The Dutch nitrogen crisis
Historical perspective and potential solutions

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- The Dutch nitrogen crisis: air quality and biodiversity
    - Nitrogen effects: eutrophication and acidification
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    - Evaluation current N policy versus Remkes and my advice
    - Circular agriculture

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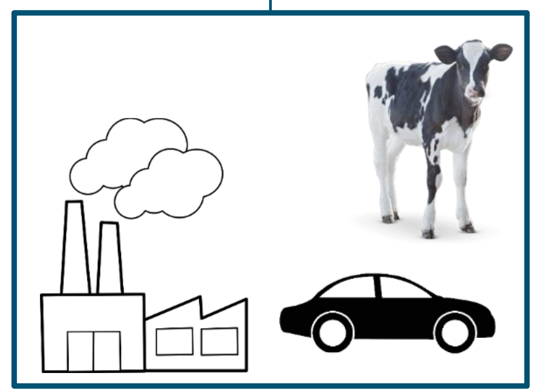
Effects of nitrogen deposition op nature: the old acid rain problem

NH_3, NO_x (SO_2)

NH_4^+, NO_3 (SO_4)

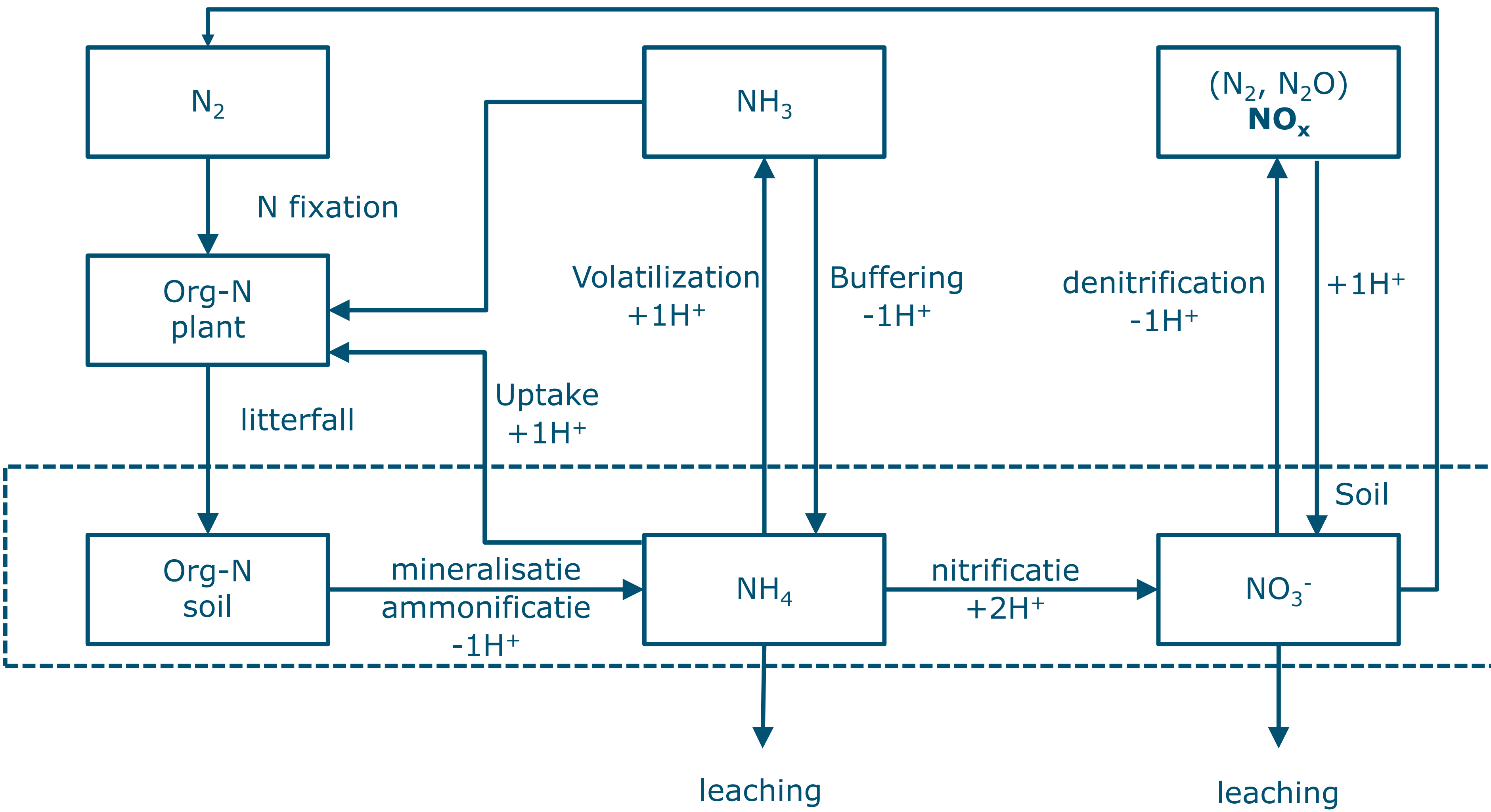
NH_3, NO_x (SO_2)



Decrease in diversity of plants due to:
Eutrophication: N excess
Acidification: Ca, Mg, K deficiency

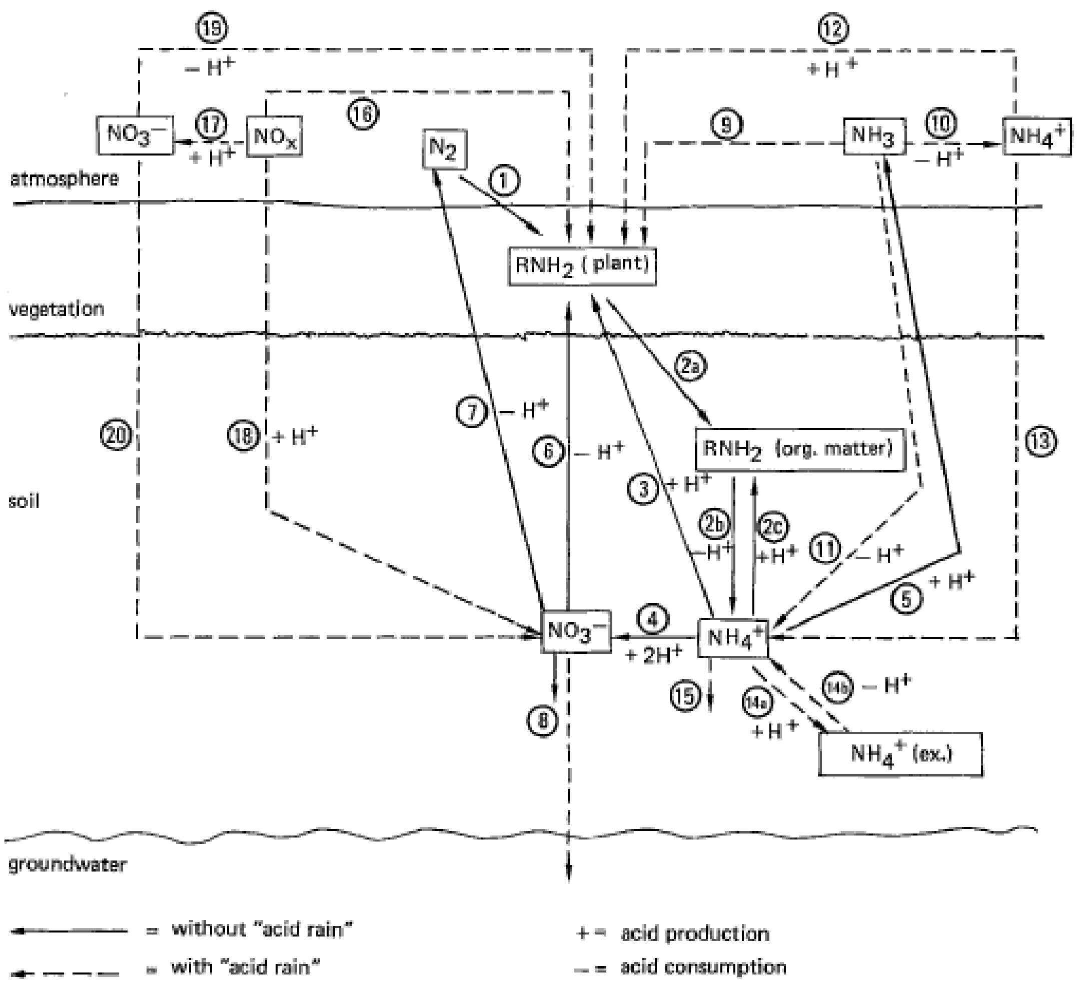
De Vries et al. (2017) Nitrogen most important cause ongoing acidification

N transformations en H^+ production/consumption



Acidification only occurs if NO_3 (by NO_x) or after nitrification (of NH_3) leaches from the soil

Details on nitrogen transformations and acid production and consumption



Source: De Vries and Breeuwsma, 1987

Acid consumption by NH_3 in air

NH_3 **+ H^+** <--> NH_4^+

Acid production by NH_4 in soil:

$NH_4^+ + 2O_2$ ->

NO_3^-**+ 2H^+**+ H_2O (nitrificatie)

Acid production by NO_2 in air

4 $NO_2 + O_2 + 2\ H_2O$ ->

4 NO_3 + 4 H^+ (oxidation)

Acid consumption by uptake NO_3 or transformation of NO_3 to N_2

5 CH_2O+ 4 NO_3 + **4 H^+** ->

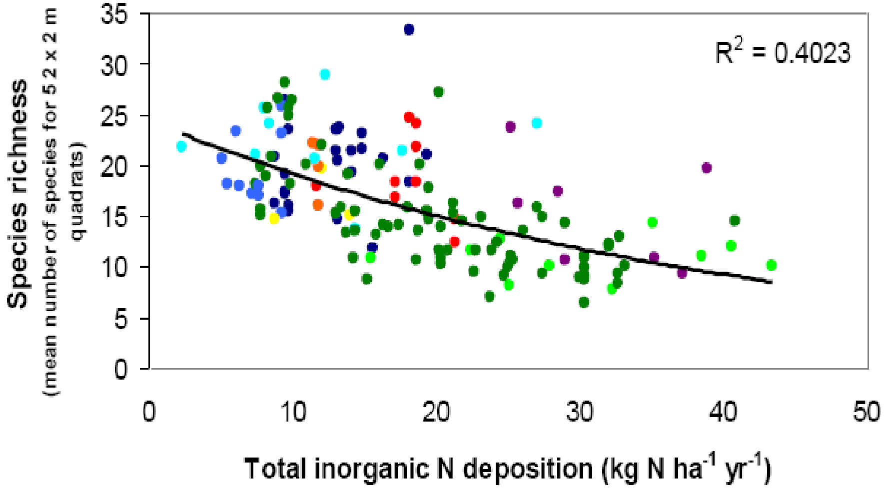
2 N_2 + 5 CO_2 + 4 H_2O (denitrification)

Acidification only occurs if NO_3 (by NOx) or after nitrification of nH3) leaches from the soil

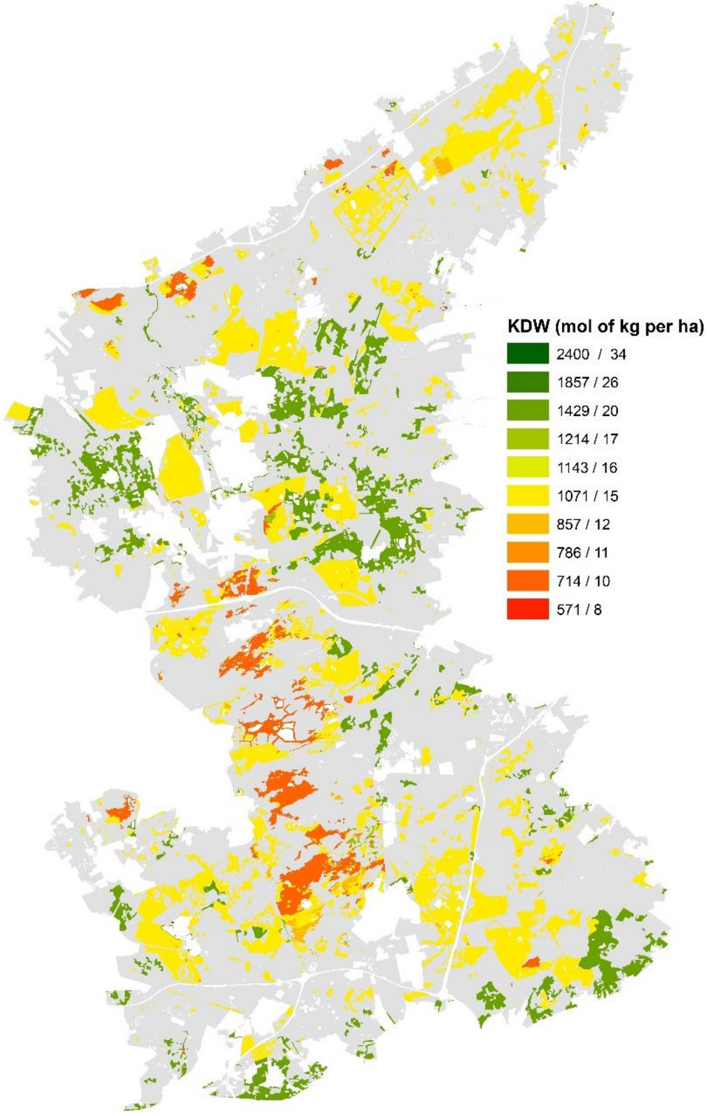
Derivation of critical nitrogen loads (KDWs)

Critical N loads are derived by:

- **N addition experiments**
- Effects N deposition over time
- *Effects N deposition over gradient*
- Model calculations



Critical nitrogen loads
Kritische depositiewaarden (KDWs)



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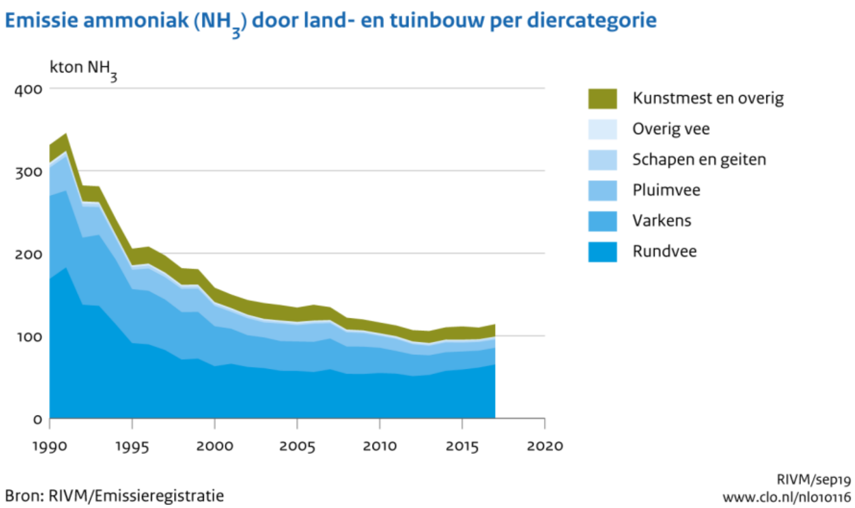
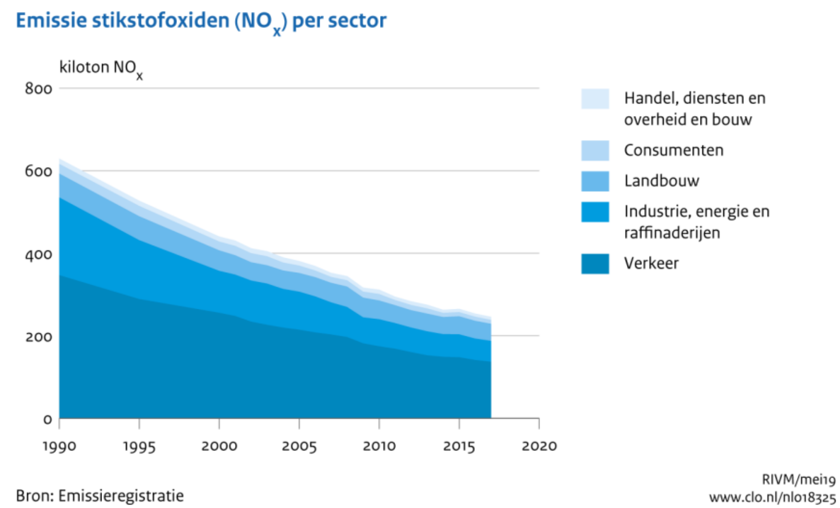
Emission-deposition-policy since 1990

- 90'ties: Separate emission protocols SO_2, NO_x and NH_3
- 1999: Combined S-N-O3 Gothenburg Protocol (UN-ECE)
- 2001: NEC directive (EU)
  - Linked to health impacts and habitat protection by N, S
  - Generic objectives; NL: 128 kton NH_3/260 kton NO_x 2010
- 1992 Habitat Directive
  - Habitat protection
  - Requires specific objectives per Nature area
  - Nitrogen not explicitly mentioned (external effect) but now linked to N deposition

Decrease in nitrogen emission and deposition 1990-2017 in the Netherlands





Ammonia emissions decreased by more than 60% in 1990-2017, mainly due to **low-emission fertilization**, covering manure storage, low-emission stables, livestock reduction, protein-poor feed.
No more ammonia reduction since 2012 (release of milk quota 2015; during PAS).
NOx reduction has continued

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2019

PAS rejected by

Raad van State

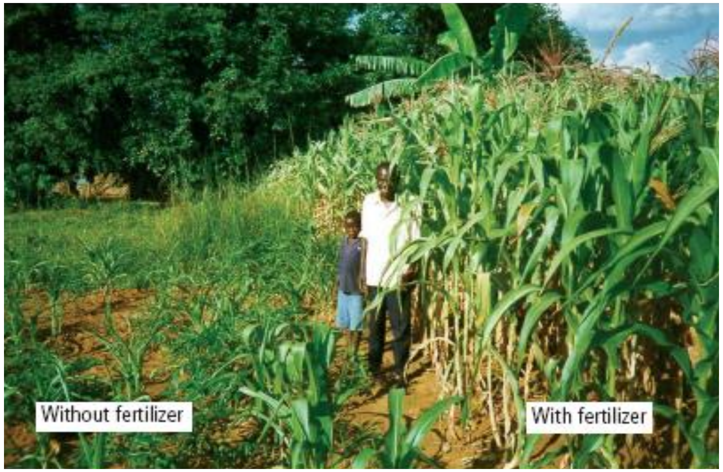
The Nitrogen crisis

The current N crisis

- Since the eighties ("acid rain"), emissions of ammonia (NH_3) and nitrogen oxides (NOx) have decreased by> 50%
- Nevertheless, "current" N deposition values exceed critical loads (KDWs) in 75% of the approximately 160 nature reserves
- Purpose of the PAS scheme: to slightly reduce deposition by giving a license based on reductions by other economic activities
- Permits issued on the basis of expected reductions that were not met
- The Council of State rejected PAS in May 29 2019
- Construction sector (with <1% contribution) also included in PAS
- Reductions needed mainly in the agricultural sector

Effects of N fertilizer on food production

- N fertilizer increases crop yields by a factor of 3-6.
- About 50% of the world's population is fed by N from fertilizers.
- It is estimated that an additional 2-3 billion people will be fed by 2050.



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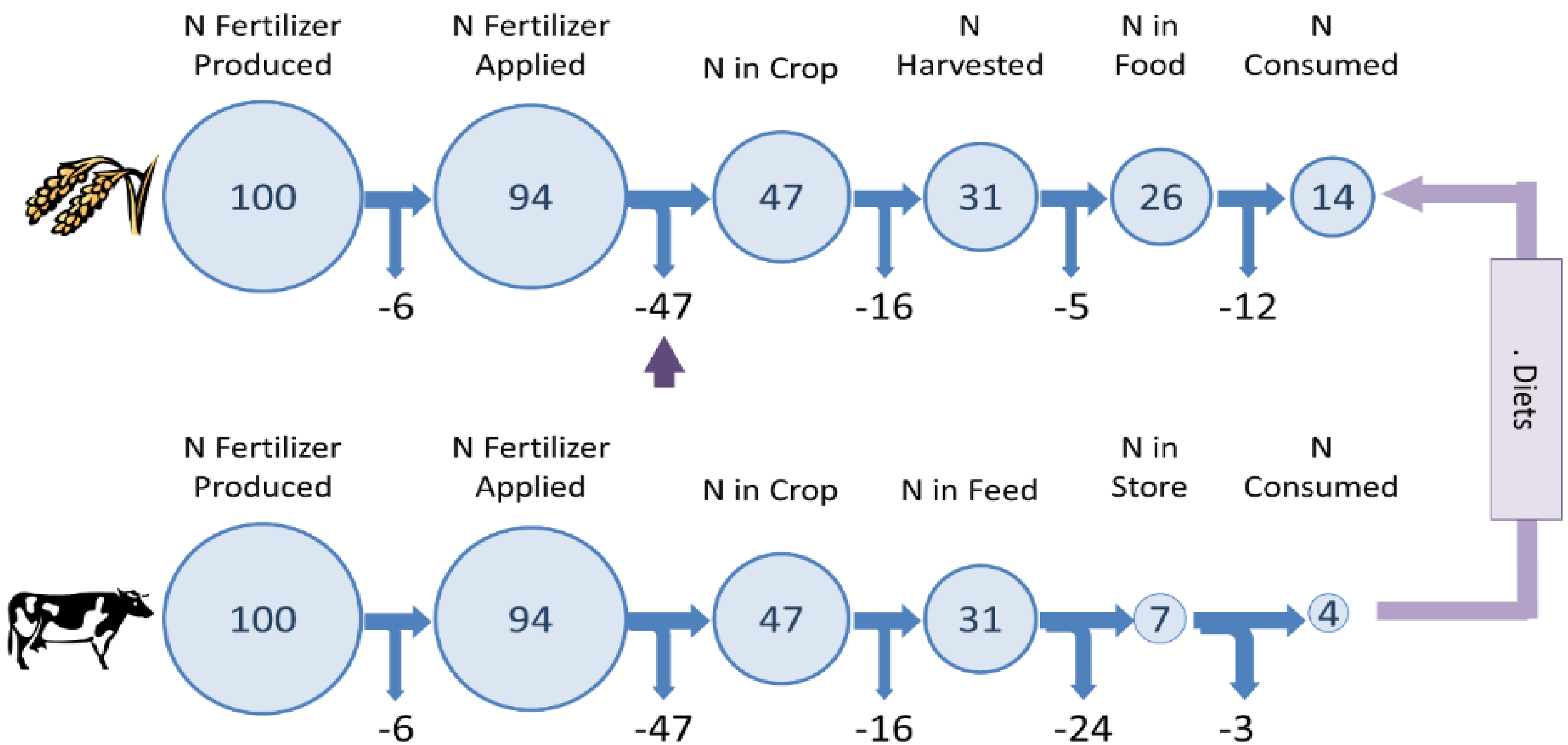
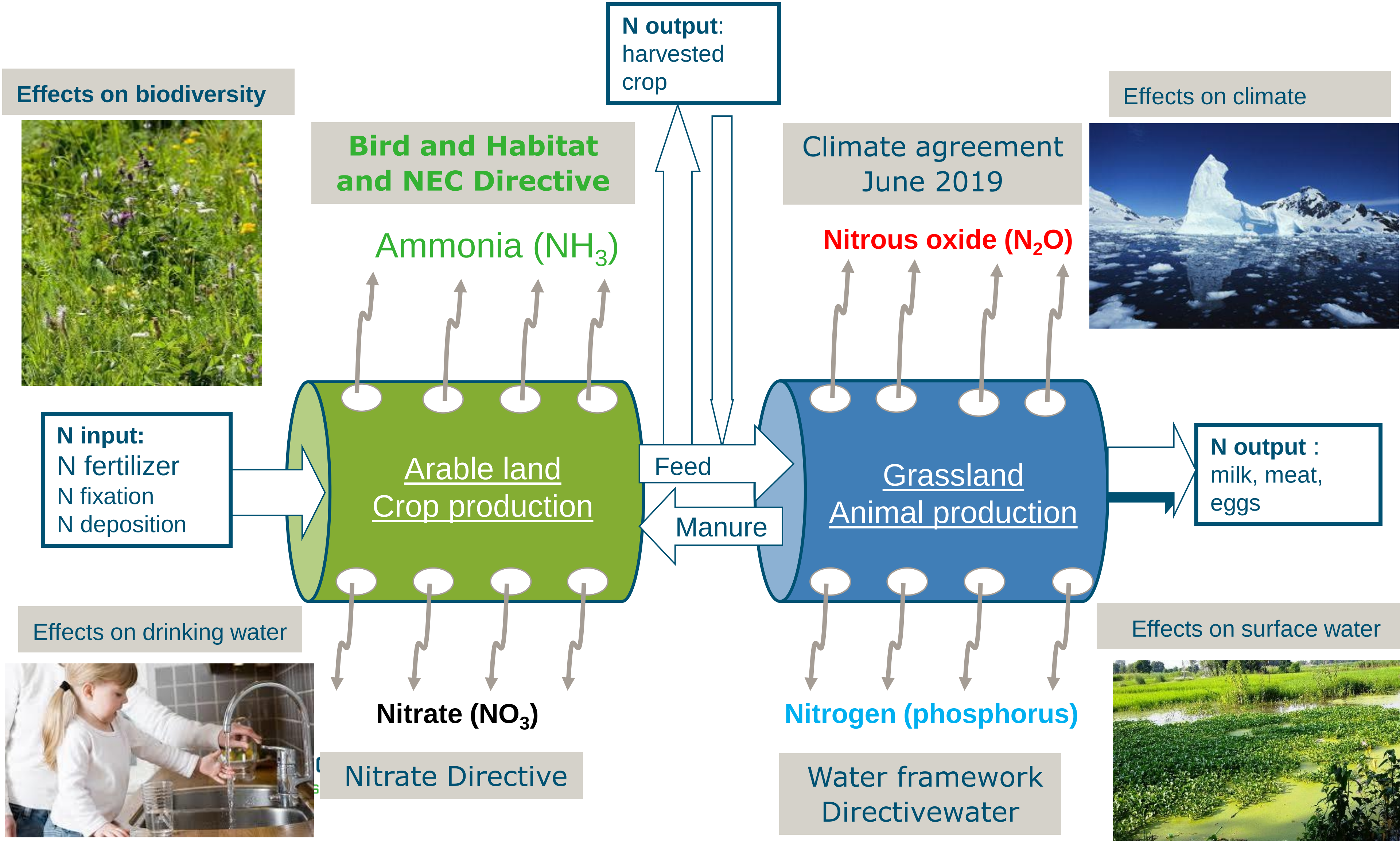
Nitrogen losses to air and water in the food chain



After Galloway and Cowling (2003)

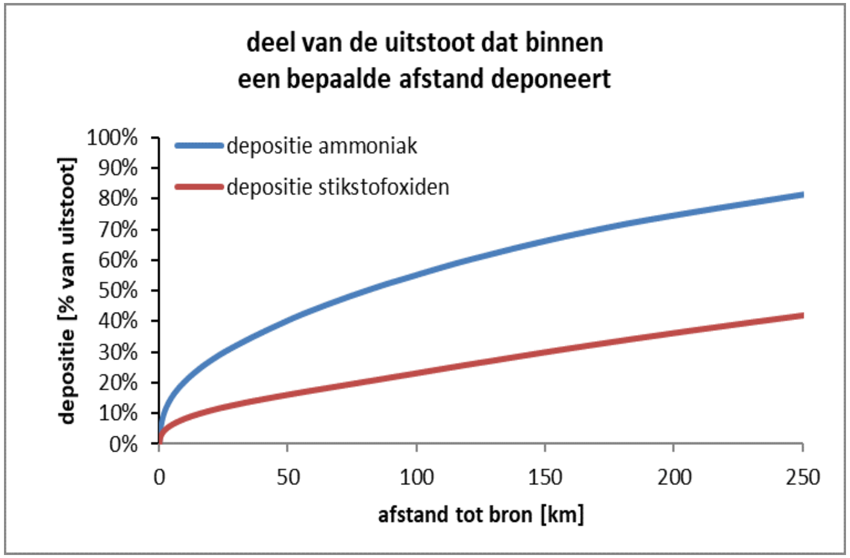
Directives to reduce N use/N losses in view of related impacts



Current Dutch nitrogen policy

License for activities causing N emissions based on permissible increase in deposition on N-2000 areas using a model (AERIUS). Questionable:

- No harmonization between national *emission* policy (NEC directive) and provincial *deposition* policy (Habitat Directive)
- Uncertainties in total N deposition and extra N deposition due to an economic activity on a local scale (ha)
- N emissions cause a deposition increase over hundreds of kilometers



Bouwstenen voor nieuw stikstofbeleid

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Commission Remkes: evaluation

- Focus on integrated approach (link N use/emissions to water quality by N and P losses, GHG and PM emissions): nutrient balance accounting, avoid trade-offs.
- Balanced contribution of all sectors to reduction measures (50% reduction in both NO_x and NH_3 in 2030).
- NO_x generic (country level) and NH_3 region specific (provincial level): provincial nitrogen emission ceilings.
- Minimizing locally high emissions (deposition) near N-2000
- In addition, customized measures for provinces to reach KDW (contribution provinces to deposition mostly <25%).
- Policy is legally tenable (result obligation and not an effort obligation or an endeavour) and feasible (not feasible for reaching all KDW's in 2040).

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My options for a new policy versus Remkes

- Focus on reduction N surplus (reduces all N effects)
- Change from deposition policy to emission policy and determine target for emission reduction (mixed emission-deposition; all KDW's reached 2040; not feasible, N import!)
- Divide the national emission ceiling for ammonia between the provinces (e.g. based on agricultural area).
- Do not give permission for extra activities < 1 km of N-2000.
- Focus on reducing emission ceilings in neighboring countries to reach KDWs as much as possible.
- Introduce an ammonia emission rights system (N surplus reduction is not linearly related to NH_3 emission reduction).

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Generic measures

- With management measures, significant ammonia emission reductions can be achieved:
  - Less protein in feed (less N import) and more grazing
  - Separate liquid and solid manure in stable
  - Dilute fertilizer with water or acidifying fertilizer
- Note:
  - Effectiveness of measure is not always well known
  - Effect of management measures must be monitored
  - Focus is on ammonia. Think about all N losses: Danger of pollution swapping
- In total 50% reduction in 10 years hardly (not) possible without livestock reduction. Reduce feed import is partly reduce livestock

Transition to circular agriculture

- Change to circular agriculture (reduction of external N import)
  - Focus on the use of residual flows by animals (limiting imports of nitrogen and phosphate via animal feed): fewer animals
  - in addition to NH_3 (biodiversity), there are also NO_3 (groundwater), N (surface water) and N_2O (climate) problems

- Link to climate agreement:
  - Reduce nitrous oxide (N_2O) and methane (CH_4) emissions
  - Carbon (CO_2) sequestration in agricultural lands (climate smart)
  - Reduction of CO_2 emissions by reducing/stopping the lowering of ground water level in peat soils

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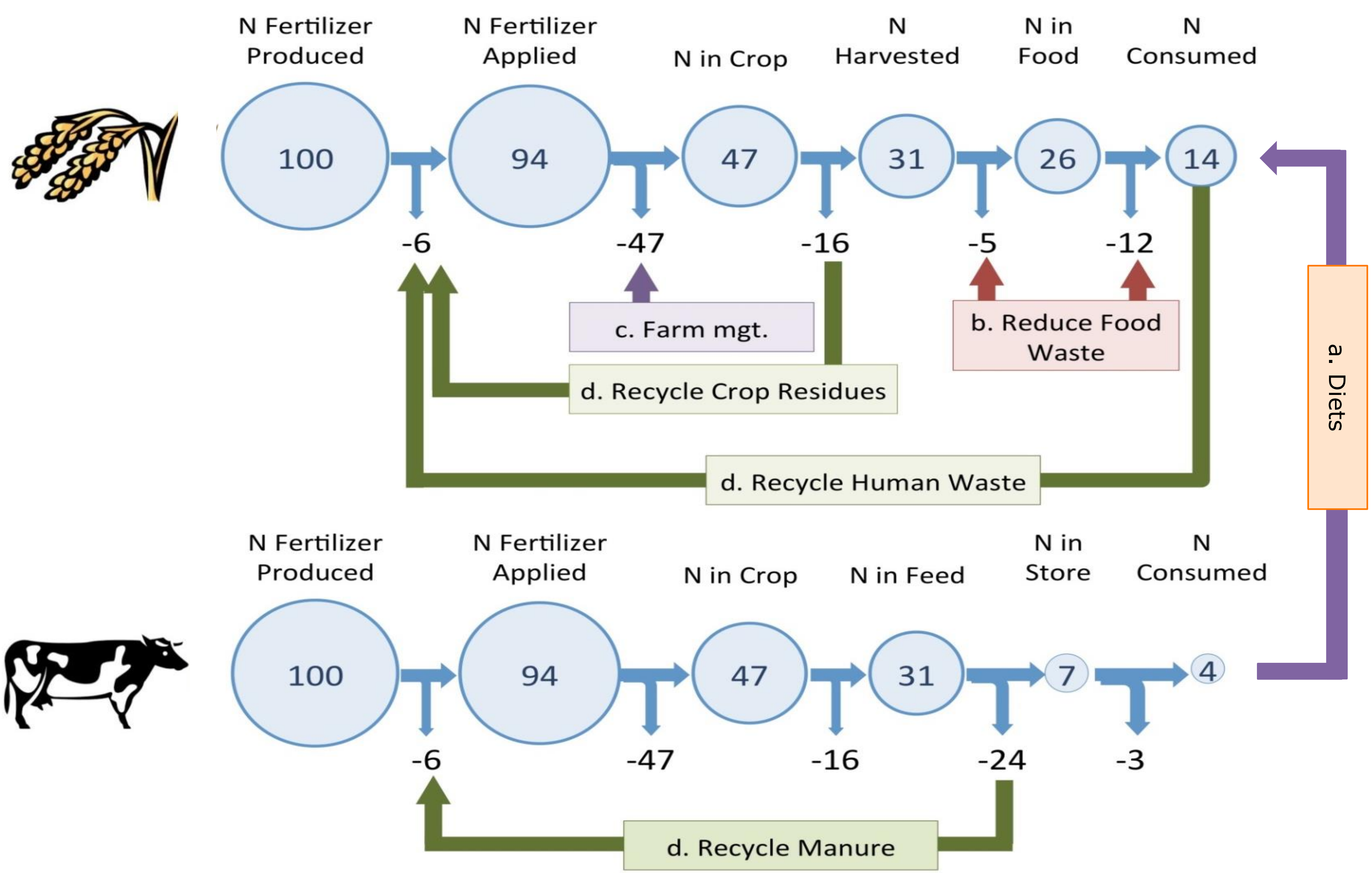
Options to reduce nitrogen losses to air and water in the food chain



Thanks for the attention

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