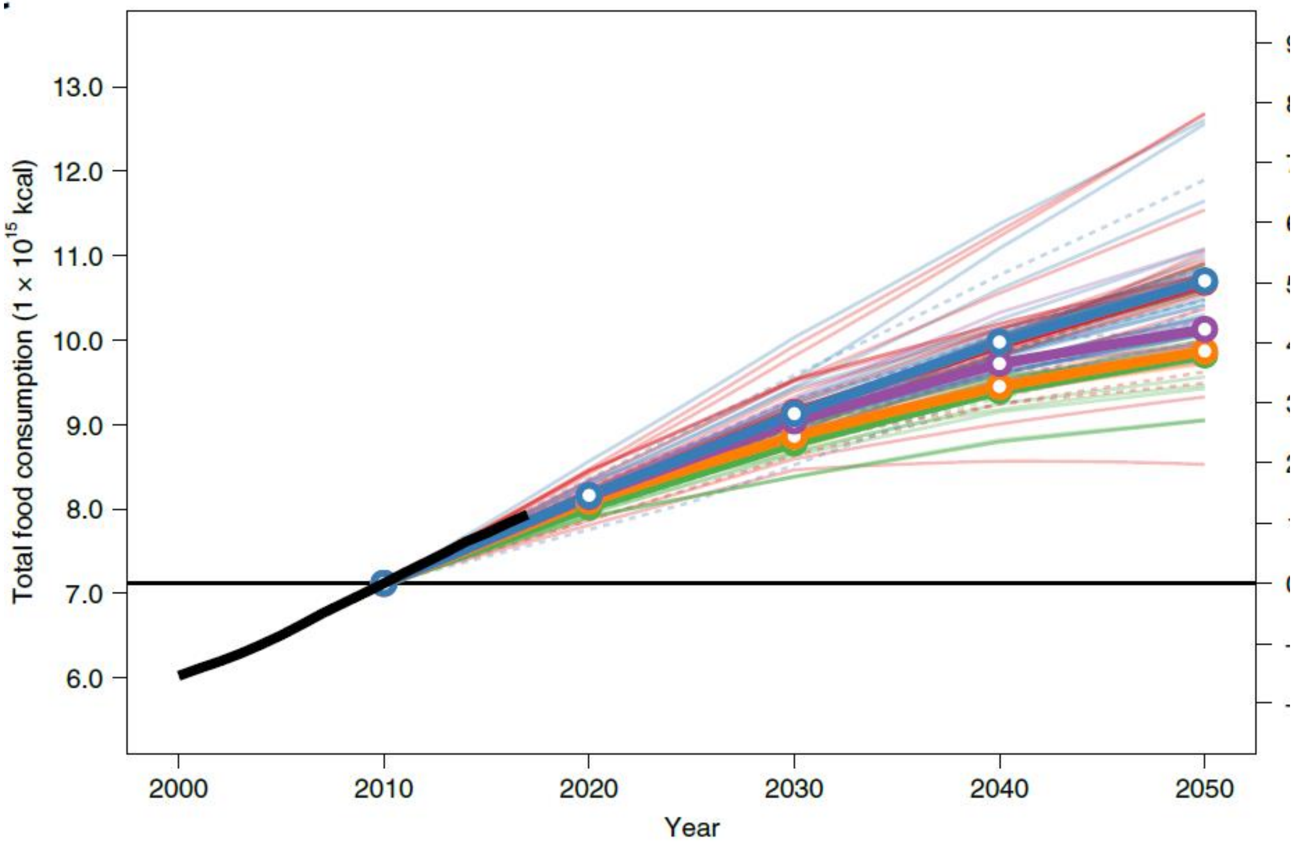
Source; IFA

N fertilizer production and use

Galloway et al. (2021)



Projections of food consumption 2010–2050



Van Dijk et al. (2021)

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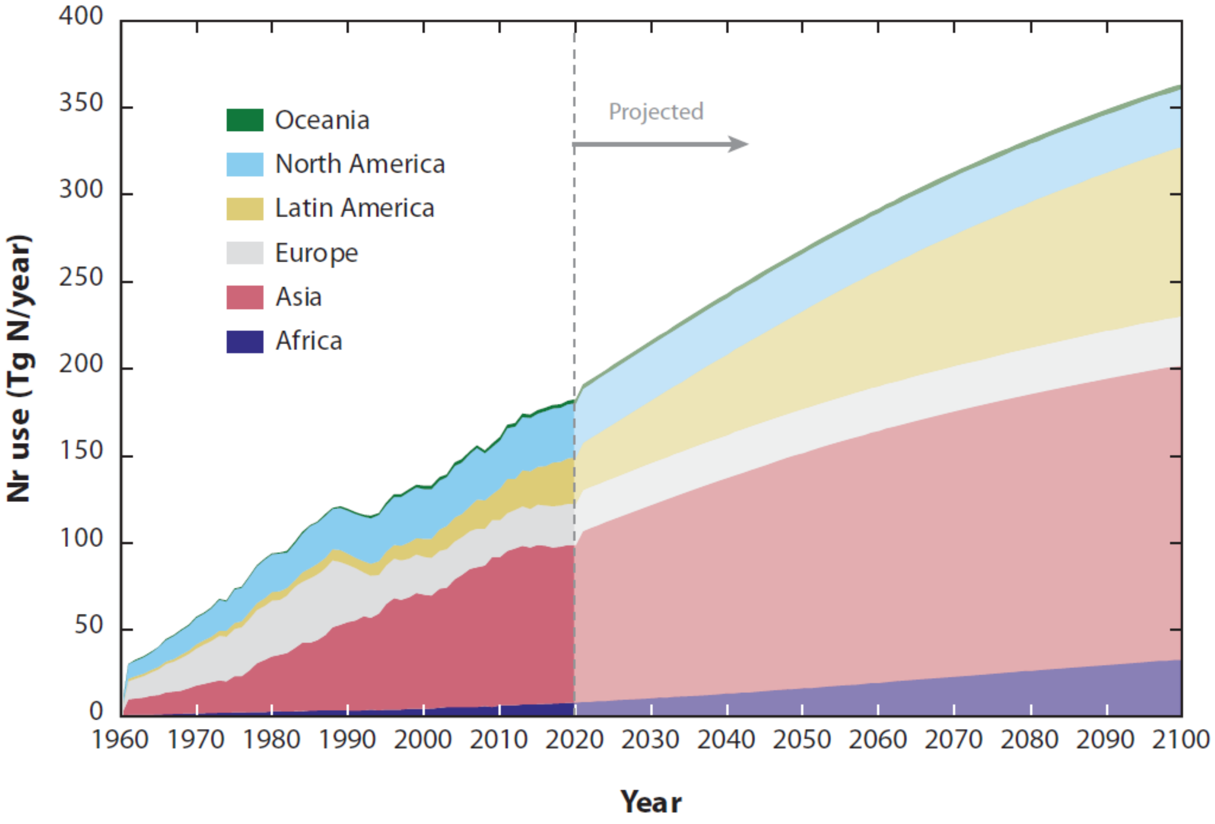
Future trends of reactive nitrogen use



Galloway et al. (2021)

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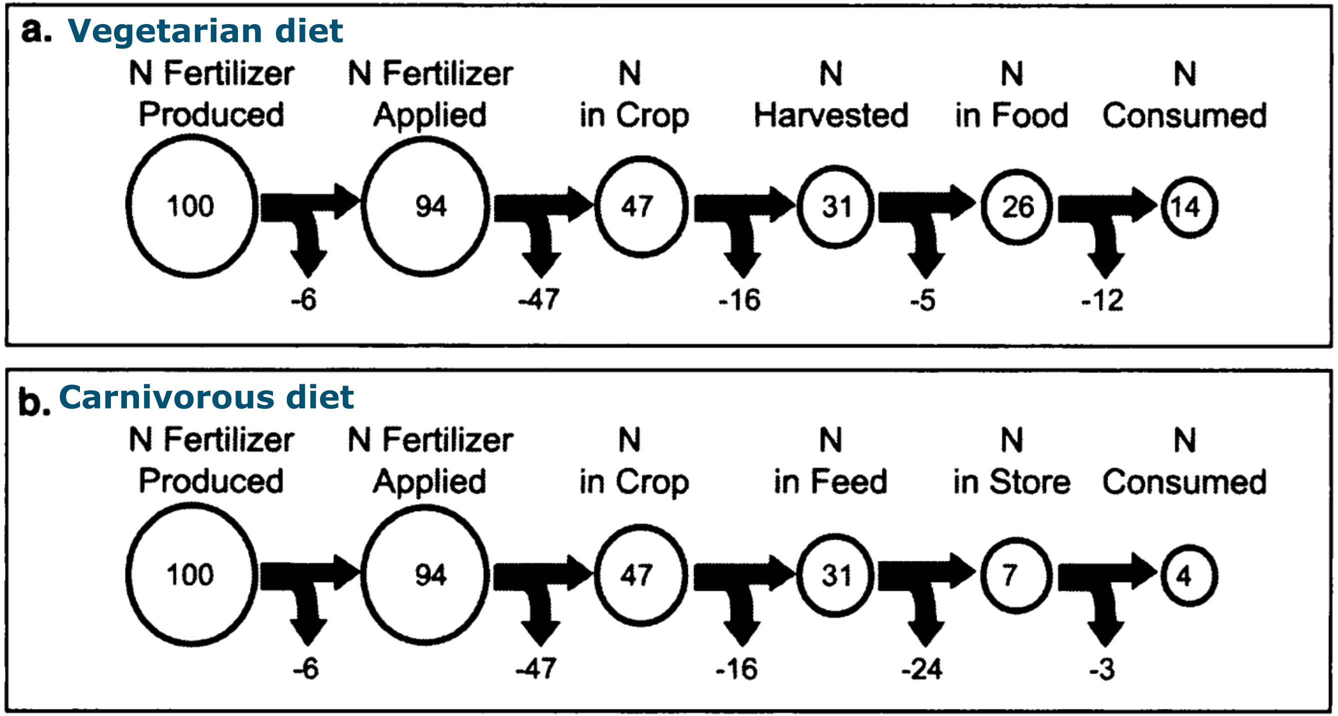
Nitrogen losses from fertilizers applied to soils

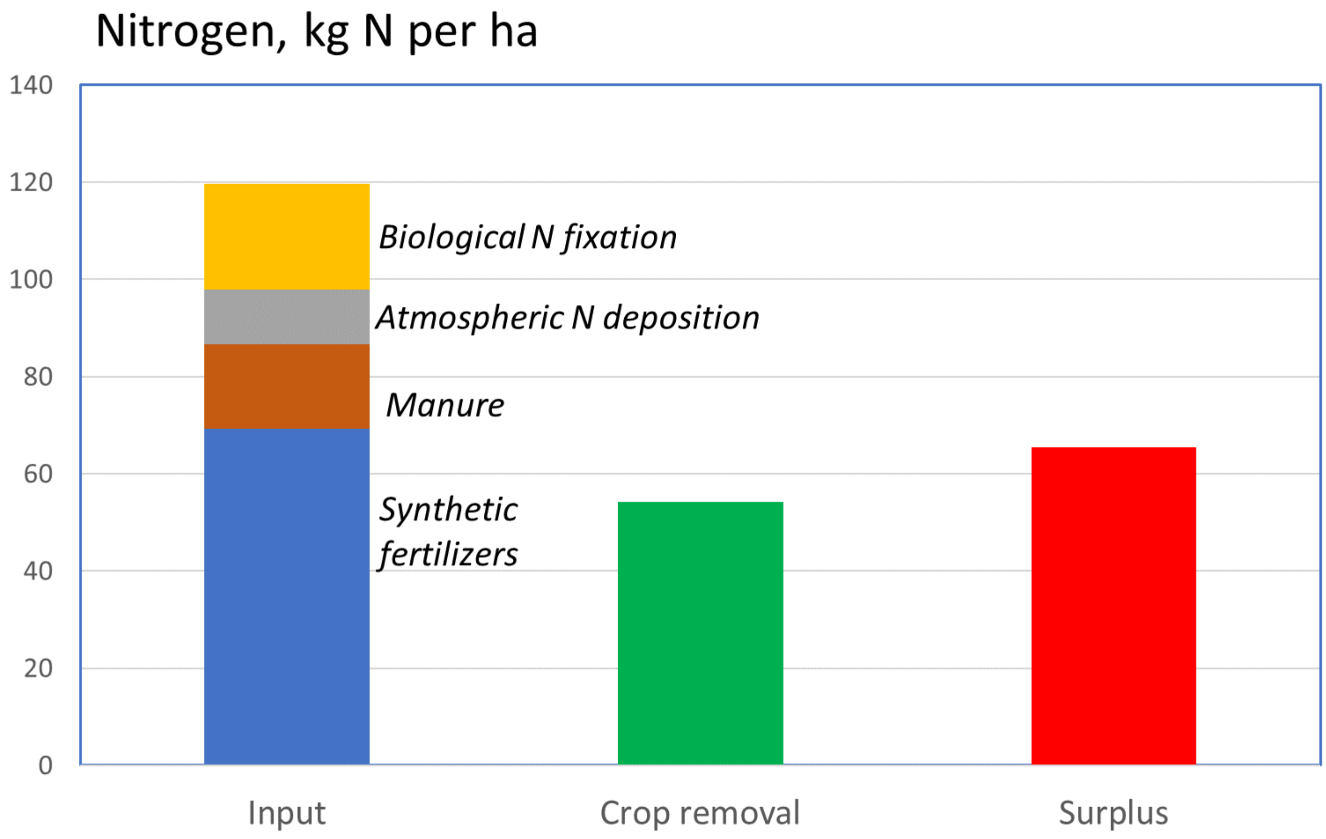
Do we use nitrogen fertilizer efficiently?



Only 4-14% of the produced N fertilizer ends on the plate of the consumer

Galloway et al. (2002)

Average global nitrogen budget of cropland



FAOSTAT

Recycling of N in manure

- Synthetic fertilizer use: 123 Tg N

- Manure production: 128 Tg N
    - From which
        - 27 Tg N applied to soils
        - 90 Tg N excreted during grazing

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Main nitrogen losses from agricultural soils

N loss	Compound	Environmental effect
Ammonia emission	NH_3	Biodiversity
		Soil acidification
		Air quality; fine particles
Nitrate/nitrogen leaching	NO_3^-, NH_4^+, organic N	Drinking water quality
		Eutrophication surface water
Nitrous oxide emission	N_2O	Greenhouse gas
		Destruction ozone layer
Nitrogen oxide emission	NOx	Biodiversity
		Soil acidification
Dinitrogen emission	N_2	Harmless

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Ammonia loss from applied urea worldwide

Large risk on ammonia emission from urea fertilizers

$$CO(NH_2)_2 + H_2O \xrightarrow{urease} CO_2 + 2NH_3$$

Continent	N loss as NH_3		
	%		
	Mean	Median	Range
Asia			
East Asia	15.9	13.3	1.7–48.0
South Asia	30.7	21.9	3.0–56.7
Southeast Asia	16.1	14.5	14.4–19.5
Australasia	16	18.5	2.0–30.0
Europe	13	10.6	0.9–29.8
North America	17.5	15.3	0.6–64.0
South America	14.2	13.3	1.7–31.8
Average	17.6	15.3	0.9–64.0

Pan et al. (2016)

Measures to decrease nitrogen losses and increase nitrogen use efficiency

Increase nitrogen use efficiency of fertilizers

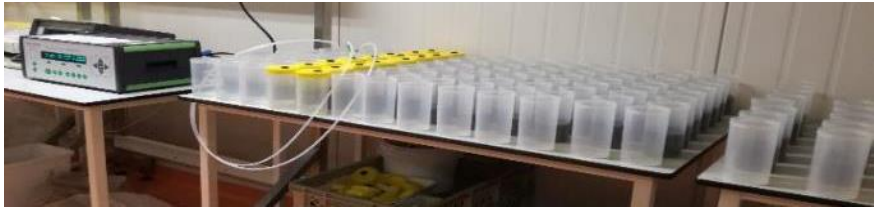
4R Nutrient Stewardship

- Right fertilizer source
- Right rate
- Right place
- Right time

Bruulsema et al. (2016)

Right fertilizer source: N fertilizer type

- Urea based fertilizers versus nitrate fertilizers:
    - Ammonia emission: urea >> nitrate
    - Nitrous oxide emission:
        - Wet conditions in grasslands: nitrate > urea
        - Arable soil and dry conditions: urea ≥ nitrate
    - Nitrate leaching: dependent on total input



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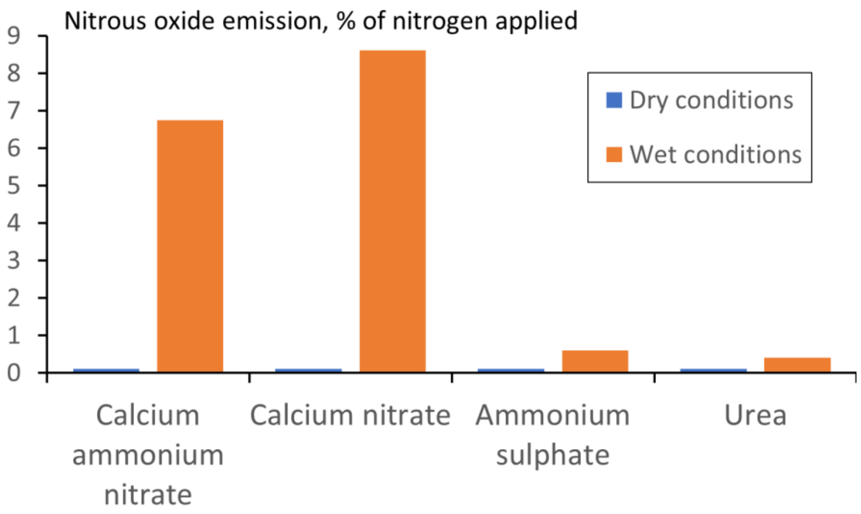
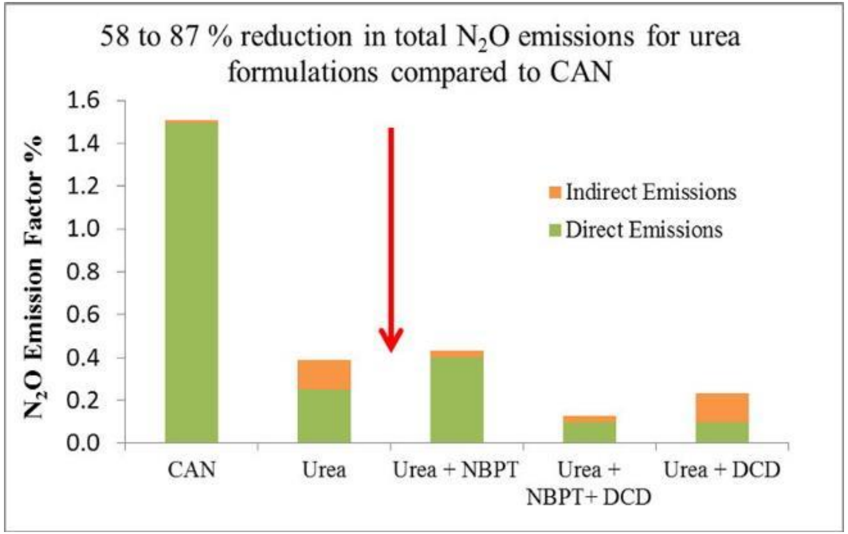
Nitrous oxide conditions from grasslands





Netherlands (Velthof et al., 1997)

Ireland (Harty et al., 2016)

Right fertilizer source: enhanced efficiency urea

- High enhanced efficiency urea fertilizers reduce ammonia losses
  - Urease inhibitors: 54%
  - Mixing with amendments (zeolite, pyrite, organic acids): 35%
  - Controlled release urea: 68%

- Controlled release urea on maize
  - 25% reduction of nitrous oxide emission
  - 27% reduction of nitrogen leaching
  - 5% increase of yield

Pan et al. (2016); Zhang et al. (2016)

Right rate

- Fertilizer application rate based on nitrogen demand of the crop and the nitrogen supply from manure, organic fertilizers and soil

- Precision fertilization become increasingly important
    - Rapid soil and crop tests
    - Remote sensing, GIS and GPS
    - Internet based fertilization tools
    - Use of weather data and projections
    - Crop growth models

Right place

- Incorporation in the soil reduces ammonia emission from urea:

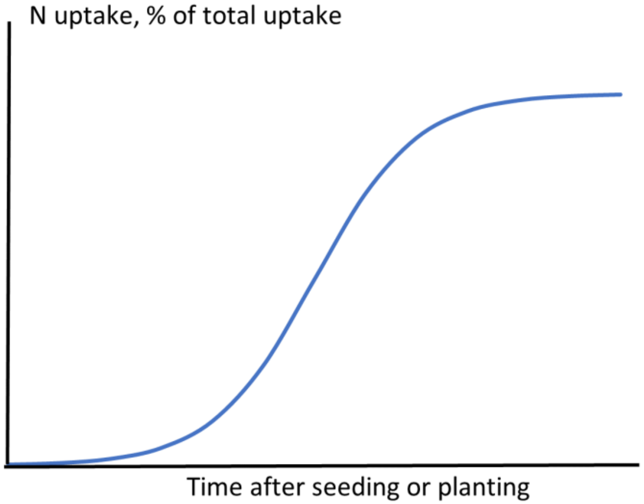
  - Incorporation or injection (55% reduction)
  - Irrigation after urea application (35% reduction)

Pan et al. (2016)

- Use of large granular urea in paddy rice may also decrease ammonia emission if urea penetrates in the soil

Right time

- Apply N fertilizer just before or during growing period of the crop



- Urea: avoid application at moments of high risk of ammonia emission (dry and windy)

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Conclusions

- Urea is the most used fertilizer on a global scale
- Global food demand will increase → need of chemical fertilizers will also increase
- Large part of applied nitrogen fertilizers is lost by gaseous emissions and leaching

  → High risk on ammonia losses from urea (15 – 30% of N applied)
- 4R nutrient management strategy to decrease nitrogen losses and increase nitrogen use efficiency: Right source, rate, place, and time

  → Losses from urea can be strongly decreased (up to 70%) by urease inhibitors, coatings and direct incorporation in the soil

Thank you!